16. Abstract
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Surface Modification to Protect Permafrost

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>iii</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>iv</td>
</tr>
<tr>
<td>List of Figures</td>
<td>vi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>viii</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>ix</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Theoretical Considerations</td>
<td>3</td>
</tr>
<tr>
<td>Roadway Section Geometry</td>
<td>6</td>
</tr>
<tr>
<td>Method of Analysis</td>
<td>9</td>
</tr>
<tr>
<td>Finite Element Mesh</td>
<td>19</td>
</tr>
<tr>
<td>Cases Analyzed</td>
<td>24</td>
</tr>
<tr>
<td>Discussion</td>
<td>28</td>
</tr>
<tr>
<td>Field Tests</td>
<td>28</td>
</tr>
<tr>
<td>Field Sites</td>
<td>28</td>
</tr>
<tr>
<td>Field Data</td>
<td>31</td>
</tr>
<tr>
<td>Conclusions</td>
<td>43</td>
</tr>
<tr>
<td>References</td>
<td>45</td>
</tr>
<tr>
<td>Appendix A Sample Calculation of Sinusoidal Temperature Variation</td>
<td>49</td>
</tr>
<tr>
<td>Appendix B Monthly Isotherms for Eight Cases Analyzed</td>
<td>53</td>
</tr>
<tr>
<td>Case 1</td>
<td>54</td>
</tr>
<tr>
<td>Case 2</td>
<td>63</td>
</tr>
</tbody>
</table>
Case 3 ..................................................... 72
Case 4 ..................................................... 81
Case 5 ..................................................... 90
Case 6 ..................................................... 99
Case 7 ..................................................... 108
Case 8 ..................................................... 117

Appendix C Monthly Temperature Records for Brown’s Quarry Field Site ...... 126
Appendix D Monthly Temperature Records for Mitchell Expressway Field Site ... 160
Appendix E Annotated Bibliography .........................................................
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Geometry of Roadway Section Being Studied</td>
</tr>
<tr>
<td>2</td>
<td>Roadway Section with Subregions Shown and Material Types</td>
</tr>
<tr>
<td>3</td>
<td>Harmonic temperature variation for boundary condition #1 of Table 2</td>
</tr>
<tr>
<td>4</td>
<td>Harmonic temperature variation for boundary condition #2 and #5 of Table 2</td>
</tr>
<tr>
<td>5</td>
<td>Harmonic temperature variation for boundary condition #3 of Table 2</td>
</tr>
<tr>
<td>6</td>
<td>Harmonic temperature variation for boundary condition #4 of Table 2</td>
</tr>
<tr>
<td>7</td>
<td>Harmonic temperature variation for boundary condition #6 of Table 2</td>
</tr>
<tr>
<td>8</td>
<td>Smoothed harmonic temperature variation for boundary condition #7 of Table 2</td>
</tr>
<tr>
<td>9</td>
<td>Harmonic temperature variation for boundary condition #8 of Table 2</td>
</tr>
<tr>
<td>10</td>
<td>Finite Element Mesh</td>
</tr>
<tr>
<td>11</td>
<td>Maximum Depth of Thaw on October 1st after 6 years of simulation at toe-of-slope</td>
</tr>
<tr>
<td>12</td>
<td>Maximum Depth of Thaw on October 1st after 6 years of simulation at center-line</td>
</tr>
<tr>
<td>13</td>
<td>Bull rock placed to a depth of four feet on a two-on-one embankment</td>
</tr>
<tr>
<td>14</td>
<td>Data logger and thermistor strings</td>
</tr>
<tr>
<td>15</td>
<td>Thermistor string with sensor buried just below ground surface</td>
</tr>
<tr>
<td>16</td>
<td>Tamper-proof data logger housing</td>
</tr>
<tr>
<td>17</td>
<td>January data from Brown’s Hill Quarry site</td>
</tr>
<tr>
<td>18</td>
<td>Brown’s Hill Quarry - Ambient Air Degree Days</td>
</tr>
<tr>
<td>19</td>
<td>Brown’s Hill Quarry - Center Rock Degree Days</td>
</tr>
</tbody>
</table>
20 - Brown's Hill Quarry - Ground Surface Degree Days ..................... 36
21 - Mitchell Expressway - Ambient Air Degree Days .............................. 39
22 - Mitchell Expressway - Uncleared Ground Degree Days .................... 40
23 - Mitchell Expressway - Cleared Ground Degree Days ....................... 41
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Thermal Properties of Solids</td>
<td>11</td>
</tr>
<tr>
<td>2 - Boundary Conditions</td>
<td>11</td>
</tr>
<tr>
<td>3 - Eight cases analyzed</td>
<td>21</td>
</tr>
<tr>
<td>4 - Brown’s Hill Quarry Air and Surface Freezing Degree Days</td>
<td>37</td>
</tr>
<tr>
<td>5 - Brown’s Hill Quarry Air and Surface Thawing Degree Days</td>
<td>37</td>
</tr>
<tr>
<td>6 - Mitchell Expressway Air and Surface Freezing Degree Days</td>
<td>42</td>
</tr>
<tr>
<td>7 - Mitchell Expressway Air and Surface Freezing Degree Days</td>
<td>42</td>
</tr>
</tbody>
</table>
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INTRODUCTION

Pervasive permafrost in northern regions has required highway engineers to carefully examine the effect of any given construction on the thermal regime of the ground. In both continuous and discontinuous permafrost areas, changing ground surface conditions can lead to thaw degradation of the underlying permafrost, and subsequent thaw consolidation and settlement in ice-rich soils. It is well established that differences of up to 10°F can exist between the mean annual air and ground surface temperatures. These differences are a function of slope and surface orientation, vegetative and snow cover, soil thermal properties, meteorological conditions, and surface and subsurface drainage. As one example, consider that shading the ground surface from the summer sun and removing the insulating snow cover during the winter months results in the mean annual soil surface temperature (MASST) approaching equality with the mean annual air temperature. If these modifications lower the MASST below 32°F, permafrost will tend to be formed and thaw degradation of the permafrost will be either prevented or stopped.

In arctic regions, the most common method of protecting a roadway constructed over permafrost against thaw settlement is through the use of gravel fill of sufficient thickness to contain the active layer. As the MASST increases toward the melting temperature, the required fill thickness increases. Using the fill solution becomes an expensive practice in subarctic regions where the MASST approaches 32°F. Fill thicknesses can be reduced through the use of rigid foam plastic insulation (Esch, 1983). In cases where the fill will protect the permafrost beneath the center of the roadway, the sloping of the fill to zero thickness at the toe of the embankment allows this region to experience localized thaw degradation. This problem is exacerbated by snow plowing during winter, which increases the thickness of snow cover on the side slopes and
the toe zone, further insulating the ground from the cold air. When the side slope thaw front penetrates ice-rich permafrost, consolidation and thaw settlements occur. The effects of this settlement are sliding or rotation of the slopes and longitudinal cracking of the roadway surface.

In discontinuous permafrost areas, the MASST of the paved roadway and gravel side slopes may be above 32°F. In this case, no amount of insulation or fill will prevent thaw degradation; such measures only slow thawing. Berg et al. (1984) have applied white and yellow paints as well as several other pavement surface treatments in attempts to lower the MASST. As their study demonstrated, a painted roadway surface does yield a lower surface temperature, but traffic quickly degrades the high solar albedo of the surface. Additionally, there are safety considerations when using painted roadway surfaces, which become slippery when wet. Other schemes of stabilizing roadway embankments using insulation and air ducts have been reported by Zarling et al. (1983, 1988).

This study addresses two schemes in an attempt to achieve colder ground surface temperatures: snow management on the side slopes and natural convective cooling in porous rock placed on the side slopes.

The removal of snow from the side slopes of the roadway embankment throughout the winter season will reduce ground surface temperatures. However, leaving a blanket of snow on the surface to delay surface warming in the spring may also help retain the low ground temperatures achieved during the winter. A finite element geotechnical thermal analysis has been conducted as well as research at a field site on the enhanced cooling of the ground due to snow clearing.

The second technique of ground cooling evaluated in this study is the use of a thick layer of coarse rock placed on the side slopes of the roadway embankment. This technology has been
observed in Russia (Rooney, 1992) to stabilize the railroad bed built over permafrost on the
Bajkal Railroad. In essence the rock serves as a solar shade during the summer months and
promotes the natural convective cooling of the ground during the winter months to achieve lower
annual ground surface temperatures.

THEORETICAL CONSIDERATIONS

One measure of the annual freezing and thawing potential at the surface of the ground is the
surface freezing and thawing indices. These indices are defined as the cumulative summation
of the surface freezing or thawing degree days over the freezing or thawing season. A sinusoidal
surface temperature function can be derived from these indices and used as the driving function
for numerical simulations such as the finite element and finite difference methods. Detailed
development of the following equations are presented in Heuer et al. (1985) and Zarling and
Braley (1988).

Air temperatures and air freezing (AFI) and thawing (ATI) indices are generally available for
most locations, and parameters known as surface n-factors have been empirically determined for
many surfaces, for both the freeze and thaw seasons, in order to relate surface to air temperatures
(Lunardini, 1978; Esche, 1988). Surface n-factors are defined as the ratio of the surface
freezing or thawing index to the air freezing or thawing index, or

\[ n_f = \frac{SFI}{AFI} \]  

(1)

\[ n_c = \frac{STI}{ATI} \]  

(2)

The values of the \( n \)-factors as defined above depend upon the surface temperatures which are functions of the total heat transfer at the surface. The components making up the total surface energy balance include net short- and long-wave length radiation, evapotranspiration, convection from the ground surface to the air, and conduction from the surface into or out of the soil. N-factors not only vary from location to location, but will also vary from year to year at the same site.

If it is assumed that the soil surface temperature follows a sinusoidal function, then

\[ T_s(t) = T_{ns} - A_{os} \cos \left[ \frac{2\pi (t - \phi_s)}{365} \right] \]  

(3)

where \( T_{ns} \), \( A_{os} \), and \( \phi_s \) are the mean annual soil surface temperature, amplitude of surface temperature variation, and phase lag (from January 1) of the soil surface temperature, respectively. The mean annual soil surface temperature can be estimated from air freezing and thawing indices and \( n \)-factors as

\[ T_{ns} = \frac{n_c (ATI) - n_f (AFT)}{365} + T_f \]  

(4)

where \( T_f \) is the phase change temperature of water. The amplitude of the soil surface temperature variation can be determined from the surface thawing and freezing indices, the mean annual soil
surface temperature, surface temperature phase lag, and the beginning and ending of the thawing season as

\[
A_{os} = \frac{STI - (T_{ms} - T_f) (t_{2s} - t_{1s})}{\frac{365}{\pi} \sin \left[ \frac{2\pi (t_{1s} - \phi_s)}{365} \right]} \tag{5}
\]

The beginning, \(t_{1s}\), and ending, \(t_{2s}\), of the thawing season can be calculated using

\[
t_{1s} = \frac{365}{2\pi} \cos^{-1} \left[ \frac{T_{ms} - T_f}{A_{os}} \right] + \phi_s \tag{6}
\]

and

\[
t_{2s} = \frac{365}{2\pi} \left[ 2\pi - \cos^{-1} \left( \frac{T_{ms} - T_f}{A_{os}} \right) \right] + \phi_s \tag{7}
\]

An iterative approach must be used to calculate \(A_{os}\), Equation (5). The first approximation to \(t_{1s}\) and \(t_{2s}\) can be estimated using \(A_o\), the amplitude of the annual air temperature variation in Eqns (6) and (7). Then, the first approximation to \(A_{os}\) can be calculated using Eqn (5). The process is repeated using the new value of \(A_{os}\) in Eqns (6) and (7) for improved values of \(t_{1s}\) and \(t_{2s}\), etc. (see Appendix A for example calculation).

Decreasing the surface thawing n-factor and increasing the surface freezing n-factor yields a lower MASST. A measure of a system’s performance in changing the MASST is directly related to the surface n-factors, or surface freeze and thaw indices.
ROADWAY SECTION GEOMETRY

Figure 1 shows the roadway section studied using the finite element modelling program TDHC, Goering and Zarling (1985). The geometry was specified by McHattie (1992) as typical of the "barn roof" design presently being used by AKDOT&PF. Figure 2 shows the same roadway section divided into subregions with the soil types noted.
Fig. 1 Geometry of Roadway Section Being Studied
Fig. 2 Roadway Section with Subregions Shown and Material Types
METHOD OF ANALYSIS

In freezing and thawing problems, the heat conduction equation is nonlinear. These nonlinearities occur because the thermal properties, thermal conductivity and specific heat, are temperature dependent. In addition, the phase change that occurs releases or absorbs latent heat along a moving boundary.

A two dimensional finite element code, TDHC, written by Goering and Zarling (1985), has the capability to solve the aforementioned nonlinear problem by assigning the appropriate thermal properties to the elements at every time step. Although some iteration methods produce greater accuracy, the TDHC approach makes possible high rates of computer economy compared to these alternative schemes. As long as time steps are relatively small, little accuracy will be sacrificed using this approach.

The non-steady state heat diffusion equation is the governing equation for this problem:

\[ C \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} \left( k \frac{\partial T}{\partial x} \right) + \frac{\partial}{\partial y} \left( k \frac{\partial T}{\partial y} \right) \]  \hspace{1cm} (8)

where \( x \) and \( y \) are the space coordinates, \( T \) is soil temperature, \( t \) is time, \( C \) is the volumetric heat capacity, \( k \) is thermal conductivity, and \( L \) is the volumetric latent heat of the soil. Freezing at a discrete temperature is assumed and the thermal properties are assigned as follows:

\[ C = C_f \quad \text{for frozen soil} \]
\[ C = C_t \quad \text{for thawed soil} \]
\[ k = k_f \quad \text{for frozen soil} \]
\[ k = k_t \quad \text{for thawed soil} \]  \hspace{1cm} (9)
Presented in Table I are the dry densities, moisture contents, and thermal properties of the gravels and silts used in the simulations. Thermal conductivities are from Kerstren (1949). Volumetric, specific, and latent heats were calculated using the equations given below.

\[
C_f = \gamma_D (0.2 + 0.5 \frac{w}{100})
\]  

\[
C_e = \gamma_D (0.2 + 1.0 \frac{w}{100})
\]  

\[
L = 144 \gamma_D \frac{w}{100}
\]  

Boundary conditions used to model the roadway embankment were of three types. Along the surfaces of the embankment, the n-factor approach was used to arrive at sinusoidal surface temperature variations. Table 2 gives the parameters \( T_m, A_0, \) and \( \phi_s \) used in Eqn (3) for the various surface boundary condition cases analyzed. Figures 3 through 9 are graphs of the annual harmonic temperature variation for boundary conditions one through nine of Table 2. These boundary conditions characterize a discontinuous permafrost location similar to interior Alaska and a site like Fairbanks. Air temperature data for the site are 25.6°F mean annual air temperature, 35°F annual temperature amplitude variation, and an eight day phase lag from January 1. Air thawing and freezing indices for the site are 3,000 °F-days and 5,500 °F-days, respectively. The lower boundary of the roadway section was modeled using an upward geothermal heat flux of 0.012 BTU/hr-ft². Vertical boundaries were specified as zero heat flux boundaries (i.e., lines
Table 1. Thermal Properties of Solids

<table>
<thead>
<tr>
<th>Sub Region No.</th>
<th>Material</th>
<th>$\gamma_{d}$</th>
<th>$\omega$</th>
<th>$K_f$</th>
<th>$K_t$</th>
<th>$C_f$</th>
<th>$C_t$</th>
<th>$L$</th>
<th>$T_i$</th>
</tr>
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<tbody>
<tr>
<td>1,2,3,4</td>
<td>Gravel</td>
<td>135</td>
<td>4</td>
<td>1.4</td>
<td>1.5</td>
<td>27.0</td>
<td>29.7</td>
<td>780</td>
<td>33</td>
</tr>
<tr>
<td>5,6,7</td>
<td>Silt</td>
<td>75</td>
<td>42</td>
<td>1.2</td>
<td>0.6</td>
<td>29.3</td>
<td>45.0</td>
<td>4540</td>
<td>31</td>
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Table 2. Boundary Conditions

<table>
<thead>
<tr>
<th>No.</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Roadway (asphalt) paved surface</td>
</tr>
<tr>
<td>2.</td>
<td>Roadway gravel surface</td>
</tr>
<tr>
<td>3.</td>
<td>Snow covered gravel surface</td>
</tr>
<tr>
<td>4.</td>
<td>Snow covered gravel surface with low $n_f$</td>
</tr>
<tr>
<td>5.</td>
<td>Gravel surface without snow</td>
</tr>
<tr>
<td>6.</td>
<td>Gravel surface without snow and low $n_f$</td>
</tr>
<tr>
<td>7.</td>
<td>Gravel surface with snow management</td>
</tr>
<tr>
<td>8.</td>
<td>Snow covered turf/brush surface</td>
</tr>
<tr>
<td>9.</td>
<td>Air temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time Period</th>
<th>$n_f$</th>
<th>$n_t$</th>
<th>$T_{ms}$</th>
<th>$A_{ms}$</th>
<th>$\Theta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.-Dec.</td>
<td>1.0</td>
<td>1.9</td>
<td>32.90</td>
<td>47.10</td>
<td>8</td>
</tr>
<tr>
<td>Jan.-Dec.</td>
<td>1.0</td>
<td>1.7</td>
<td>31.30</td>
<td>44.50</td>
<td>8</td>
</tr>
<tr>
<td>Jan.-Dec.</td>
<td>0.4</td>
<td>1.7</td>
<td>40.00</td>
<td>29.80</td>
<td>8</td>
</tr>
<tr>
<td>Jan.-Dec.</td>
<td>0.4</td>
<td>1.0</td>
<td>34.30</td>
<td>21.80</td>
<td>8</td>
</tr>
<tr>
<td>Jan.-Dec.</td>
<td>1.0</td>
<td>1.7</td>
<td>31.30</td>
<td>44.50</td>
<td>8</td>
</tr>
<tr>
<td>Jan.-Dec.</td>
<td>1.0</td>
<td>1.0</td>
<td>25.60</td>
<td>35.00</td>
<td>8</td>
</tr>
<tr>
<td>Oct.-Dec.</td>
<td>1.0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>January</td>
<td>0.8</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>0.6</td>
<td>1.7</td>
<td>37.09</td>
<td>35.03</td>
<td>8</td>
</tr>
<tr>
<td>Mar.-Sep.</td>
<td>0.4</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.-Dec.</td>
<td>0.5</td>
<td>0.8</td>
<td>31.00</td>
<td>22.00</td>
<td>8</td>
</tr>
</tbody>
</table>
Fig. 3  Harmonic temperature variation for boundary condition #1 of Table 2.

Jan. - Dec.
T_{ms} = 32.9\degree F
A_{os} = 47.1\degree F
\phi_{s} = 8\text{ days}
Fig. 4  Harmonic temperature variation for boundary condition #2 and #5 of Table 2.

Jan. - Dec.
T_{ms} = 31.3{}^\circ F
A_{os} = 44.5{}^\circ F
\phi_s = 8 \text{ days}
Fig. 5 Harmonic temperature variation for boundary condition #3 of Table 2.

Jan. - Dec.
\[ T_{ms} = 40.0^\circ F \]
\[ A_{os} = 29.8 F^\circ \]
\[ \phi_s = 8 \text{ days} \]
Fig.6  Harmonic temperature variation for boundary condition #4 of Table 2.

Jan. - Dec.
Tms = 34.3°F
Aos = 21.8°F
ø8 = 8 days
Fig. 7 Harmonic temperature variation for boundary condition #6 of Table 2.

Jan. - Dec.

\[T_{\text{min}} = 25.6^\circ F\]
\[A_{\text{os}} = 35.0^\circ F\]
\[\phi_s = 8 \text{ days}\]
Fig. 8 Smoothed harmonic temperature variation for boundary condition #7 of Table 2.

Using weighted $n_f$

$T_{ms} = 37.1^\circ F$

$A_{os} = 35.0^\circ F$

$\phi_s = 8$ days
Fig. 9  Harmonic temperature variation for boundary condition #8 of Table 2.

Jan. - Dec.
\( T_{\text{ins}} = 31.0^\circ\text{F} \)
\( A_{\text{os}} = 22.0 \text{ F}^2 \)
\( \phi_s = 8 \text{ days} \)
of symmetry). This assumption along the roadway centerline forces the opposing side slopes to be mirror images or have identical temperatures. The other vertical boundary beyond the toe of slope must be defined at a sufficient distance from the toe of slope so the heat flow is, in fact, one dimensional. These boundary conditions (along the horizontal base, surface, and the two vertical sides) can be expressed respectively as

\[-K \frac{\partial T}{\partial y} = 0.012 \text{ BTU/hr-ft}^2 \text{ at } y = D\]

\[T(s,t) = T_{ns} - A_{ns} \cos \left( \frac{2\pi(t - \phi_s)}{365} \right)\] (13)

\[\frac{\partial T}{\partial x} = 0 \text{ at } x = 0 \text{ and } x = W\]

Finite Element Mesh

The finite element mesh used for all simulations is shown in Figure 10. Linear triangular elements were used for all analyses. Total number of nodes and elements were 1,980 and 2,956, respectively. The region extended to a depth, D, of 78 feet and a width, W, of 64 feet to ensure one dimensional heat flow along the bottom and right hand side (see Fig. 1). Because larger temperature gradients occur at the ground surface, smaller elements were specified along this boundary to improve accuracy.
Table 3. Eight cases analyzed

<table>
<thead>
<tr>
<th>Case</th>
<th>Option</th>
<th>Boundary conditions (see Table 2)</th>
<th>BC#</th>
</tr>
</thead>
</table>
| 1    | a. Roadway surface - Gravel, \( n_f = 1.0, n_t = 1.7 \)  
     | b. Gravel embankment surface - snow cover, \( n_f = 0.4, n_t = 1.7 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 2   |
|      | a. Roadway surface - Asphalt, \( n_f = 1.0, n_t = 1.9 \) | 1   |
|      | b. Gravel embankment surface - snow cover, \( n_f = 0.4, n_t = 1.7 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 3   |
| 2    | a. Roadway surface - Gravel, \( n_f = 1.0, n_t = 1.7 \)  
     | b. Gravel embankment surface - snow cover and low \( n_b \), \( n_f = 0.4, n_t = 1.0 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 4   |
|      | a. Roadway surface - Asphalt, \( n_f = 1.0, n_t = 1.9 \) | 1   |
|      | b. Gravel embankment surface - snow cover and low \( n_b \), \( n_f = 0.4, n_t = 1.0 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 3   |
| 3    | a. Roadway surface - Gravel, \( n_f = 1.0, n_t = 1.7 \)  
     | b. Gravel embankment surface - no snow cover, \( n_f = 1.0, n_t = 1.7 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 2   |
|      | a. Roadway surface - Asphalt, \( n_f = 1.0, n_t = 1.9 \) | 1   |
|      | b. Gravel embankment surface - no snow cover, \( n_f = 1.0, n_t = 1.7 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 5   |
| 4    | a. Roadway surface - Gravel, \( n_f = 1.0, n_t = 1.7 \)  
     | b. Gravel embankment surface - no snow cover and low \( n_b \), \( n_f = 1.0, n_t = 1.0 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 2   |
|      | a. Roadway surface - Asphalt, \( n_f = 1.0, n_t = 1.9 \) | 1   |
|      | b. Gravel embankment surface - no snow cover and low \( n_b \), \( n_f = 1.0, n_t = 1.0 \)  
     | c. Undisturbed surface beyond toe of slope, \( n_f = 0.5, n_t = 0.8 \) | 6   |
Table 3. (continued)

<table>
<thead>
<tr>
<th>Case</th>
<th>Option</th>
<th>Boundary conditions (see Table 2)</th>
<th>BC#</th>
</tr>
</thead>
</table>
| 5.   | 1      | a. Roadway surface - Gravel, $n_f = 1.0$, $n_t = 1.7$  
      |        | b. Gravel embankment surface - no snow cover until January 1 and then snow accumulates.  
      |        | c. Undisturbed surface beyond toe of slope, $n_f = 0.5$, $n_t = 0.8$ | 2  |
|      |        |                                   | 7  |
|      |        |                                   | 8  |
| 6.   | 1      | a. Roadway surface - Gravel, $n_f = 1.0$, $n_t = 1.7$  
      |        | b. Shallow slope embankment - no snow cover until January 1 and then snow accumulates.  
      |        | c. Steep slope embankment - snow cover, $n_f = 0.4$, $n_t = 1.7$  
      |        | d. Undisturbed surface beyond toe of slope, $n_f = 0.5$, $n_t = 0.8$ | 2  |
|      |        |                                   | 7  |
|      |        |                                   | 3  |
|      |        |                                   | 8  |
| 7.   | 1      | a. Roadway surface - Gravel, $n_f = 1.0$, $n_t = 1.7$  
      |        | b. Shallow slope embankment - no snow cover, $n_f = 1.0$, $n_t = 1.7$  
      |        | c. Steep slope embankment - snow cover, $n_f = 0.4$, $n_t = 1.7$  
      |        | d. Undisturbed surface beyond toe of slope, $n_f = 0.5$, $n_t = 0.8$ | 2  |
|      |        |                                   | 5  |
|      |        |                                   | 3  |
|      |        |                                   | 8  |
| 8.   | 2      | a. Roadway surface - Asphalt, $n_f = 1.0$, $n_t = 1.9$  
      |        | b. Shallow slope embankment - no snow cover, $n_f = 1.0$, $n_t = 1.7$  
      |        | c. Steep slope embankment - snow cover, $n_f = 0.4$, $n_t = 1.7$  
      |        | d. Undisturbed surface beyond toe of slope, $n_f = 0.5$, $n_t = 0.8$ | 1  |
|      |        |                                   | 5  |
|      |        |                                   | 3  |
|      |        |                                   | 8  |
Table 3. (continued)

<table>
<thead>
<tr>
<th>Case</th>
<th>Option</th>
<th>Boundary conditions (see Table 2)</th>
<th>BC#</th>
</tr>
</thead>
</table>
| 8.   | 1      | a. Roadway surface - Gravel, $n_f = 1.0$, $n_t = 1.7$
|      |        | b. Shallow slope embankment - no snow cover and low $n_b$, $n_f = 1.0$, $n_t = 1.0$
|      |        | c. Steep slope embankment - snow cover, $n_f = 0.4$, $n_t = 1.7$
|      |        | d. Undisturbed surface beyond toe of slope, $n_f = 0.5$, $n_t = 0.8$
|      | 2      | a. Roadway surface - Asphalt, $n_f = 1.0$, $n_t = 1.9$
|      |        | b. Shallow slope embankment - no snow cover and low $n_b$, $n_f = 1.0$, $n_t = 1.0$
|      |        | c. Steep slope embankment - snow cover, $n_f = 0.4$, $n_t = 1.7$
|      |        | d. Undisturbed surface beyond toe of slope, $n_f = 0.5$, $n_t = 0.8$
|      |        | 2 6 3 8 |
|      |        | 1 6 3 8 |
Cases Analyzed

Table 3 describes the eight cases analyzed in this study using the TDHC finite element program. The surface boundary conditions for each case are listed and explained as follows (note that each case has two options):

Case 1: Normal roadway and embankment without snow management. This should be considered the base case. Option 1 is a gravel roadway surface and Option 2 is an asphalt roadway surface.

Case 2: Similar to Case 1 except the gravel embankment has a lower thawing n-factor to simulate ground cover such as a shading type of vegetation. This will result in lower ground surface temperatures in the summer.

Case 3: Snow management on the entire roadway embankment resulting in the removal of all snow so that the freezing n-factor is one resulting in lower winter ground surface temperatures. All other conditions are identical to Case 1.

Case 4: Snow management on the entire roadway embankment, resulting in the removal of all snow so that the freezing n-factor is one. All other conditions are identical to Case 2.

Case 5: Snow management on the entire roadway embankment. Snow was removed until January 1, then allowed to accumulate. All other conditions identical to Case 1.

Case 6: Snow management on the shallow sloped section of the roadway embankment. Snow was removed until February 1, then allowed to accumulate. All other conditions identical to Case 1.
Case 7: Snow management on the shallow sloped section of the roadway embankment. Snow was removed throughout the winter, resulting in a freezing n-factor of one. All other conditions identical to Case 1.

Case 8: Snow management on the shallow sloped section of the roadway embankment. Snow was removed throughout the winter resulting in a freezing n-factor of one. All other conditions identical to Case 2.

Monthly isothermal contour plots for both options and for each of the eight cases are presented in Appendix B. Following the progression of the freezing isotherm, 32°F, allows comparisons to be made of the impact of the various surface boundary conditions. A summary of active layer depths on October 1 is presented in Figures 11 and 12. Figure 11 is the depth of thaw at the toe-of-slope of the roadway embankment at a distance of 44.2 feet from the roadway centerline. Figure 12 is the depth of thaw at the centerline of the road section. Option 2 in these tables generally shows a greater depth of thaw as expected. This is due to the warmer surface temperature of the paved asphalt roadway in comparison to the gravel surface. Case 4 shows the least amount of the thaw of the eight cases. Referring back to Table 3, this case yields the lowest embankment temperature and mean annual soil surface temperature. It is the snow management case in which the snow is removed for the entire season from all road and slope surfaces.
Fig. 11 Maximum Depth of Thaw on October 1st after 6 years of simulation at toe-of-slope.
Fig. 12 Maximum Depth of Thaw on October 1st after 6 years of simulation at center-line.
DISCUSSION

The finite element analysis used in this study is a pure conduction code allowing convective boundary conditions on the surfaces. It does not account for either the convective movement of water or air within the porous soil structure of the roadway embankment. Goering (1994) has modified the TDHC finite element code to account for convective phenomena within roadway embankments. In his study an entire roadway embankment of porous material was constructed to enhance the winter time cooling of the subgrade. In this study porous material was only used on the embankment side slopes which may offer some advantages in material utilization and cost.

The heat transfer taking place within the rock covered embankment is combined conductive, radiative and convective heat transfer. This is typical of the heat transfer modes that occur within porous materials. The major modes of heat transfer are the conduction and convection. During the winter season, convective circulation occurs within the rocks as the relatively warm ground heats the air in the voids. This buoyant warmed air rises to the surface where it is either cooled or escapes. In the summer time the air becomes dormant as a stable situation is developed with the relatively cool ground stratifying the air.

FIELD TESTS

Field Sites

Two field test sites were established for this study. The first site is at the Yutan Construction Company’s Brown’s Hill Quarry, located on Badger Road near North Pole, Alaska. At this site, quarry rock (4-inch to 6-inch cobbles) was placed to a thickness of four feet on an existing two-on-one embankment slope. Figures 13 and 14 are photographs showing the rock placement and
placement and instrumentation that was installed during construction. The snow was cleared away prior to placing rock on the side slope. Six thermistors were laid on the ground surface, then hand covered with rocks to hold them in place prior to the front end loader dumping the rocks. A seventh thermistor was installed in a radiation shield about two meters above the ground surface to measure ambient air temperature. Two thermistors were placed under the undisturbed snow to measure ground surface temperatures as a comparison. Seven of the thermistors were connected to a Campbell Scientific Model CR21 data logger that was programmed to record data every minute and calculate and store hourly averages. Five of these thermistors were located beneath the rock pile and the remaining two measured air and under-snow ground surface temperatures. A 12 volt automotive battery was used to power the data logger; the entire system was housed in a picnic cooler. Construction and installation of the rock covered embankment took place on January 7, 1993. Data logging also commenced at that time. No data were collected from May 1, 1993 until July 1, 1993 due to an operator error (switches were left in an incorrect position on the data logger memory module). No data were collected from March 9, 1994 until May 19, 1994 -- the cause is unknown (it is suspected that someone tampered with the data logger). Data are presently being collected at the site. As of May 19, 1994 the temperature under the rock pile was 26°F.

The second field site is located on the northwest corner of the intersection of the Mitchell Expressway and University Avenue in Fairbanks. At this test site, the effect of removing snow from a roadway embankment was evaluated using a similar data logging system. This site was instrumented on February 12, 1993. Seven thermistors were installed and monitored at
Fig. 13  Bull rock placed to a depth of four feet on a two-on-one embankment.

Fig. 14  Data logger and thermistor strings.
this site. Two thermistors were placed under the undisturbed snow, four on the cleared ground surface, and one thermistor was radiation shielded for measuring ambient air temperature. A Campbell Scientific Model CR21 data logger was used to monitor data. Figures 15 and 16 are photographs showing a thermistor string and data logger housing in place. The data set was continuous at this site from February 17, 1993 until January 21, 1994. No data were recorded from January 21 until March 9, 1994 due to an operator error (the Campbell Scientific data logger was left in the *6, or views input mode rather than returned to the *0, or logger mode). Data collection was terminated at this site on May 17, 1994, and the data logging equipment has been removed.

Field Data

The data analyzed from the Brown's Hill Quarry site are the ambient air, ground surface under the center of rock pile, and the undisturbed surface under the snow. Data for the month of January 1994 are shown in Fig. 17. Three thermistors that had the most complete data for air, under rock surface, and undisturbed surface were chosen for analysis. Monthly temperature plots for these three thermistor locations are given in Appendix C. Summary bar charts of the freezing and thawing degree days are given in Figs. 18 through 20. Tables 4 and 5 provide a tabulated summary of the degree days of freezing and thawing as well as the calculated freezing and thawing n-factors.

Using annual average air thawing and freezing indices for Fairbanks, Alaska and the n-factors from the data presented above, the mean annual soil surface temperatures can be calculated using Eqn (4). Under the rock-covered embankment slope, the mean annual temperature was 27.4°F compared to the uncovered ground surface, with a mean annual
Fig. 15  Thermistor string with sensor buried just below ground surface.

Fig. 16  Tamper-proof data logger housing.
Figure 17 January data from Brown's Hill Quarry site
Brown's Hill Quarry - Ambient Air Degree Days

Figure 18
Brown's Hill Quarry - Center Rock Degree Days

Surface Thawing Degree Days

Surface Freezing Degree Days

Feb-93  Mar-93  Apr-93  Jul-93  Aug-93  Sep-93  Oct-93  Nov-93  Dec-93  Jan-94  Feb-94

542.44  328.13  43.96  514.54  466  235.22  17.28  76.95  320.86  658.3  764.18  653.16
Brown's Hill Quarry - Ground Surface Degree Days

Figure 20
### Table 4.

**Brown's Hill Quarry**  
**Air and Surface Freezing Degree Days**

<table>
<thead>
<tr>
<th>Date</th>
<th>AFDD</th>
<th>SFDD Rocks</th>
<th>SFDD Snow</th>
<th>Nf Rocks</th>
<th>Nf Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/1 - 2/28/93</td>
<td>771</td>
<td>542</td>
<td>207</td>
<td>.70</td>
<td>.27</td>
</tr>
<tr>
<td>3/1 - 3/31/93</td>
<td>376</td>
<td>328</td>
<td>133</td>
<td>.87</td>
<td>.35</td>
</tr>
<tr>
<td>9/1 - 9/30/93</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10/1 - 10/31/93</td>
<td>171</td>
<td>77</td>
<td>46</td>
<td>.45</td>
<td>.27</td>
</tr>
<tr>
<td>11/1 - 11/30/93</td>
<td>727</td>
<td>321</td>
<td>158</td>
<td>.44</td>
<td>.22</td>
</tr>
<tr>
<td>12/1 - 12/31/93</td>
<td>987</td>
<td>658</td>
<td>312</td>
<td>.67</td>
<td>.32</td>
</tr>
<tr>
<td>1/1/94 - 1/31/94</td>
<td>1000</td>
<td>764</td>
<td>306</td>
<td>.76</td>
<td>.31</td>
</tr>
<tr>
<td>2/1/94 - 2/28/94</td>
<td>988</td>
<td>653</td>
<td>216</td>
<td>.66</td>
<td>.22</td>
</tr>
<tr>
<td><strong>Annual Total</strong></td>
<td>4,258</td>
<td>2,801</td>
<td>1,171</td>
<td>.66</td>
<td>.28</td>
</tr>
</tbody>
</table>

### Table 5.

**Brown's Hill Quarry**  
**Air and Surface Thawing Degree Days**

<table>
<thead>
<tr>
<th>Date</th>
<th>ATDD</th>
<th>STDD Rocks</th>
<th>STDD Snow</th>
<th>Nt Rocks</th>
<th>Nt Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/1 - 3/31/93</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4/1 - 4/30/93</td>
<td>325</td>
<td>1</td>
<td>229</td>
<td>.47</td>
<td>.70</td>
</tr>
<tr>
<td>7/1 - 7/31/93</td>
<td>1,100</td>
<td>515</td>
<td>1,359</td>
<td>.61</td>
<td>1.23</td>
</tr>
<tr>
<td>8/1 - 8/31/93</td>
<td>762</td>
<td>466</td>
<td>899</td>
<td>.64</td>
<td>1.18</td>
</tr>
<tr>
<td>9/1 - 9/30/93</td>
<td>368</td>
<td>235</td>
<td>410</td>
<td>.17</td>
<td>1.11</td>
</tr>
<tr>
<td>10/1 - 10/31/93</td>
<td>102</td>
<td>17</td>
<td>94</td>
<td>.64</td>
<td>.92</td>
</tr>
<tr>
<td><strong>Partial Total</strong></td>
<td>1,925</td>
<td>1,233</td>
<td>2,991</td>
<td>.64</td>
<td>1.55</td>
</tr>
</tbody>
</table>
temperature of 40.5°F. This is a 13.1°F temperature decrease in the ground surface temperature due to the convective heat transfer that occurs within the rocks.

The data analyzed from the Mitchell Expressway site are ambient air temperature, ground surface at cleared area, and ground surface under undisturbed snow. The thermistor string closest to the highway was dug up twice. We believe this occurred once due to snow clearing activities, the second time by a well meaning "clean-up-day" person. Therefore the thermistor furthest from the highway was chosen for data analysis. Another problem was the installation of thermistors to measure surface temperature. If they are too shallow, air temperature is measured; and if too deep, then the temperatures tend to be colder than surface temperature during the summer period. It is likely that a 10% error exists in these temperatures as opposed to true summer surface temperatures. Because a snow layer covered the thermistors during the winter, the percentage of error is reduced. Monthly temperature plots for these three thermistor locations are given in Appendix D. Summary bar charts of the freezing and thawing degree days are given in Figs. 21 through 23. Tables 6 and 7 provide a tabulated summary of the degree days of freezing and thawing as well as the calculated freezing and thawing n-factors.
Figure 21

Mitchell Expressway - Ambient Air Degree Days

<table>
<thead>
<tr>
<th>Month</th>
<th>Air Freezing Degree Days</th>
<th>Air Thawing Degree Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb-93</td>
<td>194.22</td>
<td>863.03</td>
</tr>
<tr>
<td>Mar-93</td>
<td>384.14</td>
<td>1030.32</td>
</tr>
<tr>
<td>Apr-93</td>
<td>259.10</td>
<td>1056.51</td>
</tr>
<tr>
<td>May-93</td>
<td>685.62</td>
<td>724.95</td>
</tr>
<tr>
<td>Jun-93</td>
<td>895.81</td>
<td>336.35</td>
</tr>
<tr>
<td>Jul-93</td>
<td>1056.51</td>
<td>72.98</td>
</tr>
<tr>
<td>Aug-93</td>
<td>336.35</td>
<td>13.35</td>
</tr>
<tr>
<td>Sep-93</td>
<td>746.58</td>
<td>189.75</td>
</tr>
<tr>
<td>Oct-93</td>
<td>189.75</td>
<td>863.03</td>
</tr>
<tr>
<td>Nov-93</td>
<td>746.58</td>
<td>1030.32</td>
</tr>
<tr>
<td>Dec-93</td>
<td>1030.32</td>
<td>863.03</td>
</tr>
<tr>
<td>Jan-94</td>
<td>863.03</td>
<td>863.03</td>
</tr>
</tbody>
</table>
Figure 23

Mitchell Expressway - Cleared Ground Degree Days

Surface Thawing Degree Days

Surface Freezing Degree Days

Feb-93 | Mar-93 | Apr-93 | May-93 | Jun-93 | Jul-93 | Aug-93 | Sep-93 | Oct-93 | Nov-93 | Dec-93 | Jan-94

135.32 | 332.45 | 267.57 | 578.82 | 1018.13 | 1240.15 | 830.11 | 345.18 | 38.82 | 14.76 | 45.47 | 326.10 | 624.26 | 631.44
Table 6. Mitchell Expressway
Air and Surface Freezing Degree Days

<table>
<thead>
<tr>
<th>Date</th>
<th>AFDD</th>
<th>SFDD Cleared</th>
<th>SFDD Snow</th>
<th>Nf Snow Cleared</th>
<th>Nf Snow Not Cleared</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/17 - 2/28/93</td>
<td>194</td>
<td>135</td>
<td>60</td>
<td>0.70</td>
<td>0.31</td>
</tr>
<tr>
<td>3/1 - 3/31/93</td>
<td>384</td>
<td>332</td>
<td>141</td>
<td>0.86</td>
<td>0.37</td>
</tr>
<tr>
<td>9/1 - 9/30/93</td>
<td>13</td>
<td>15</td>
<td>19</td>
<td>1.15</td>
<td>1.46</td>
</tr>
<tr>
<td>10/1 - 10/31/93</td>
<td>190</td>
<td>45</td>
<td>94</td>
<td>0.24</td>
<td>0.49</td>
</tr>
<tr>
<td>11/1 - 11/30/93</td>
<td>747</td>
<td>326</td>
<td>287</td>
<td>0.44</td>
<td>0.38</td>
</tr>
<tr>
<td>12/1 - 12/31/93</td>
<td>1030</td>
<td>624</td>
<td>584</td>
<td>0.61</td>
<td>0.57</td>
</tr>
<tr>
<td>1/1 - 1/20/94</td>
<td>863</td>
<td>631</td>
<td>528</td>
<td>0.73</td>
<td>0.61</td>
</tr>
<tr>
<td>Partial Total</td>
<td>3421</td>
<td>2108</td>
<td>1713</td>
<td>0.62</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Table 7. Mitchell Expressway
Air and Surface Freezing Degree Days

<table>
<thead>
<tr>
<th>Date</th>
<th>ATDD</th>
<th>STDD Cleared</th>
<th>STDD Snow</th>
<th>Nt Snow Cleared</th>
<th>Nt Snow Not Cleared</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/1 - 4/30/93</td>
<td>259</td>
<td>268</td>
<td>167</td>
<td>1.04</td>
<td>0.64</td>
</tr>
<tr>
<td>5/1-5/31/93</td>
<td>686</td>
<td>579</td>
<td>553</td>
<td>0.84</td>
<td>0.81</td>
</tr>
<tr>
<td>6/1 - 6/30/93</td>
<td>896</td>
<td>1018</td>
<td>862</td>
<td>1.14</td>
<td>0.96</td>
</tr>
<tr>
<td>7/1 - 7/30/93</td>
<td>1057</td>
<td>1240</td>
<td>995</td>
<td>1.17</td>
<td>0.94</td>
</tr>
<tr>
<td>8/1 - 8/31/93</td>
<td>725</td>
<td>830</td>
<td>680</td>
<td>1.14</td>
<td>0.94</td>
</tr>
<tr>
<td>9/1 - 9/30/93</td>
<td>336</td>
<td>345</td>
<td>293</td>
<td>1.03</td>
<td>0.87</td>
</tr>
<tr>
<td>10/1 - 10/31/93</td>
<td>73</td>
<td>39</td>
<td>15</td>
<td>0.53</td>
<td>0.20</td>
</tr>
<tr>
<td>Partial Total</td>
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<td>4319</td>
<td>3565</td>
<td>6.89</td>
<td>5.36</td>
</tr>
</tbody>
</table>
CONCLUSIONS

The initial effort undertaken in this study was a computer literature search through the Dialog service of the TRIS (Transportation Research Information System) database for citations involving techniques used to stabilize permafrost beneath roadways. The only direct references to surface modification techniques have been quoted in this report. Appendix E contains the complete annotated bibliography that was produced by the literature search.

An extensive geotechnical thermal analysis was conducted of a typical "barn roof" roadway section. Eight different boundary conditions were applied to the roadway embankment for two road surface options: gravel and asphalt. The full-season snow clearing scenario produced the lowest ground surface temperatures and the least amount of thaw.

Two field sites were established to evaluate the potential of snow clearing and the use of coarse rock "cobbles" (3"-6") to thermally stabilize roadway embanks built over permafrost. The n-factor data from the snow management site are not conclusive as to the effectiveness of this technique. The data show a slightly higher ground surface freezing n-factor for the cleared area. However, during the summer, the surface thawing n-factor for the cleared area is also lower than the uncleared area when, in fact, they should be about equal. The wintertime n-factor data from the coarse rock site are quite encouraging. The winter surface n-factor under the rock pile is more than twice the value for the undisturbed surface. During the summer thaw season, the surface n-factor under the rocks is less than one-half the surface thawing n-factor for the undisturbed surface. The net effect was an estimated mean annual temperature of 27.4°F under the rock cover compared to 40.5°F for the undisturbed surface.
It is recommended that AKDOT&PF pursue the use of rock cover on the embankment side-slopes of several problem roadway sections. A more complete test of this concept along an actual roadway could be carried out under the Federal Highway's Experimental Features Program. Temperature instrumentation of the ground surface should be included as part of the project to further establish the potential of this method of stabilizing roadways built over permafrost.
REFERENCES


McHattie, R., 1992. Personal communication, Alaska Department of Transportation and Public Facilities, Fairbanks, AK.


APPENDIX A

Sample Calculation of Sinusoidal Temperature Variation
Calculation of Harmonic Boundary Conditions

From the Environmental Atlas of Alaska, for Fairbanks,

\[ T_m = 25.6^\circ\text{F} \]
\[ A_0 = 35.0 \text{ F}^* \]
\[ \varnothing = 8 \text{ days} \]

Using these data, the beginning and ending of the air thawing season are calculated as,

\[ t_1 = \frac{365}{2\pi} \cos^{-1}\left[\frac{T_m - T_f}{A_0}\right] + \varnothing \]
\[ = \frac{365}{2\pi} \cos^{-1}\left[\frac{25.6 - 32}{35}\right] + 8 \]
\[ = 110 \text{ days} \]
\[ t_2 = \frac{365}{2\pi} \left[2\pi - \cos^{-1}\left[\frac{T_m - T_f}{A_0}\right]\right] + \varnothing \]
\[ = \frac{365}{2\pi} \left[2\pi - \cos^{-1}\left[\frac{25.6 - 32}{35}\right]\right] + 8 \]
\[ = 271 \text{ days} \]

Now, the air thawing and air freezing indices are calculated,

\[ \text{ATI} = \frac{(T_m - T_f)(t_2 - t_1) + \frac{365 A_0}{\pi} \sin \frac{2\pi (t_1 - \varnothing)}{365}}{\frac{365 x 35}{\pi} \sin \frac{2\pi (110 - 8)}{365}} \]
\[ = 2967 \text{ F-days} \]

\[ \text{AFI} = \frac{2 (T_f - T_m) (t_1 - \varnothing) + \frac{365 A_0}{\pi} \sin \frac{2\pi (t_1 - \varnothing)}{365}}{\frac{365 x 35}{\pi} \sin \frac{2\pi (110 - 8)}{365}} \]
\[ = 5303 \text{ F-days} \]

Boundary condition #2 of table 2

For Subregion #1 (gravel surface) the appropriate n-factors are picked as

\[ n_f = 1.0, \quad n_t = 1.7 \]

The mean annual soil surface temperature is now estimated,
\[ T_{ms} = T_f + \frac{n_t (ATL) - n_t (AFI)}{365} \]
\[ = 32 + \frac{1.7 (2967) - 1.0 (5303)}{365} \]
\[ = 31.3 \, ^\circ F \]

Using the above data, the amplitude of cosine function for the ground surface temperature variation is estimated,

\[ A_{os} = \frac{\pi}{365 \sin \left[ \frac{2\pi (t_1 - \phi)}{365} \right]} \left[ \text{STI} - (T_{ms} - T_f) (t_2 - t_1) \right] \]
\[ = \frac{\pi}{365 \sin \left[ \frac{2\pi (110 - 8)}{365} \right]} \left[ 5043 - (31.3 - 32) (271 - 110) \right] \]
\[ = 46 \, ^\circ F \]

Now, new values of \( t_1 \) and \( t_2 \) are found

\[ t_1 = \frac{365}{2\pi} \cos^{-1} \left[ \frac{T_{ms} - T_f}{A_{os}} \right] + \phi \]
\[ = \frac{365}{2\pi} \cos^{-1} \left[ \frac{31.3 - 32}{46} \right] + 8 \]
\[ = 101 \, \text{days} \]

\[ t_2 = \frac{365}{2\pi} \left[ 2\pi - \cos^{-1} \left[ \frac{T_m - T_f}{A_0} \right] \right] + \phi \]
\[ = \frac{365}{2\pi} \left[ 2\pi - \cos^{-1} \left[ \frac{31.3 - 32}{46} \right] \right] + 8 \]
\[ = 281 \, \text{days} \]

Solving again the equation for \( A_{os} \) gives,

\[ A_{os} = \frac{\pi}{365 \sin \left[ \frac{2\pi (t_1 - \phi)}{365} \right]} \left[ \text{STI} - (T_{ms} - T_f) (t_2 - t_1) \right] \]
\[ = \frac{\pi}{365 \sin \left[ \frac{2\pi (101 - 8)}{365} \right]} \left[ 5043 - (31.3 - 32) (281 - 101) \right] \]
\[ = 44.5 \, ^\circ F \]

Thus the approximate seasonal ground surface temperature variation is

\[ T(t) = 31.3 - 44.5 \cos \left[ \frac{2\pi}{365} (t - 8) \right] \]
Boundary condition #1 of table 2
\[ n_f = 1.0, \quad n_t = 1.9 \]
\[ T(t) = 32.9 - 47.1 \cos \left( \frac{2\pi}{365} (t-8) \right) \]

Boundary condition #3 of table 2
\[ n_f = 0.4, \quad n_t = 1.7 \]
\[ T(t) = 40 - 29.8 \cos \left( \frac{2\pi}{365} (t-8) \right) \]

Boundary condition #4 of table 2
\[ n_f = 0.4, \quad n_t = 1.0 \]
\[ T(t) = 34.3 - 21.8 \cos \left( \frac{2\pi}{365} (t-8) \right) \]

Boundary condition #5 of table 2
\[ n_f = 1.0, \quad n_t = 1.7 \]
\[ T(t) = 31.3 - 44.5 \cos \left( \frac{2\pi}{365} (t-8) \right) \]

Boundary condition #6 and #9 of table 2
\[ n_f = 1.0, \quad n_t = 1.0 \]
\[ T(t) = 25.6 - 35 \cos \left( \frac{2\pi}{365} (t-8) \right) \]

Boundary condition #7 of table 2
Gravel surface with snow management
- Oct. - Dec. \( n_f = 1.0, \quad n_t = 1.7 \)
- Jan. \( n_f = 0.8 \)
- Feb. \( n_f = 0.6 \)
- Mar. - Sep. \( n_f = 0.4 \)

Weighted \( n_f = 0.6 \)
\[ T(t) = 37.09 - 35 \cos \left( \frac{2\pi}{365} (t-8) \right) \]

Boundary condition #8 of table 2
\[ n_f = 0.5, \quad n_t = 0.8 \]
\[ T(t) = 31 - 22 \cos \left( \frac{2\pi}{365} (t-8) \right) \]
APPENDIX B

Monthly Isotherms for Eight Cases Analyzed
Case 1
Case 1: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover
Steep slope: Snow cover
Day: January 1
Case 1: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover
Steep slope: Snow cover
Day: April 1

Distance from center of the road (ft)
Case 1: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover
Steep slope: Snow cover
Day: July 1
Case 1: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover
Steep slope: Snow cover
Day: October 1
Case 1: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover
Steep slope: Snow cover
Day: January 1
Case 1: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover
Steep slope: Snow cover
Day: April 1
Case 1: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover
Steep slope: Snow cover
Day: July 1
Case 1: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover
Steep slope: Snow cover
Day: October 1
Case 2
Case 2: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover and low n
Steep slope: Snow cover and low n
Day: April 1
Case 2: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover and low $n_t$
Steep slope: Snow cover and low $n_t$
Day: July 1
Case 2: Option 1:
Roadway Surface: Gravel
Shallow slope: Snow cover and low $n_r$
Steep slope: Snow cover and low $n_r$
Day: October 1
Case 2: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover and low $n_t$
Steep slope: Snow cover and low $n_t$
Day: January 1
Case 2: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover and low $n_t$
Steep slope: Snow cover and low $n_t$
Day: April 1
Case 2: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover and low n_t
Steep slope: Snow cover and low n_t
Day: July 1
Case 2: Option 2:
Roadway Surface: Paved
Shallow slope: Snow cover and low $n_t$
Steep slope: Snow cover and low $n_t$
Day: October 1
Case 3
Case 3: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: No snow cover
Day: January 1
Case 3: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: No snow cover
Day: April 1
Case 3: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: No snow cover
Day: July 1
Case 3: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: No snow cover
Day: October 1
Case 3: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: No snow cover
Day: January 1
Case 3: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: No snow cover
Day: April 1
Case 3: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: No snow cover
Day: July 1
Case 3: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: No snow cover
Day: October 1
Case 4
Case 4: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low $n_t$
Steep slope: No snow cover and low $n_t$
Day: January 1
Case 4: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low n_s
Steep slope: No snow cover and low n_s
Day: April 1
Case 4: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low n
Steep slope: No snow cover and low n
Day: July 1
Case 4: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low $n_t$
Steep slope: No snow cover and low $n_t$
Day: January 1
Case 4: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low $n_t$
Steep slope: No snow cover and low $n_t$
Day: April 1
Case 4: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low $n_t$
Steep slope: No snow cover and low $n_t$
Day: July 1
Case 4: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low $n_t$
Steep slope: No snow cover and low $n_t$
Day: October 1
Case 5
Case 5: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: January 1
Case 5: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: April 1
Case 5: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: July 1
Case 5: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: October 1
Case 5: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: January 1
Case 5: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: April 1
Case 5: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: July 1
Case 5: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: No snow cover until Jan. 1
Day: October 1
Case 6
Case 6: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: Snow cover
Day: January 1
Case 6: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: Snow cover
Day: April 1
Case 6: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan. 1
Steep slope: Snow cover
Day: July 1
Case 6: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover until Jan.1
Steep slope: Snow cover
Day: October 1
Case 6: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: Snow cover
Day: January 1
Case 6: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan.
Steep slope: Snow cover
Day: April 1
Case 6: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: Snow cover
Day: July 1
Case 6: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover until Jan. 1
Steep slope: Snow cover
Day: October 1
Case 7
Case 7: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: Snow cover
Day: January 1
Case 7: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: Snow cover
Day: April 1
Case 7: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: Snow cover
Day: July 1
Case 7: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover
Steep slope: Snow cover
Day: October 1
Case 7: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: Snow cover
Day: January 1
Case 7: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: Snow cover
Day: April 1
Case 7: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: Snow cover
Day: July 1
Case 7: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover
Steep slope: Snow cover
Day: October 1
Case 8
Case 8: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low $n_t$
Steep slope: Snow cover
Day: January 1
Case 8: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low n_i
Steep slope: Snow cover
Day: April 1

Distance from center of the road (ft)
Case 8: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low n,
Steep slope: Snow cover
Day: July 1
Case 8: Option 1:
Roadway Surface: Gravel
Shallow slope: No snow cover and low n_t
Steep slope: Snow cover
Day: October 1
Case 8: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low η
Steep slope: Snow cover
Day: January 1
Case 8: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low $n_f$
Steep slope: Snow cover
Day: April 1
Case 8: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low n_t
Steep slope: Snow cover
Day: July 1
Case 8: Option 2:
Roadway Surface: Paved
Shallow slope: No snow cover and low $n_i$
Steep slope: Snow cover
Day: October 1
APPENDIX C

Monthly Temperature Records for Brown's Quarry Field Site
Air Freezing Days = 30.43

Browns Hill Quarry - Ambient Air
Air Freezing Degree Days = 761.9
Air Thawing Degree Days = 0.00

Brown's Hill Quarry - Ambient Air
Browns Hill Quarry - Ambient Air

Air Freezing Degree Days = 357.68
Air Heating Degree Days = 8.58
Brown's Hill Quarry - Ambient Air

Air Freezing Degree Days = 98.8

Air Thawing Degree Days = 0.0
Brown's Hill Quarry - Ground Surface

Surface Freezing Degree Days = 0.00

Surface Freezing Degree Days = 20.7°

Date

Temperature (Fahrenheit)
Brown's Hill Quarry - Ground Surface

Surface Thawing Degree Days = 0.00
Surface Freezing Degree Days = 132.83
Browns Hill Quarry - Ground Surface

Surface Freezing Degree Days = 22.9°
Surface Thawing Degree Days = 0°
Surface Freezing Degree Days = 83.4

Brown's Hill Quarry - Ground Surface

Date

Temperature (Fahrenheit)
Date

11/2/93
11/3/93
11/4/93
11/5/93
11/6/93
11/7/93
11/8/93
11/9/93
11/10/93
11/11/93
11/12/93
11/13/93
11/14/93
11/15/93
11/16/93
11/17/93
11/18/93
11/19/93
11/20/93
11/21/93
11/22/93
11/23/93
11/24/93
11/25/93
11/26/93
11/27/93
11/28/93
11/29/93
11/30/93

Temperature (Fahrenheit)
APPENDIX D

Monthly Temperature Records for Mitchell Expressway Field Site
Mitchell Expressway - Ambient Air

Air Thawing Degree Days = 0.00
Air Freezing Degree Days = 194.22

Temperature (Fahrenheit)

Date

Temperature (Fahrenheit)

<table>
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Temperature (Fahrenheit)

Date

5/2/93
5/3/93
5/4/93
5/5/93
5/6/93
5/7/93
5/8/93
5/9/93
5/10/93
5/11/93
5/12/93
5/13/93
5/14/93
5/15/93
5/16/93
5/17/93
5/18/93
5/19/93
5/20/93
5/21/93
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5/23/93
5/24/93
5/25/93
5/26/93
5/27/93
5/28/93
5/29/93
5/30/93
5/31/93

Air Thawing Degree Days = 685.62
Air Freezing Degree Days = 0.00

Mitchell Expressway - Ambient Air
Mitchell Expressway - Ambient Air

Air Freezing Degree Days = 885.81
Air Thawing Degree Days = 0.00
Mitchell Expressway - Ambient Air

Air Freezing Degree Days = 1056.5°

Air Thawing Degree Days = 1056.5°
Mitchell Expressway - Ambient Air

Air Freezing Degree Days = 336.35
Mitchell Expressway - Ambient Air

Air Freezing Degree Days = 72.98

Air Thawing Degree Days = 189.75
Temperature (Fahrenheit)

11/2/93
11/3/93
11/4/93
11/5/93
11/6/93
11/7/93
11/8/93
11/9/93
11/10/93
11/11/93
11/12/93
11/13/93
11/14/93
11/15/93
11/16/93
11/17/93
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11/19/93
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11/25/93
11/26/93
11/27/93
11/28/93
11/29/93
11/30/93

Mitchell Expressway - Ambient Air

Air Freezing Degree Days = 746.53

Air Thawing Degree Days = 0.00
Mitchell Expressway - Cleared Surface

Surface Thawing Degree Days = 0.00  Surface Freezing Degree Days = 135.32
Date

3/09/93
3/10/93
3/11/93
3/12/93
3/13/93
3/14/93
3/15/93
3/16/93
3/17/93
3/18/93
3/19/93
3/20/93
3/21/93
3/22/93
3/23/93
3/24/93
3/25/93
3/26/93
3/27/93
3/28/93
3/29/93
3/30/93
3/31/93

Temperature (Fahrenheit)

Mitchell Expressway - Cleared Surface

Surface Thawing Degree Days = 0.00
Surface Freezing Degree Days = 332.45
Surface Thawing Degree Days = 345.18
Surface Freezing Degree Days = 147.0

Mitchell Expressway - Cleared Surface
Mitchell Expressway - Cleared Surface

Date

Temperature (Fahrenheit)

Surface Freezing Degree Days = 36.82

Surface Thawing Degree Days = 45.47
Mitchell Expressway - Cleared Surface

Surface Thawing Degree Days = 0.00
Surface Freezing Degree Days = 326.10
Mitchell Expressway - Cleared Surface

Surface Thawing Degree Days = 0.00

Surface Freezing Degree Days = 624.26
Mitchell Expressway - Uncleared Surface

Surface Thawing Degree Days = 0.00  Surface Freezing Degree Days = 59.43
Surface Thawing Degree Days = 0.00
Surface Freezing Degree Days = 140.85
Temperature (Fahrenheit)

4/2/93
4/3/93
4/4/93
4/5/93
4/6/93
4/7/93
4/8/93
4/9/93
4/10/93
4/11/93
4/12/93
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4/28/93
4/29/93
4/30/93

Mitchell Expressway - Uncleared Surface

Surface Thawing Degree Days = 167.29
Surface Freezing Degree Days = 0.00
Surface Thawing Degree Days = 552.60
Mitchell Expressway - Uncleared Surface
Surface Freezing Degree Days = 0.00
Mitchell Expressway - Uncleared Surface

Surface Thawing Degree Days = 292.21
Surface Freezing Degree Days = 18.63
Mitchell Expressway - Uncleared Surface

Surface Thawing Degree Days = 0.00
Surface Freezing Degree Days = 583.69
APPENDIX E

Annotated Bibliography
IMPLICATIONS OF LONG-TERM CLIMATIC CHANGES FOR TRANSPORTATION IN CANADA

Irwin, NA; Johnson, WF
Transportation Research Board
Transportation Research Record No. 1267 1990 pp 12-25 2 Fig. 4
Tab. 2 Ref.
SUBFILE: HRIS; MRIS; RRIS; ATRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

A preliminary, strategic assessment of the implications of long-term climatic changes due to the greenhouse effect for future conditions in Canada and the likely impacts of such developments on Canadian transportation are presented. It is assumed that emissions of greenhouse gases will be controlled through international cooperation so that their concentrations in the atmosphere stabilize by about 2050 at conditions equal to the "Bonnite x CO2" scenario (equivalent to twice the preindustrial concentration of carbon dioxide) and that longer-term responses (e.g., melting of ocean ice cover and northward movement of permafrost, the tree line, and agriculture) will reach equilibrium during the following decades. The most significant changes affecting Canadian transportation would probably be increased marine and air services followed by a northward extension of road and rail networks and a new equilibrium between marine and land transportation that would reflect the longer shipping season in the St. Lawrence Seaway and year-round operation of the Port of Churchill on Hudson Bay. Major expenditures would be required to protect coastal transportation facilities from floods and possibly to maintain navigation in the face of lower water levels on the Great Lakes. In general, however, if global temperatures stabilize as assumed, the implications for Canadian transportation of the postulated scenario will probably be, on balance, positive for Canadian transportation. There would, however, be significant costs in adapting to the new circumstances, and a number of implications for policy and research and development are outlined. This paper appears in Transportation Research Record No. 1267, Global Warming: Transportation and Energy Considerations 1990.

DESCRIPTORS: AIR TRANSPORTATION; CANADA; CLIMATE; COSTS; ENERGY AND ENVIRONMENT; GLOBAL WARMING; GREENHOUSE EFFECT; HIGHWAY TRANSPORTATION; IMPACT; POLICY; RAIL TRANSPORTATION; RESEARCH AND DEVELOPMENT; TRANSPORTATION; WATER TRANSPORTATION

OBSERVATIONS ON RECENT HIGHWAY CUTS IN PERMAFROST
PUFAHL, DE; MORGENSTERN, NR; ROEGGENSACK, WD
INFORMATION CANADA
REPORT - ENVIRONMENTAL-SOCIAL COMMITTEE, NORTHERN Mar 1975
53 PP ENGLISH
SUBFILE: UCITS; TLIB
BY D. E. PFUHL, N. R. MORGENSTERN AND W. D. ROEGGENSACK
OTHER PHYS. DESCRIPTION: III COL. ILL., MAPS SUMMARY IN FRENCH
BIBLIOGRAPHY: P. 48-49 MORGENSTERN, NORMAN R., JOINT AUTHOR ROEGGENSACK, W. D., JOINT AUTHOR REPORT - ENVIRONMENTAL-SOCIAL COMMITTEE, NORTHERN PIPELINES, TASK FORCE ON NORTHERN OIL DEVELOPMENT NO 74-32 -UNTRACED SERIES
DESCRIPTORS: ALASKA; CANADA; FROZEN GROUND; ROADS

USE OF GEOGRIDS FOR LIMITING LONGITUDINAL CRACKING IN ROADS ON PERMAFROST: FINAL REPORT
SAVAGE, RM (SCHOOL OF ENGINEERING, UNIVERSITY OF ALASKA)
ALASKA DEPT OF TRANSPORTATION AND PUBLIC FAIRBANKS ALASKA
May 1991 107 PP ENGLISH
SUBFILE: UCITS; TLIB
AVAILABLE FROM: NATIONAL TECHNICAL INFORMATION SERVICE SPRINGFIELD, VA

The objective of this study is to monitor existing road sections with experimental permafrost control features. The study will evaluate the long term benefits of insulated embankments, air-cooling ducts, thermal syphons, and snow sheds in controlling permafrost-thaw-related roadway distress.

DESCRIPTORS: AIR COOLING; CONTROL; DUCTS; EMBANKMENTS; FOUNDATIONS (SOILS); INSULATION; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT SUBGRADES; PERMAFROST; RESEARCH PROJECT THAWING

NEW ALASKAN ROAD BEATS DRAINAGE PROBLEMS
Groves (SCHOOL OF ENGINEERING, UNIVERSITY OF ALASKA)
ALASKA DEPT OF TRANSPORTATION AND PUBLIC FAIRBANKS ALASKA
May 1991 107 PP ENGLISH
SUBFILE: UCITS; TLIB
AVAILABLE FROM: NATIONAL TECHNICAL INFORMATION SERVICE SPRINGFIELD, VA

011721
The article describes the construction of a 53-mile road across the tundra, in which pipes, geotextiles, and shotrock were used to resolve drainage problems. Specifications called for fill placement primarily during the winter so that construction equipment could be used on the tundra without damage to the insulating tundra mat. The need for culverts with seams strong enough to resist the forces of frost heave and differential permafrost settlement led to the selection of continuous welded-seam corrugated steel pipe. Research indicated that it performed as well as riveted heavy-gauge pipe, and could be manufactured quicker. A 200-man crew hauled 694 pieces of equipment to meet a 2000-ft per day schedule in constructing the road. Thaw pipe was installed inside the culverts to help prevent the build up of on the bottom of the culverts during the winter. Geotextile was sewn into 25-ft wide panels and used over the entire alignment to prevent degradation of the tundra mat and provide separation between the fill and the tundra.

Peat has been used in Norway since 1903 as a soil replacement layer to control frost heaving. The large amount of latent heat removal required to freeze the moisture results in a reduction of frost penetration. Decay of the peat has been negligible in the cold, oxygen-starved environment. The thermal conductivity of ice is more than three times that of water. Peat usually contains very large amounts of moisture, and because of this moisture results in a reduction of frost penetration. Decay of the peat has been negligible in the cold, oxygen-starved environment. The thermal conductivity of ice is more than three times that of water. Peat usually contains very large amounts of moisture, and because of this peat is typically nearly twice as conductive in summer as when thawed. A peat layer will therefore behave (in relative terms) as a thermal insulator in summer and as a conductor in winter. Peat should thus be even more effective at preventing the thaw of permafrost than at preventing seasonal frost penetration. This report summarizes 18 years of study of experimental roadway cut sections which utilized layers of buried peat in an attempt to reduce or prevent differential settlements. The sections were built in a newly realigned section of the Richardson Highway traversing warm permafrost and located about 68 miles southeast of Fairbanks, Alaska. Applications of insulation for frost heave control have been numerous, totaling 11 lane-miles. Materials used for subgrade insulations have been primarily extruded-expanded polystyrene foam (Dow's Styrofoam H1 and UCI Foamular) with one installation of polyurethane foam and three of molded polystyrene "beadboard." Evaluations of the long-term performance of these installations have included sampling and testing of the insulations to determine their retained thickness, thermal conductivity, and compressive strength properties. Based on these observations, foamed-in-place polyurethane insulation is not accepted for use as a subgrade insulation by the Department, while extruded polystyrene beadboard has demonstrated comparable thermal performance and longevity. Molded polystyrene beadboard insulation layers have given acceptable performance, but must be installed at a thickness 30 to 50% greater than the extruded polystyrenes to provide comparable thermal performance. Comparisons were made between those of permafrost thaw depths for insulated airfields, and calculating thaw depths using the "Modified Berggren" calculation method and actual site soil and insulation properties. These comparisons demonstrated that...
this method of calculation results in calculated thaw depths
slightly greater than the actual values, but provides
reasonable values for a conservative design.

DESCRIPTORS: AIRPORT RUNWAYS; ALASKA; COLD REGIONS;
COMPRESSIVE STRENGTH; FROST HEAVE; GENERAL MATERIALS; HIGHWAY
PAVEMENTS; INSULATION; PAVEMENT DESIGN; PAVEMENT DESIGN AND
PERFORMANCE; PERFORMANCE EVALUATION; PERMAFROST; POLYSTYRENE;
POLYURETHANE; SUBGRADES; THAWING; THERMAL CONDUCTIVITY;
THICKNESS

488197 DA
DALTON HIGHWAY: CHARACTERIZATION OF FOUNDATION SOILS
Vita, CL; Rooney, JW; Riddle, CH; Acomb, LJ
Alaska Department of Transp and Public Facilities 2301 Peger
Road Fairbanks Alaska 99701
1984 8p
REPORT NO: AK-RD-85-28
SUBFILE: HRIS
AVAILABLE FROM: Alaska Department of Transp and Public
Facilities 2301 Peger Road Fairbanks Alaska 99701
This report serves to gather together all known test hole
information for foundation soils on the Dalton Highway. In
addition, it analyzes this data by statistical methods and
characterizes foundation soils to be expected along the route.
It identifies thermal state and frost classification
for the soil types, and calculates thaw strain and settlement
depth due to permafrost degradation. This report shows
that nearly all of the foundation soils along the route are in
permafrost zones, most of it ice rich, with a potentially high
settlement when thawing. Only a few short sections of river
bottom and the hill top alignment at miles 95-100 and 105-112
lack permafrost or have any extent of non-frost susceptible
soils. Data from this report could be applied toward answering
questions on paving of the Dalton Highway. The cold continuous
permafrost of the Arctic Foothills and Arctic Coastal Plain
Subprovinces should allow paving with no subsequent
degradation of the permafrost foundation soils provided the
thickness of gravel embankment is sufficient to prevent
thawing below the existing permafrost surface. The remainder of
the route to the south will require careful analysis and
strengthening or replacement of foundation soils.
Sections of the road having weak base and subbase layers would
need rebuilding to obtain thick enough layers of free draining
non-frost susceptible material under a pavement. In all cases,
route alignment and grades should be improved where needed
before any paving is done.

DESCRIPTORS: ALASKA; ARCTIC AREA; EMBANKMENTS; FOUNDATION
SOILS; FOUNDATIONS (SOILS); HIGHWAY CONSTRUCTION; PERMAFROST;
STRAINS; THAWING; THICKNESS

488191 DA
WHITE PAINT FOR HIGHWAY THAW SETTLEMENT CONTROL. INTERIM
REPORT
Reckard, MK
Alaska Department of Transp and Public Facilities 2301 Peger
Road Fairbanks Alaska 99701; Alaska Department of Transp and
Public Facilities Pouch Z Juneau Alaska 99811; Federal Highway
Administration 400 7th Street, SW Washington D.C. 20590
May 1983 4p
REPORT NO: FHWA-AK-RD-83-16
CONTRACT NO: F24572; Contract
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285
Port Royal Road Springfield Virginia 22161
The report discusses the effects of painting roadways over
thaw sensitive ground. An experimental program including four
test sections on Interior Alaskan roads is described along
with the results of two years of settlement and subsurface
temperature measurements. The report concludes that the higher
albedo of the painted sections resulted in less thaw
settlement and lower subsurface temperatures. It is
recommended, however, that the technique not be used as a
regular road maintenance procedure due to several factors.
These include the high cost of painting, the difficulty of
pinpointing areas with subsoils favorable to the procedure,
and the inability of the paint to reduce heat input through
the embankment slopes (an "edge effect"). Road slipperiness
was also found to be a major drawback to the technique. The
painted sections provided less skid resistance than unpainted
pavements; they also experienced localized icing such as
on the bridge decks.

DESCRIPTORS: COLD REGIONS; COSTS; ICING; PAINTING; PAVEMENT
DESIGN AND PERFORMANCE; PAVEMENTS; PERFORMANCE EVALUATION;
PERMAFROST; PREVENTION; SKID RESISTANCE; SUBSURFACE
TEMPERATURE; TEST SECTIONS; THAWING; WHITE

488450 DA
GRAVITY MEASUREMENTS IN PERMAFROST TERRAIN CONTAINING
MASSIVE GROUND ICE
Kawasaki, K; Osterkamp, TE; Kienle, J; Jurick, RW
Alaska Department of Transp and Public Facilities 2301 Peger
Road Fairbanks Alaska 99701; Federal Highway Administration
400 7th Street, SW Washington D.C. 20590
1982 34p
REPORT NO: FHWA-AK-RD-83-07
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285
Port Royal Road Springfield Virginia 22161
Gravity measurements were made with a very sensitive
gravimeter in permafrost terrain containing massive ground ice
and other segregated ice. Measurements were first taken along
a line over undisturbed terrain where a road cut was to be
made; a second set of measurements was subsequently made along
the edge of the roadbed after road construction. Data from
pre-construction borings and a profile of subsurface soil and
ice conditions, synthesized from information obtained during
cutting, were used for ground truth information and compared
with the gravity measurements. The horizontal dimensions and
locations of the ground ice deposits embedded in the soil
layer correlated reasonably well with the dimensions and locations of the lows in the gravity profile. However, the second profile, taken along the roadbed, also showed significant variation even after the usual types of gravity corrections were applied suggesting there are significant horizontal variations in the density of the topmost layers of the underlying bedrock (schist) through which the cut was made. The density contrast of the undisturbed ice-rich soil beneath the first profile was estimated assuming the contrast was produced by infinitely long, rectangular blocks of given dimensions but unknown density. A set of equations dependent on permafrost, totaling 3.6 lane-mi, have been insulated by Hill and UCI Foamular with one installation of polyurethane foam and three of molded polystyrene beadboard. Evaluations of these installations have given acceptable insulation properties. These comparisons demonstrated that molded polystyrene beadboard insulation layers have given acceptable performance, but must be installed at a thickness 30 percent to 50 percent greater than the extruded polystyrene to provide comparable thermal performance. Comparisons were made between measured late-summer permafrost thaw depths for insulated airfields, and calculated thaw depths using the Modified Berggren calculation method and actual site soil and insulation properties. These comparisons demonstrated that this method of calculation results in calculated thaw depths slightly greater than the actual values, but provides reasonable values for a conservative design. This paper appeared in Transportation Research Record No. 1146, Frost Protection and Insulation for Transportation Facilities.

DESCRIPTORS: AIRPORT RUNWAYS; ALASKA; COMPRESSIVE STRENGTH; DEPTH; DURABILITY; FOUNDATIONS (SOILS); FROST HEAVE; GENERAL MATERIALS; INSULATION; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENTS; PERFORMANCE EVALUATION; PERMAFROST; PLASTIC FOAM; POLYSTYRENE; POLYURETHANE FOAM; SUBGRADES; THAWING; THERMAL CONDUCTIVITY; THICKNESS

474767 DA

DISTURBANCE AND RECOVERY OF ARCTIC ALASKAN TUNDRA TERRAIN: A REVIEW OF RECENT INVESTIGATIONS

Walker, DA; Cate, D; Brown, J; Racine, C
Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755
Jul 1987 70p 36 Fig. 9 Tab. Photos. Refs. 1 App.
REPORT NO: CRREL-R-87-11
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151
This document is a summary of over a decade of CRREL-managed research regarding disturbance and recovery in northern Alaska. Much of this research was sponsored by the U.S. Geological Survey’s National Petroleum Reserve-Alaska exploration program and the Department of Energy’s environmental research program, although numerous other agencies and members of the oil industry have also made contributions to several of the university participants. This work comes at a time of major transition in the focus of northern Alaska environmental research from single-impact studies to analysis of cumulative impacts. Thus, it summarizes studies of anthropogenic disturbances in northern Alaska and discusses the immediate need for new methods to approach the problems of revegetation, restoration and cumulative impacts of terrain underlain by permafrost. This heritage of research comes from many research sites in northern Alaska, including Cape Thompson, the Seward Peninsula, Barrow, Fish Creek, Oumalik, East Oumalik, Prudhoe Bay, the Arctic National Wildlife Refuge and along the trans-Alaska pipeline. The impacts that are discussed include bladed trails, off-road vehicle trails, winter trails, ice roads, gravel pads and roads, borrow pits, roadside impoundments, road dust, hydrocarbon spills and seawater spills.

DESCRIPTORS: ARCTIC AREA; BORROW PITS; DRILLING; DUSTS; ENVIRONMENTAL IMPACT; HIGHWAY CONSTRUCTION; HYDROCARBONS; OFF THE ROAD VEHICLES; PERMAFROST; SEA WATER; SOIL SCIENCE; (cont. next page)
A ROAD OVER PERMAFROST: DESIGN OF ACCESS ROAD IN ALASKA
Hartley, MC; Bannister-Parks, M

SUBFILE: HRIS
AVAILABLE FROM: Industrial Fabrics Association International
345 Cedar Building, Suite 450 St Paul Minnesota 55101
Geosynthetics helped meet the challenges in arctic road construction in the design of more than 50 miles of road in northwest Alaska. The relatively large design loads combined with the sensitive nature of the permafrost required special design considerations. Of primary importance was maintaining the frozen condition of the ground to ensure stability of the road embankment. A foot of crushed surfacing was specified as a running course, with final road crowning to be performed later. The final geotextile section design specified 24-foot wide fabric overlapped along the centerline in thinner fills and underlying shoulders in fills up to 10 feet thick. Details of the geotextile installation are summarized. This geotextile application provided the following: a fill separator, reducing the total quantity of fill over soft, thermally sensitive soils; protection of the insulative qualities of the organic tundra mat, preventing thaw degradation; and distribution of the loads, enforcing the road embankment thereby reducing road construction and maintenance costs.

DESCRIPTORS: ARCTIC AREA; FACILITIES DESIGN; FILLS; GENERAL MATERIALS; GEOSYNTHETICS; HIGHWAY DESIGN; INSULATORS; LOAD DISTRIBUTION; PERMAFROST; REINFORCEMENT; SEPARATORS

USE OF WOOD FIBER IN LIGHTWEIGHT EMBANKMENTS FOR NORTHERN APPLICATIONS
McManus, R; Godfrey, RN

SUBFILE: HRIS
The application of wood fibers to roadway embankments may provide a convenient solution to the most perplexing problem northern engineers face. Prior case studies have yielded excellent results in the State of Washington when used for soft soil conditions. Much work needs to be done in the areas of further defining both wood fiber and permafrost engineering properties. Important values need to be established for the viscoelastic properties of permafrost as well as engineering properties of the wood fibers such as compressibility values as in clays, and reliable values for the modulus of elasticities of various fiber sizes and species. Only time will tell how long the design life of wood fiber fills will be and for that matter if they have been effective in the treatment of viscoelastic permafrost. The indications are, however, that wood will be used as a road building material for quite sometime to come.

DESCRIPTORS: EMBANKMENTS; FIBERS; GENERAL MATERIALS; MODULUS OF ELASTICITY; PERMAFROST REGIONS; VISCOELASTICITY; WOOD CHIPS

THAW STABILIZATION OF ROADWAY EMBANKMENTS CONSTRUCTED OVER PERMAFROST. DRAFT FINAL REPORT
Zarling, UP; Braley, WA
Alaska University, Fairbanks Engineering Research Center, Inst of Northern Engineering Fairbanks Alaska 99775; Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701; Federal Highway Administration 400 7th Street, Sw Washington D.C. 20590
Dec 1986 34p 16 Fig. 8 Tab. 6 Ref. REPORT NO: FHWA-AR-87-20
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The thermal degradation of permafrost beneath Alaskan roads leads to expensive maintenance and repair costs. This project evaluated three methods to stabilize the thaw. Snow sheds were built at intervals along two sections of roadways to shade the ground during summer and prevent snow from acting as an insulating blanket during winter. The second method consisted of removing snow during the winter months to reduce surface temperature. Third, thermosyphon devices were installed along two roadway sections to extract heat over the winter season. The results show that the snow sheds were most effective in decreasing the ground surface temperature and, as such, the concept should be further developed.

DESCRIPTORS: EFFECTIVENESS; EMBANKMENTS; PERMAFROST REGIONS PREVENTION; SHADING; SNOW REMOVAL; SNOW SHEDS; SOIL SCIENCE; SURFACE TEMPERATURE; THAWING; THERMOSPHERN DEVICES

ENGINEERING SURVEYS ALONG THE TRANS-ALASKA PIPELINE
Godfrey, RN; Eaton, RA
Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755; Office of the Chief of Engineers Washington D.C. 20314
Sep 1986 91p 70 Fig. 33 Tab. 4 Ref. REPORT NO: Special Rept. 86-28; DA Proj 44762730AT42
SUBFILE: HRIS
AVAILABLE FROM: Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755
During the spring of 1976, environmental engineering investigations along the Alyeska Pipeline Haul Road and TAPS (Trans-Alaska Pipeline System) Road were initiated by CRREL in conjunction with the Federal Highway Administration and the Alaska Department of Highways. The three-year research project had two general objectives: 1) to systematically obtain data (cont. next page)
on selected highway, airfield and pipeline workpad test sites and adjacent terrain to establish the rate and types of modifications in permafrost-dominated regions, and 2) to provide the basis for improved design criteria and specifications governing road, airfield and workpad construction and restoration in permafrost zones that are influenced by many different seasonal climatic regimes. This report presents the results of 14 test areas covered in CRREL Report 80-19, "Environmental Engineering and Ecological Baseline Investigations along the Yukon River-Prudhoe Bay Haul Road" (Brown and Berg 1980). The data presented here will be utilized for improving road, workpad and airfield design and construction, and for developing methods of minimizing the impacts on the environment in Alaska. The results show that thaw depths adjacent to the test sites increased each year from 1976 to 1978, causing continued settlement along the embankments. The depths of thaw beneath the gravel surface road and the air thawing index decreased from south to north. The subsidence of the road sideslopes resulted from the accumulation of water in the sideslopes should be avoided to eliminate subsidence caused by heat absorption.

DESCRIPTIONS: DESIGN CRITERIA; ENVIRONMENTAL ENGINEERING; EXPLORATION; CLASSIFICATION (SOILS); FACILITIES DESIGN; MECHANICS (EARTH MASS); PAVEMENT CONSTRUCTION; PERMAFROST REGIONS; RUNOFF; RUNWAYS; SITE SURVEYS; SOIL SCIENCE; SUBSIDENCE; SOIL; THAWING

459251 DA
ROADS ON PERMAFROST IN USSR
Raty, J
Technical Research Centre of Finland
VTI-TIED N483 1985 11sp 50 Fig. 9 Tab. 10 Ref. Finnish
SUBFILE: HRIS; TRRL: IRRD
AVAILABLE FROM: Technical Research Centre of Finland Technical Information Service, Vuorimiehentie 5 SF-02150 Espoo 15 Finland

The report is about the methods of planning, building and maintenance of roads on permafrost in the USSR and includes a short description of permafrost as a building site. The method of embankment design is influenced mainly by thermal, frost and drainage factors, while construction of embankments on permafrost should be well planned before the beginning of the work. The repair and maintenance of roads are difficult on permafrost and the provision of good drainage is a major consideration. Icings are very costly to correct and they should be predicted in advance. This information is collected mainly from Soviet handbooks and articles published in Russian. (TRRL)

DESCRIPTIONS: CONSTRUCTION; EMBANKMENTS; HIGHWAY CONSTRUCTION
The development of a pavement design evaluation system (PDES), which provides a systematic, consistent, and efficient procedure to evaluate alternative initial designs for paved highways in Alaska on the basis of their total life-cycle costs, is described. The major components of PDES are initial cost of construction, cost of routine maintenance required to keep a pavement serviceable, possible salvage value, and user costs. PDES consists of four subsystems: pavement performance subsystem, cost subsystem, life-cycle cost procedure, and optimization subsystem. Mechanistic procedures tailored to Alaskan conditions and calibrated with empirical data and engineering judgments have been used to predict future physical characteristics of alternative pavement designs. The performance variables for which prediction models are developed are roughness caused by cumulative application of traffic loading, roughness caused by thaw settlement in permafrost regions, fatigue cracking, and major transverse cracking. Uncertainties associated with the prediction of future pavement performance are explicitly considered in PDES to calculate the total expected costs during a specified analysis period and to determine the minimum cost alternative that satisfies desired reliability constraints. As a tool for the designer and decision maker, PDES provides a means of documenting and justifying specific design selections for site-specific projects contemplated for construction in Alaska. This paper appeared in Transportation Research Record N997, which provides a systematic, consistent, and efficient procedure to evaluate alternative initial designs for paved highways in Alaska on the basis of their total life-cycle costs. The major components of PDES are initial cost of construction, cost of routine maintenance required to keep a pavement serviceable, possible salvage value, and user costs. PDES consists of four subsystems: pavement performance subsystem, cost subsystem, life-cycle cost procedure, and optimization subsystem. Mechanistic procedures tailored to Alaskan conditions and calibrated with empirical data and engineering judgments have been used to predict future physical characteristics of alternative pavement designs. The performance variables for which prediction models are developed are roughness caused by cumulative application of traffic loading, roughness caused by thaw settlement in permafrost regions, fatigue cracking, and major transverse cracking. Uncertainties associated with the prediction of future pavement performance are explicitly considered in PDES to calculate the total expected costs during a specified analysis period and to determine the minimum cost alternative that satisfies desired reliability constraints. As a tool for the designer and decision maker, PDES provides a means of documenting and justifying specific design selections for site-specific projects contemplated for construction in Alaska. This paper appeared in Transportation Research Record N997. The Pavement Management Activities. DESCRIPTORS: CONSTRUCTION COSTS; FORECASTING; HIGHWAY COSTS HIGHWAY PAVEMENTS; HIGHWAY USER COSTS; LIFE CYCLE COSTING /LCC/; MAINTENANCE COSTS; MAINTENANCE; GENERAL; PAVEMENT CRACKING; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST; ROAD ROUGHNESS; SETTLEMENT /STRUCTURAL/; THAWING; TRAFFIC LOADS.

The performance of pavement built over deep muskegs has been defined in terms of long-term settlement, change in pavement roughness, structural behavior, and deterioration of the surface. On the whole, 8 years after construction, the pavement built over deep muskeg is satisfactory: Long-term settlement generally varies between 25 and 50 percent of the thickness of the peat deposit except where ice is present under the peat; the riding quality, which still has a good rating, is 50 percent rougher over peat deposits than elsewhere; there is a loose relationship between the height of embankment and the maximum deflection; the dynamic modulus of peat under the embankment is on the order of 50 MPa under Dynaflect loading conditions; and longitudinal cracking is twice as long as that over peat deposits than (cont. next page)
398857 DA
EXPERIENCE WITH DEVELOPMENT OF PEAT DEPOSITS AT WALT DISNEY WORLD, FLORIDA
Swantko, TD; Berry, SW; Ringo, WP (Dames & Moore, Georgia; Dames & Moore, California)
Transportation Research Record N978 1984 pp 60-67 10 Fig. 7
Ref.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

Considerable experience was gained with the development of sites underlain with peat and highly organic soils at Walt Disney World in central Florida. The most straightforward approach was to totally excavate the organics and replace them with sand fill. The excavation techniques and equipment used depended on the total depth of organics, the size of the area to be excavated, and the seasonal groundwater conditions. Various surcharging techniques were used to stabilize the peat before construction. Several specialized approaches were used successfully: (a) A portion of a major lagoon was developed by compressing a thick organic profile by surcharging. Vertical compressions of up to 15 ft (3.0 to 4.6 m) were achieved, thus avoiding the need for significant excavation and disposal. (b) A controlled surcharge program was used to develop over 3,000 linear ft. (929 km) of a major four-lane access road over an organic profile extending to depths of 10 to 14 ft (3.0 to 12.2 m). Surcharging was found to stabilize the peat by removing primary consolidation and reducing the rate of secondary compression. (c) A section of an elevated monorail system in a deep organic area was developed in a phased sequence of surcharging, partial removal of surcharge, driving piles, and additional surcharge removal. (d) A finite-element program was used to assess the general vertical and horizontal displacement pattern within a sand fill extending partly over highly compressible organic soils. The purpose of this study was to evaluate the distance from the edge of the soft ground area where a structure could be safely supported in the sand fill. This paper appeared in Transportation Research Record N978, Construction and Difficult Geology: Karstic Limestone, Permafrost, Wetlands, and Peat Deposits.

396652 DA
ROAD CONSTRUCTION IN PALSA FIELDS
Ringer, JH; Laforte, MA (Ecole Polytechnique, Canada; Center for Construction Research, Canada)
Transportation Research Record N978 1984 pp 26-36 15 Fig. 1
Tab. 16 Ref.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

Palsa is an important feature of the discontinuous permafrost regions of northwestern Quebec. Because of the development of hydroelectric complexes along La Grande and Great Whale rivers, the road network will be expanded by the addition of 2000 km of road with many sections crossing palsa fields. Problems related to the design, construction, and maintenance of roads in palsa fields are identified and described. The observations are mainly based on the performance of a test embankment built 3 years ago on a large palsa and the performance of 620 km of road, paved in 1978, that cuts through several palsa fields. The topics discussed are topology, occurrence and distribution of palsa fields in northern Quebec, dating of palsa ice, description of a typical palsa field, description of the physical characteristics of a typical palsa, temperature regime in the palsa, performance of a test embankment, and predicted versus observed rate of settlement of existing embankments. Based on the results of these investigations, recommendations are made for the design and maintenance of roads that cross palsa fields. This paper appeared in Transportation Research Record N978, Construction and Difficult Geology: Karstic Limestone, Permafrost, Wetlands, and Peat Deposits.

396372 DA
SECTION 110(C) STUDY -- QUALITY OF HIGHWAY AND BRIDGES, APPENDIX C, RESPONSES TO WORKSHOPS
Federal Highway Administration 400 7th Street, SW Washington D.C. 20590; United States Congress Washington D.C. 20510; Department of Transportation 400 7th Street, SW Washington D.C. 20590
Feb 1984 20p Refs.
SUBFILE: HRIS
AVAILABLE FROM: Federal Highway Administration 400 7th Street, SW Washington D.C. 20590
The Federal Highway Administration (FHWA) assumed the lead role in conducting the study and identified 10 activities, procedures, and systems influencing the quality of highways and bridges. A white paper discussing each of the 10 areas was prepared by a member of either the FHWA staff or the National Bureau of Standards staff. The titles of the 10 papers were: (cont. next page)
(1) Developing Pavement Design Criteria; (2) "Quality of Bridge Design"; (3) "Bidding and Contract Award"; (4) "Quality of Specifications"; (5) "Acceptance Plans"; (6) "Quality of Highway Construction"; (7) "FHWA Construction-Related Policies, Procedures and Guidelines"; (8) "Uniform Standards - Construction: FHWA Region 3 Experience"; (9) "Training and Certification of Technicians"; and (10) "Evaluation and Accreditation of Construction Materials Laboratories." This was followed by a conference to discuss these 10 white papers and other pertinent topics. All the State highway agencies, trade organizations, standards developing bodies, consulting engineers and other Federal agencies responsible for road building were invited to participate in the conference which was open to the public. This appendix contains synopses of each of the workshops. Conference on Quality Assurance of Highways and Bridges, Federal Highway Administration, August 30-31, 1983, National Bureau of Standards.

DESCRIPTORS: BRIDGE DESIGN; CONTRACTS; DESIGN CRITERIA; DESIGN STANDARDS; HIGHWAY CONSTRUCTION; HIGHWAY DESIGN; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST REGIONS; SPECIFICATIONS; STATE OF THE ART STUDIES; STRUCTURES DESIGN AND PERFORMANCE; UNIFORMITY; WORKSHOPS /MEETINGS /

396370 DA

SECTION 110(C) STUDY -- QUALITY OF HIGHWAYS AND BRIDGES.

DEVELOPING PAVEMENT DESIGN CRITERIA -- APPENDIX A


SUBFILE: HRIS

AVAILABLE FROM: Federal Highway Administration 400 7th Street, SW Washington D.C. 20550; United States Congress Washington D.C. 20510; Department of Transportation 400 7th Street, SW Washington D.C. 20590

Section 110(c) of the Surface Transportation Assistance Act of 1982 directed the Secretary of Transportation to coordinate a study to determine the existing quality of design, construction, products, use and systems for highways and bridges; the need for uniform standards and criteria for design, processing, products and applications including personnel training and implementation of enforcement techniques and the manpower needs and costs for developing a national system for the formulation, testing and inspection agencies. The Federal Highway Administration (FHWA) assumed the lead role in conducting the study and identified 10 activities, procedures or systems influencing the quality of highways and bridges. A white paper discussing each of the 10 areas was prepared by either the FHWA staff or the National Bureau of Standards staff. The titles of the papers were: (1) "Developing Pavement Design Criteria"; (2) "Quality of Bridge Design"; (3) "Bidding and Contract Award"; (4) "Quality of Specifications"; (5) "Acceptance Plans"; (6) "Quality of Highway Construction"; (7) "FHWA Construction-Related Policies, Procedures and Guidelines"; (8) "Uniform Standards - Construction: FHWA Region 3 Experience"; (9) "Training and Certification of Technicians"; and (10) "Evaluation and Accreditation of Construction Materials Laboratories." This was followed by a conference to discuss these 10 white papers and other pertinent topics. All the State highway agencies, trade organizations, standards developing bodies, consulting engineers and other Federal agencies responsible for road building were invited to participate in the conference which was open to the public. This appendix contains synopses of each of the workshops. Conference on Quality Assurance of Highways and Bridges, Federal Highway Administration, August 30-31, 1983, National Bureau of Standards.

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396370 DA

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Federal Highway Administration 400 7th Street, SW Washington D.C. 20550; United States Congress Washington D.C. 20510; Department of Transportation 400 7th Street, SW Washington D.C. 20590


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011729
State highway agencies, trade organizations, standards developing bodies, consulting engineers and other Federal agencies responsible for road building were invited to participate in the conference which was open to the public. This appendix contains the texts of the white papers.

### SECTION 110(C) STUDY -- QUALITY OF HIGHWAYS AND BRIDGES

**EXECUTIVE SUMMARY**

Federal Highway Administration 400 7th Street, SW Washington D.C. 20590; United States Congress Washington D.C. 20510; Department of Transportation 400 7th Street, SW Washington D.C. 20590

Feb 1984 31p 15 Ref.

**SUBFILE:** HRIS

**AVAILABLE FROM:** Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

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**DESCRIPTORS:** BRIDGE DESIGN; CONTRACTS; DESIGN CRITERIA; DESIGN STANDARDS; HIGHWAY CONSTRUCTION; HIGHWAY DESIGN; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST REGIONS; SPECIFICATIONS; STATE OF THE ART STUDIES; STRUCTURES DESIGN AND PERFORMANCE; UNIFORMITY

### WHITE PAINT FOR HIGHWAY THAW SETTLEMENT CONTROL

Reckard, MK

Alaska Department of Transp and Public Facilities Research Notes VOl. 4 NO. 7 Jan 1985 2p

**SUBFILE:** HRIS

**AVAILABLE FROM:** Alaska Department of Transp and Public Facilities Division of Planning, Northern Region, 2301 Peger Road Fairbanks Alaska 99701

Roads built on permafrost are often difficult to maintain because of permafrost melt induced settlement caused by black pavement absorbing more sunlight than a lighter-colored surface. One way to counteract this would be to paint the pavement white to reflect more sunlight measurements of several short painting pavement sections between Fairbanks and Delta, Alaska, show that this does indeed reduce settlement. However, there are some grave drawbacks: the cost of applying paint, safety (i.e. increase slipperiness and snow sticking), and frost forming sooner on the cooler surface), and settlement continuing near unpainted shoulders even though the center of the road is protected.

**DESCRIPTORS:** ABSORPTION; COSTS; DIFFERENTIAL SETTLEMENT; GENERAL MATERIALS; HEAT; MAINTENANCE; GENERAL; MECHANICS (EARTH MASS); PAINTS; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT MAINTENANCE; PERMAFROST; REFLECTIVITY; SAFETY; SETTLEMENT /STRUCTURAL; THAWING; WHITE PIGMENTS

### INTERACTION OF GRAVEL FILLS, SURFACE DRAINAGE AND CULVERTS WITH PERMAFROST TERRAIN

Brown, J; Brockett, BE; Howe, KE

Cold Regions Research and Engineering Laboratory P.O. Box 28700, Interior Alaska Department of Transp and Public Facilities Pouch Z Juneau Alaska 99811

Jan 1984 Final Rpt. 41p 13 Fig. 7 Tab. Refs.

**REPORT NO.** AK-RD-84-11

(cont. next page)
DIAログ File: TRIS  70-92/JUL

CONTRACT NO: F15631; Contract
SUBFILE: HRIS

During the summers of 1981 and 1982, the thaw regime of gravel roads and the performance of culverts were observed in the Prudhoe Bay and Kuparuk River oilfields, northern Alaska. This relatively flat to gently rolling coastal plain is covered by shallow lakes, drained lake basins and interconnecting ice-wedge polygons. Depth of seasonal thaw of the fine-grained soils is less than 50 cm. The permafrost temperature is about -10 deg C. A combination of visual frost tube readings and temperature measurements were obtained in the roadbed, in an area immediately adjacent to an insulated culvert, and in areas undisturbed by construction. Gravel roads up to 2 m thick that are not intrinsically thawed penetrate into the consolidated active layer. Where depth of thaw exceeds the thickness of the active layer, ice-rich permafrost begins to thaw. Adjacent to the roads, newly formed surface troughs indicate melting of the underlying ice wedges. Shallow impoundments form on the upslope sides of roads where culverts have not been adequately sited or installed. More standardized practices for culvert placement, installation, and maintenance are desirable to minimize disruption of natural drainage.

DESCRIPTORS: CULVERTS; FILLS; GRAVEL ROADS; HYDROLOGY AND HYDRAULICS; INTERACTION; PERMAFROST; SOIL SCIENCE; SURFACE DRAINAGE; THAWING

376807 DA

ECONOMIC ASPECTS OF HIGH SPEED GRAVEL ROADS
Reckard, M
Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701; Federal Highway Administration P.O. Box 1648 Juneau Alaska 99802
Nov 1982 Final Rpt. 83p
REPORT NO: FHWA-AK-RD-83-20
SUBFILE: HRIS

AVAILAIBLE FROM: National Technical Information Service 5285
Port Royal Road Springfield Virginia 22161

The report examines the comparative costs of gravel-surfaced and paved roads for carrying traffic safely at 55 m.p.h. Gravel surfaces are found to be a practical alternative to asphalt concrete pavement for rural highways in many areas in Alaska. Construction costs are significantly less as a result of the elimination of paving costs and differences in the requirements for embankment material quality and thickness. Maintenance costs are found to favor paved roads where the embankment and original ground conditions are very good, but favor gravel surfaces where these conditions are fair to poor, and especially where permafrost thaw settlement is a maintenance problem. Dust control treatment of gravel-surfaced roads is found to be necessary for providing safe, high speed travel. The expense of such treatment is found to be partially offset by the resulting reduction in the need for maintenance grading and surfacing gravel replacement. The report recommends that gravel-surfaced roads be given greater consideration in transportation planning for Alaska. It further recommends that the state adopt standard specifications for gravel surface course material, that a regular regraveling program for unpaved highways be initiated, and that Alaskan design limits on road embankment fines content be reexamined where the highway will not be paved.

DESCRIPTORS: ALTERNATIVES; ASPHALTIC CONCRETE: CONTENT; COST COMPARISONS; DUST CONTROL; ECONOMIC EVALUATIONS; FINE/MATERIALS/ GRAVEL ROADS; GROUND CONDITIONS; HIGH SPEED; MAINTENANCE COSTS; PAVED ROADS; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST; SETTLEMENT /STRUCTURAL/; THAWING

371051 DA

THE PRODUCTION OF CALCIUM AND MAGNESIUM ACETATES AS ALTERNATIVE DE-ICING AGENTS
Economides, MJ; Ostermann, RD; Theuveny, B
Geophysical Institute
Northern Engineer VOL. 14 NO. 3 1982 pp 22-28 1 Fig. 1 Tab. 10 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Geophysical Institute Alaska University
Fairbanks Alaska 99701

High-speed gravel roads merit serious consideration on Alaska's rural highways, particularly where poor foundation conditions--such as permafrost and muskeg--are encountered and in areas where clean gravels unsusceptible to frost are scarce. Asphalt pavements are likely to perform poorly in such areas and to have high construction and maintenance costs. Neither highway users, nor state highway personnel, nor taxpayers will be happy if, a few years after an expensive paving project, a road is as bad as or worse than it was before. Even some parts of Alaska's highways which are now paved might be improved by taking the "backward" step of giving them a high-quality gravel surface--and money could be saved in the process.

DESCRIPTORS: ACETATES; ACETIC ACID; CALCIUM COMPOUNDS; CARBONATES; CHEMICAL REACTIONS; CHEMICALS; DEICING; DOLOMITE; LIMESTONES; MAGNESIUM COMPOUNDS; MAINTENANCE; GENERAL; PRODUCTION
PRINTS

User:005102 13may93 P214: PR S3/5/ALL (items 1-73)

DIALOG File 63: TRIS _ 70-92/JUL

dolomite. A series of experiments was undertaken to define the process kinetics and ultimate degree of completion as functions of the reaction temperature, reactant concentrations, and particle size for calcium carbonate. Alaskan limestone, delivered from a quarry near Livengood, Alaska, and acetic acid were used as reactants. This work resulted in a number of original findings. A reaction scheme involving acetic acid and native limestone has resulted in good yield of calcium acetate. While dolomites were equally effective, the calcium-magnesium acetate mixture that was produced did not exhibit a better de-icing performance than that of calcium acetate. Hence, in view of the scope of this work, only the reaction of limestone (CaCO3) with acetic acid can be considered as a viable means to produce an acetate de-icing agent. A process design and economic evaluation was presented. The price of CMA varied from $580/ton for a 10,000 gallon per day plant at $2.50 per gallon of acetic acid, to $230/ton for a 50,000 gallon per day plant at $1.29 per gallon of acetic acid. These prices are within the ranges of prices for present de-icing compounds. The immense secondary costs associated with the use of chloride salts make the acetates even more attractive. (Author)

DESCRIPTIONS: ASPHALT PAVEMENTS: COLD REGIONS; COMPARISONS: COST; CONSTRUCTION; EFFECTIVENESS; DURABILITY; GRAVEL ROADS; MAINTENANCE; GENERAL; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST; RURAL HIGHWAYS

367043 DA

METHOD FOR CALCULATION OF FROST HEAVE
Freden, S
National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoping Sweden 0347-6049
1981 Monograph 22p 9 Fig. 1 Tab. 23 Ref. SWEDISH REPORT NO. No. 274
SUBFILE: TRRL; IRRD; HRS
The method presented here makes it possible to calculate the depth of permafrost, frost heave and by that also the water content increase in road constructions. The change of temperature in the road structure is connected to road surface temperature and to a store of heat under the road. This store, which is the stratified heat from the summer period, is described as a surface with constant temperature beneath the maximum depth of the permafrost, or as a flow of heat from the subsoil up to the freezing zone. The frost heave properties of the frost heave parameter and the heave is a non-linear function of the net heat flow in the freezing zone and the total pressure. The calculation program is in BASIC and PASCAL. In this report calculations of frost depth are compared with measurements in the field. TRRL DESCRIPTIONS: COMPUTER PROGRAMS; DEPTH; EVALUATION; ASSESSMENT; FREEZING; THAWING; CYCLE; FROST; FROST DAMAGE; FROST HEAVE; HEAT TRANSFER; HEAVING; HIGHWAY CONSTRUCTION; MATHEMATICAL MODEL; MEASUREMENT; MEASURING; METHOD; PERMAFROST; ROAD STRUCTURE; ROAD SURFACES; SOIL SCIENCE; SURFACE; SURFACE TEMPERATURE; TEMPERATURE; WATER CONTENT

324961 DA

A BRIEF REVIEW OF FOUNDATION CONSTRUCTION IN THE WESTERN CANADIAN ARCTIC
Thomson, S (Alberta University, Canada)
SUBFILE: TRRL; IRRD; HRS
Problems of design and construction of foundations in permafrost additional to those encountered in temperate regions are discussed. Consideration must be given to the temperature profile in the subsurface, its variation with time and any changes imposed on it, as well as to strength and deformation properties of the frozen soils. Design schemes for foundations in permafrost are outlined. If the foundation soil is stable when thawed, normal temperate zone foundation design may be used. If the thawed state is potentially unstable, three possibilities to be considered are: (1) preservation of the permafrost, (2) acceptance of changes in the thermal regime caused by the structure, (3) modification of the foundation conditions prior to construction. Appropriate construction procedures are outlined. Pile foundations, spread footings and highway construction are briefly discussed. TRRL
DESCRIPTIONS: ARCTIC AREA; CANADA; CONSTRUCTION; CONSTRUCTION PROBLEMS; DESIGN (OVERALL DESIGN); EMBANKMENT; FOUNDATION; FOUNDATION ENGINEERING; FOUNDATIONS (SOILS); FREEZE THAW CYCLE; FREEZING; THAWING; CYCLE; FROST; FROZEN SOILS; HIGHWAY CONSTRUCTION; PILE FOUNDATIONS; PERMAFROST; PILE FOUNDATIONS; SHALLOW FOUNDATION; SPREAD FOOTINGS; STABILITY; TEMPERATURE

322934 DA

PAVEMENT DESIGN FOR PERMAFROST CONDITIONS: STRUCTURAL AND THERMAL REQUIREMENTS
Cow Falls, LGC; Haas, R (Research Council of Alberta, Canada; Waterloo University, Canada)
Transportation Research Board Transportation Research Record N755 1980 pp 30-35 COST 5 Ref.
SUBFILE: HRS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
The existing Arctic road network is made up almost completely of gravel-surfaced secondary roads which design, construction, and maintenance procedures are adequate. Proposed reconstruction and paving of the Alaska Highway in the next decade has raised several questions about the adequacy of pavement-design technology for permafrost areas. Because of the nature of permafrost terrain the problems of pavement design are twofold: provision of a structurally sound, smooth pavement to allow safe passage of vehicles during critical thaw periods and prevention of thermal degradation of the subgrade and right-of-way. Recent research (cont. next page)
has concentrated on the evaluation of new materials and design configurations that minimize subgrade thaw settlement. Research into the structural performance of pavements on permafrost has been minimal. Identification of the structural and thermal bases for pavement design in permafrost areas is a key requirement for the development of a design technology that includes economic analysis and evaluation. This paper examines the effects of environment, materials, and loading on the thermal and structural responses of insulated and conventional pavement designs on discontinuous permafrost. The vertical temperature and stress distribution for a range of feasible designs was analyzed by means of two computer programs. Dynamic traffic loading of the structures investigated did not produce excessive subgrade strains. However, the dead load of the structure contributed greatly to thaw consolidation of the subgrade. None of the designs completely prevented subgrade thaw. A trade-off between dead load, structural and thermal protection of the subgrade was identified. This conclusion provides a new justification for the use of low-density insulating layers in pavements on unstable permafrost. (Author) This paper appeared in Transportation Research Record No. 755 Evaluation and Analysis of pavement Components and Materials. (SOILS; ICE; GENERAL MATERIALS; INSULATION; PAVEMENT DESIGN: PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST REGIONS; SETTLEMENT /STRUCTURAL/; SOIL MECHANICS; STRUCTURAL DESIGN; SOIL CLASSIFICATION SYSTEMS; SOIL SCIENCE; SOIL TESTS; TEST METHODS; VISUAL CLASSIFICATIONS 

300364 DA PHYSICAL AND THERMAL DISTURBANCE AND PROTECTION OF PERMAFROST
Brown, J; Grave, NA (Permafrost Institute)
Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755 DA Proj 4A06212A894
Sep 1979 30 p.
REPORT NO: CRREL-79-18
SUBFILE: NT; TRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Temperatures of the subgrade and of sulfur foam insulation test sections in an expedient road were monitored with thermocouples to document freezing and thawing conditions. Vehicular trafficking was conducted on a limited basis to determine the load supporting capabilities of the foam. The sulfur foam, placed directly under a prefabricated surface mat, was found to be unsuitable for use as an expedient thermal insulation and traffic load supporting material primarily because of its low tensile strength and high brittleness. The insulating value of sulfur foam produced by the batch process in the field was about one-half that of extruded polystyrene, meaning double the thickness for equal protection against thaw. (Author)

DESIGNERS: COLD REGIONS; COLD WEATHER CONSTRUCTION; COLD WEATHER ENGINEERING; COMPONENTS and MATERIALS; FOAM; FOAMS; FOUNDATIONS (SOILS); FRAME; GENERAL MATERIALS; INSULATION; PAVEMENTS; PERMAFROST; PHYSICAL PROPERTIES; ROADS; RUNWAYS; SUBGRADES; TENSILE STRENGTH; TEST AND EVALUATION; THERMAL INSULATION; TRAFFIC LOADS; TRAFFIC SIGN MATERIALS

304987 DA INSULATING AND LOAD-SUPPORTING PROPERTIES OF SULFUR FOAM FOR EXPEDITED ROADS IN COLD REGIONS
Smith, N; Pazsint, DA

Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755

A standard practice is suggested for the description of frozen soils. This report is based on a review paper presented at the Third International Conference on Permafrost held in July 1978 at Edmonton, Canada. It reviews the literature covering 1974-1978 and covers subjects related to natural and human induced disturbance of terrain underlain by permafrost. Subjects included regard investigations undertaken in conjunction with oil and gas pipelines, terrain mapping, methods for estimating terrain sensitivity, methods of protecting terrain, and the thermal effects of off road transportation, oil spills, fire, removal of the surface soil layers, snow conditions, mining and other construction practices. Methods of protecting and restoring permafrost in the USSR are presented in tabular form. An appendix summarizes results of modeling and microclimatic investigation, and the distribution and properties of subsea, land-based, and alpine permafrost. /Authors/

(cont. next page)
be a comprehensive land use plan which would allocate appropriate areas for all activities. The taps (trans-alaska pipeline system) haul road might be considered an experiment designed to develop the techniques by which a first class heavy duty highway can be constructed through the subarctic forest. /author/

DESCRIPTORS: CONSTRUCTION PRACTICE; ENVIRONMENTAL EFFECTS; HIGHWAY CONSTRUCTION; LAND USE PLANNING; ROUTES; SOCIOECONOMICS; WILDERNESS

1974 Res Rpt. 49 pp 38 Fig. 9 Tab. 20 Ref. REPORT NO: RR 324

Fig. 6 Tab, 8 REF. 1 APP

beaches in some arctic areas afford natural routes for summer transportation, since the tundra is then impassible to conventional rubber tired vehicles. In the vicinity of the barrow, Alaska, the beach materials have been rounded and sorted into size grades by geologic agencies of transportation. The rounded sand grains and the uniform particle size give the barrow beach sands a low trafficability and one which constitutes an engineering problem in an area of potential strategic importance. A possible solution to the barrow beach road problem is to stabilize the beach sand by admixing locally available binder materials. At least two major problems are associated with the utilization of binder soil deposits. First, the presence of permafrost prohibits ordinary excavation of a binder material below a depth of 1 to 3 feet, depending upon the depth of summer thaw. Second, the arctic climate restricts chemical weathering and soil profile formation so that those binder materials which are available contain large amounts of finely ground peat but very little mineral clay. It was found that extra amounts of binder produced higher strength in the compacted mixes. Laboratory tests indicate that with optimum amounts of a tundra clay and ice-rafted beach gravel, the soaked CBR of the compacted beach material is increased approximately ten times, from 3 to 31. However, for some purposes, this is not high enough, and other binders are now being investigated. A short discussion of these is included in the paper. /author/

DESCRIPTORS: BEACHES; BINDERS; CBR; COLD WEATHER OPERATIONS FOUNDATIONS (SOILS); MECHANICAL EQUIPMENT; PERMAFROST; SOIL COMPACTION; SOIL PROFILES; SOIL SCIENCE; SOIL STABILIZATION; UNSTABLE SOIL

highway construction often require that a careful assessment be made of the presence or absence of frozen ground, of the ice content of frozen ground. The airborne resistivity data obtained in this study were contoured and the contour maps were compared with surficial geological maps and other ground truth data available. The following conclusions were reached: 1) In areas where near surface sediments are relatively uniform, VLF resistivity best delineates permafrost; and 2) in areas where surface sediments vary widely (e.g., recent flood plains), resistivity at all frequencies gives little information on permafrost conditions, but provides other important information, such as bedrock type, depth to bedrock, soil type and layering.

DESCRIPTORS: AIRBORNE SURVEYING; EXPLORATION CLASSIFICATION (SOILS); FROZEN GROUND; GROUND CONTROL; MAPPING; PERMAFROST; RADIO WAVES; RESISTIVITY SURVEYS; ROUTE SELECTION; SITE INVESTIGATIONS; SOIL SURVEYS

construction of a new highway through a wilderness area starts an irreversible series of more or less predictable events. Healing of the construction scars takes place at varying rates, but can be accelerated by careful construction practices, selection of a route which avoids the worst permafrost areas and which takes gravel and other materials from concealed sites near, but not on, the right-of-way. The greatest environmental problems are created by those who will use the highways for purposes of access and exploitation of a heretofore inaccessible wilderness. It is essential that there
permafrost distribution reaches one-fifth of the dry land surface of the world and the need for more knowledge on it is derived from the necessity of opening new frontier areas. The occurrence is complex and is connected with many phenomena not found in other parts of the world. Patterned ground, ice wedges, pingoes, and icings are described in general terms. The mechanical properties of soil improve drastically by freezing. Strength of frozen ground is discussed. Since frozen ground is close to its melting point and displays creep, its rheology is discussed. Foundation construction, roads, highways and airfields could not be successful without the engineering geologist. Excavation tunneling and mining are different in permafrost than elsewhere. The thermal regime of artificial subsurface openings may be regulated successfully and inexpensively. Besides permafrost, there is artificial frost. Freezing ground by artificial means has colossal advantages and is widely used. The paper reviews principal topics in engineering geology in permafrost. Case histories and design considerations are omitted due to space considerations. Mechanisms, forces, and energies are emphasized and only pertinent literature is quoted. Lcpc/rpl/

DESCRIPTORS: ENGINEERING GEOLOGY; EXPLORATION CLASSIFICATION (SOILS); FROZEN SOILS; MECHANICAL PROPERTIES; MINING; PERMAFROST; RHEOLOGY; SOIL SCIENCE; TUNNELING

237544 DA
FROST ACTION IN ROADS AND AIRFIELDS: A REVIEW OF THE LITERATURE, 1765-1951
Rod Johnson, AW
Highway Research Board Special Reports 1952 No 1, 299 PP, 242 FIG, 79 TAB, 813 REF, 1 APP
SUBFILE: HRIS

contests: historical introduction definition of frost action the physical processes of soil freezing and thawing magnitude of frost heave and increase in soil moisture bearing value of ice and frozen soils magnitude of reduction in load bearing capacity factors influencing magnitude, rate, and nature of frost action and reduction in load carrying capacity penetration of frost design methods for preventing detrimental frost action construction practices relative to frost action permafrost hoar frost

DESCRIPTORS: AIRPORT RUNWAYS; BIBLIOGRAPHIES; FREEZING THAWING EFFECTS; FROST ACTION; FROST HEAVE; FROST PENETRATION ICE; PERMAFROST; REVIEWS; ROADS; SOIL BEARING CAPACITY; SOIL FREEZING; SOIL MOISTURE; SOIL SCIENCE

237286 DA
PERMAFROST INVESTIGATIONS IN BRITISH COLUMBIA AND YUKON TERRITORY
Brown, JL
Nrc Div Bldg Research /Can/
Nrc 9762, 115 PP, 41 FIG, 6TAB, 22 REF, 1APP
SUBFILE: RTAC; HRIS

INFORMATION REGARDING DISTRIBUTION AND CHARACTERISTICS OF PERMAFROST IS VITAL TO THE SOLVING OF CONSTRUCTION PROBLEMS CAUSED BY PERMAFROST. THE SOUTHERN FRINGE OF THE PERMAFROST REGION IS PRESENTLY EXPERIENCING INCREASING ECONOMIC DEVELOPMENT WITH THE ESTABLISHMENT OF NEW TOWNS AND COMMUNITIES ON LINES. MINES AND OIL EXPLORATION AND THE CONSTRUCTION OF NEW ROADS. BECAUSE OF THIS NEW DEVELOPMENT AND BECAUSE OF THE MANY CONSTRUCTION PROBLEMS ENCOUNTERED, THE DIVISION OF BUILDING RESEARCH INITIATED A LONG RANGE PROGRAM OF FIELD SURVEYS OF THE SOUTHERN PORTIONS OF THE PROVINCE. THE FIELD SURVEY WAS CARRIED OUT IN NORTHERN BRITISH COLUMBIA AND SOUTHERN YUKON TERRITORY WHICH RESULTED IN THIS REPORT. /CGRA/ DESCRIPTORS: CHARACTERISTICS; CONSTRUCTION; DISTRIBUTION; ECONOMIC DEVELOPMENT; PERMAFROST: PERMAFROST REGIONS; SOIL SCIENCE

232791 DA
THERMAL DESIGN IN PERMAFROST SOILS
Peyton, HR
Canadian Conf Proc On Permafrost /Third Conf Tech Memo NO 96, PP 85-119, 20 FIG, 3 TAB, 5 REF
SUBFILE: HRIS

METHODS OF CALCULATING THE THERMAL REGIME FOR THERMAL DESIGN IN PERMAFROST SOILS ARE DISCUSSED, AND A SET OF EXAMPLES PRESENTED WHICH ILLUSTRATE SOME DESIGN PROCESSES. THE OCCURRENCE OF PERMAFROST IS SCHEMATICALLY SHOWN, BUT THE CURVE WHICH IS THAT WHICH IS NEVER WARMER THAN 32 F DURING THE YEAR. THE ACTIVE LAYER AT THE GROUND SURFACE IS SEASONALLY THAWED AND FROZEN, AND THE SOIL BELOW THE PERMAFROST LAYER HAS A DIFFERENT CASE OF THE MANY INDIVIDUAL SYSTEMS WHICH WILL HAVE A DIFFERENT CASE OF THE MANY INDIVIDUAL SYSTEMS WHICH WILL HAVE A THREE-DIMENSIONAL SOLUTION. THE LAYERED CASE CAN BE PROPERLY SOLVED BY USING RELATIVELY SIMPLE STEADY STATE HEAT FLOW CALCULATIONS. THE GREAT ADVANTAGE TO STEADY STATE ANALYSIS IS THAT SUPERPOSITION CAN BE APPLIED. A USEFUL, ANALYTICAL METHOD USING SUPERPOSITION BY AN EASY GRAPHICAL METHOD IS DESCRIBED. THIS METHOD IS CALLED THE TWO-LANE ROAD CASE BECAUSE HEAT FLOW LINES ARE SEGMENTS OF CIRCLES AND ISOOTHERMS ARE EQUALLY SPACED RADIAL LINES. TWO SOLUTIONS OF THIS TYPE CAN BE SUPERIMPOSED WHERE THE DISTURBANCE CAUSED BY THE HEATED REGION IS ADDED TO THE ORIGINAL UNIFORM SOIL TEMPERATURE. THE ISOOTHERMS ARE THEN CONSTRUCTED BY CONTOURING THE MANY INDIVIDUAL POINTS OF EQUAL TEMPERATURE AT INTERSECTIONS OF RADIAL LINES. THIS TYPE OF SOLUTIONS ASSUMES A HOMOGENEOUS SOIL, AND A LAYERED SYSTEM OF SOILS WITH VARIABLE THERMAL CONDUCTIVITY WILL HAVE A DIFFERENT THERMAL REGIME. THE LAYERED CASE CAN BE SOLVED BY SUPERPOSITION, BUT NOT DIRECTLY BY THIS METHOD. ANOTHER STEADY STATE SOLUTION IS THE CASE OF HEATED PIPELINE SUCH AS ONE CARRYING WARM CRUDE OIL. A SOLUTION HAS BEEN ANALYTICALLY SOLVED USING THREE-DIMENSIONAL SOLUTIONS WHICH REQUIRE A THREE-DIMENSIONAL SOLUTION ARE CONSIDERABLY MORE DIFFICULT TO ANALYZE. AN EXCELLENT ANALYTICAL PROCEDURE WITH MANY APPLICATIONS HAS BEEN DEVELOPED BY LACHENBRUCH, 1958. THIS PROBLEM ALLOWS A RATHER COMPLETE DESCRIPTION OF THE THERMAL REGIME UNDER DISTURBED GROUND SURFACE AREAS OF ANY SHAPE AND IS APPLICABLE TO PROBLEMS ASSOCIATED WITH BUILDINGS, ROADS, AIRFIELDS, LAKES, AND SHORELINES. SEVERAL NUMERICAL (cont. next page)
TECHNIQUES ARE AVAILABLE FOR SOLVING STEADY STATE PROBLEMS, HOWEVER, ONLY RELAXATION IS DISCUSSED. THE TWO-DIMENSIONAL CASE IS USED AS AN EXAMPLE, AND IT IS SEEN THAT THE THREE-DIMENSIONAL CASE IS A SIMPLE EXTENSION. SINCE ROAD CONSTRUCTION INCREASES THE MEAN ANNUAL SOIL SURFACE TEMPERATURE AND THE VARIATION OF SEASONAL SOIL TEMPERATURE, BOTH OF WHICH INCREASE THE DEPTH OF SEASONAL THAW AND CAN CAUSE PERMAFROST THAWING, THE SOLUTION IS TO APPLY ENOUGH INSULATION BELOW THE ROAD SURFACE TO PREVENT PERMAFROST DEGRADATION.

DESCRIPTORS: DESIGN; FOUNDATIONS (SOILS); GRAPHICAL ANALYSIS; HEAT EXCHANGE; HIGHWAY CONSTRUCTION; PERMAFROST; PIPELINES; SOIL SCIENCE; SOIL TEMPERATURE; STEADY STATE; SUPERPOSITION; THERMAL ANALYSIS; THERMAL CONDUCTIVITY; THERMAL INSULATION; THREE DIMENSIONAL.

229204 DA

SOME POSSIBLE PROBLEMS WITH PIPELINES IN PERMAFROST REGIONS

Canadian Conf Proc On Permafrost /Third Conf Tech Memo ND 96, PP 79-84
SUBFILE: HRIS


DESCRIPTORS: EMBANKMENTS; FOUNDATIONS (SOILS); OIL TANKERS; OILS; PERMAFROST; PIPELINES; RIVERS; ROADSIDE; SOIL SCIENCE; STREAM CHANNELS; SUSPENDED STRUCTURES; THERMAL INSULATION; THERMAL PROPERTIES; TRANSPORTATION

229144 DA

APPLICATIONS OF AERIAL-PHOTOGRAPHIC TECHNIQUES TO ENGINEERING APPENDIX C: INTEGRATION OF PHOTOGRAMMETRY AND ELECTRONIC COMPUTATION IN HIGHWAY ENGINEERING

Lucas, J. Mcgraw Hill Book Company pp 305-341, 441-445, 3 fig, 15 phot SUBFILE: HRIS

CONTENTS: ROUTE LOCATION STAGES OF ROUTE LOCATION AERIAL-PHOTOGRAPHIC TECHNIQUES FOR ROAD AND RAILWAY LOCATION RECONNAISSANCE OF AREA AND CORRIDOR AERIAL-PHOTOGRAPHIC TECHNIQUES FOR ROAD AND RAILWAY LOCATION - RECONNAISSANCE ANALYSIS OF ALTERNATIVE ROUTES RECONNAISSANCE ESTIMATES OF CONSTRUCTION COSTS FROM PHOTO DATA APPLICATION OF (cont. next page)
Numerous transportation facilities have been proposed for arctic and subarctic regions. Most will be constructed on embankments. Incorporation of a thermo-insulating layer within the embankment may permit use of reduced quantities of embankment material. Thermal design and analysis procedures applicable to embankments are reviewed and a two-dimensional numerical method coupling heat and mass transfer and vertical displacement is proposed. The method developed by Lachenbruch, and a finite difference technique are used to illustrate design and analysis methods for insulated embankments on permafrost. More than sixty thermo-insulating materials suitable for incorporation into embankments are currently available; however, only seventeen materials have been used. Most applications of insulation have been in seasonal frost areas but a few test sections have been constructed on permafrost. Stability of thermal and physical properties is a desirable characteristic of thermo-insulating layers. Moisture absorption causes increased thermal conductivity and degradation of strength of some insulating materials. Several types of moisture barriers have been used but the most successful have been polyethylene sheets. Laboratory tests presently used to evaluate properties of insulating materials do not provide quantitative design information. A new device that could provide this information is proposed. Other suggestions for future research are made.

188338 DA

RAILWAY BRIDGING PROBLEMS ACROSS SIBERIA

Pechenyuk, I

Highways and Road Construction International Vol. 46 No. 1821 pp 29-30 2 Phot.

DESCRIPTORS: ARCTIC REGIONS; COLD WEATHER OPERATIONS; CONSTRUCTION; CONSTRUCTION MATERIALS; EMBANKMENTS; ENVIRONMENTAL TESTS; FOUNDATIONS; FREEZING; FROZEN SOIL; GEOTECHNICAL MATERIALS; HIGHWAY INSULATION; MOISTURE CONTROL; PERMAFROST; PHYSICAL PROPERTIES; POLYETHYLENES; ROAD BUILDING EQUIPMENT; SOIL MECHANICS; STRENGTH OF MATERIALS; THERMAL CONDUCTIVITY; THERMAL INSULATION; THERMOINSULATION

191561 DA

THERMOINSULATING MEDIA WITHIN EMBANKMEN TS ON PERENNIALY FROZEN SOIL

Berg, R.

Cold Regions Research and Engineering Laboratory; Department of the Army, P.O. Box 282; Hanover; New Hampshire 03755


DESCRIPTORS: CONSTRUCTION; MILITARY ENGINEERING; MILITARY TRANSPORTATION; PERMAFROST REGIONS; TRAFFICABILITY

215481 DA

MILITARY ROAD CONSTRUCTION IN FOREIGN THEATERS

Highway Research Board; Nelson, HE 1948 71 Pp. 102 FIG

DESCRIPTORS: AERIAL PHOTOGRAPHY; AIR PHOTOINTERPRETATION; CANAL OF ELABORATION CLASSIFICATION; FACILITIES DESIGN HIGHWAY ENGINEERING; HIGHWAY LOCATION; LANDSLIDES; LOCATIONS; MATERIAL SURVEYS; PERMAFROST; PHOTOGRAPHY; PIPELINES; RAILROADS; RECONNAISSANCE SURVEYS; WATER RESOURCES
**DIALOG File 63: TRIS _ 70-92/JUL**

**construction sites are remote from any industrial centre.**

**CONSTRUCTION; CONSTRUCTION METHOD; FROST; LOW**

**MOTORWAY; PERMAFROST; RAILWAY; RIGHT OF WAY; ROAD CONSTRUCTION**

; SOIL; TUNNEL; TUNNELING; USSR; USSR RAILWAYS

188628 DA

**PROCEEDINGS OF THE SURFACE PROTECTION SEMINAR. THEME: TRAVEL**

**AND TRANSPORTATION PRACTICES TO PREVENT SURFACE DESTRUCTION IN**

**THE NORTHERN ENVIRONMENT HELD AT ANCHORAGE, ALASKA ON JANUARY**

**19-22, 1976**

Bureau of Land Management, Anchorage, Alaska.

Aug 1976 306p

**REPORT NO: BLM/AK/PROC-76/01**

**SUBFILE: NTIS**

**AVAILABLE FROM: National Technical Information Service 5285**

Port Royal Road Springfield Virginia 22161

Seminar discussions covered two broad topics: surface disturbance and surface protection. Federal and state laws and trans-Alaska oil pipeline regulations were discussed. Other subjects included the following: effects of vehicle travel, industrial development, construction, and fire control on the surface in the northern environment; agency and corporation policies and procedures regarding surface protection; resource data needs; equipment development and regulation; stabilization and maintenance of disturbed surfaces. The proceedings include about 50 papers, with abstracts, from talks and discussions by scientists and representatives of many government agencies and industries.

**DESCRIPTORS: ALASKA; ARCTIC REGIONS; COLD WEATHER TESTS; ENERGY SOURCE DEVELOPMENT; ENVIRONMENTAL IMPACTS; FOREST FIRES; GOVERNMENT POLICIES; LAND USE; LEGISLATION; MANAGEMENT PLANNING; MEETINGS; MINING; NATIONAL GOVERNMENT; NATURAL RESOURCES; OFF THE ROAD VEHICLES; PERMAFROST; PIPELINES; PROTECTION; REGULATIONS; ROADS; SOIL CONSERVATION; STATE GOVERNMENT; TRANSPORTATION**

174491 DA

**FINITE ELEMENT MODEL OF TRANSIENT HEAT CONDUCTION WITH**

**ISOTHERMAL PHASE CHANGE (TWO AND THREE DIMENSIONAL)**

Guymon, GL; Hromadka, TVII

Cold Regions Research and Engineering Lab Hanover N H

Nov 1977 167p

**REPORT NO: CRREL-SR-77-38**

**SUBFILE: NTIS**

**AVAILABLE FROM: National Technical Information Service 5285**

Port Royal Road Springfield Virginia 22161

The partial differential equation for transient heat conduction is solved by a finite element analog using a quadratic weighting function for the discretized spatial domain. The transient problem is solved by the Crank-Nicolson approximation. Two-dimensional and three-dimensional models incorporated in the same computer program are presented. The finite element method is reviewed, assumptions and limitations upon which the model is based are presented, and a complete derivation of the system analog is included. Certain problems can only be modeled as a three-dimensional system, e.g., thaw degradation around roadway culverts, embankment dams on permafrost where dam length is short relative to dam width, and thaw and freezeback under buildings. In most cases, however, the more economical two-dimensional model can be used. Numerical tests of both models have been accomplished but field verification has not been attempted. A user's manual and a FORTRAN IV computer listing of the program are presented. (Author)

**DESCRIPTORS: COLD REGIONS; COMPUTER PROGRAMS; COMPUTERIZED SIMULATION; CONDUCTION HEAT TRANSFER; DAMS; DEGRADATION; FINITE ELEMENT ANALYSIS; FORTRAN; FROST; HEAT FLUX; MATHEMATICAL MODELING; PARTIAL DIFFERENTIAL EQUATIONS; PERMAFROST; PROGRAMMING MANUALS; ROADS; SOIL MECHANICS; THAWING; THREE DIMENSIONAL; TRANSIENTS; TWO DIMENSIONAL**

172547 DA

**PAVING ON PERMAFROST**

Mack, R; Borowski, L (Department of Transport, Canada)

Shell International Petroleum Company Limited

Shell Bitumen Review N66 Sep 1977 pp 3-8 6 Fig. 6 Phot.

**SUBFILE: TRRL; IRRD; HRIS**

Halft of the land area of Canada and that portion which is most dependent on air transport is perennially frozen. Two methods of building paved runways in permafrost areas are described. Two projects are considered: one at Hay River in a zone of discontinuous permafrost and the other at Inuvik, the first project of any kind north of the Arctic Circle in continental Canada. Data collected before and after paving show the effect of paving on the thermal regime, and the problems associated with moving supplies and equipment into a land where roads and railroads are scarce or non-existent are discussed. An addendum provides information on the performance of the pavements at Hay River, Inuvik and Norman Wells since their construction about seven years ago. /TRRL/

**DESCRIPTORS: CANADA; CONSTRUCTION; DURABILITY; FROST; PAVEMENT CONSTRUCTION; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST; PERMAFROST REGIONS; POLAR REGIONS; ROAD CONSTRUCTION; RUNWAY; RUNWAYS; SOIL; TEMPERATURE**

169401 DA

**PAVEMENT RECYCLING USING A HEAVY BULLDOZER MOUNTED**

**PULVERIZER**

Eaton, RA; Garfield, DA

Cold Regions Research and Engineering Laboratory:

Department of the Army, P.O. Box 282; Hanover: New Hampshire

03755

Sep 1977 30 pp

**REPORT NO: CRREL-SR-77-30**

**SUBFILE: NTIS; HRIS**

**AVAILABLE FROM: National Technical Information Service 5285**

Port Royal Road Springfield Virginia 22161

(cont. next page)
Recycling of paving materials is gaining acceptance as a means of savings in pavement reconstruction or rehabilitation. The need to conserve natural resources and decreasing costs of select virgin materials have made recycling pavements economically attractive. Pavements that currently have low means of savings in pavement reconstruction or rehabilitation. A prototype test rig was constructed. Tests were conducted on a permafrost excavating attachment for heavy bulldozers and a serviceability indices due to surface irregularities such as select virgin materials have made recycling pavements reused as a base for the new surface. CRREL developed a prototype test rig was constructed. Tests were conducted on frozen soils, gravels, and ledge. In September 1976, this rig was used to pulverize a flexible street pavement in Hanover, N.H. and highway pavement test sections at a CRREL test facility. The resultant processed material met Corps of Engineers base course gradation requirements. The machine can process 120 square ft of pavement structure per minute to a depth of 12 inches. The most uniformly graded material was obtained at a drum speed of 15 revolutions per minute. Once the pavement is broken down from the solid mass (asphalt concrete pavement), the machine does not further break down or pulverize the aggregate. A minor amount of dust was evident during the operations.

163681 DA

THERMAL GEOTECHNICS

Junikis, AR

Rutgers University Press; 30 College Avenue; New Brunswick

New Jersey; 08903

Monograph 375 pp 101 Fig. 34 Tab. 13 App.

SUBFILE: HRIS

The application is discussed of the present knowledge of frost problems in geotechnics in relation to important environmental factors such as engineering soil properties, temperature, heat, thermal radiation and heat conduction, basic principles of frost penetration into soil, insulation of roads against frost, and concepts about engineering in permafrost. The results are incorporated of some 25 years of theoretical and experimental research on soil freezing and associated soil moisture migration. The scientific and technical information presented could help suggest basic methods of solving practical problems related to frost action in soils. The principles governing the unsaturated water film flow mechanism in a thermo-osmotic soil moisture transfer process from groundwater toward the cold front upon freezing are given. The book concludes with a brief discussion of lunar soil mechanics.

DESCRIPTORS: ENGINEERING PROPERTIES; FOUNDATIONS (SOILS); FROST ACTION; GEOTECHNICS; GROUNDWATER; HEAT FLOW; INSULATION; LUNAR SOILS; MECHANICS (EARTH MASS); MOISTURE CONTENT; PERMAFROST; RESEARCH; SOIL MECHANICS; SOIL MOISTURE; SOIL PROPERTIES; SOIL SCIENCE; TEMPERATURE; THERMAL RADIATION

159084 DA

FUNDAMENTALS OF FROST FORECASTING IN GEOLOGICAL ENGINEERING INVESTIGATIONS (OSNOVY MERZLOTNOGO PROGNOZA PRI INZHENERNO-GEOLOGICHESKIM ISSLEDUVANIIKH)

Kudryavtsev, VA; Garagulya, LS; Kondratyeva, KA; Melamed, VG

Cold Regions Research and Engineering Lab Hanover N H

Mar 1977 496p

REPORT NO: CRREL-TL-606

SUBFILE: NTIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The textbook 'Fundamentals of Frost Forecasting in Geological Engineering Investigations' in regions of seasonally and permanently frozen rocks is the first and still the only contemporary textbook in the Soviet and foreign literature which embraces the main questions of frost forecasting. In it the methodological, mathematical and thermodynamic principles of frost forecasting are examined and methods and calculation procedures are given for determining the influence of various factors and the productive activity of man on frost and geological engineering conditions. The procedure of compilation of a frost forecast is illustrated by a large number of examples of calculations based on concrete material. The textbook is intended for the study and teaching of the procedure of frost investigations and the procedure of compilation of a frost forecast. At the same time, the book concludes with a brief discussion of lunar soil mechanics.

DESCRIPTORS: ADVERSE CONDITIONS; BUILDINGS; COLD REGIONS; COLD WEATHER OPERATIONS; COMPUTATIONS; CONSTRUCTION; DAMS; ENGINEERING GEOLOGY; EQUATIONS; FORECASTING; FROST; FROST HEAVE; GEOLOGICAL SURVEY; HEAT TRANSFER; MAPPING; MASS TRANSFER; PERMAFROST; ROADS; ROCK MECHANICS; SOIL MECHANICS; TEMPERATURE; TEXTBOOKS; THERMAL CONDUCTIVITY; TRANSLATIONS; USSR
The Symposium on Geography of Polar Countries held in Leningrad 22-26 July 1976 as part of the XXIII International Geographical Congress consisted of three sessions: (1) Polar environment, natural resources, their exploration and exploitation. (2) Past, present and future economic developments in the polar regions. (3) Polar environment protection. This report presents the full text or extended summaries of a number of the papers, and English and Russian summaries of the Soviet contributions related to environmental protection. The papers and summaries presented in this report reflect the participation of members and of the joint US-USSR environmental protection agreement project, Protection of Northern Ecosystems. The U.S. papers deal with land use planning to mitigate environmental impact; the impact of resource development on natives, fish and wildlife, and permafrost, the impacts of pipelines and roads on the environment, and computer modeling to simulate terrain modification due to man's activities. The Soviet summaries deal with subjects of properties and changes in arctic and subarctic flora, fauna, terrain, and permafrost, and methods of predicting changes in the environment. (Author)

DESCRIPTORS: ALASKA; CONSTRUCTION; ECOSYSTEMS; ENVIRONMENTAL IMPACTS; ENVIRONMENTAL MANAGEMENT; ENVIRONMENTAL PROTECTION; EXPLOITATION; EXPLORATION; FISHES; GEOGRAPHY; HIGHWAYS; LAND USE; MANAGEMENT; PLANNING AND CONTROL; MEETINGS; NATURAL RESOURCES; PERMAFROST; POLAR REGIONS; UNITED STATES; USSR; VEGETATION; WATER POLLUTION; WILDLIFE
embankment subgrades. Lateral drainage ditches of sufficient width to handle construction excavation equipment, along with near-vertical slope cuts with hand-cleared tops equal in width to one and one-half times the height of the cuts, significantly enhance natural processes of slope stabilization. Right-of-way clearing limited to the toe of embankment fill slopes minimizes subsidence of the roadway and its shoulder slopes. In extremely ice-rich soil cuts, the seeding of the slopes should not be attempted until late in the first thaw season for best results. Natural woody growth can be expected to have a substantial stabilizing effect after five or six thaw seasons but could be accomplished sooner by planting tree seedlings. Attempts to stabilize ice-rich cut slopes with applications of insulation are not very effective and seem to prolong the natural stabilization process.

(Author)

DESCRIPTORS: ALASKA; CHEMICAL PROCESSES; CONSTRUCTION; CUTS DRAINAGE; EMBANKMENTS; EROSION; EXCAVATING MACHINERY; EXCAVATION; FROZEN GROUND; GENERAL MATERIALS; LIVENGOOD ALASKA; PERMAFROST; PIPELINES; ROADS; SEEDING; SEEDS; SLOPE STABILIZATION; SOIL STABILIZATION; VEGETATION; YUKON RIVER

147124 DA

POLAR TRANSPORTATION EQUIPMENT--FOUR-WHEEL-DRIVE VEHICLE WITH HIGH-FLotation TIRES

Beard, WH

Naval Civil Engineering Lab Port Hueneme Calif

July 1974, 7p

REPORT NO: NCEL-TR-630

SUBFILE: NTIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

A four-wheel-drive vehicle with a V-8 engine, automatic transmission, 11:00 x 15 bar-tread, high-flotation tires, and a panel delivery body was tested over improved roads on abutting areas of snow, ice and frozen ground at McMurdo Station, Antarctica, for a 2-year period between Deep Freezes 67 and 69. It was used to haul light cargo and passengers both summer and winter in all kinds of weather, including temperatures to -80F. It was driven without major incidents. This vehicle is recommended for Military transportation, in the event that a polar coastal station becomes accessible by ice-free seas. Cold weather construction problems are discussed.

(Author)

DESCRIPTORS: ALASKA; COLD WEATHER CONSTRUCTION; CONSTRUCTION; CONSTRUCTION MATERIALS; DEGRADATION; DRAINAGE; EMBANKMENTS; FILLS; FOUNDATIONS; FREEZING; HIGHWAY CONSTRUCTION; HIGHWAY MAINTENANCE; INSULATION; MAINTENANCE, GENERAL; MEMBRANE ENCAPSULATED SOIL LAYERS; MEMBRANES; PAVEMENT BASES; PAVEMENTS; PIPELINES; ROADS; RUNOFF; SHOULDERS PAVEMENTS; SITE SELECTION; SLOPE SLOPE STABILITY; SOIL STABILIZATION; SUBSURFACE DRAINAGE; WATER EROSION

144092 DA

A SURVEY OF ROAD CONSTRUCTION AND MAINTENANCE PROBLEMS IN CENTRAL ALASKA

Clark, EF; Simoni, OW

Cold Regions Research and Engineering Laboratory; P.O. Box 282; Hanover; New Hampshire; 03755

Oct 1976, 42 pp

REPORT NO: CRREL-SR-76-8

SUBFILE: NTIS; HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

A survey of road construction and maintenance problems in central Alaska is presented. The problems of poor fill and foundation material, permafrost degradation under pavement and shoulders, slope instability, water erosion, road icing from subsurface seepage, and culvert icing are described. Possible solutions to road maintenance problems in central Alaska include the use of insulating materials in permafrost areas. MSFL construction when non-frost-susceptible soils are unavailable, and the use of improved drainage in areas where extensive icing occurs. Bridge damage, erosion of sidehill cuts and embankment instability are also discussed and potential solutions are given.

(Author)

DESCRIPTORS: ALASKA; COLD WEATHER CONSTRUCTION; CONSTRUCTION; FROZEN GROUND; GENERAL MATERIALS; LIVENGOOD ALASKA; PERMAFROST; PIPELINES; ROADS; SEEDING; SEEDS; SLOPE STABILIZATION; SOIL STABILIZATION; VEGETATION; YUKON RIVER

144052 DA

CURRENT ROAD CONSTRUCTION PRACTICE IN NORTHERN SASKATCHEWAN

MacDonald, AB (Saskatchewan Department of Highways & Transp, Can)

Manitoba Department of Transportation, Canada 1075 Portage Avenue Winnipeg Manitoba Canada

Apr 1974 Proceeding 14 pp 1 Fig.

SUBFILE: RTAC; HRIS

Current methods of road location, design, and construction used in Northern Saskatchewan are reviewed. Special features such as silty soilorganic terrain, permafrost, rock outcrops, corrosion of culverts, and location of aggregate supplies are discussed. Finally, information on the construction and utilization of ice roads is presented.


DESCRIPTORS: CONSTRUCTION; CULVERTS; FOUNDATIONS (SOILS); HIGHWAY CONSTRUCTION; HIGHWAY DESIGN; HIGHWAY LOCATION; ORGANIC SOILS; PERMAFROST; SILTY SANDS
The condition of the roadbed on one of the long-term construction railroad sections in the Far East attests convincingly to the possibility of constructing a roadbed with permafrost degradation. This line passes through slanting terraces, going across into a contour of low, rounded, isolated hills, covered, in places, as a rule, by turfed ridges with swampy patches between, covered by dense growth, with separate thermal karst valleys and hillocks of heaving. The average yearly temperature of the air is 3.8 degrees C.; the air temperature oscillates within the limits of -53.5 degree and +33 degree. Strong solar radiation is observed. The possibility of constructing a roadbed with permafrost degradation here shows promise of year-around building in similar circumstances with normal construction techniques. The increase of the volume of earth work upon the supplementary enlargement of the embankment and the replacement from the settlement of hidden soils of the foundation do not exceed the analogous increase of the volumes of soil on the crowning off of the road shoulder, and also the required over estimation of the height of the embankment during construction with preservation of the permafrost. Manual labor is fully excluded, which is inescapable in the construction of turf holding plate foundations. The reliability of the roadbed in operation is guaranteed inasmuch as the possible settlements are reckoned into the constructions of the roadbed, and the reversibility of frost processes and soil freezing of the embankment below cannot cause random deformations. Full (cont. next page)
Novoryazanskaya ul., Dom 12 Moscow 288 USSR

In the Trans-Siberian, Trans-Baikal, and Far East roads located in permafrost regions, embankment sediments are widely distributed. Two types of sediments can be distinguished. The first type consists of soils in the embankment foundations, in the form of loams, sandy loams, and turf located at a certain depth (2-3.5 m.) in permafrost conditions or underlying more stable ground: sand, conglomerate rock. The second type of sediment is distributed mainly on sections with heavy masses closely deposited on the surface of ice-impregnated permafrost soils. Sediments of this type occur as well as the result of the compression of heavily moistened soils of the foundation. Abstract only is available in English, original untranslated as of November 1976.

DESCRIPTORS: EMBANKMENTS; ICE; LOAMS; PERMAFROST; PERMAFROST REGIONS; RAIL TRANSPORTATION; RIGHT OF WAY; SEDIMENTS; SOIL CLASSIFICATION; SOIL MECHANICS; SOIL MOISTURE; SOIL SCIENCE; TURF

082840 DA

SULFUR FOAM TESTED AS FROST HEAVE PREVENTIVE

Public Works VOL. 106 No. 2 Feb 1975 pp 68-69

DESCRIPTIONS: BEARING TESTS; CONSTRUCTION; FOAMS; FROST HEAVE; GENERAL MATERIALS; HIGHWAY CONSTRUCTION; SULFUR; THERMAL INSULATION

072204 DA

CONSTRUCTION STANDARDS AND RULES. PART III, SECTION E, CHAPTER 6: HIGHWAYS. NORMS OF PRODUCTION AND WORK APPROVAL. Council of Ministers of the Union of USSR: State Committee on Construction; Moscow; Ussr Jul 1973 87 pp 9 Tab. 2 App. Russian

SUBFILE: HRIS

This pamphlet applies to the regulations and work acceptance norms for the construction and reconstruction of automobile roads of the following categories: general state, republic, and local roads, and access and internal roads of industrial and agricultural enterprises. Main chapters include such... (cont. next page)
topics as technical organization and preparation for construction; construction of anti-freeze, insulated, drainage, and leveling layers; foundations and road surfacings from soil, sandy gravel, and crushed-stone mixtures, strengthened with organic and inorganic cementing materials; crushed stone, gravel, and slag foundations and surfacings; bridges; road surfacings and foundations formed from bituminous and tar-mineral mixtures and crushed stone treated with organic astringents; asphalt surfacings; monolithic and aggregate cement road pavements; finishing and strengthening the road edges; regulations for work production. The appendices covers such topics as the selection of means of mechanization for excavation work of a general nature, for excavation in permafrost regions, for planning, and for the production of drainage systems. Also included is a sample report for the finished work product.

DESCRIPTORS: ADMINISTRATION; CONSTRUCTION; DRAINAGE; FACILITIES DESIGN; FOUNDATIONS; HIGHWAY CONSTRUCTION; MATERIALS; REGULATIONS; STANDARDS; SURFACING

046845 DA

THERMAL MODEL FOR ROADS, AIRSTRIPS AND BUILDING FOUNDATIONS IN PERMAFROST REGIONS

Meyer, GH; Keller, HH; Couch, EJ (Mobil Research and Development Corporation).


SUBFILE: EI; RRIS

AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017

A thermal model describing the one-dimensional heat conduction in a layered system is developed. Up to ten homogeneous layers, each having different thermal properties, porosity, water content and thickness, can be accommodated. A periodic temperature is input for the surface condition. The computed results consist of the depth of the thawed region as a function of time. The layered model is applied to the design of foundations for roads and airstrips in permafrost regions. A sensitivity study was made to find the effect on thaw depth of varying physical properties of the materials used, the geometry of the construction and the surface temperature. The means for extension of the model to building foundation design by modification of the surface boundary condition is presented.

DESCRIPTORS: COLD WEATHER OPERATIONS; FOUNDATIONS; PERMAFROST; RIGHT OF WAY; SOIL MECHANICS
This purpose of this publication is to suggest a number of alternative rolling patterns to ensure the proper compaction of the whole road pavement within the limited time the materials remain flexible. Its objectives are a) to assist the engineer to properly plan the rolling operation, and b) to help the supervisor and operator to achieve consistent compaction of the bituminous pavements. The criteria used for determining the optimum rolling pattern and rolling length are presented first. Site instructions and operations, and the methods for checking rolling pattern are recommended. The importance of the temperature of the coated asphalt at delivery and during rolling upon the quality of the pavement is emphasised. A graph is provided of cooling rates for 25mm and 250mm thicknesses of asphalt layers at 10 degrees C ambient temperature. Also included, in Appendix 8, are some notes for roller drivers, which contain useful practical information for site operators. (TRRL)

DESCRIPTORS: BITUMINOUS PAVEMENTS; COMPACTION; CONSTRUCTION PAVEMENT DESIGN AND PERFORMANCE; ROLLERS

680612 DA

VEHICLE ENGINEERING HANDBOOK

Montgomery, G.

Freight Transport Association Hermes House, St John's Road Tunbridge Wells Kent England

1990 336p

SUBFILE: HRIS; TRRL; IRRD

AVAILABLE FROM: Freight Transport Association Hermes House, St John's Road Tunbridge Wells Kent England

This handbook discusses those aspects of lorry design and engineering that either affect its running costs and efficiency, or which are subject to United Kingdom, EEC, or international legislation. Sections are provided on: aerodynamics; axle loadings and weight distribution; bodywork; brakes; demountable body systems; drawbar combinations; engine performance measurement; exhaust emission control; fuel economy and technology; load retention; lubricants; maintenance; noise emission; plating and testing; road speed limiters; tires; spray suppression; suspension systems; tachographs; transmission trends; turbocharging and charge-cooling; vehicle stability; weights and dimensions; wheel security; winter preparation; and the design, layout and safety of vehicle workshops. Special sections are provided on fork lift trucks, and tippers. International vehicle categories are defined in the appendix. (TRRL)

DESCRIPTORS: EUROPE; HANDBOOKS; LAWS; TRUCKS; VEHICLE CHARACTERISTICS; VEHICLE DESIGN; VEHICLE OPERATING COST

604769 DA

MECHANICAL PROPERTIES, DURABILITY AND VIABILITY OF SAND/SULPHUR/BITUMEN MIXES AS ROAD PAVEMENT MATERIALS

Yousef, MAHA

Queen's University of Belfast Department of Civil Engineering, University Road Belfast Ireland

1989 425p

SUBFILE: HRIS; TRRL; IRRD

This thesis deals mainly with the durability of sand/sulphur/bitumen (SSB) mixes used as paving materials for road construction in hot desert like areas. SSB mixes with different SSB ratios (17/3, 15/5 and 13/7) were cast. Control (cont. next page)
specimens of sand/limestone filler/bitumen were also made by substituting an equal volume of limestone filler in place of the sulphur in each mix. Specimens in both mixes were then airfreighted to Jordan and exposed to local weathering conditions. To determine the effect of weathering on their mechanical properties, specimens were airfreighted back to Belfast for testing after 6, 12, 18 and 24 months period of weathering. The engineering characteristics investigated included: Marshall stability, tensile and flexural strengths, dynamic modulus of elasticity and fatigue properties. Other related tests included permeability measurements and microscopic analysis of the weathered mix structure. Recovered bitumen from the weathered mixes was subjected to tests for viscosity, penetration and ring and ball softening point.

Unweathered specimens were also tested to determine their thermal properties and effect of water attack and heating/cooling cycles in the laboratory. Theoretical studies were made on thermal stress prediction and low temperature cracking. The mechanical properties of SSE mixes compared with those of using sand of different gradings were investigated. A desk study was done on the hazards of using sulphur and means of reducing poisonous gas emissions. A pavement thickness design was conducted in order to compare use of sand/sulphur/bitumen mixes with asphaltic concrete pavement. An elastic layered analysis was used and, on the basis of the calculated design thickness requirements, an economic evaluation was made. (A)

DESCRIPTORS: BITUMINOUS MIXTURE; DANGER; DEFLECTION; DESERT DURABILITY; EVALUATION; LABORATORY (NOT AN ORGANIZATION); LIMESTONE; MARSHALL; MODULUS OF ELASTICITY; PENETRATION; PERMEABILITY; RING AND BALL (TEST); SAND; STABILITY; STRENGTH (MATER); MARSHALL; TEMPERATURE; TENSION; TEST; THESIS; VISCOSITY; WEATHERING
system supporting hardware will eliminate fatigue failures in the muffler support system. A higher tear strength, flexible rubber boot is required on the reduced noise level cooling system to allow utilization of the engine-mounted shroud. The intake system modifications performed very well and remained in good physical condition. The unmodified engine noise source did not change significantly in noise level during fleet operations. Fuel mileage was higher for the modified vs. nonmodified trucks. Maintenance costs of the enclosed trucks were much higher than the nonenclosed trucks ($0.0378/mi vs. $0.0325/mi), with the nonenclosed trucks showing a smaller increase ($0.0328). Rept. for Mar 1977-Oct 1978.

**EVALUATION OF FMVSS 103 IDLE TEST VERSUS ROAD LOAD TEST.**

**FINAL REPORT**

Pears, Wayne E. L.; Kabat, R. J.
Ball Bros. Res. Corp., P.O. Box 1062, Boulder, Colo. 80306
1977 245P
REPORT NO: HS-802 297
CONTRACT NO: DOT-HS-6-01380; Contract
SUBFILE: HSL
AVAILABLE FROM: NTIS
Eight vehicles with a wide range of characteristics are tested in both the idle and road load test modes of Federal Motor Vehicle Safety Standard (FMVSS) 103, "Windshield Defrosting and Defogging System," for evaluation and comparison of the test modes. Four, six, and eight cylinder engine models as well as one wankel and one diesel are included. Based on data comparisons, it is concluded that the two test modes are not equivalent and that all vehicles will defrost faster in the road load test mode. The road load test mode leads to operation of some vehicles in a mode which would not be safe for highway operation. To correct these conditions, the road load test mode should be deleted from FMVSS 103 and the nominal rpm of vehicles with engines of less than 100 cubic inch displacement increased to 2000 rpm. Ambient air should be circulated to prevent overheating of catalytic converters, cooling systems, and exhaust components. Electrical systems should be checked for normal operation during testing preparation and then be allowed to operate without attempts to control blower voltage to 115% of nominal. Soak time should be reduced to a minimum of seven hours after engine "off" or until the oil sump temperature reaches +5°F. Smaller engines cool much more quickly and significant test cost savings with no decrease in test validity may be achieved by monitoring the oil temperature. Any change requiring a faster defrosting rate should take into account the fact that differential temperature through the windshield will increase rapidly as defrosting rate increases. Appendices include additional data on test procedure and equipment used. Rept. for Jun-Dec 1976.

**UNIFORM TIRE QUALITY GRADING--TREADWEAR. CITY TEST. FINAL REPORT**

Davis, K. B.; Pierce, R. N.
Southwest Res. Inst., P. O. Drawer 28510, San Antonio, Tex. 78284
1975 64P
REPORT NO: HS-801 735
CONTRACT NO: DOT-HS-5-01070; Contract
SUBFILE: HSL
AVAILABLE FROM: NTIS
The development of a practical means of establishing relative passenger tire treadwear rates is discussed. Five thousand miles of repetitive testing over 39 miles of city streets and access roads generated data for establishing tread wear-rates of radial, bias-belted, and bias construction passenger tires. Test vehicles were 1975 Chevrolet Malibu 4-door sedans loaded to between 1140 and 1154 pounds per tire (at 24 pounds per square inch pressure). Drivers were rotated after each 39 mile run and tires were rotated one position clockwise after each 156 miles and to the next car after each 625 mile test increment. The method of the tread wear-rating calculations is described. The final test route (280 turns, 480 stops, and 480 starts per 156 mile segment) was modified from the original plan which put an extreme imposition on the...
mechanical integrity of the test cars. It is concluded that: good, relatable data can be generated on a test course of the type used; the consistency of data and the good definition of the wear responses of all the tires achieved are significant in the establishment of treadwear rates; the problems encountered on urban-suburban thoroughfares need study to improve the city test; and the procedure, if provisions for brake cooling are made, may be the basis for an acceptable test method. Rept. for Apr-Jul 1975.

526698 DA
THE TRANSPORT AND ROAD RESEARCH LABORATORY QUIET HEAVY VEHICLE PROJECT
Cawthorne, A. R.; Tyler, J. W.
Transport and Road Res. Lab., Transport HS-025 991 (SAE-P-80), "Diesel Engine Noise Conf. 1979 Monograph ence Proce edings," W arrendale, Pa., 1979 p315-41 REPORT NO: SAE-790452; HS-026 019 SUBFILE: HSL AVAILABLE FROM: In HS-025 991 The Transport and Road Res. Lab. (England) Quiet Heavy Vehicle Proj. has succeeded in producing two diesel-engined research tractor units having greatly reduced external and internal noise levels. The first vehicle is based upon the Leyland Buffalo with a gross vehicle weight (GVW) limit of 32 tons and an engine of 212 bhp. The second is a Foden vehicle designed for a maximum GVW of 44 tons and fitted with a Rolls Royce engine of 350 bhp. The project has demonstrated that engine redesign can result in a reduction of noise of 5 dB(A) to 10 dB(A) within reasonable production, performance, and cost restraints. Attention to the exhaust system, cooling package, engine covers, and chassis design has resulted in a 10 dB(A) reduction in cab noise. The Foden/Rolls Royce tractor has been developed to demonstration form by Fodens. This fully engineered, practical vehicle includes a version of the ISVR research engine designed and built to produce engineering standards by Rolls-Royce, a production version of the mufflers, and the new cooling system based on the NEL mixed-flow fan. In this form, the project has the target of 80 dB(A) for external noise and at 72 dB(A) has exceeded the target for internal cab noise. The costs of production and operation are still being evaluated. Prepared for presentation at Ordinary Meeting of Automobile Div., Institution of Mechanical Engineers, Warrington, England, 15 Feb 1979.

525469 DA
MOPEDS. PT 1
Consumer's Research Magazine v62 n1 1979 Monograph p14-7, 20 REPORT ND: HS-024 906 SUBFILE: HSL AVAILABLE FROM: See publication Various legal requirements and characteristics of mopeds are reviewed with reference to specific moped models (2 American and 8 European) tested (results to be included in Pt. 2). The regulations governing mopeds vary widely: classification of the vehicle, rules of the road, standards of required equipment, minimum age of the rider, licensing, registration, insurance requirements, and limits on the machine's power and speed differ among jurisdictions in the U.S. and Canada. Mopeds such as those tested fall into two very distinct classes, the first almost literally being a motorized bicycle (as exemplified by the Velosolex and AMF models), the second, more common type, being what might be termed a small "pedalized motorcycle". An important difference between mopeds and motorcycles is that the simple moped transmissions are all automatic; in most cases, the moped has only a single, fixed gear ratio and an automatic centrifugal clutch. Most mopeds can be started either while they are stationary on a center stand with a rear wheel off the ground, or while rolling. Two kinds of seats were found on the mopeds tested: a large, horizontal, rigidly-mounted cushion extending back over the rear wheel, and a type resembling a wide bicycle seat, mounted on springs. The models tested, except for the rigid-framed AMF and Solex, had motorcycle-style suspension systems for both wheels. Components such as speedometers, brakes, pedals, and fuel controls, and accessories, such as tires and chains, are made by a limited number of specialized manufacturers. Almost exclusively, mopeds have drum brakes on both wheels, controlled via Bowden cables from hand levers. As

526665 DA
THE TRRL TRANSPORT AND ROAD RESEARCH LABORATORY QUIET HEAVY VEHICLE PROJECT
Tyler, J. W.
Proceedings of the Institution of Mechanical Engin 1979 Monograph eers v193 p137-47 (Mar 1979) REPORT NO: HS-026 276 SUBFILE: HSL AVAILABLE FROM: See publication A cooperative program sponsored by the Transport and Road Research Lab. (England), and initiated in 1971 resulted in heavy, diesel-engined tractors having considerably lower external and internal noise levels than heavy commercial trucks in current operation. Other organizations involved were Fodens Ltd., Rolls-Royce Motors Ltd., Leyland Vehicles, the Motor Industry Res. Assoc., the Inst. of Sound and Vibration Res. (ISVR) of Southampton Univ., and the National Engineering Lab (NEL). The work was directed at reducing the levels of noise from the engine, exhaust and cooling systems, tire-road surface interaction, and the transmission of noise into the cab. The TRRL Quiet Heavy Vehicle Projekt was successful in producing two research vehicles emitting external noise levels 10 dB(A) less than the original vehicles and having greatly reduced internal noise levels. The Foden/Rolls-Royce tractor has been developed to demonstration form by Fodens. This fully engineered, practical vehicle includes a version of the ISVR research engine designed and built to produce engineering standards by Rolls-Royce, a production version of the mufflers, and the new cooling system based on the NEL mixed-flow fan. In this form, the project has the target of 80 dB(A) for external noise and at 72 dB(A) has exceeded the target for internal cab noise. The costs of production and operation are still being evaluated. Prepared for presentation at Ordinary Meeting of Automobile Div., Institution of Mechanical Engineers, Warrington, England, 15 Feb 1979.
mopeds normally have no batteries, the lights and horn function only while the engine is running. Weak points of mopeds include the need for signaling by hand (most mopeds are equipped with turn signals), made more difficult in braking situations because right hand is needed to control front brake, and mirror attached to handlebar (vibration causing reduced visibility). The machines tested were based on natural cooling of engines, except Cimatti and Vespa which have cooling fans. Oil mixed with gasoline, in proportions varying from 2% to 4%, is needed for models tested. Mopeds require a good deal of maintenance. Whatever the official rules, the moped rider must, as a practical matter, behave more as a bicyclist than as a motorcyclist.

525010 DA
SPOT CAR PROBLEMS EARLY WITH A FINGERS-AND-FLASHLIGHT
INSPECTION
Lindsay, E. F.
Popular Science v124 n4 1979 Monograph p110-1, 14 6 (Apr 1979)
REPORT NO: HS-025 873
SUBFILE: HSL
AVAILABLE FROM: See publication
The automobile owner who is not a mechanic is advised to "thump, tap, shake, and tug; listen, look, and feel" in order to prevent the most common on-the-road failures: sudden cooling system blow-up; fan, alternator and power steering failures; brake line failure under sudden stress; and falling exhaust pipe. Among the warning signs are oiliness, wetness, stickiness, and rough, dent, or worn spots. Parts should not rattle or rub against something else. This type of inspection should cover both the top and the bottom of the vehicle. Among the items covered by a bottom inspection are the muffler, hydraulic brake lines, and gasoline line. Top inspection items include air cleaner and tubes, heater and radiator hoses, gas lines, wiper connections and power steering hoses. Precautions for safety are outlined (wait for engine to cool; remove ignition key; remove or cover rings and wristwatch; don't start engine with fingers or flashlight in engine compartment). Both cars and the manufacturing process will consume less fuel. The use of aluminum is expected to save much weight, but will fall short of all-aluminum bodies, since aluminum production uses more energy than steel, and aluminum is also an exhaustible commodity. High strength steel and plastics can also save weight. Better packaging of a small car will provide 12% more inside space and 18% more luggage room, accomplished by smaller engine size, smaller, more efficient radiators, space-saving suspension design, smaller fuel tanks, disposal of the spare tire, thinner, plastic molded seat back rests, and reflector mirror systems allowing luggage to be stowed up to roof level. An encapsulated engine is designed to reduce noise, but may create cooling and maintenance problems. More widespread use of the turbocharger is envisioned, especially for the diesel engine, enabling it to achieve a 70 mpg fuel consumption. Electronic ignition will be accompanied by digital idling stabilizing (DLS) electronics, LCD electronic instrument display, a multiplex board network, electronic gearshift control, and an electronic atlas (Bosch AAL system). The future of the electric car is not promising, until there is a breakthrough in batteries. In an energy crisis, synthetic fuels, alcohols, hydrogen, liquefied petroleum gas, and synthetic 'natural' gas are fuel possibilities. Better seat belts, particularly passive belts, are being developed. Volkswagen's prediction for the features of the 1988 car are summarized in a table, compared with the 1978 car.
control optimization for smaller passenger cars; effects of engine variables and exhaust gas recirculation on emissions and fuel economy (Pt. 4); unregulated emissions from a programmed combustion (PROCO) engine powered vehicle; single-cylinder PROCO engine studies; octane requirement increase (ORI) of today's vehicles (Pt. 3); influence of cooling systems on ORI; evaluation of three-way catalysts (Pt. 3); effect of air/fuel ratio modulation on conversion efficiency of three-way catalysts; 50,000 miles vehicle road test of three-way catalysts and oxides of nitrogen reduction catalyst systems; typical fuel volatility effects on driveability, emissions and fuel economy of stratified charge and conventionally powered vehicles; fuel volatility effects on driveability of vehicles equipped with current and advanced fuel management systems; and influence of fuel characteristics on vaporization in the S.I. (spark ignition) engine cylinder during cranking at low temperature. Includes HS-023 660-673.


524149 DA

A NEW GAS TURBINE FOR TRUCKS

R. E. W. Detwiler

Owner Operator v8 n5 1978 Monograph p41-5 78)

REPORT NO: HS-024 203

SUBFILE: HSL

AVAILABLE FROM: See publication

A new gas turbine engine for trucks, the GT601, is being developed by Industrial Turbines International (ITI), a consortium of Mack Trucks, Inc. and Garrett Corp., American firms, and one German company, Kloeckner-Humboldt-Deutz A.G. All have extensive backgrounds in worldwide truck engine manufacturing. The GT601 is an all-metric design that ITI refers to as a recuperated cycle free power turbine engine in the 300 kW to 560 kW (405 hp to 750 hp) shaft power class. The engine weighs 988 kg (2178 lb) and measures 1492-mm (58 3/4-in) long, 1038-mm (41-in) wide, and 1119-mm (44-in) high. All engine accessories are gear driven, and include the starter, lubrication pumps, fuel pump, governor, and an air pump which is used for starting only. Likewise, all vehicle accessories (brake air compressor, air-conditioning compressor, alternator, and power steering pump) are gear driven. Aeromechanically, the engine consists of a gas compressor section, a recuperator section, a combustor section, and a power turbine section. An electronic computer governs the engine for minimum fuel consumption. At its commercial rating of 410 kW (550 hp), the GT601 should have an overhual life of 10,000 hr in over-the-road truck use. The lack of belt-drive accessories and water-cooling system contribute to low maintenance, and there is easy access to engine components. The variable stator, variable power turbine design makes transmission requirements relatively simple. Though laboratory test-cell and in-vehicle evaluations of the GT601 have just begun, results to date look very good. In combustion tests, the GT601 produced 3.7 g/bhp-hr nitrogen oxides and hydrocarbon; the carbon monoxide content of the exhaust was 0.076 g/bhp-hr. Installed in an 80,000-lb tractor-trailer combination, the engine accelerated the loaded rig from a dead stop to road speed using only top gear of a 6-speed manual transmission. Initial fuel consumption results are in the area of 238 g/kw-hr (0.39 lb/np-hr) which is within the diesel engine range. If all goes well, production of the GT601 could begin as early as 1981.

522670 DA
TRAPPING OF LEAD PARTICULATES IN AUTOMOTIVE EXHAUST
Treuhaft, Martin B.; Wisnewski, John P.
PPG Industries, Inc., Houston Chemical Co.
1977 23p 27refs
REPORT NO: SAE-770059; HS-021 522
SUBFILE: HSL
AVAILABLE FROM: SAE

Systems for controlling automotive exhaust particulates, especially lead particulates, are discussed and a suitable method for determining automotive particulate emission levels during on-the-road vehicle operation is presented. A Particulate Performance Evaluation Filter consists of glass microfibers bonded with a stable organic resin, installed in a stainless steel housing mounted on an automobile's trunk lid and connected to the car's tail pipe by a teflon-lined flexible silicon hose. Use of this filter in on-the-road tests is thought to provide more accurate measurement of exhaust particulate levels than chassis dynamometer tests, since underbody cooling of vehicles on the road lowers the temperature affecting lead particulate emission. Data are presented for a large number of vehicles. The evaluation system is suited for use with a large variety of vehicles during all modes of vehicle operation. A total emissions control system, capable of meeting the strict 1978 statutory gaseous emissions levels with virtually zero particulate emissions, is also discussed. This emissions control system is compatible with leaded and unleaded fuels. The economic implications of lead additive restriction, as a means of reducing lead airborne particulates, are briefly considered. The reduction of airborne lead, by trapping it in the exhaust system, is more cost effective and energy conservative than is reduction by regulation of the fuel supply. Particulate traps coupled with lead-tolerant emission control systems allow this alternative. Engine noise can also be controlled and emission levels of other particulates can be reduced. The Particulate Evaluation Filter provides an easy and effective method for measuring exhaust particulates in all modes of vehicle operation. Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.

National Res. Council Canada, Engine Lab., Ottawa, Ont. 1977 28p 4refs
REPORT NO: DME/NAE-1977(3); HS-022 014
SUBFILE: HSL
AVAILABLE FROM: Corporate author

Datum road tests and preliminary wind-tunnel testing were conducted on a 1976 Ford Granada as the test vehicle in the 3m x 6m Propulsion Wind Tunnel of the Div. of Mechanical Engineering, National Res. Council of Canada. The wind tunnel section was of the closed type and was provided with an elevated ground plane on which the test vehicle was placed. It was found that the centerline air speed averaged over the distance equal to hood height minus ground clearance is 88% of the maximum speed of the test vehicle. The air speeds below the front bumper were lower than at one meter ahead of the test vehicle. The static pressures underneath the engine bay were very close to pressures inside the engine bay and slightly positive relative to ambient. Coolant system resistance had to be held constant to achieve stable radiator temperatures.Cooling air flows, fan thrust, and torque appear to show dependence on temperature and ram air speed. The temperature dependence apparently cannot be accounted for by density changes alone. The combination of the test vehicle and the ground board structure did not produce turbulence disturbances in the wind tunnel flow. The blockage effects due to the vehicle and ground board structure in the wind tunnel are significant and dependent on vehicle position on the ground board relative to the ground board's leading edge. The air speeds underneath the vehicle without its catchment pan tended to exceed those observed during road tests. The engine bay pressure was correspondingly low, but still positive. The cooling air catchment duct caused a local blockage effect that reduced the maximum velocity overshoot underneath the front bumper observed for the clean vehicle configuration. Use of slot suction just upstream of the catchment pan facilitated adjusting this velocity maximum to match road test data. Representative distributions of cooling air flow behind the radiator can be produced in the wind tunnel provided that the correct engine bay pressure and velocity maximum in the profile below the front bumper are generated. Prepared in cooperation with Canadian Fram Ltd., Ontario Ministry of Transport and Communication, Canadian Ministry of Transport, and Township of Gloucester.

521830 DA
SO YOU WANT A MOTORCYCLE
Huntington, Roger
Consumers' Research Magazine v60 n3 1977 Monograph p12-5
REPORT NO: HS-020 351
SUBFILE: HSL
AVAILABLE FROM: See publication

When preparing to buy a motorcycle, assume that it will be for recreational use. There is the choice to be made whether to buy a street bike (designed strictly for street and highway use).
riding) or a dual-purpose or "enduro" bike (designed for off-road and on-road use). If you don't plan to do a lot of off-road riding, then a street bike only should be looked at. The factor of engine size is one of the most important choices to be made in selecting a motorcycle, and the range in size is from 125 cc to 1200 cc. The most popular street and enduro bikes fall in the range of 200 to 400 cc's. Engine size should correlate with the weight of the bike. Important factors include comfort of seating, the controls with easy motions, holding the bike upright when standing still, maneuvering it around for parking. Also, in relation to the size, is the question of the horsepower-to-weight ratio. There is not a direct ratio (weight doesn't double when cc's are doubled). Beginning riders should lean towards bikes under 250 cc's. Also, there is the choice between two-stroke (engine fires once for every revolution) and four-stroke (combustion in each cylinder every other revolution of the crankshaft) engines. Two-stroke engines are smaller and lighter in relation to their power, less expensive, and are better for off-road dirt riding, but they also use more gas and are harder on spark plugs. Also, this type doesn't carry its oil supply inside the engine crankcase, and the oil must be mixed with the gasoline which tends to make the engine wear out faster than a four-stroke engine. That circulates its oil by pump. Many smaller, less expensive bikes have two-stroke engines; the medium and larger bikes come in two-stroke and four-stroke models. The location of driving controls on motorcycles is pretty much standardized by tradition and by law. It is recommended that a driver do his learning on an off-road trail. Motorcycles are not "safe" in the same sense as a car, but chances of survival are infinitely improved if you practice sharp defensive driving and stay alert at all times. Motorcycles are much more sensitive to proper maintenance than passenger cars. Operating cost of motorcycles is pretty low; however, insurance may run 50-100% higher than that for a family car. Accessories and options are not installed at the factory and must be bought through a dealer. Major new design trends in motorcycles include multicylinder engines (3, 4, and 6 cylinders), liquid cooling, and automatic transmissions and are bound to filter down quickly to the medium-priced lines.

TRUCK NOISE R -- NOISE REDUCTION STUDY OF AN IN-SERVICE DIESEL-POWERED TRUCK. VOL. 1: TEXT. FINAL REPORT

Lemann, W. Guy
Department of Transportation, Transportation Systems Center
Kendall Square, Cam
1977

REPORT NO: DOT-TSC-OST-76-3, I; HS-020 500
CONTRACT NO: DOT-TSC-T76-4; Contract
SUBFILE: HSL

AVAILABLE FROM: NTIS

A series of tests were used to select retrofittable components which could be applied to reduce the total vehicle noise. The original truck's A-weighted sound level during controlled acceleration tests (SAE J-366) was 90 dBA; The comparable contributions of the systems were 87 dBA for the engine, 84 dBA for the exhaust system, 76 dBA for the cooling system and 72 dBA for the induction system. The interior cab noise was 94 dBA. A quieted truck test configuration had a sound level of 82 dBA on the left and 81 dBA on the right, with the fan disengaged. This configuration was not commercially feasible or usable on the road. The final operational retrofitted configuration had a J-366 sound level of 87 dBA. The interior cab noise was 92 dBA. The final truck had the original induction system, a new intake manifold muffler, a clutched fan drive and engine covers. All of the retrofitted components are commercially available and in stock. The total cost of all three changes is between $1000 and $1445 for a 3 dBA noise reduction. A 2 dBA noise reduction could be attained with engine covers only at a cost of from $70 to $770. Subcontracted to McDonnell Douglas Astronautics Co., 5301 Bolsa Ave., Huntington Beach, Calif. 92647. Rept. for Mar 1974-Apr 1975. Vol. 2 (Appendix) is HS-020 499.

TEST TECHNOLOGY APPLIED TO COMMERCIAL VEHICLES

Morgan, B.; Taylor, D. J.; Salmon, P. R.
Consame Dynamics Ltd., Chesterfield, England
HS-020 949, "ISATA 76. Proceedings of an Internat 1976 Monograph with Final Symposium on Automotive Technology and Autom
REPORT NO: HS-020 955
SUBFILE: HSL

AVAILABLE FROM: In HS-020 949

Test technology, an automotive testing process developed by Consame Dynamics Ltd., is applied to brake and cooling systems, electric vehicle transmissions, and general performance for commercial vehicles. A 6,000 HP inertia brake dynamometer is used in development of a braking system for high speed trains. The test rig consists of a tail stock type test center using two banks of flywheels. A chassis dynamometer, incorporating flywheel masses, is used to test brakes for quality audit purposes within a completed vehicle. A test rig for commercial vehicle transmissions accommodates systems up to 450 HP with maximum input speeds of 6,000 rpm. Interchangeable transducers are used to facilitate testing of the complete range of units. Testing of transmission components within a high output environment is accomplished by an axle test facility which evaluates each axle for noise generated by components. Electrical transmission systems are evaluated by two test units: high torque/low-speed machines (maximum speed 2,500 rpm) and higher speed machines (maximum speed 5,000 rpm). DC electrical dynamometers are used to test test truck engines. Those such dynamometers, light-weight and low-cost, are a perforated disc type. Chassis dynamometers are ideal for simulations of actual road conditions for completed (cont. next page)
vehicles, and vary in configuration depending on type of vehicle being tested. Power is absorbed on the testing unit by a liquid cooled eddy-current device. Torque speed and horsepower are measured. Chassis dynamometers are also used by commercial vehicle manufacturers for end of line quality audit purposes. Side restraint facilities are incorporated on all chassis dynamometers. Test capabilities include smoke, brake, tractive effort, third differential, and electrical testing. Symposium held in Rome, Italy, 27 Sep-1 Oct 1976.

521219 DA

EXPERIENCES WITH AN AUTOMATED CHASSIS DYNAMOMETER TEST SYSTEM

Johnsson, Leif
AB Volvo Car Div.
HS-020 949, "ISATA" 76. Proceedings of an Internat 1976 Monograph on Automotive Technology and Autom
REPORT NO: HS-020 963
SUBFILE: HSL
AVAILABLE FROM: In HS-020 949

A test facility designed by Volvo consists of six chassis dynamometers for mileage accumulation of exhaust emission test vehicles and required human supervision for only 40 hours a week. The test facility is of a straightforward electrical and mechanical design using a System 330 MC computer for control and measuring. A single pair of chassis rolls, including a pivoted axle with differential, is mounted on a concrete foundation. Inertia simulation is mechanical. Due to high speed of the propeller shaft and basic road load created by the fan, a small air-cooled eddy-current brake is used. Transducers and monitoring equipment are used for safety purposes. Transducers are installed on each dynamometer to monitor engine speed, inlet manifold pressure, oil pressure, temperature, and water level in the cooling system. All vehicles are equipped with flame detectors in the engine compartment. A tooth wheel on the propeller shaft and an inductive transducer are used to measure distance, speed, and acceleration. A straingauge transducer monitors vehicle torque. Electric servomotors are used for throttle and clutch control. The gear shifter is operated pneumatically and controlled by the computer. The test routine takes about one hour to set up. The control system permits exactly the same installation time. Attended operation is possible with a high safety factor. Symposium held in Rome, Italy, 27 Sep-1 Oct 1976.

521211 DA

AN ENDURANCE TEST WITH TWO VOLKSWAGEN GOLF THROUGH TWO CONTINENTS FROM ALASKA TO FIRELAND (TIERRA DEL FUEGO)

Peschke, Wolfgang; Farber, Peter

Volkswagenwerk AG, Passenger Car Div.
HS-020 949, "ISATA" 76. Proceedings of an Internat 1976 Monograph on Automotive Technology and Autom
REPORT NO: HS-020 971
SUBFILE: HSL
AVAILABLE FROM: In HS-020 949

Volkswagen GOLFs have been run on the Pan American Highway from Alaska to Fireland (Tierra del Fuego). This route covers almost every kind of climate, road type, and traffic. The GOLF design concept is diametrically opposed to the Beetle in its front engine, water cooling, four doors, and tailgate and variable luggage space. During the Alaskan section of the trip, the GOLF proved equal to temperatures as low as -20°C and were adequately protected from large quantities of dirt and mud. Covering long distances at low constant speeds indicated the importance of good seat design, seating positions, good ventilation, absence of vibration and noise, and precise straight-line running. The standard GOLF model can withstand rough-road duty, although a soft and smooth, so a very rough-road version is recommended in such terrains. The cooling system withstands temperatures up to 40°C in full sunlight, registering temperatures of over 100°F on several parts of the interior trim. Importance of attention to cooling system for engine cooling when traveling through high altitudes was evidenced in Mexico City. Driving in Central and South America requires vehicle capability for maneuvering ashly, granular road. Passage through streams requires a high-positioned and protected distributor. In parts of South America the electric fan for engine cooling worked constantly, but the temperature gauge did not reach the highest mark. At altitudes above 5000 m only half the engine's normal power output was being developed. The GOLF sustained extensive damage to its undersides without detrimental effects on running capability. Conclusions indicate that vehicles in rough southern hemisphere territory must be very strongly built and absolutely reliable; equipped with a large displacement engine; have the same ground clearance as a truck; and have user benefit value similar to that of a truck. Vehicles must be capable of running on grades of fuel down to the 70-octane level; should avoid large glass areas or highly painted windows; be equipped with front-door vent windows for ventilation; and be provided with carefully constructed seats for comfort on rough terrain. Vehicle design and marketing should account for the fact that agrarian economies tend to favor trucks for transport of people and goods. Further, vehicle styling is more important that usually supposed for sales in under-developed countries. Symposium held in Rome, Italy, 27 Sep-1 Oct 1976.
CONCLUDING ENGINE COOLING WITH HEAT-DRIVEN AIR CONDITIONING TO IMPROVE AUTOMOTIVE FUEL ECONOMY

Lowi, Alvin, Jr.; Balasubramaniam, Mani; Schrenk, George L.


REPORT NO: HS-021 253

SUBFILE: HSL

AVAILABLE FROM: In HS-021 234

Conventional automotive air conditioning equipment, with its highly excited belt-driven reciprocating compressor, is examined for its penalties to fuel economy, which arise from both fixed weight contributions to road load as well as parasitic shaft load. Penalties in fuel consumption due to equippage and usage have been found to run as high as 20% under adverse weather and driving conditions with average annual fuel penalties of about 6% in the equipped automotive population as a whole. The A/C equippage rate of new automobiles sold in the U.S. is currently exceeding 75% and is projected to reach 95% by 1980. The Rankine bottoming cycle approach is an alternative: an organic fluid engine cooling system combined with a novel jet-vapor-compression automotive air conditioning system. The weight reducing waste heat driven Rankine ejector bottoming cycle system, tested on 1973 model year cars, shows that over 70% of fuel consumption due to use of a conventional air conditioner can be saved without attempting to capitalize on all of the weight/economy potential available. Although use of chlorinated hydrocarbons in the alternative system might be a drawback to its general acceptability, their environmental impact is not measured well enough to limit their use at the present time. Presented at the Symposium, Washington, D.C., 17-22 Apr 1977.


AB Svensk Bilprovning, Fack, S-162 10 Vaellby Sweden 1976 145p

REPORT NO: HS-020 290

SUBFILE: HSL

AVAILABLE FROM: Corporate author

A review of statistical data obtained from the annual compulsory inspection of motor vehicles and trailers for 1976 performed by AB Svensk Bilprovning, the Swedish Motor Vehicle Inspection Company, is presented in tabular form. This periodic inspection is a technical examination of the vehicle, with the purpose of checking its traffic safety standard, and applies to all registered motor vehicles and trailers which are two years old or older. The technical examination is performed according to a special inspection program in which inspection methods for the different components are specified. Defects observed are assessed in accordance with standards laid down by the National Swedish Road Safety Office. The results of these analyses are presented mainly in the form of relative observation frequencies (percentages) for different component systems and subsystems and for different kinds of vehicles. High observation frequencies have been considered to indicate "weak points" in vehicles in general as well as in particular kinds of vehicles and vehicle makes/types. This review of observation frequencies obviously does not constitute a basis for a complete assessment of the quality and durability of different cars, nor can it be used for an analysis of all their advantages and disadvantages. However, as far as faults that have an influence on the traffic safety are concerned, the review draws the attention to components that should be watched. This year the review of the "weak points of cars" is based on a new inspection report form which has enabled the "defect pattern" of the vehicles to be presented in a more systematic manner. Also, it has made possible information more detailed than previously. The form lists the following systems (and subsystems): structure (side member, cross member, floor); wheel system (tire, wheel balance, wheel bearing, swivel joint, wishbone pivot, spring, shock absorber); propulsion (engine mechanical parts, engine cylinder balance, fuel system, exhaust system, CO-content/smoke density, starter system, cooling system, electronic fuel system, transmission); brakes (service brake (front, rear, and travel reserve), brake tube, brake hose, and parking brake (efficiency and travel reserve)); steering (steering joint, steering gear); body (door, wing, windshield, seat belt, load compartment); communication (windshield wiper, windshield washer, rear-view mirror); light (headlamp (aiming, light distribution, reflector, lens, cleaned), parking light, taillight, license plate light, stop light, reflector, directional signal, horn); instrumentation (speedometer, oil pressure indicator); other items including trailer coupling. In addition to the 1976 inspection data, a separate account of the faults of cars of the model years 1970, 1972, and 1974 is presented; another section deals with passenger cars of the 1975 model year.

COOLING ANALYSIS OF DISC BRAKE ROTORS

Limpert, Rudolf

University of Utah, Mechanical Engineering Dept.

1975 8p 5refs

REPORT NO: SAE-751014; HS-018 766

SUBFILE: HSL

AVAILABLE FROM: SAE

Equations for determining the convective heat transfer coefficients of solid and ventilated disc brakes are presented. Analysis of data indicates that the cooling capacity of a ventilated rotor is sharply reduced at lower speeds, and most cooling is provided by the increased surface area. A general relationship derived from road test data (heating the brakes to about 700°F) and measuring the subsequent cooling at constant vehicle speeds ranging from 10
to 50 mph is presented that yields the heat transfer coefficients for both disc and drum brakes of commercial vehicles. Presented at the Truck Meeting, Philadelphia, Pa., 10-13 Nov 1975.

The ROVAC Automotive Air Conditioning System
Edwards, Thomas C.
Rovac Corp.
1975 11p 3refs
REPORT NO: SAE-750403; HS-017 783
SUBFILE: HSL
AVAILABLE FROM: SAE

A new automotive air conditioning system (the ROVAC system), a combination rotary compressor/expander unit that employs air as the refrigerant, is described. Prototype modeling, design, fabrication, laboratory testing, and field testing in a full size four door 1973 Dodge Coronet are presented. Schematics of the ROVAC system are provided. It was found that the prototype system installed in the Coronet produced delivered cooling capacity on the order of one to one and a half tons per thousand rpm's and delivered coefficients of performance at relatively high humidity levels (150-180 grains of water per pound of dry air) rivaling the best developed conventional vapor compression air conditioning systems. During actual in-car jury tests, the prototype ROVAC air conditioning system brought the average passenger compartment temperature from a thermally soaked condition of 107 F down to 72 F in less than two minutes with five passengers at an average road speed of 30 mph. Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

The Effect of Selected Coolants on Metal Temperatures in a Rotary Engine
Paul, G. A.
Dow Chemical Co., Ag-Organics Dept.
1975 13p 495
REPORT NO: HS-016 495
SUBFILE: HSL
AVAILABLE FROM: SAE

The metal temperatures of many points of the rotary engine with standard and experimental coolants were studied in an attempt to develop a product with superior heat rejection properties in a conventional cooling system. The engine used was a two-rotor liquid-cooled Wankel engine from a 1972 Mazda R-100. Both road and chassis dynamometer evaluations were run over a wide range of operating conditions to obtain a comprehensive look at coolant performance. The parameters studied for each coolant were road speed, engine load, coolant concentration, and ambient temperature; the coolants tested were ethylene glycol, water, and the experimental coolants XA-1318L and XA-1318.1L. Pure water was found to produce the lowest rotor housing metal temperatures under mild conditions of the four fluids tested; ethylene glycol produced metal housing temperatures above acceptable levels under severe test conditions. Both experimental coolants reduced peak rotor housing metal temperatures compared to ethylene glycol, although XA-1318L was slightly inferior. Under more severe test conditions, the two experimental brands were the most effective in reducing metal housing temperatures. It was concluded that XA-1318L or XA-1318.1L would be satisfactory coolants in a rotary engine. Presented at the Automobile Engineering Meeting, Toronto, Canada, 21-25 Oct 1974.

Review of Truck and Bus Design in Relation to Road Safety (in Australia)
Joubert, P. N.
University of Melbourne, Dept. of Mechanical Engineering, Melbourne, Australia
1973 134p 64refs
REPORT NO: HS-017 093
SUBFILE: HSL

The special problems involved in truck accidents are surveyed and recommendations are made for design changes to help reduce the accidents involving trucks and the consequences of such accidents (1500 to 2000 school bus, 'accident'), and school buses, are considered separately and again, important design changes are recommended. Truck and bus accident statistics for Australia (Victoria, New South Wales, and Queensland), England and the United States are reported. Truck body design changes emphasizing yielding, two spoke and drum brakes of commercial vehicles which provide safe decelerations at the same level as cars under all conditions of loading; the proper securing of loads should be treated as an operational problem; parking brake operation should be simplified and design should allow for any effects due to brake cooling; tires are discussed. The following conclusions from a review of present research are presented: more information based on Australian data is required; brakes are required on commercial vehicles which provide safe decelerations at the same level as cars under all conditions of loading; the proper securing of loads should be treated as an operational problem; parking brake operation should be simplified and design should allow for any effects due to brake cooling; brakes are required on commercial vehicles which provide safe decelerations at the same level as cars under all conditions of loading; the proper securing of loads should be treated as an operational problem; parking brake operation should be simplified and design should allow for any effects due to brake cooling; there should be no increase in truck width or height without proper study of aerodynamic effects; design criteria for best handling need to be established; very heavy, articulated trucks need springs of variable stiffness to counter roll resonance; the special characteristics required for commercial tires should be determined; consideration should be given, after study, to the banning of retreaded tires for commercial vehicles; tread depth standards for truck tires are needed; and safety rims should be used on all truck wheels. Changes in the design of truck bodies are considered in terms of anthropometry and

(cot. next page)
driver capabilities, vision, road spray and driver fatigue. It is suggested that the following be studied or implemented in Australia: present cabin layout improvements; a forward field of view standard for trucks; rear lighting and turn signal improvement; headlight improvement; mudflaps; noise standards for inside the cabs; and improvement of heating, ventilation and vibration insulation to reduce driver fatigue. It is also suggested that studies be made of both acceleration and evacuation facilities, and the necessary regulatory standards. In addition, brief consideration of the new steam engines can burn practically any fuel, and never need a starting motor, carburetor, cooling system, complex ignition wiring, muffler, or smog control devices. Some of the new steam engines can burn practically any fuel, and never need tuning.

DESCRIPTORS: AUSTRALIA; ENGINE DESIGN; ENGINE PERFORMANCE; EMISSION CONTROL; FUEL CONSUMPTION; FUEL ECONOMY; PROTOTYPES, RANKINE CYCLE ENGINES; STANLEY STEAMERS; STEAM ENGINES; UNITED STATES

515288 DA
THE NEW RAMBLER SIX ENGINE--TORQUE COMMAND 232
Leydorff, Jr., G. F.; Potter, D. V.; Lawler, R. L.
American Motors Corp., Detroit
1964 15p
REPORT NO: SAE-884B: HS-015 777
SUBFILE: HSL
AVAILABLE FROM: SAE

The design approach and development program which produced the new engine meeting all the desired criteria is described, as subsequently proved in a two million-mile test program under varying conditions. The concept was to provide an engine which would approach the driving feel of a moderate displacement V-8, with the operating economy and cost savings of a six. By judicious choice of basic engine parameters and by designing to take advantage of the most modern fabrication techniques, the price paid to meet the higher standards was kept minimal and the weight target was met. Descriptions are given of the induction system, valve train, cylinder head, piston, connecting rod, crankshaft and bearings, cylinder block, flywheel, lubrication and cooling systems, crankcase ventilation, engine performance, manifolds, heat valve, vibration problems, and photostress analysis. General specifications are included. Presented at the SAE Summer Meeting, Chicago, 8-12 Jun 1964.

DESCRIPTORS: COOLING SYSTEM DESIGN; COST MINIMIZATION; CRANKCASE VENTILATION SYSTEMS; CYLINDER HEADS; DISPLACEMENT; ECONOMIC FACTORS; ENGINE BLOCKS; ENGINE DESIGN; ENGINE PERFORMANCE; ENGINE SIZE; FLYWHEELS; INDUCTION MOTORS; LUBRICATION SYSTEMS; MANIFOLDS; PARAMETERS; PISTONS; ROAD TESTS; STRESS ANALYSIS; TORQUE; V-8 ENGINES; VALVE TRAIN NOISE; VEHICLE HANDLING; VEHICLE RIDING QUALITIES; VEHICLE WEIGHT; VIBRATION RESPONSE

515206 DA
NOISE CONTROL HANDBOOK FOR DIESEL-POWERED VEHICLES. INTERIM REPORT
Damkevala, R. J.; Manning, J. E.; Lyon, R. H.
Cambridge Collaborative, Inc., 238 Main St.,
1974 214p
REPORT NO: HS-015 859
CONTRACT NO: DOT-TSC-5B7; Contract
SUBFILE: HSL
AVAILABLE FROM: NTIS

A handbook to assist the truck fleet operator and the independent truck owner operator in understanding and diagnosing noise problems and in selecting retrofittable components to lower truck exterior and interior noise levels is presented. The handbook includes procedures for identifying acoustic materials, procedures for minimizing exhaust, intake and cooling fan noise, and methods for the minimization of in-cab noise levels. Appendices cover standard noise measurement procedures, muffler and intake filter selection data, cooling system design considerations, and a list of known manufacturers of acoustic materials. Rept. for Oct 1972-Mar 1974 on "Engineering data services on over the road vehicle acoustics and vibration."
The Oshkosh transmission design consists of a two-speed splitter auxiliary attached to the four-speed main drop box to provide a transmission with eight forward and two reverse speeds. Omitting the auxiliary provides a transmission with four forward speeds and one reverse speed. The eight-speed transmission is capable of use with high speed, low torque engines, or with low speed, high torque engines by changing the input ratio gears. The overall ratio of the transmissions may be changed to match tire size and/or axle ratios. The ratio changes for engine speed-torque and/or overall ratio may be made without affecting the transmission range or physical configurations. Bearing, gear, clutch pack, all wheel drive, shafts, and oil supply design, and cooling requirements and component selection are discussed. Simulation and road tests were performed, and application of powermatic transmissions to construction, rescue, and snow removal vehicles is described. Presents National Commercial Vehicle Engineering and Operations Meeting, Fort Wayne, 9-12 Oct 1972.

511959 DA
INERTIA DYNAMOMETER EVALUATION OF BRAKE LINING MATERIALS
Preston, J. D.
National Hwy. Traf. Safety Administration
1973 10p
REPORT NO: HS-013 049
AVAILABLE FROM: SAE

Brake lining performance as depicted by small friction machines does not reflect the performance obtained during vehicle brake tests. This paper shows that an inertia dynamometer using full-scale vehicle brake hardware can be programmed to simulate vehicle test conditions and produce brake performance data corresponding to vehicle test data. Methods for determining the dynamometer flywheel inertia and brake cooling airflow are discussed. Presented at International Automotive Engineering Congress, Detroit, 8-12 Jan 1973.

511946 DA
THE NEW CHRYSLER WIND TUNNEL
Lanktree, H. E.; Lindsay, J. P.
Chrysler Corp.
1973 8p 5refs
REPORT NO: SAE-730239; HS-013 062
AVAILABLE FROM: SAE

The Chrysler wind tunnel is a closed-circuit, single-return, semiopen jet facility used for performing engine cooling, transmission cooling, engine compartment airflow, underhood component temperature, air-conditioning, and other types of tests. It operates over a 0-120 mph speed range with 400 hp rear-wheel power absorption capacity. Special provisions have been made for idle, city traffic, and tail wind tests. Facility controls provide precise setting capability, and comprehensive instrumentation and data acquisition systems permit measurement of many parameters and real time data reduction. Presented at International Automotive Engineering Congress, Detroit, 8-12 Jan 1973.
HYDROGEN AND OXYGEN COMBUSTION FOR POLLUTION FREE OPERATION OF EXISTING STANDARD AUTOMOTIVE ENGINES

Dieges, Paul; Underwood, Patrick
Perris Smogless Automobile Assoc.
REPORT NO: SAE-719046; HS-011 682
SUBFILE: SAE
AVAILABLE FROM: In HS-011 703
Road tests have been made using gaseous and cryogenically stored propellants with data based on the gaseous test showing promise that the system can be technologically and economically sound as a solution to the exhaust pollution problem. Tests using a very rich hydrogen to oxygen mixture ratio to eliminate combustion knock and crankcase explosions, and a re-circulation system to recover unburned fuel from condensed exhaust water for reuse in the cycle are described. Changes to the Otto cycle engine were made to the fuel induction, exhaust, and cooling systems. Utilization of waste exhaust heat to vaporize the exhaust water improves the thermodynamic performance of the system. Presented at the conference held in Boston, 3-5 Aug 1971.

LUBRICANT STUDIES IN ROTARY-COMBUSTION ENGINES

Rogers, T. W.; Lemke, W.; Lefevre, J.; Ohzawa, T.
Mobil Res. and Devel. Corp. Mobile Oil A.G. (West Germany)
Mobile Oil Fransaise
1972 14p 15r
REPORT NO: HS-012 000
SUBFILE: SAE
AVAILABLE FROM: SAE
A Discussion of the rotary-combustion engine's history, operation, and lubrication illustrates the role of various quality level engine oils in providing the necessary functions of engine seal wear protection, bearing lubrication, rotor cooling, and overall combustion chamber area cleanliness. Specific examples of current quality and experimental type engine oil influence on overall engine durability, including seal and housing surface wear, are cited for various engine designs. Data evaluating lube oil effects on engine cleanliness and oil consumption characteristics are also discussed. Analysis of used oil from a number of test engines is presented showing the rotary-combustion engine to yield oil deterioration typical of current piston engines. Presented at National Automobile Engineering Meeting, Detroit, 22-26 May 1972.

DESIGNATORS: AIR COOLED ENGINES; APEX SEALS; ENGINE OPERATING CONDITIONS; ENGINE TESTS; ENGINE WEAR; LABORATORY TESTS; LUBRICATING OIL TESTS; LUBRICATING OILS; LUBRICATION SYSTEMS; OIL SEALS; ROAD TESTS; ROTARY PISTON ENGINES; WANKEL ENGINES; WATER COOLED ENGINES; WEAR TESTS

PROBLEMS OF GROUND SIMULATION IN AUTOMOTIVE AERODYNAMICS

Beauvais, FN; Fignor, SC
Ford Motor Co.
1972 14p 15r
REPORT NO: HS-001 817
SUBFILE: SAE
Studies using fixed and moving ground planes are discussed and influential of model bottom detail, cooling system air flow, and ground clearance are evaluated. Ford Motor Company, Dearborn, Michigan in cooperation with Bureau of Public Roads, Washington, D.C.

DESIGNATORS: AERODYNAMICS; GROUND CLEARANCES; ROAD SIMULATORS; VEHICLE ROAD INTERFACE

ASH IS CASH: FLY ASH APPLICATIONS

Bacher, Jr.
Public Works Journal Corporation
Public Works Vol. 120 No. 9 Aug 1990 pp 44-45 1 Fig. 1 Phot.
SUBFILE: HRIS
AVAILABLE FROM: Public Works Journal Corporation 200 South Broad Street Ridgewood New Jersey 07451
This article describes three projects in which fly ash from the Delmarva Power and Light Company, Wilmington, Delaware, was utilized. In project ASHRAMP, nearly 10,000 tons of fly ash were used as embankment material in two of six new interchange ramps connecting Interstate 495 with Edge Moore Road and Governor Printz Boulevard. Data from this project confirmed that fly ash is an environmentally and technically acceptable alternative to natural soil when used in an unstabilized form on highway applications. Project ASHREEF involved the construction of an artificial ocean reef from cement or lime stabilized coal ash. Studies verified that...
stabilized ash blocks were acceptable both structurally and environmentally in marine applications. The project further demonstrated that marine organisms would not only survive, but thrive on the ash mixtures. Flowable, cement-stabilized ash mixtures were used on project ASHFILL to backfill excavated areas and as a structural base material in the construction of a cooling tower. Its versatility in meeting job-specific requirements resulted in significant time and construction material cost savings. Flowable fly ash has also been used to repair an undermined bridge approach following a "100 year" storm and to successfully backfill voids submerged in water.

DESCRIPTORS: APPLICATIONS; ARTIFICIAL OCEAN REEFS; BACKFILLS; BRIDGE APPROACHES; COST EFFECTIVENESS; EMBANKMENTS; ENVIRONMENTAL IMPACT; FLOWABLE FLY ASH; FLY ASH; GENERAL MATERIALS

493749 DA
BON VOYAGE UNDER THE SEA
Benard, A; Morton, A
Reed Business Publishing Limited
Photo.
SUBFILE: HRIS; RRIS
AVAILABLE FROM: Reed Business Publishing Limited Quadrant Subscription Serv, Oakfield House, Perrymount Rd Haywards Heath Sussex RH16 3DH England

An overall look at the Eurotunnel which is scheduled for completion on June 15, 1993 is given under the following titles: Anatomy of a Channel Tunnel, p 261; Safe Havens Cut Fire Risk-Safety, p 265; Where Road Meets Rail-Terminals, pp 268-269; Rolling Highway Below the Waves-Shuttles and Track, pp 273-276; Central Nervous System-Control, p 281; Sinews of Power-Catenary, p 285; Fresh Air in Demand-Cooling the Running Tunnels at Drainage, pp 288-289; and Maintenance Keeps Wheels Turning, p 293.

DESCRIPTORS: CATERORIES; CHANNEL TUNNEL; COMMUNICATIONS; FACILITIES DESIGN; FIRES; FREIGHT TRANSPORTATION; HIGHWAY TRANSPORTATION; PASSENGER TRANSPORTATION; PLANNING, RAIL TRANSPORTATION; RAILROAD TRACK; SAFETY; SHUTTLE SERVICE; TERMINALS, TRANSPORTATION; TUNNEL CONSTRUCTION; TUNNEL DESIGN

489329 PR
PERMAFROST CONTROL FEATURES
INVESTIGATORS: Esch, D
SPONSORING ORG: Alaska Department of Transp and Public Facilities; Federal Highway Administration
PERFORMING ORG: Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701
CONTRACT NO: AK-88-06-HPR
PROJECT START DATE: ND
PROJECT TERMINATION DATE: 9009
SUBFILE: HRIS

The objective of this study is to monitor existing road sections with experimental permafrost control features. The study will evaluate the long term benefits of insulated embankments, air-cooling ducts, thermal syphons, and snow sheds in controlling permafrost-thaw-related roadway distress.

DESCRIPTORS: AIR COOLING; CONTROL; DUCTS; EMBANKMENTS; FOUNDATIONS (SOILS); INSULATION; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT SUBGRADES; PERMAFROST; RESEARCH PROJECT THAWING

487823 DA
LIQUEFIED AIR IN OVERLONG TUNNELS ---PAPERS PRESENTED AT THE 8TH INTERNATIONAL SYMPOSIUM ON THE AERODYNAMICS AND VENTILATION OF VEHICLE TUNNELS, DURHAM, 27-29 SEPT 1988
Meekings, K; Marsieh, W
SUBFILE: HRIS; RRIS; IRRD
This article describes the layout and design of the planned undersea japan-korea tunnel, which will incorporate both a railway and a road. The proposed system to use liquid air for cooling both parts of the tunnel are also described briefly. The moisture, and air pollutants, such as carbon monoxide and the possibility of the concrete infrastructure cracking if any of the liquid air is accidentally spilt on it. For the covering abstract of the conference see IRRD 819827.

DESCRIPTORS: AIR; CONFERENCE; COOLING (MATER); DESIGN (OVERALL DESIGN); LAYOUT; LIQUID; NITROGEN; TUNNEL; VENTILATION

482057 DA
Daines, ME
EUROBITUME BD EMILE BOCKSTEAU 35! Bruxelles Belgique 1985 236-42 FRANCAIS
SUBFILE: HRIS; RRIS; IRRD
The life of a hot-laid bituminous material may be reduced considerably by inadequate compaction, and this is frequently the result when material is too cold to be compacted satisfactorily. A computer program developed at TRRL has been modified to study the effect of laid thickness for a range of wind speeds and air temperatures and for initial laying temperatures of 160 deg and 150 deg c and cooling curves were obtained experimentally for initial temperatures ranging from 180 deg to 100 deg c. The effect of extended periods of solar (cont. next page)
radiation was also investigated. The results predicted by the modified computer program were verified experimentally, both in the laboratory tests and on two experimental road sites, where asphalts were laid 35 mm and 50 mm thick; very good agreement was obtained in the laboratory tests and in general, agreement with the measurements from road sites was good when allowance was made for the effects of local sheltering. The strong dependency of cooling time on the thickness of an asphalt layer was also demonstrated. The program demonstrated that the effect of initial laying and final temperature of a bituminous layer on the time taken for it to cool approaches to a log-linear relationship. Also it was found that the cooling time is proportional to the laid thickness to the power 1.8 for any set of environmental conditions. Thus doubling the laid thickness increases the cooling time by a factor of 2-1.8 = 3.5 times. Alternatively a 50 per cent increase in cooling time is provided by an increase of only 25 per cent in laid thickness. Using the described relationships, supplemented by experimental data, a set of tables has been devised to estimate the compaction time available from a knowledge of laying and environmental conditions. The compaction time is given by the product of three factors relating to environment, initial laying and minimum compaction temperatures, and laid thickness. A fourth optional factor to correct for the cumulative effect of solar radiation is also included. The tables may be used at the planning stage in order to predict the likely compaction time of various construction options making use of meteorological office data. The implications of these results with regard to the compaction of three types of rolled asphalt and the laid thicknesses required to achieve reasonable compaction times are discussed. (a) For the covering abstract of the symposium see IRRD 815173.

DESCRIPTORS: BITUMINOUS MIXTURE; COMPACTION; CONFERENCE; COOLING (WATER); HOT COATED MATERIAL; LAYER; LAYING; PROGRAM (COMPUTER); ROLLED ASPHALT; SUN; TEMPERATURE; THICKNESS; TIME

480355 DA
BS 594 - A USER'S VIEW
Hunter, RN
D.R. Publications Limited
Highways VOL. 56 NO. 3 1988 pp 9-10 7 Ref.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: D.R. Publications Limited Faversham House, 111 St James Road Croydon Surrey CR9 2TH England
A summary of BS 594 Part 2 1985 (Hot Rolled Asphalt for Roads and Other Paved Areas. Part 2. Specification for the Transport, Laying and Compaction of Rolled Asphalt) where it relates to chipped hot rolled asphalt wearing courses is provided and its shortcomings discussed. Parts of the standard are not specific and are therefore open to a variety of interpretations. It is suggested that the British Standards Institute should decide whether its documents are standards or options. If it opts for the former then some amendment is necessary. The section on wind chilling of the wearing course is too vague to have any meaningful effect, the section on compaction needs considerable expansion and the section on laying in cold weather has little foundation. A conclusion is suggested as a satisfactory answer.

DESCRIPTORS: BITUMINOUS MATERIALS AND MIXES; COLD WEATHER CONSTRUCTION; COMPACTION; CONSTRUCTION; COOLING; GREAT BRITAIN; HOT ROLLED ASPHALT; SPECIFICATIONS; WEARING COURSES; WIND

457874 DA
INSTALLATION REPORT - EXPERIMENTAL MIXES ON RICHMOND-PETERSBURG TURNPIKE -- 1985
Hughes, CS
Virginia Highway & Transportation Research Council P.O. Box 3817, University Station Charlottesville VA 22903; Virginia Department of Highways and Transportation 1221 East Broad Street Richmond Virginia 23219; Federal Highway Administration 400 7th Street, SW Washington D.C. 20550
Jan 1988 45p 5 fig. 15 tab. 4 App.
REPORT NO: FHWA-VA-86-26; VHTRC 86-R26
CONTRACT NO: 68-03-198; HP&R
SUBFILE: HRIS
AVAILABLE FROM: Virginia Highway & Transportation Research Council P.O. Box 3817, University Station Charlottesville Virginia 22903
This report describes the materials and construction details involved in the design and placement of four experimental mixes on I-95 (Richmond-Petersburg Turnpike) between Maury Avenue and Bells Road in 1985. The mixes were designed to initially resist rutting and to provide several years' service before failing from fatigue or the intrusion of water. The early results indicate that the gradation chosen is more important in minimizing early rutting than are the asphalt cement-additive combinations used. However, some strength tests point to the value of using an AC-30 cement as opposed to an AC-20. Controlling traffic sufficiently long to allow the pavement to cool to a temperature at which traffic does not prolong the compaction process is critical. (Author)

DESCRIPTORS: ADDITIVES; ASPHALT CEMENTS; BITUMINOUS MATERIALS AND MIXES; COOLING; DENSITY; EXPERIMENTAL PAVEMENTS GRADATION; PAVEMENT DESIGN AND PERFORMANCE; RUTS; STRENGTH

453773 DA
HIGH-TEMPERATURE BATTERIES, STATE OF DEVELOPMENT AND POSSIBILITIES OF APPLICATION
Fischer, W (Brown, Boveri and Cie)
Verlag R Oldenbourg
Elektrische Bahnen VOL. 82 NO. 11 Nov 1984 pp 348-353 17 Ref. German
SUBFILE: EIT; UMTIRS (cont. next page)
The most important components of a sodium/sulfur battery are the cells, a vacuum thermal insulation and a heating/cooling system. Laboratory tests with a VW van with 12-kw-12-kWh-batteries have demonstrated the basic ability of such batteries to function. The development is continued with the objective to improve the battery characteristics as energy density, power density and service life. Sodium/sulfur batteries are being developed to propel road vehicles. They can be also utilized for other purposes, such as propulsion of rail vehicles or load leveling in electric networks. (Edited with author abstract)

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459647 DA
AIRCRAFT SYSTEMS FOR ROADWAY STABILIZATION OVER PERMAFROST AREAS

Zarling, J; Connor, B; Goering, D
Alaska University, Fairbanks Department of Mechanical Engineering, Fairbanks Alaska 99701; Alaska Department of Transp and Public Facilities Pouch 2 Juneau Alaska 99811; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590 Mar 1984 Final Rpt. 55p
REPORT NO: FHWA-AK-84-10
CONTRACT NO: F66192; Contract
SUBFILE: HRIS

AVAILABLE FROM: Alaska University, Fairbanks Department of Mechanical Engineering Fairbanks Alaska 99701

In the discontinuous permafrost regions of Alaska it is not always possible to route roads over non-permafrost ground. For areas like these, highway engineers face a tremendous design challenge in attempting to provide a stable roadway base. Several active and passive systems have been used in the past to protect the underlying permafrost from thermal degradation. In Alaska, small diameter corrugated metal pipes (culverts) have been placed in the fill material covering the underlying permafrost. Both ends of the culverts are brought to the surface with one end having a long vertical section attached to serve as a stack. Cold air enters the lower end of the culvert, flows through the horizontal section under the roadway, cooling the ground (warming the air) and then exits through the vertical stack at the other end of the culvert. Flow is established by the stack or chimney effect, i.e. the warm air is forced up and out of the vertical stack by the heavier surrounding ambient cold air. This report presents the results of both an experimental and analytical research program undertaken to develop design criteria for air duct systems. An experimental duct was assembled and instrumented to determine the relationship between air flow rates and temperature difference, heat transfer rate, air duct length, stack height, etc. A finite element computer model has also been used to investigate the placement of the air duct under the roadway. Optimum design of an air duct system would allow sufficient winter cooling of the ground so that degradation of the underlying permafrost would not occur during the summer thawing season. Temperature contours resulting from the finite element simulations showing the effects of air duct placement on the thermal regime are presented.


451849 DA
CARS WITH CLOSED ENGINE COMPARTMENT - EFFECT UPON EXTERIOR NOISE AND PASSENGER COMFORT

Thien, GE; Brandl, FK; Kirnheger, W; Winkhofer, E (Avilist GmbH, Graz, Austra)
Mechanical Engineering Publications Limited Box 24, Northgate Avenue Bury St. Edmunds Suffolk IP3 6PW England

1984 pp 121-130 7 Fig. 20 Ref.
SUBFILE: TRRL; IRID: HRIS
AVAILABLE FROM: Mechanical Engineering Publications Limited Box 24, Northgate Avenue Bury St. Edmunds Suffolk IP3 6PW England

The exterior noise of vehicles is primarily determined by the sound radiated from the power unit. Lower noise levels have been reached through improved knowledge, but this reduction is not sufficient for the current stringent standards. A complete enclosing of the power unit is an efficient approach to the problem. An economic solution for passenger cars is to enclose the engine compartment in a sound proof manner. This approach has been adopted in the past by AVL and is discussed in this paper. One of the design characteristics is that the cooling system is placed outside the enclosure so that optimum sound insulation of the engine is obtained. With prototype vehicles using an improved exhaust muffler system a noise reduction of 8 dba in the ISO pass by acceleration test can be achieved. The exterior noise measured when the engine is idling, especially in front of the vehicle, is up to 10 dba lower. Sound levels within the enclosure are usually higher than in the non enclosed case; however, this does not necessarily result in a deterioration in passenger comfort. Because of the closed engine compartment, sound radiated downwards, reflected on the road, surface and transmitted back into the passenger compartment is suppressed. Therefore, with the additional treatment of the firewall an even lower interior noise can be achieved in the middle and high frequency range, whereas at low frequencies when the transmission of structural vibrations is dominating, the influence of the enclosure can be neglected. In this paper the concept of a closed engine compartment is described and supported by the results of the research project TRIS 451834. (TRRL) Vehicle Noise and Vibration. Papers read at the International Conference held at the Institution of Mechanical Engineers, London 5-7 June 1984.

DESCRIPTORS: AUTOMOBILE ENGINES; CAR: COMFORT; CONFERENCE; (cont. next page)
451593 DA
THE COMPRESSOR PRESSURE WAVE SUPERCHARGER IN PASSENGER CAR APPLICATIONS
Mayer, A; Kirchofer, H (Brown Boveri and Company, Limited)
Inderscience Enterprises Limited
International Journal of Vehicle Design Vol. 6 No. 1 Jan 1985 pp 1-23 Figs. 4 Tab. 8 Ref.
REPORT NO: HS-039 010
SUBFILE: HR5: HSL
AVAILABLE FROM: Inderscience Enterprises Limited World Trade Center Building, 110 Avenue Louis Casai, CP 306 Geneva-aeroport Switzerland

The pressure wave machine COMPREX has proven to be a very effective supercharging device for diesel vehicle engines. A supercharger family with six types covers the entire passenger vehicle swept volume range has been released for manufacture. The design and the charger map are presented. Using the example of a medium type CX 85 for the supercharging of a 1.6 litre IDI engine, the design method is described and the engine map is shown with and without charge air cooling. Road performance calculations relating to the test vehicle VW-Passat are compared to measurements in drive cycle and in city driving and show possibilities for further optimization, whereby in particular fuel economy is improved.

DESCRIPTORS: DESIGN; DIESEL ENGINES; FUEL ECONOMY; PERFORMANCE; SUPERCHARGER; VEHICLE CHARACTERISTICS

408178 DA
COOLING OF BITUMINOUS LAYERS AND TIME AVAILABLE FOR THEIR COMPACTION
DAINES, ME
TRANSPORT AND ROAD RESEARCH LABORATORY
TRRL RESEARCH REPORT N 4 1985 ii PP ENGLISH
SUBFILE: UCITS; TLIB
BY M.E. DAINES CHARTS INCLUDES BIBLIOGRAPHICAL REFERENCES ADDL CORP. AUTHOR INFO: TRANSPORT AND ROAD RESEARCH LABORATORY DESCRIPTORS: BITUMINOUS MATERIALS; DESIGN AND CONSTRUCTION; PAVEMENTS, ASPHALT

399058 DA
ON-HIGHWAY PERFORMANCE EVALUATION OF A CUMMINS DIESEL ENGINE FEATURING OPTIMIZED CHARGE AIR COOLING
Davidson, SD (Cummins Engine Company, Incorporated)
Society of Automotive Engineers, Incorporated
SAE Technical Paper Series 1984 pp 13 Figs. 1 Ref.
REPORT NO: SAE 840996; HS-038 579
SUBFILE: HSL
AVAILABLE FROM: Society of Automotive Engineers, Incorporated 400 Commonwealth Drive Warrendale Pennsylvania 15096

Optimized charge air cooling (or optimized aftercooler) applied to Cummins diesel engines can provide fuel economy, performance, and drivability benefits. The reliance of this concept upon the optimum performance of both the engine and the vehicle cooling system dictated evaluation of the total package while operating in a vehicle environment. Engine and vehicle performance were measured on-highway using a unique test trailer featuring an integral dynamometer, and a computerized data acquisition system. Parameters measured included a variety of engine temperatures, pressures, and flows, as well as power required, engine speed, and road speed. Tests were conducted in the ambient temperature range of several speed and load conditions. On-highway, road load operation was also evaluated. Presented at the SAE West Coast International Meeting and Exposition San Diego, California, August 6-9, 1984.

DESCRIPTORS: AIR COOLING; DIESEL ENGINES; DRIVEABILITY; ENGINE PERFORMANCE; PERFORMANCE EVALUATION; VEHICLE PERFORMANCE

396092 DA
QUANTIFYING MOTOR VEHICLE FUEL CONSERVATION STRATEGIES
Melbourne University, Australia Department of Mechanical Engineering, Grattan Street Parkville Victoria 3052 Australia 1984 Monograph n.p. Figs. Tabs. 55 Ref.
SUBFILE: TRRL: IR5D: HRS

This report covers the period up to the commencement of the car fleet survey which began in October 1983. It is reported that gradient is an important factor affecting on-road fuel consumption. The influence of some vehicle component temperatures and use of the choke have been found to be important variables affecting cold start fuel consumption measured over the range of seasonal conditions along 10 different home to work routes. The replication of on-road component temperatures on the chassis dynamometer with the aid of the computer controlled cooling fans, is an important factor in replicating on-road fuel consumption. Use of a trailer, with two force transducer to measure the rolling resistance of several sets of tyres on the road has been only partially successful. These data are needed to obtain a correction factor for the rolling resistance on the dynamometer. Achievements of the models for fuel consumption and exhaust emissions are discussed. In October work moved into its most important phase - the measurement of data for a fleet of cars. The specially developed test program is described. (TRRL)

DESCRIPTORS: AIR POLLUTION; APPARATUS (MEASURING); AUTOMOBILES; CHOKE; COLD START; COLD STARTING; COOLING SYSTEMS; DYNAMOMETERS; ENERGY CONSERVATION; EQUIPMENT; EXHAUST FUMES; FORCE; FUEL CONSUMPTION; GRADIENT; MEASUREMENT; MEASURING; ROLLING RESISTANCE; SEASONAL VARIATIONS; TEMPERATURE; TIRES; VEHICLE; VEHICLE CHARACTERISTICS; VEHICLE COMPONENTS
However the brake parts on the dynamometer will not operate at velocities as parameters show good coincidence with the actual because the cooling factors are different. Also the load on effects of road salt; 2) fuels with alcohol additives; 3) effectively estimate brake performance at planning stage of engineering plastics: 1) weathering, impact by stones and from dynamometer tests using different line pressures and only minimally affected by the cooling factors and load. Brake 392492 DA

There are special thermoplastics available for these cases CROSSREFERENCES;

CHARACTERISTICS;

MATERIALS; INDUSTRY; LUBRICANTS;

SIMULATION OF VEHICLE BRAKE PERFORMANCE ON BRAKE DYNAMOMETER
Harada, H; Shimizu, H; Sugitani, T; Gomi, M
Society of Automotive Engineers, Incorporated 400 Commonwealth Drive Warrendale Pennsylvania 15096
May 1984 p 2.326 17 Fig. 3 Ref. REPORT NO: SAE 8405064; HS-037 448
SUBFILE: HSL AVAILABLE FROM: Society of Automotive Engineers, Incorporated 400 Commonwealth Drive Warrendale Pennsylvania 15096
At an early stage of developments, brake performances are usually obtained from a simulation using a brake dynamometer. However the brake parts on the dynamometer will not operate at exactly the same temperature as that fitted to a road vehicle, because the cooling factors are different. Also the load on the brakes on the dynamometer is different from the actual load. The effects of temperature and load on brake performance were investigated and it was found that over a considerably wide range the frictional coefficients of brake materials are only minimally affected by the cooling factors and load. Brake performances calculated from the experimental data obtained from dynamometer tests using different line pressures and vehicle as parameters show good coincidence with the actual road test results, so the simulations can be used to effectively estimate brake performance at planning stage of the vehicle. Twentieth FISITA Congress, (SAE P-143), The Automotive Future, Volume 2, Austria, 6-11 May 1984.

DESCRIPTORS: BRAKES; /FOR ARRESTING MOTION/; DYNAMOMETERS; LOADS; PERFORMANCE; SIMULATIONS; TEMPERATURE

ENGINEERING PLASTICS AND NEW APPLICATIONS IN THE AUTOMOTIVE INDUSTRY
Hartig, U (Basf Australia Limited)
Society of Automotive Engineers (Australasia) 191 Royal Parade Parkville Victoria 3052 Australia
Mar 1984 12p 10 Fig. 5 Tab. SUBFILE: TRRL; IRRD; HS-035 155
In the automotive industry, four specific cases can be selected out of the spectrum of the total demands placed on engineering plastics: 1) weathering, impact by stones and effects of road salt; 2) fuels with alcohol additives; 3) motor and transmission lubricants; and 4) cooling liquids. There are special thermoplastics available for these cases today. New, modified plastics are presented and new applications are discussed. (Author/TRRL) This paper was presented during the Seminar, Advances in Automotive Plastics, Melbourne, Australia, March 1984.

DESCRIPTORS: ADDITIVES; /ALCOHOLS/; AUTOMOBILE INDUSTRY; COMPONENTS OF THE CAR; CONFERENCE; COOLANTS; FUELS; GENERAL MATERIALS; INDUSTRY; LUBRICANTS; PLASTIC MATERIALS; PLASTICS; PROPERTIES; SPECIFICATIONS; THERMOPLASTIC; VEHICLE; VEHICLE CHARACTERISTICS; WEATHERING

FOCUS ON BRAKES AND BRAKE SYSTEMS
Mechanical Engineering Publications Limited
Automotive Engineering Vol. 8 No. 2 Apr 1983 10p 22 Fig. REPORT NO: HS-035 155 SUBFILE: HSL AVAILABLE FROM: Mechanical Engineering Publications Limited Box 24, Northgate Avenue Bury St. Edmunds Suffolk IP32 6W (cont. next page)
This article reports design and development aspects of brakes and brake systems revealed at the IMechE AD conference, "Braking of road vehicles," held at Loughborough University of Technology, together with reports from major foundation-brake manufacturers approached separately by AE. The article is divided into three sections. Section 1 deals with passenger car units and vehicle stability in braking. Topics covered include the effect of vehicle design on car brakes, the effect of fuel conservation on the course of brake design, inertia-sensitive brake control valves, braking stability affected by differential wheel forces, and commercial vehicle braking on a curve. Section 2, entitled CV brake systems covered these topics: air systems linked with foundation brakes, the critical role of water cooling, recent developments, user benefit from air-actuation/braking link, anti-lock as part of an air system, footbrake valves: human aspects of response times, estimating air brake times, and advances in systems for non-rigid CVs. Section 3, CV foundation brakes, covers these topics: cam operated drum brakes, performance variations, S-cam brake design advances, brakes for future medium weight commercials, application of disc brakes to CVs, disc brakes for HGVs: developing a disc rotor design, commercial vehicle disc brake with U.S. operational experience, and the ease of service, and brakebirders.

DESCRIPTORS: AIR BRAKES; ANTI LOCK BRAKES; BRAKE CONTROLLERS; BRAKES / FOR ARRESTING MOTION/; DESIGN; DISC BRAKES; DRUM BRAKES; HIGHWAY CURVES; PERFORMANCE; RESEARCH AND DEVELOPMENT; RESPONSE TIME; TECHNOLOGICAL INNOVATION; TRUCK BRAKES; VEHICLE STABILITY; WATER COOLING

372486 DA
BRIDGE ICING CONTROL
Kornelsen, R
Alberta Transportation Magazine
SUBFILE: HRIS
AVAILABLE FROM: Alberta Transportation Magazine 157 Transportation Building, 9630 106th Street Edmonton Alberta T6G 2B8 Canada

An experimental bridge designed to battle the problem of differential has been constructed over the Ioseguen River in Alberta. It has an 850-mm covering of earth (base course) and asphaltic pavement on the deck creating a surface similar to that of the highway. The fill material is expected to store heat, so the existence of cooling is more like the rest of the road. In addition, to reduce heat loss through the bottom of the bridge, the prestressed concrete girders were insulated with styrofoam. If, under certain weather conditions, the experimental bridge surface ices at the same rate as the surface of the highway and a nearby conventional bridge is wet, the experiment can be deemed a success.

DESCRIPTORS: BRIDGE DECKS; BRIDGE DESIGN; HIGHWAY BRIDGES; ICING; MAINTENANCE, GENERAL; PREVENTION; SAFETY; STRUCTURES DESIGN AND PERFORMANCE

370566 DA
RAPID REPAIR OF CONCRETE PAVINGS
El-Jazairi, B
Cement and Concrete Association
Concrete Vol. 16 NO. 9 Sep 1982 pp 12-15 2 Fig. 9 Tab. 3
Phot. 11 Ref.

SUBFILE: TRRL; IRRD; HS

The author discusses the properties of the single component magnesium phosphate cement (mpc) patching product, febsset-45, explaining the features leading to typical applications. The material is a chemical setting cement mainly of magnesia, a mixture of phosphates blended with fine aggregates. When it is added to the gauging water, an exothermic reaction produces materials, setting in about 15 minutes and hardening to a sufficient strength 20n/mm squared to be able to take heavy traffic within one hour. Normal strength gain can be obtained in adverse weather by either heating or cooling the gauging water. The percentage of water added is critical as too much produces segregation and bleeding. Examples are given of the use of the material in the repair of roads, airports and industrial floors (including cold stores). Good flow characteristics permit the material to be used for repairs of up to 200mm without the need of vibration. Because of its good bonding characteristics, no primer is needed on any repair work. (Author/TRRL)

DESCRIPTORS: ADHESION; BONDING; CEMENT AND CONCRETE; CONCRETE; CONCRETE PAVEMENT MAINTENANCE; DURABILITY; MAGNESIUM; MAGNESIUM COMPOUNDS; MAINTENANCE, GENERAL; OXIDE; PATCHING; PATCHING MORTAR; RAPID HARDENING; RAPID METHODS; REPAIR; REPAIRS; RIGID PAVEMENT; STABILITY; STRENGTH (MATER); WATER

369244 DA
WINTERIZATION STARTS WITH HOSE AND BELT MAINTENANCE
(AUTOMOTIVE COOLING SYSTEM)
Bobit Publishing Company
Automotive Fleet Vol. 20 NO. 2 Dec 1980 4p
REPORT NO: HS-031 050
SUBFILE: HSL

AVAILABLE FROM: Bobit Publishing Company 2500 Artesia Boulevard Redondo Beach California 90278

Including suggestions by the Gates Rubber Company, information is provided for the fleet manager on the periodic servicing of vehicle cooling systems (hoses and belts). Preventive maintenance guidelines for hoses include replacing all coolant hoses (except silicone) during major engine overhauls, inspecting hoses frequently for abrasion and tightening hose clamps often, and protecting hoses susceptible to damage by road hazards. Some examples are given of hose failure: hardening from high heat, external cracks and breaks, internal flaking from coolant deterioration, and oil-soaked or swollen areas; the replacement procedure is described. Covered and bandless V-belts are described, and conditions listed for detection in the inspection of fan, alternator, (cont. next page)
PRINTS

DIALOG File 63: TRIS _ 70-92/JUL

air-conditioning, power steering, and air pump belts: cracking, oil soaking, glazing, and wearing of cover. Worn pulley grooves are also identified as a frequent cause of V-belt trouble. Information is given on proper belt selection and the procedure for changing belts. Guidelines are presented for tensioning belts, as well as additional tensioning checkpoints.

Dialog File 63: TRIS _ 70-92/JUL

368465 DA

PROPERTIES OF STABILIZED BLAST FURNACE SLAG ROAD BASE

Heaton, BS; Bullen, F (Newcastle University; Papua New Guinea University of Technology)

Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0572-1431 1982 pp 168-176 8 Fig. 2 Tab. 14 Ref.

SUBFILE: TRRL; IRRD; HRIS

Blast furnace slag, either crushed in situ or as plant crushed graded macadam, has become increasingly important as a base or sub-base on heavily trafficked roads in the Newcastle, Sydney, Wollongong region. The material predominantly used has been blast furnace slag which is considered to have self stabilizing action but at a level too weak to be classified a bound material. The investigation described in the paper examined the properties of stabilized air-cooled blast furnace slag base. Agents used to stabilize the slag were granulated slag activated either with lime or steel slag. Mixtures were evaluated which were economically feasible and which satisfied the requirements for stabilized crushed rock. Properties determined were unconfined compressive strength and resilient modulus, a property relevant to the elastic analysis of road pavements by computer methods. Alternative pavement designs using the stabilized materials were evaluated and are presented (a). The number of the covering abstract of the conference is TRIS No. 368448. (TRRL) Proceedings of the Eleventh Australian Road Research Board Conference, held at the University of Melbourne, August 23-27, 1982.

Descriptors: ACCURACY; AUSTRALIA; BRIDGE DECK; CONCRETE BRIDGES; CONFERENCE; CYCLIC LOADING; DEFORMATION; GRADIENT; LOAD; LONG TERM; METHOD; RELAXATION (MECH); SEASONAL VARIATIONS; STRESS ANALYSIS; STRUCTURES DESIGN AND PERFORMANCE; TEMPERATURE; WEATHER

367881 DA

EMISSIONS AND FUEL CONSUMPTION PROJECTIONS FOR DYNAMIC FLEET POPULATIONS

Hamilton, RB; Cass, MR; McFarlane, I (Shell Australia)

Society of Automotive Engineers (Australasia) 191 Royal Parade Parkville Victoria 3052 Australia May 1982 pp 1-21 4 Fig. 16 Tab. 23 Ref.

REPORT NO: Paper 15 SUBFILE: TRRL; IRRD; HRIS

A model is described that uses variables such as population, vehicle ownership, annual distance travelled and average vehicle emission rates (g/km) to generate gross emissions levels or gross petrol consumption. The model is dynamic in that perceived changes in the assumptions surrounding the variables can be accommodated. Differences between the standard cycle and on road conditions are significant sources of error when modelling for emissions and fuel consumption. The fleet average fuel consumption for cars and station wagons in 1987 is estimated to be 10.1 km/l. The rate of future fuel consumption improvements will be slowed if the current trends towards automatics and air conditioning continue. The paper concludes by using the model to compare the economic benefits of an

(Continued next page)

011765
imposed petrol consumption improvement with the cost of achieving the improvement. In the evaluation, distinctions are made between a single vehicle, the average vehicle and the compliance fleet, and because of the long time period involved, benefits/costs are discounted. In general, the discounted savings for the compliance fleet will only be about 40 per cent of the benefits for a single vehicle (3). The paper was presented as Paper 15—Session 5—Emissions Modelling (SAE 82145). The number of the covering abstract of the conference is TRIS no. 367871. (TRRL) Second Conference on achieving the improvement. In the evaluation, distinctions are made between traffic, energy and emissions, Melbourne, May 1982. Program and Papers.

DESCRIPTORS: AIR; AIR CONDITIONING; AUTOMATIC; AUTOMATIC TRANSMISSIONS; BENEFIT COST ANALYSIS; CONFERENCE; COOLING (MATER); ECONOMICS: ENERGY AND ENVIRONMENT; EXHAUST EMISSIONS; EXHAUST FUMES; FLEETS; FORECAST; FORECASTING; FUEL CONSUMPTION; INTERIOR (CAR); JOURNEY; LENGTH; MATHEMATICAL MODEL; MATHEMATICAL MODELS; POPULATION; SAVINGS; TRANSMISSION (VEH); VEHICLE CHARACTERISTICS; VEHICLE MILES; VEHICLE OWNERSHIP

349378 DA
AC DRIVE MOTORS FOR ELECTRIC ROAD VEHICLES
Gascoigne, AE
Institution of Engineers, Australia 11 National Circuit
Barton A.C.T. 2000 Australia 0 85825 167 1
1981 pp 33-39 6 Fig. 3 Tab. 11 Ref.
REPORT NO: NATL CONF PUB 81/11
SUBFILE: TRRL; IRRD; HRIS; UMTRIS
DESCRIPTIONS: ASPHALT PAVEMENTS; BITUMINOUS MATERIALS AND MIXES; BITUMINOUS MIXTURE; CONFERENCE; COST; EQUIPMENT; HIGHWAY MAINTENANCE; HOT MIX PLANTS; LOW COST; LOW COST ROAD; MAINTENANCE COSTS; MAINTENANCE, GENERAL; MIXING PLANT; RECYCLING: RECYCLING (MATER); REPAIR; REPAIRS

348101 DA
LOW COST ROAD REPAIR
Schwarzinger, A
Svenska Vaegpforseningen Box 27115 S-102 52 Stockholm Sweden
1981 pp 319-330 12 Prot. German
SUBFILE: TRRL; IRRD; HRIS

These methods used currently are too expensive and not practicable. The problem lies in the high expense involved in getting hot mixed asphalt to the location and in the difficulties which occur when spreading the material. Hot mixed asphalt is produced in large mixing plants. These frequently are far away from the place of repair and in the cold season they are often shut down completely. The result is high transportation costs for hot mixed asphalt or non-availability altogether. Since hot mixed asphalt can only be spread while hot early cooling of the material during spreading causes problems and loss of material. These difficulties are the cause of poor maintenance or re-repair altogether. Since 1980 Bonag offers a machine that can solve this problem. The Ar 5 asphalt recycler is a small mixing plant mounted on a trailer. It can be towed by a small truck or even a passenger car right to the location. Old asphalt chunks, crushed or milled asphalt pavements are heated up and mixed on a trailer. Thus scrap material which normally would have to be disposed of is recycled, producing patch material of excellent quality at extremely low cost.

(1) Papers from the 9th IFRA World Meeting, Roads Into the Future—Road Maintenance—TS5, held in Stockholm, June 1-5, 1981.

DESCRIPTORS: ASPHALT PAVEMENTS; BITUMINOUS MATERIALS AND MIXES; BITUMINOUS MIXTURE; CONFERENCE; COST; EQUIPMENT; HIGHWAY MAINTENANCE; HOT MIX PLANTS; LOW COST; LOW COST ROAD; MAINTENANCE COSTS; MAINTENANCE, GENERAL; MIXING PLANT; RECYCLING; RECYCLING (MATER); REPAIR; REPAIRS

346321 DA
FOREIGN NOISE RESEARCH IN SURFACE TRANSPORTATION, 1978-1981
Barber, D; Modig, C
Informatics, Incorporated 600 Executive Boulevard Rockville Maryland 20852; Environmental Protection Agency Office of Noise Abatement and Control, 1921 Jeff Davis Hwy Arlington Virginia 20460
May 1981 373p
REPORT NO: EPA-550/9-81-317
SUBFILE: NTIS; HRIS; UMTRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Information on foreign research projects in surface transportation noise abatement was collected from both individuals and organizations. These contacts were queried on their research. The following are their names and addresses of other surface transportation noise researchers. In total, some 700 researchers were contacted. They were asked to respond with information about research (cont. next page)
projects that deal with: highway vehicle noise control (trucks, buses, cars, etc.); vehicle component noise control (engines, exhaust mufflers, cooling systems, power trains, tires, etc.); roadway surface materials, tire/road interaction; path control (barriers, insulation, highway planning and land management); highway noise analysis (prediction models, propagation theory, etc.); rail noise (guided mass transit, light rail), elevated structures, wheel/rail interaction; off road and recreational vehicle noise; measurement, monitoring and enforcement research. From these contacts, 294 surface transportation noise research projects were identified.

DESCRIPTORS: ABSTRACTS; COST ANALYSIS; ENERGY AND ENVIRONMENT; FOREIGN TECHNOLOGY; HIGHWAY TRANSPORTATION; LAND USE PLANNING; LAW ENFORCEMENT; MEASURING; MODELS; NOISE CONTROL; NOISE LEVELS; NOISE POLLUTION; NOISE REDUCTION; NOISE SOURCES; PREDICTIONS; PROJECT MANAGEMENT; RAIL TRANSPORTATION RESEARCH MANAGEMENT; RESEARCH PROJECTS; RESEARCH PROJECTS: TECHNOLOGY ASSESSMENT; TRANSPORTATION NOISE; VEHICLE CHARACTERISTICS; WHEEL RAIL INTERACTION

345802 DA
A THEORETICAL/EXPERIMENTAL ANALYSIS FOR REDUCING THE FUEL CONSUMPTION OF COMMERCIAL VEHICLES OVER LONG DISTANCES
Norzi, A; Vedda, R (Iveco Engineering, Turin)
Associazione Tecnica dell'Automobile
ATA Associazione Tecnica dell'Automobile VOL. 34 NO. 4 April 1981 pp 227-233 14 Fig. Italian
SUBFILE: TRRL; IRRD; HRIS
A research programme began at IVECO a few years ago with the object of improving the profitability of transport operation by examining vehicle and component modifications so as to optimise energy consumption and save fuel. The programme covered various aspects of vehicle and component design, two of which are dealt with here. Firstly, forward-motion resistance is treated theoretically by deriving an expression for it, which contains expressions for rolling, drive-train and aerodynamic resistance. This is followed by a report of a number of experiments on dynamometer tests and tests using a half-scale model at Fiat Research Centre windtunnel. The results of these experiments were compared with road tests. As a result of this work, a deflector for large vehicles was developed which gives fuel savings of up to 9%. Secondly, vehicle cooling systems are described, and modifications to various components, e.g., the radiator, are suggested for fuel-economy improvements. (TRRL)

DESCRIPTORS: AERODYNAMICS; COMMERCIAL VEHICLES; COMPONENTS OF THE CAR; COOLING; COOLING (MATER); DEFLECTION; DELIVERY VEHICLES; DYNAMOMETERS; EQUIPMENT; FUEL CONSUMPTION; LORRY; MOTOR; OPTIMUM DESIGN; RADIATORS; RESISTANCE; TEST; TEST RIG; VEHICLE CHARACTERISTICS; VEHICLE COMPONENTS; VEHICLE DESIGN; WIND TUNNELS

342141 DA
HOW TO RUN A TEST STRIP FOR ASPHALT ROLLING
Thomson, P
Scranton Gillette Communications, Incorporated
Rural and Urban Roads VOL. 19 NO. 9 Sep 1981 pp 46-47 1 Fig. Phot.
SUBFILE: HRIS
Available FROM: Scranton Gillette Communications, Incorporated 380 Northwest Highway Des Plaines Illinois 60016
All paving jobs are measured by the amount of asphalt laid down on an hourly basis. To estimate roller requirements, one must estimate the net average speed of the paver covering the particular road cross-section, the hourly laydown tonnage, and paver efficiency. Prior to running a test strip, the paving foreman must estimate the capacity of the roller train necessary to keep up with the paver for the hourly tonnage to be achieved on the project. This requires knowing the density of the mix. The density will be a laboratory density according to Marshall density or to theoretical maximum density. A certain percentage factor must be applied to determine the passing density and this will determine the nuclear count required to meet the specified density for the project. The test strip should be a straight run of at least 100 yards where there are no interruptions. The proper roller must be selected and tested for operation. The use of the nuclear gauge is described. Effort must be made to obtain a roller pattern giving the least number of passes to get the optimum density and smooth surface. The vibration frequency of the roller, roller speed, the number of laps necessary to cover a roadway section, and the cooling rate of the asphalt are all discussed.

DESCRIPTORS: ASPHALTS; BITUMINOUS MATERIALS AND MIXES; BITUMINOUS MIXTURES; COOLING; DENSITY; EFFICIENCY; LAYING; NUCLEAR METERS; PAVING EQUIPMENT; ROLLER COVERAGE; ROLLERS; ROLLING; SPEED; TEST SECTIONS; VIBRATORY ROLLING

334147 DA
A METHOD OF ESTIMATING EXTERIOR VEHICLE NOISE TAKING INTO ACCOUNT THE REFLECTION AND DIFFRACTION EFFECT OF THE BODY AND THE ROAD SURFACE
Shinizu, M; Abe, T (Nissan Motor Company)
Society of Automotive Engineers of Japan, Inc
JSAE Review N3 Nov 1980 pp 65-72 11 Fig. 3 Tab. 5 Ref.
SUBFILE: TRRL; IRRD; HRIS
The major noise sources of exterior vehicle noise (mainly on acceleration) are the engine, exhaust, air intake, cooling fan, and tires. The exhaust outlet, cooling fan, and tires can be considered to be simple sound or point noise sources because they are small in geometrical size. Some effect of sound reflection from the road surface, however, may be taken into account. Because of its size, the engine should be considered as a plane noise source. The effect of sound reflection from road surface, however, must be considered and also the effect of the engine being screened by side panels or

(cont. next page)
engine compartment panels. In the experiments the propagation characteristics of engine noise were calculated by using a geometrical acoustic model which used noise screening devices such as body panels and engine compartment panels. The calculated results were in close agreement with the experimental results obtained from using a test vehicle.

(TRR) DESCRIPTORS: ABSORPTION; ACCELERATION; ACOUSTICS; AUTOMOBILE BODIES; AUTOMOBILE TIRES; CALCULATION; DIFFRACTION; ENGINE NOISE; EXHAUST PIPE; GEOMETRIC DESIGN; MEASUREMENT; MOTOR; MOTOR VEHICLES; NOISE /SOUND/; REFLECTIONS; ROAD SURFACES; SOUND; TIRE PAVEMENT INTERFACE; TYRE; VEHICLE; VEHICLE CHARACTERISTICS; VIBRATIONS

330618 DA
FIELD COOLING RATES OF ASPHALT CONCRETE OVERLAYS AT LOW TEMPERATURES
Eaton, RA; Berg, RL
Cold Regions Research and Engineering Laboratory P.O. Box 282 Hanover New Hampshire 03755
Dec 1980 18p
REPORT NO: CRREL Rpt. 80-30
SUBFILE: HRIS
AVAILABLE FROM: Cold Regions Research and Engineering Laboratory P.O. Box 282 Hanover New Hampshire 03755
Six overlay test sections were placed on an existing test road in Hanover, New Hampshire, to gain experience in compaction of asphalt pavements at rolling temperatures as low as -150 deg C. The asphalt cement and aggregate used had mix characteristics similar to those of the mix expected to be used for a proposed overlay project at Thule Air Base, Greenland. Results of the overlay tests showed that computer-modeled cooling curves can be accurate predictors of the actual asphalt overlay cooling with time. In addition, the effects of temperature upon compaction were determined and it was found that nuclear gauges, when used and calibrated properly, successfully monitored mix density changes during compaction. (Author)

DESCRIPTORS: ASPHALTIC CONCRETE; BITUMINOUS MATERIALS AND MIXES; CHANGES; COOLING; DENSITY; LOW TEMPERATURES; MIX DESIGN; NUCLEAR METERS; OVERLAY COURSE

322854 DA
RAM AIR EFFECTS ON THE AIR SIDE COOLING SYSTEM PERFORMANCE OF A TYPICAL NORTH AMERICAN PASSENGER CAR
Schaub, UW; Charles, HN (National Research Council of Canada) Society of Automotive Engineers Society of Automotive Engineers Preprints 1980 19 p 5 Ref.
REPORT NO: SAE 800032
SUBFILE: EIT; HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017
A standard engine mounted cooling fan in a 1976 Ford Granada equipped with air conditioning and a 4.9l (302 cu. in.) V-8 engine was performance-tested on the road and under wind tunnel generated ram air conditions. To achieve appropriate back pressure variation the whole engine bay was pressurized through use of remotely placed exhaust machinery. System resistance was studied over a range of ram air conditions. Fan pressure-flow characteristics were measured for various fan speeds and three ram conditions. These were observed to correlate as one universal map. This universal characteristic together with the measured front and resistances and ram pressure was interpreted as series-operated fans consisting of a supercharging first stage and the cooling fan acting as a second stage. This model and the identified resistance mechanisms enable accurate performance prediction to be made. From the SAE Meeting held February 25-29, 1980.

DESCRIPTORS: AIR COOLING; AUTOMOBILE ENGINES; AUTOMOBILES; COOLING; COOLING SYSTEMS; FANS; PERFORMANCE; SUPERCHARGER; VEHICLE CHARACTERISTICS

322500 DA
CONSEQUENCES OF CRACKING IN A CEMENT STABILIZED ROADBASE FOR THE DEVELOPMENT OF STRAIN IN A FLEXIBLE PAVEMENT
Leewis, M (Stichting Betonresearch Bnc) Technische Hogeschool Stevinweg 1 Delft Netherlands Aug 1979 23p 21 Fig. 1 Tab. 18 Ref. Dutch
SUBFILE: TRRL; IRRD; HRIS
This paper was presented at the study session "cement and Concrete in Road- and Railroad Construction", held in Delft, May 1979. The causes of cracking by shrinkage (desiccation and cooling) of sand-cement are discussed. It is pointed out that the width and distance of cracks in sand-cement depend upon the shrinkage, the creep and the strain at rupture and furthermore on the friction between the stabilized roadbase and the subbase. It is stated that a high friction between the stabilized roadbase and the subbase must be strived for. In order to reduce the tensile stress of asphaltic concrete on the spot of a crack in the sand-cement it is recommended to apply a basecourse of 1 cm with e=1000 n/sq mm. It is also stated that with a wearing course of asphaltic concrete with e=5000 n/sq mm on cracked sand-cement an e-modulus has to be assumed, which totals half of the e-modulus of not-cracked sand-cement. Cracking pattern figures are incorporated. (TRRL) Study Session "Cement and Concrete in Road and Railroad Construction".

DESCRIPTORS: ASPHALTIC CONCRETE; BASECOURSE; BITUMINOUS MIXTURE; CEMENT; CEMENT TREATED BASES; CONFERENCE; CRACKING; CRACKING/FRACTURING/CREEP/CRACK; DEFORMATION; FLEXIBLE PAVEMENT; FLEXIBLE PAVEMENTS; FOUNDATIONS (SOILS); MODULUS OF ELASTICITY; MOISTURE CONTENT; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; ROADBASE STABILIZATION; RUPTURING; SAND STABILIZATION; SHRINKAGE; SHRINKAGE CRACKS; STRAINS; SUBBASE; TEMPERATURE; TENSILE STRESS; WEARING COURSE
This report describes a cooperative programme sponsored by TRRL which has produced heavy diesel engine articulated vehicles having considerably lower external and internal noise levels than vehicles in current operation. The other organisation involved were Rolls Royce Motors Limited, Leyland Vehicles, MIRA, ISVR, and NEL, and the work was aimed at reducing the noise levels from the engine, exhaust and cooling systems and tyre-road surface interaction. Results are given from a number of experimental vehicle builds and a demonstration vehicle built to production standards, which emitted no more than 80 dB(a), is described. (a) (TRRL)

DESCRIPTORS: ARTICULATED VEHICLE; ARTICULATED VEHICLES; CONTACT (TYRE ROAD); COOLING; DECREASE; DIESEL ENGINE; DIESEL ENGINES; DIESEL TRUCKS; EXHAUST SYSTEMS; HEAVY VEHICLES; LORRY; NOISE CONTROL; NOISE LEVELS; QUIET VEHICLE; REDUCTION; SOUND; SOUND LEVEL; TIRE PAVEMENT INTERFACE; UNITED KINGDOM; VEHICLE CHARACTERISTICS

The project examined the mechanisms of crack formation in restrained, lightly reinforced members subjected only to tension induced by shrinkage and cooling. The minimum ratios of various types of reinforcement required to prevent yield of the steel across a single crack, and the ratios required to ensure a pattern of cracks of acceptable width, were determined. A finite difference analysis was evolved and shown to predict accurately the crack spacings and widths in a member. A simplified analysis was also developed. As a result of the understanding of the problem provided by the first stage of the research, and because of the large reinforcement ratios shown to be necessary for adequate crack control by conventional reinforcement, a new and unconventional approach to the problem was proposed and investigated. It was shown that the concept of internal crack initiators and "strategic reinforcement" could be used to ensure a pattern of cracks of predetermined spacing and width, to suit a range of exposure conditions, with very much less steel than would be required with conventional reinforcement practice. The method would seem to be particularly applicable to continuously reinforced road pavements, long retaining walls and in suspended slabs with a large length to width ratio (A).

DESCRIPTORS: CEMENT AND CONCRETE; CONCRETE CRACKING; CONTROL; COOLING; LENGTH; PATTERNS; RATIOS; REINFORCED CONCRETE SLABS; SHRINKAGE CRACKS; THERMAL STRESSES; WIDTHS

This article describes a device developed to meet traffic regulations for buses in certain countries. Operating on a hydrodynamic principle and with pneumatic valve control, oil in the device is dissipated into the engine cooling water. Operation is by hand or service brake pedal. Results of road tests with and without the retarder are included. Advantages claimed for using the device are listed, including reduction in tyre wear due to the prevention of wheel locking. (TRRL)

DESCRIPTORS: CEMENT; CONCRETE; CONCRETE CONSTRUCTION; CONTINUOUSLY REINFORCED CONCRETE; PAVEMENTS; CRACKING; INTERVALS; JOINTS; PAVEMENT CRACKING; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENTS; PORTLAND CEMENT CONCRETES; REINFORCED CONCRETE; ROADS AND STREETS; TENSILE STRENGTH

This report describes a programme aimed at reducing the noise levels from the engine, under conditions, with very much less steel than would be required of the understanding of the problem provided by the first stage of the research, and because of the large reinforcement ratios shown to be necessary for adequate crack control by conventional reinforcement, a new and unconventional approach to the problem was proposed and investigated. It was shown that the concept of internal crack initiators and "strategic reinforcement" could be used to ensure a pattern of cracks of predetermined spacing and width, to suit a range of exposure conditions, with very much less steel than would be required with conventional reinforcement practice. The method would seem to be particularly applicable to continuously reinforced road pavements, long retaining walls and in suspended slabs with a large length to width ratio (A).
Pavement prints

Dialog File 63: TRIS _ 70-92/JUL

303516 DA

THE COOLING OF ASPHALT LAYERS DURING THE COMPACTION OPERATION

Dickinson, EJ
Australian Road Research Board
Australian Road Research Board Conference Proc Vol. 9 No. 4
1979 pp 247-259 Item 9 Tab. 9 Ref.

This paper was presented at Session 20 - Pavement design 2.
Data on current bituminous hot mix primary compaction practice in Victoria indicated that, to give four passes of a light twin tandem steel-wheeled roller to a layer, the time elapsing between laydown and completion of the operation would be at least nine minutes. This time could be reduced to seven minutes if a heavier compactor with a greater rollwidth is used. Calculation using an improved heat transfer model showed that, for layers less than 50 mm thick laid in cool or cold weather, the layer can cool to below the temperature at which compaction is effective before the primary compaction operation can be completed. Rate of cooling is influenced by layer thickness (most important factor), laydown and substrate temperatures, layer conductivity and wind speed. An equation is given for calculating the (approximate) time required for a layer to cool to a nominated compaction cessation temperature in terms of these five factors. An indication is also given of substrate temperatures below which layers of asphalt of different nominal thickness and laydown temperature should not be laid. This applies only to fine, cool and cold weather conditions and substrate temperatures for those conditions at any locality in Victoria can be approximately estimated from monthly mean maximum air temperature (MMAT) data. /TRRL/ Proceedings from Ninth Australian Road Research Board Conference, Brisbane, 21-25 August 1978.

Descriptors: Asphalt; Bituminous Paving Mixtures; Compaction; Compaction Equipment; Compactors; Construction; Cooling; Hot in Mix Paving Mixtures; Layers; Pavement Construction; Pavement Design; Rollers; Temperature

303435 DA

INSTALLATION OF A DIESEL-ORGANIC RANKINE COMPOUND ENGINE IN A CLASS 8 TRUCK FOR A SINGLE-VEHICLE TEST

Doyle, E; Dinanno, L; Kramer, S
Society of Automotive Engineers
Society of Automotive Engineers Preprints Jun 1979 p. 7 Ref.

Report No: SAE 790646
Subfile: EIT: HRIS
Available From: Engineering Societies Library 345 East 47th Street New York New York 10017

A class 8 truck has been equipped with a diesel-organic Rankine compound engine in preparation for a 1-year test program. The compound engine consists of an organic Rankine bottoming cycle system directly coupled to a Mack diesel engine from which it recovers the waste heat in the exhaust gases. The components of the bottoming cycle system are described, and their installations in three pre-assembled modules -- a power conversion package, a vapor generator, and a cooling system -- are discussed. Plans for the 1-year test program, including baseline performance tests on the compound engine, chassis dynamometer tests, noise tests, and over-the-road fuel economy measurements, are also outlined. From the SAE Meeting June 11-15, 1979.

Descriptors: Cooling; Diesel Bottoming Engines; Diesel Engines; Diesel Organic Rankine Compound Engine; Dynamometers; Experimental Safety Vehicles; Fuel Consumption; Noise Levels; Performance Tests; Power Systems; Rankine Cycle Energy Recovery Systems; Rankine Engine; Testing; Trucks; Vehicle Characteristics; Waste Heat Utilization

303387 DA

ELECTRIC COOLING FAN WITH HIGH RAM AIRFLOW -- A FUEL ECONOMY IMPROVEMENT

Laise, TK; Mellin, RC; Pryjmak, BI; Longhouse, RE (General Motors Corporation)
Society of Automotive Engineers
Society of Automotive Engineers Preprints Jun 1979 p. 4 Ref.

Report No: SAE 790722
Subfile: EIT: HRIS
Available From: Engineering Societies Library 345 East 47th Street New York New York 10017

The 1980 front-wheel-drive-car engine cooling system is designed to aid in maximizing fuel economy. An electrically driven fan was selected to provide airflow to meet the above objective. Several other design objectives such as light weight and low noise level are also very well satisfied by the electric fan. This paper describes the strategy and techniques used to meet the fuel economy improvement goal while still providing acceptable engine cooling and the airflow required for adequate air conditioning condensing. This strategy consisted of maximizing ram airflow via methods of wind tunnel, flowmeter and on road development. The heat exchangers where then sized to perform adequately with only ram airflow in a road load condition. Finally the additional airflow required at idle and at high heat rejection points was determined. A high peak efficiency fan was selected to provide the airflow needed when operating near its maximum efficiency. From the SAE Meeting June 11-15, 1979.

Descriptors: Air Flow; Automobile Engines; Automotive Engineering; Cooling; Electric Drive; Fans; Front Wheel Drive; Fuel Consumption; Fuel Economy; Heat Exchange; Noise Levels; Strategy; Vehicle Characteristics; Wind Tunnels
DIALOG File 63: TRIS - 70-92/Jul

302884 DA

TAR AND ITS TREATMENT
Refrigal, S
SUBFILE: TRRL; IRRD; HRIS

This paper was presented to the Conference on Bituminous Binders and Materials, Paris, 3 March 1977. At the present time, only coal tars derived from the combustion of fat coal at about 1200 deg C exist in France, and their production reached 45000 t/yr. In 1970, world production has risen to 16 million tonnes. Tar is fractionated using the normal technique of vacuum distillation or by introduction of steam and expansion. At the base of the column, pitch is collected, cooling at 70-80 deg C, and this represents about 50% of the initial raw tar. The pitch is used for caking oil filters, the manufacture of road binders - representing 20% of the raw tar - the manufacture of pitch for electrodes as well as for paints. From bottom to the top of the distillation column are collected successively - base oil distilling between 420 and 480 deg C; chrysene oil distilling between 360 and 420 deg C, used in manufacturing road binders and as a base for carbon black; anthracene oil between 300 and 350 deg C giving the anthracene base to synthetic colorants; -acenaphthene oil between 225 and 300 deg C; - phenolic oil between 160 and 200 deg C (containing principally phenols as well as pyridic bases - polylene pyridines - and indene. After extraction of phenols and pyridic bases, this oil is used as flux oil for bituminous binders); - light oil at 80-140 deg C. TRRL/DESCRIPTORS: TAR; BINDER; BITUMINOUS MATERIALS AND MIXES; COAL TARS; CONFERENCE; DISTILLATION; DISTILLATION / REFINING PROCESS/; PHENOLS; PITCH / MATERIALS/; TAR; USE; UTILIZATION

265563 DA

PLANNING OF ROAD PROJECTS-EARTHWORKS-BELGIUM
Coene, J; Becco, P; De Beer, E; Doyen, A (Autoroute Association; Roadway Research Centre, Belgium)
Permanent International Association of Road Congr; 43 Avenue du President Wilson; 75-paris 16; France 22 pp 8 Fig. Tabs.
REPORT NO: Book I-3
SUBFILE: HRI

A Belgian System for the computerized study of motorway projects is described which consists of the following characteristics: the employment of a specialized language (similar to the technical vocabulary of the user) for the introduction of the data; the automatic sequencing of the programs in such a way as to carry out a complete study under the supervision of the computer; the automatic administration of card indices, continually kept up to date by the introduction of the data improved by the interpretation of simplified instructions intelligible to a non-specialist user. The system is based on the use of a mathematical pattern to establish a relationship between the dimensions of drains and rainfall statistics, and the setting up of a sub soil survey and site management by means of electronic record and automatic map-making. In regions with silt top soil and a damp, variable climate, the use of the silt which on occasions contains more natural water than the quantity which causes it to reach its limit of liquidity, presents some serious difficulties in embankment construction. Substantial improvements have been effected in such construction by the addition of 2 to 3 percent quicklime to the silts. Embankment construction by hydraulic means in fine, silty sands necessitates the removal of some fines. This requires that grain sizes should be sufficiently graded. In a consideration of the protection against effects of rain and frost, and effort is described to create a thermal barrier between the roadway and the frost susceptible soil. The insulation has been found to be of importance at times of intense cold and its presence can at all times act as a barrier to the rapid cooling of the soil. Observations were made of the water content under surfacings of varied permeability, and the need is indicated to improve methods of measuring permeability. Presented at the XIVth World Road Congress, Prague, Czechoslovakia, 1971.

DESCRIPTORS: COMPUTER APPLICATIONS; COMPUTER PROGRAMS; DRAINAGE; EARTHWORK PLANNING; EMBANKMENTS; FROST PROTECTION; GEOMETRY; HYDRAULIC EQUIPMENT; MATHEMATICAL ANALYSIS; PLANNING ; QUICKLIMES; RAINFALL; SILTS; SITES; SUBSOIL; WATER CONTENT

011771
A form of pavement distress prevalent in Canada and the northern United States. This distress induces a deterioration in pavement performance through spalling, heaving or settling at the cracks and reduces pavement service life. In 1967, a test road, designed and instrumented for the investigation of this problem, was constructed at Ste. Anne, Manitoba. This road incorporated twenty-nine test sections involving a number of different bituminous mix materials, pavement structures and subgrade types, believed to be potentially important in the study of transverse cracking. After five years of service, the following conclusions can be drawn with respect to the relative performance of the test sections: (1) Pavements incorporating high viscosity type asphalts and softer grade asphalts exhibit a greater resistance to transverse cracking. (2) The type of subgrade influences the frequency of transverse cracking. (3) The asphalt content of the mix, in the range of one percent below Marshall optimum to one-half percent above Marshall optimum does not appear to be significant in affecting transverse cracking. (4) A laboratory study was conducted in conjunction with the field programme to investigate the possibility of correlating laboratory predicted fracture temperatures with the actual field performance of the St. Anne test sections. Predicted fracture temperatures were determined by calculating the temperature at which accumulated thermal stresses exceed the tensile strength of the compacted mix. Additionally since the tensile properties of an asphalt binder are proportional to the tensile properties of a mix made with that binder, the possibility of predicting pavement field performance by a knowledge of binder properties alone was investigated. Accumulated thermal stresses of the binders and their mixes were calculated from their respective stiffness moduli at one-half hour loading time (cooling rate) over the appropriate temperature range. Accumulated thermal stress and breaking stress (tensile strength) were plotted as a function of temperature. The predicted fracture temperature is the intercept of these curves. Comparison of the laboratory and field results revealed that there is an excellent correlation between the laboratory predicted fracture temperatures of the binder and mix and the temperature of initial cracking of the asphaltic pavement in the field. For practical purposes, therefore, the tendency of an asphaltic pavement to crack can be predicted by a knowledge of the binder stiffness modulus at low temperatures and long loading time. Conversely, the binder, or mix, stiffness parameter may be used as a pavement design criterion to alleviate the transverse cracking problem. 

These research findings would also imply that it is necessary to be more selective in the use of materials and pavement designs with due consideration being given to their performance under the prevailing climatic conditions. 


descriptors: binders; bituminous materials and mixes; bituminous pavements; correlations; cracking /fracturing; fractures; laboratory studies; low temperatures; pavement design and performance; pavement performance; temperature; test sections; thermal stresses
prints

Prints

13may93 P215: PR 58/5/All (items 1-142)

A BOYLES Model BBS10 skid-mounted diamond drill was then used to penetrate to a total depth of 113 mm diameter core. Details are also given of the method employed. Air flushing was found to be particularly useful in the removal of water, change in density and viscosity of water, change in the dielectric constant, changes in the structure of the double charge of the soil particles, the resulting frost heaves, frost penetration soil which ultimately contribute to the damage of roads. soil moisture can be transported upward through the porous medium of soil upon freezing as: (1). liquid (bulk or film), (2) a vapor or (3) as liquid and vapor. Study of the freezing soil system in its entirety and a performance of the entire system by means of the energy concept is seen to be the most advantageous. The amount of segregated ice in a frozen soil system depends upon the intensity and the rate of freezing. The review of the various concepts used in the soil freezing experiment and the factors with their associated and induced processes consolidates and strengthens the theory on the freezing soil system, and indicates that much frost action research is needed.

Descriptors: dielectric constant; frost action; frost heave; frost penetration; liquid phases; soil freezing; soil moisture; soil science; soils; thermal properties; thermodynamics; vapor phases
PREVENTION AND CONTROL OF SOIL EROSION: THE STATE OF THE ART
Chittenden, DB
Highway Research Board Special Reports N135 pp 129-40 21 Ref
SUBFILE: HRIS

the basic fundamentals contributing to soil erosion are temperature, wind, and water. Weather disrupts rock surfaces through alternate heating and cooling, and ice wedges in the interstices and joints of rock. This prepares the material for transport by wind and water. Water that freezes in surface soil causes heaving and loosens the soil; these processes also prepare it for transport. It is imperative that control measures be developed and implemented that will prevent accelerated soil erosion. Several states have surveyed the soil erosion problem; the survey results should be disseminated to officials responsible for construction and maintenance of roads and to citizens interested in conversation and development of a quality environment.

DESCRIPTORS: EROSION CONTROL; HEAVING; MECHANICS (EARTH MASS); SOIL EROSION; SOIL FREEZING; SOIL PARTICLES; WEATHER

WHAT SUBGRADE INVESTIGATIONS HAVE BEEN SHOWN DURING THE PAST YEAR
Mullins, IB
Highway Research Board Proceedings 1925
SUBFILE: HRIS

DURING THE PAST YEAR RESEARCH WAS CONDUCTED ON THE FOLLOWING PHASES OF THE SUBGRADE PROBLEM AND THIS WORK IS DISCUSSED UNDER THE FOLLOWING HEADINGS: (1) THE RELATIONS OF PENETRATION TO BEARING AREAS, (2) SOME EFFECTS OF TEMPERATURE AND GRANULAR MATERIALS ON SUBGRADE MOISTURE, (3) DETERMINATION OF THE PERCENTAGE OF WATER FROZEN IN SUBGRADE SOILS, (4) THE EFFECT OF GRANULAR MATERIALS IN STABILIZING PLASTIC CLAY UNDER MACADAM PAVEMENTS, (5) THE PRACTICAL FIELD TESTS FOR SUBGRADE SOILS, (6) HEAVING AND FROST BOILS. TESTS WERE CONDUCTED TO DETERMINE WHETHER ANY RELATION EXISTED BETWEEN THE SUPPORTING VALUE OF A SOIL AND THE SIZE OF THE SUPERIMPOSED AREA. IT WAS CONCLUDED THAT THE RELATIVE PENETRATION OF TUBE BEARING BLOCKS ON THE SAME UNIT INTENSITY OF LOAD IS TO EACH OTHER AS THE SQUARE ROOTS OF THEIR RESPECTIVE AREAS. THE SAMPLES TAKEN FROM THE SURFACE OF EXPOSED SOILS AND FROM THE UPPER DEPTHS OF SUBGRADE UNDER PAVEMENTS SHOW THAT THE MAXIMUM MOISTURE CONTENT DURING COLD WEATHER IS USUALLY HIGHER AT THE SURFACE THAN AT THE LOWER DEPTHS. AN EXPERIMENT WAS CONDUCTED TO INVESTIGATE THIS PHENOMENON OF CAPACITY, AND IT WAS FOUND THAT MOISTURE CONTENT IN ROAD SUBGRADE MAY BE INCREASED THROUGH: (1) INCREASED SURFACE TENSION THROUGH LOWER TEMPERATURE, AND (2) CONDENSATION OF VAPORIZED MOISTURE DUE TO LOWERED TEMPERATURE. IT IS BELIEVED THAT THE INTRODUCTION OF SUCH GRANULAR MATERIALS AS SAND, GRAVEL, CINDERS, ETC., INTO THE SUBGRADE NOT ONLY TENDS TOWARD REDUCING THE CAPILLARY TENSION IN THE SUBGRADE SOIL, BUT ALLOWS THE CONDENSED MOISTURE TO BE DEPOSITED ON A SUBGRADE MADE UP OF MATERIALS WHOSE BEARING VALUE IS NOT SO DECREASED BY MOISTURE. THE PERCENTAGE OF WATER FROZEN IN SUBGRADE SOILS WAS INVESTIGATED BY THE DILATOMETER METHOD AND THE PERCENTAGE OF MOISTURE FROZEN WAS MEASURED BY THE EXPANSION OF THE ICE CRYSTALS ON FREEZING. THE SIZE OF THE PARTICLES WAS FOUND TO BE ONE OF THE FACTORS CONTROLLING THE AMOUNT OF WATER FROZEN IN THE SOIL. THE SOIL ITSELF SHRINKS UPON COOLING AND IT IS ONLY THE WATER WHICH CRYSTALLIZES AND SEEMINGLY CAUSES THE SOIL TO EXPAND. SUBGRADE STUDIES SHOW THAT THE FIELD MOISTURE EQUIVALENT TEST SEEMS TO GIVE RESULTS PRACTICALLY IDENTICAL WITH THE STANDARD LABORATORY METHODS. OBSERVATIONS ARE MADE ON THE HEAVE OF CONCRETE PAVEMENTS.

DESCRIPTORS: CAPILLARITY; CLAYS; CONCRETE PAVEMENTS; CONDENSATION; EXTENSOMETERS; FIELD TESTS; FOUNDATIONS (SOILS) FROST BOILS; FROST HEAVE; GRANULAR MATERIALS; MACADAM; MOISTURE CONTENT; PARTICLE SIZE DISTRIBUTION; PAVEMENTS; PLASTIC SOILS; SOIL SAMPLING; SOIL STABILIZATION; SUBGRADE MATERIALS; SUBGRADE MOISTURE; SURFACE TENSION; TEMPERATURE

SOIL STABILIZATION FOR LOW COST ROADS
Livneh, M; Shklarsky, E; Abulafia, B
Israel Ministry of Housing
REPORT NO: No 014-229
SUBFILE: HRIS


DESCRIPTORS: CEMENT CONTENT; COMPACTION EFFORT; FOUNDATIONS (SOILS); LAYERS; LOESS STABILIZATION; LOW COST ROADS; SETTING TIME; SOIL SAMPLING; SOIL CEMENT STABILIZATION; SOIL STABILIZATION; STABILIZED MATERIAL; THICKNESS; THICKNESS DESIGN; UNCONFined COMPRESSION TESTS; WEATHERING; WETTING AND DRYING TESTS
automated diagnostic equipment is needed to provide maintenance information to drivers and mechanics and for instantaneous inspection by regulatory inspection. A computer analysis of on-the-road conditions of 2500 vehicles, showed a wide range of out-of-specification conditions in the vehicles air-fuel ratio, front to rear brake ratio, toe in, ignition timing, and shock absorbers. Diagnostic suggestions proposed to increase the safety of the vehicle include: built-in constant reading tire gauges, cooling system leak check, direct readouts for the amounts of transmission, brake and steering fluids, brake lining detecting devices, a system for quick reading of fuel system integrity, and a light checking device. A typical automatic equipment system would consist of two stations: the first would consist primarily of manual inspection of glass, wipers, seatbelts, horn, headrests, exhaust system, leaks, tire tread, and wheel alignment; the second station would use sensors and data processing equipment to check emissions, engine performance, brake system, drive train, noise, ignition, and electrical systems. The built-in test equipment (bite) system, a program designed by the army to reduce faulty diagnosis and the time to diagnose malfunctions, is discussed. Four advanced scientific tools proposed for evaluating vehicle conditions are described: gas chromatography for indicating leaks in shock absorber and for optic techniques for indicating roughness and scoring of brake drums; pulsed laser holography for inspecting tires, brake hoses and lines; and ultrasonic, infrared, microwave and x-ray techniques for detecting tire flaws. A chronological summary of motor vehicle diagnostic-related legislation is also presented.

Descriptors: AIR FUEL RATIO; AUTOMATIC CONTROL; AUTOMATIC DIAGNOSTIC SYSTEM; BRAKES /FOR ARRESTING MOTION/; COMPUTER APPLICATIONS; DATA PROCESSING; DIAGNOSIS; FUTURE CONCEPTS; HUMAN FACTORS; IGNITION; SHOCK ABSORBERS; TIMING; VEHICLE INSPECTION

217951 DA

TESTS ON THE PROCESSING OF STRAIGHT-RUN COAL AGGREGATES
Ntiefe, H
Beton-u Fertigteilindustrie /Ger/
VOL. 38 NO. 5 1972 p 400
SUBFILE: TRL; HRIS
SMELTING CHAMBER AGGREGATES FROM STRAIGHT-RUN COAL FURNACES HAVE TO BE IN CRYSSTALLINE (RATHER THAN GLASSY) FORM IN ORDER TO ATTAIN PROPERTIES SIMILAR TO THOSE OF NATURAL ROCK. TESTS HAVE SHOWN THAT A PERFECT CRYSTALLINE SLAG IS PRODUCED IF THE COOLING RATE IS 0.1 DEGREE C PER MINUTE. THE PHYSICAL, CHEMICAL AND STRUCTURAL PROPERTIES OF GLASSY AND CRYSTALLINE SLAGS ARE COMPARSED, AND REFERENCE MADE TO THE POSSIBLE USE OF CRYSSTALINE SLAGS IN ROADS IF COSTS ARE REASONABLE. /TRL/
Descriptors: AGGREGATES; COAL; CONCRETE PAVEMENT MAINTENANCE; CONCRETE PILES; MINERAL AGGREGATES; PRODUCTION; PROPERTIES; SLAGS; TESTING

214928 DA

BITUMINOUS ROAD CONSTRUCTION IN WINTER (IN GERMAN)
Loos, H; Paulmann, C
Strassen Und Autobahn /Germany/ 1967
SUBFILE: TRL; IRDR; HRIS
INVESTIGATIONS WERE CARRIED OUT TO ESTABLISH THE EFFECT OF UNFAVORABLE WEATHER CONDITIONS ON THE PRODUCTION, TRANSPORT PLACEMENT AND COMPACTION OF BITUMINOUS MIXTURES. IT IS CONCLUDED THAT BITUMINOUS SUBFACES SHOULD NOT, IN GENERAL, BE LAID IN WINTER, OR ONLY WHEN SPECIAL TECHNICAL MEASURES ARE TAKEN TO PREVENT THE COOLING OF THE BITUMINOUS MIXTURE AS FAR AS POSSIBLE DURING TRANSPORT, PLACEMENT AND DISTRIBUTION, AND TO COMPACT THE MATERIAL AS WELL AND AS CAREFULLY AS POSSIBLE DURING THE TIME AVAILABLE FOR COOLING. COOLING BEING MORE RAPID WITH LOW AIR AND SOIL TEMPERATURES THAN DURING PLACEMENT IN THE WARMER PART OF THE YEAR SO THAT A DURABLE SMOOTH SURFACE IS ENSURED. /FG/TRL/
Descriptors: BITUMINUS MIXTURES; BITUMINOUS SURFACING; COLD (cont. next page)
WEATHER OPERATIONS: COMPACTION: CONSTRUCTION: COOLING:
DURABILITY: HIGHWAY CONSTRUCTION: PLACEMENT: SMOOTHNESS
produces a self-straining set of forces within the concrete,
the reinforcement being in tension to approximately 3,500 ps
while the concrete is in compression. /author/

DESCRIPTORS: ACOUSTICS; CEMENT AND CONCRETE; COMPRESSION;
COOLING: CREEP; HEAT OF HYDRATION; HIGHWAY BRIDGES; HYDRATION
LIMESTONE AGGREGATES; PLASTIC CONCRETE; PORTLAND CEMENT
CONCRETES; REINFORCEMENT; SHRINKAGE TESTS; STRAIN GAGES;
TEMPERATURE MEASUREMENT; TENSION; THERMAL EXPANSION;
VIBRATIONS; WATER CEMENT RATIO

214923 DA
CHANGES IN TEMPERATURE OF BITUMINOUS MIXTURES DURING
CONSTRUCTION /IN GERMAN/
Bossemeyer, HR
Darmstadt Technical University /Ger/
1966 No 17, 95 PP, 21 PHOT, 40 REF
SUBFILE: TRRL; IRRD; HRIS
THE PUBLICATION DEALS WITH THE TEMPERATURE CONDITIONS IN
BITUMINOUS ROAD COURSES AFTER THEY HAVE BEEN PLACED ON THE
SUBBASE. THE AIM IS TO DESCRIBE THE CHANGES IN TEMPERATURE BY
MEANS OF THE PHYSICAL DIMENSIONS VALID FOR HEAT CONDUCTION AND
HEAT TRANSFER. THE TEMPORAL COURSE OF TEMPERATURES IN
BITUMINOUS MIXTURES HAS PREVIOUSLY ONLY BEEN EXAMINED
THEORETICALLY DURING THE TRANSPORTING OF THE MIXTURE FROM THE
MIXING SITE TO THE PLACE OF APPLICATION CONSIDERATION OF THIS
PART OF THE PROBLEM SHOWED THAT COOLING OF THE HOT MIXTURE,
THE THICKNESS OF THE AMOUNT LOADED ONTO THE VEHICLE, AND IN
PARTICULAR BY THE VARIOUS CONDITIONS OF HEAT TRANSFER, THE
PRINCIPAL OF WHICH ARE AIR SPEED AND THE EFFECT OF INSULATING
MATERIALS. STARTING FROM THESE FACTS THE CHANGE IN TEMPERATURE
DURING THE PLACING OF BITUMINOUS MIXURES WAS INVESTIGATED
THE RESULTING INFORMATION WAS PUT INTO A FORM SUITABLE FOR
PRACTICAL USE AND EXPLAINED BY EXAMPLES. /FG/RRL/
DESCRIPTORS: BITUMINOUS CONSTRUCTION; BITUMINOUS MIXTURES;
CHANGES; CONSTRUCTION: HEAT TRANSFER: HIGHWAY CONSTRUCTION:
TEMPERATURE

212646 DA
AN INTERPRETATION OF THE RESULTS FROM VIBRATING-WIRE STRAIN
GAUGES IN FRESH CONCRETES
Tyler, RG
Highway Research Record, Hwy Res Board 1966 No 218, pp 1-17,
19 FIG, 6 TAB, 14 REF
SUBFILE: HRIS
a program of tests concerning creep, shrinkage, and
temperature movements in highway bridges is being conducted by
the bridges section of the design division of the Road
Research Laboratory. This paper describes the interpretation
of the readings from acoustic strain gauges in fresh concrete.
up to the time the heat of hydration is dissipated.
Characteristics of the vibrating-wire gauge are described,
together with the results of two labororatory experiments and
three full-scale site investigations. The results show that
usually expansions take place during the hydration of typical
bridge concretes as used in the United Kingdom. These were
manufactured from normal portland cement having water/cement
ratios in the range 0.38 to 0.40. Also discussed are the
strain changes that occur on cooling during the dissipation of
the heat of hydration in full-scale structures and cracking
caused by differential strains on cooling. The effect of using
a limestone aggregate having a low coefficient of expansion is
shown, and it is demonstrated that cooling after hydration

produces a self-straining set of forces within the concrete,
the reinforcement being in tension to approximately 3,500 ps
while the concrete is in compression. /author/

DESCRIPTORS: ACOUSTICS; CEMENT AND CONCRETE; COMPRESSION;
COOLING: CREEP; HEAT OF HYDRATION; HIGHWAY BRIDGES; HYDRATION
LIMESTONE AGGREGATES; PLASTIC CONCRETE; PORTLAND CEMENT
CONCRETES; REINFORCEMENT; SHRINKAGE TESTS; STRAIN GAGES;
TEMPERATURE MEASUREMENT; TENSION; THERMAL EXPANSION;
VIBRATIONS; WATER CEMENT RATIO

211722 DA
LABORATORY TESTING OF MATERIALS FOR SEALING CRACKS IN
BITUMINOUS CONCRETE PAVEMENTS
Tons, E; Roggeveen, VJ
Highway Res Abstracts Hwy Res Board Sep 1955 Vol 25, No 8,
PP 19-31, 11 FIG, 1 TAB, 1 APP
SUBFILE: HRIS
the experimental work described was part of a program of
research to find a material suitable for sealing narrow
reflection cracks. Its objective was to find sealers that
would merit further testing in the field. First of all,
criteria were established for a satisfactory reflection crack
sealer. These can be outlined as follows: (1) the sealer
should adhere firmly to the crack surfaces of the bituminous
concrete pavement so that it will remain in the opening and
seal it effectively under any conditions. (2) it should resist
the ingress of grit and water to protect the pavement and the
underlying joint from pumping, swelling, ravelling, and
further deterioration. (3) it should be able to withstand
repeated stretching and compression over long periods (years)
without failing in cohesion when placed in a crack which
varies from 0.125 inch (1/8 inch) in summer to 0.325 inch in
winter, an extension of 0.2 inch or about 160 percent. (4) in
hot weather the sealer should neither flow out of the crack
nor change its properties. (5) the sealer may be applied
either hot or cold. If poured hot, the heating process should
not permanently change its sealing properties. At high
temperatures handling should still be safe. (6) the sealer
should be easy to apply into the cracks with either
gravity-feed pouring or simple pumping machinery. (7) minimum
temperature of the crack prior to sealing is desirable. (8) it
should not shrink excessively due to cooling or evaporation of
solvents, so as to eliminate the need for repeated pouring.
(9) the material should be durable and should neither harden
nor soften with age. (10) the sealer should not extrude or
become tacky on its exposed surface during high summer
temperatures to avoid tracking of the material by traffic. (11)
the sealer should not be toxic to either humans or animals. (12) the
compound should not react with asphalt, salt, oil, etc. (13)
if possible, the color should not contrast unduly with the
road surface. (14) it should be reasonably economical. Tests
were selected to meet the requirements outlined. The following
conclusions may be drawn from the laboratory testing reported
herein: (1) none of the materials tested thus far has passed
(cont. next page)
all the tests planned to correspond in severity to the demands put on a sealer in a 1/8-inch reflection crack. The best available materials were not fluid enough to place in such a narrow opening. (2) the physical requirements of a sealer for 1/8-inch reflection cracks are such that an adequate material may be difficult to develop. (3) four sealers passed the 1/4-inch, 150 percent bond ductility tests, and showed satisfactory results in other tests. These sealers give promise, therefore, or performing well in a 1/4-inch wide reflection crack. (4) reflection cracks would have to be widened to 1/4-inch to use these materials.

211412 DA
WEST VIRGINIA TEST ROAD - BITUMINOUS MIXTURES STUDIES
Schaub, UM; Ruth, BE
Southeast Assoc St Huy Officials Nov 1967 pp 97-109, 8 FIG, 3 TAB
SUBFILE: HRIS

TEST ROADS WERE CONSTRUCTED IN WEST VIRGINIA TO PROVIDE FIELD DATA TO SUPPLEMENT LABORATORY STUDIES TO: (1) DEFINE THE EFFECT OF MIXING AND PLACEMENT TEMPERATURES ON THE ENGINEERING PROPERTIES OF HOT-MIX ASPHALTIC CONCRETE AND THE ORIGIN CONCRETE, (2) EVALUATE THE ADEQUACY OF A TENTATIVE DESIGN PROCEDURE FOR HOT-MIXED ASPHALTIC CONCRETE IN WEST VIRGINIA, RELATED STUDIES WERE PERFORMED DURING THE CONSTRUCTION OF THE TEST ROAD TO EVALUATE NUCLEAR DENSITY AND AIR PERMEABILITY CONTROL OF PLACEMENT OF BITUMINOUS MIXTURES, BENKELMAN BEAM DEFINITIONS, CALIBRATION AND AFTER CONSTRUCTION OF THE SURFACING, AND PRELIMINARY STUDIES OF THE EFFECT OF ROLLER PASSES ON COMPACTION OF HOT-MIXED MATERIAL. THE TEST ROAD CONSTRUCTION AND RESULTS OBTAINED ARE BRIEFLY SUMMARIZED. THE PAVEMENT SECTION CONSISTED OF THE FOLLOWING COURSES: (1) 2-IN EXPERIMENTAL WEARING COURSE; (2) 3/4-IN HOT-MASTED ASPHALTIC CONCRETE BOTTOM COURSE OF LIMESTONE; (3) 2-IN HOT-LAB ASPHALTIC CONCRETE BOTTOM COURSE OF LIMESTONE, AND (4) 16-IN CRUSHED STONE BASE. A TYPICAL COOLING CURVE IS PRESENTED WHICH WAS OBTAINED BY THE THERMOCOUPLE MEASUREMENTS OF THE MIXTURE TEMPERATURE AFTER PLACEMENT OF THE DVDING AND ROLLING OPERATION. THIS CURVE ILLUSTRATES THE TYPICAL INCREASE AND THEN DECREASE IN TEMPERATURE THAT OCCURS AT THE TOP RECORDER AND THE GENERAL DECREASE IN TEMPERATURE THAT OCCURS FOR OTHER LEVELS. THE LOSS OF HEAT AT THE MIXTURE SURFACE AND TO THE BASE APPARENTLY KEEPS THE MIDDLE OF THE MIXTURE AT A HIGHER TEMPERATURE THAN THE TEMPERATURES AT THE TOP AND BOTTOM OF THE LAYER THROUGHOUT THE PERIOD OF OBSERVATION. A GYRATORY TESTING MACHINE FOR COMPACTION WAS USED OF THE HOT-MIX TO STIMULATE FIELD COMPACTION. LABORATORY COMPACTION WAS ATTAINED BY THE FIXED-ROLLER EQUIPPED GYRATORY TESTING MACHINE USING A ONE-DEGREE ANGLE OF GYRATION, 100 PSI RAM PRESSURE, AND 30 REVOLUTIONS. TABLES ARE PRESENTED WHICH SHOW THE RESULTS OF CORES TAKEN FROM THE VARIOUS TEST SECTIONS WHICH WERE EVALUATED FOR MEAN DENSITY AND STANDARD DEVIATION. CONTINUOUS OBSERVATION OF THE TEST ROAD PAVEMENT SECTIONS SINCE THEIR CONSTRUCTION APPROXIMATELY THREE YEARS AGO WAS PERFORMED. COMPARISON OF THE AIR FLOW RATE VERSUS AIR CONTENT CURVES FOR THE DIFFERENT MIXTURES SHOWED A CONSIDERABLE VARIATION IN AIR VOID CONTENTS FOR ANY SELECTED FLOW RATE VALUE. IF EXACTING COMPACTION CONTROL IS NOT REQUIRED, IT APPEARS THAT AIR VOID CONTENT MAY BE MAINTAINED WITHIN A RANGE OF 4.0 TO 8.0 PERCENT FOR ALL MIXTURES STUDIED IF A FLOW RATE OF 300 ML./MIN. IS USED AS A FIELD CONTROL CRITERION.

DESCRIPTORS: AIR Voids Content; Asphaltic Concrete; Base Courses; Benkelman Beam; Bituminous Materials and Mixes; Paving; Sand; Temperature
BITUMINOUS MIXTURES: COMPACTION TESTS; CORES; EXPERIMENTAL ROADS; CYRATORY TESTS; HOT MIX PAVING MIXTURES; LABORATORY COMPACTION; LIMESTONE AGGREGATES; MIXING TEMPERATURE; NUCLEAR MOISTURE DENSITY DETERMINATION; PAVEMENT DESIGN; PERMEABILITY PLACING TEMPERATURE; ROAD TESTS; ROLLERS; TEST SECTIONS; THERMOCOUPLES; WEARING COURSE

211313 DA
THE INTERRELATION OF ATMOSPHERIC, BINDER, AND ROAD SURFACE TEMPERATURES
Poland, US
National Roads Board /New Zealand/; /Proc of Reading Symposium 1967
VOL. 11 P 803-39 26 Fig 3 Tab 7 Ref SESSION M
SUBFILE: TRRL; IRRD; HRIS

Temperature measurements have been made covering the following aspects of sealing: (1) relation between air temperature, that of the road and the underlying metal course; (2) cooling of binders on various surfaces; and (3) relation of binder temperature, road surface temperature and chip temperature during sealing operations. The results are presented graphically, and their significance is discussed.

DESCRIPTORS: BINDERS; BITUMINOUS MATERIALS AND MIXES; CHIPS ROAD SURFACES; SEALING; TEMPERATURE

211099 DA
TEMPERATURE CONDITIONS DURING THE PLACEMENT OF BITUMINOUS MIXTURES /IN GERMAN/
Bossemeyer, HR
Bitumen /Germany/ 1967 Vol 29, No 5, PP 133-138, 4 PHOT, 5 REF
SUBFILE: TRRL; IRRD; HRIS

Temperatures in road construction layers from the time of their placement until compaction are studied. This time cannot be calculated unless changes in temperature during the whole construction operation are known. Theories and calculations of heat conduction, and heat transfer in various layers, using a 2.8 cm thick layer of asphaltic concrete as an example, and temperature distribution within a layer and cooling off of layers are discussed.

DESCRIPTORS: BITUMINOUS MATERIALS AND MIXES; BITUMINOUS MIXTURES; COMPACTION; COMPUTATIONS; CONDUCTORS; CONSTRUCTION; CONSTRUCTION OPERATIONS; COOLING; HEAT; HEAT TRANSFER; HIGHWAY CONSTRUCTION; LAYERS; TEMPERATURE; THICKNESS; TIME

197233 DA
DEVELOPMENT STATUS AND EXPERIENCE OF VARTA'S BATTERY SYSTEMS GAINED ON ELECTRIC VEHICLES TESTED IN WEST GERMANY UNDER ACTUAL OPERATING CONDITIONS
Peters, UW (VARTA Batteries Limited, Canada)
Society of Automotive Engineers Preprints 1979 Conf Paper 10 p. 6 Ref
REPORT NO: SAE 790160
SUBFILE: EIT; HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017

This report sums up performance data obtained on lead-acid batteries and accessories especially designed for electric road vehicles. Also it encompasses special technologies such as central electrolyte refilling systems, forced cooling and central venting. Further, it describes VARTA's latest accomplishments for reduced maintenance and improvement in reliability. Another objective is exploitation of improved technologies for motive power batteries for applications such as fork lift trucks. Furthermore, it presents development stage of VARTA'S improved nickel-iron FENOX-battery. From the meeting held 26 February-2 March 1979.

DESCRIPTORS: BATTERIES; ELECTRIC BATTERIES, SECONDARY; ELECTRIC VEHICLES; ELECTROLYTES; GENERAL MATERIALS; LEAD ACID BATTERIES; PERFORMANCE TESTS; STORAGE BATTERY VEHICLES;

(cont. next page)
Auxiliary support systems accomplish the essential purpose of providing an acceptable environment for the locomotive diesel engine necessary to permit reliable operation in temperatures ranging from -40 to 115°F (-40 to 46°C), representing extremes in ambient temperatures and also to be able to accommodate transient temperatures as high as 250°F (121°C) encountered in tunnel operation. The design philosophy guiding the development of these engine support systems has developed over a period of years to provide continuing over-the-road power under the most adverse conditions without damaging or decreasing the long life capability of the engine. The auxiliary system discussed in this paper are lube oil, fuel, air, cooling, and the various protective devices incorporated into the systems which also facilitate rapid detection and correction of indicated faults. The design of these systems has been guided by the considerations imposed by weight, space, reliability, maintainability, and government environmental regulations. Contributed by the Rail Transportation Division of the American Society of Mechanical Engineers for presentation at the Winter Annual Meeting, San Francisco, California, December 10-15, 1978.

DESCRIPTORS: AIR FILTERS; COOLING SYSTEMS; DIESEL ELECTRIC LOCOMOTIVES; DIESEL ENGINE; FIELDS; FILTER MATERIALS; HIGH TEMPERATURE; LOW TEMPERATURE; LUBRICATING OILS; PROPULSION SYSTEMS; PROTECTIVE DEVICES; RELIABILITY
perhaps more ice on the road. Cleaner air would result because sulfur oxides and lead compounds would be absorbed in the condensate. This condensate, if allowed to drip from the cooler-condensers, would freeze onto the road and require a more intense snow removal effort.

DESCRIPTION: AIR POLLUTION; AIR POLLUTION CONTROL; ALASKA; ARCTIC REGIONS; AUTOMOBILE EXHAUST; AUTOMOBILES; CARBON MONOXIDE; COMPARISON; CONDENSERS; COOLING; DESIGN CRITERIA; EQUIPMENT; EXHAUST EMISSION CONTROL; EXHAUST EMISSIONS; EXHAUST GASES; FORECASTING; HEAT EXCHANGERS; HEAT TRANSFER; ICE FOG; LEAD COMPOUNDS; LEAD INORGANIC COMPOUNDS; MOTOR VEHICLES; PARTICLES; PERFORMANCE EVALUATION; SAFETY; SULFUR OXIDES; VEHICLE CHARACTERISTICS; VISIBILITY; WATER VAPOR

186416 DA DESCRIPTION AND STATUS OF NASA-LERC/DOE PHOTOVOLTAIC APPLICATIONS SYSTEMS EXPERIMENTS

Ratajczak, AF National Aeronautics and Space Administration; Lewis Research Center; Cleveland; Washington; Ohio; D.C.; 44135; 20585

REPORT NO: NASA- TM-78936
CONTRACT NO: EX-76-A-29-1022; Contract
SUBFILE: NTIS; RIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

In its role of supporting the DOE Photovoltaic Program, the NASA-Lewis Research Center has designed, fabricated and installed 46 geographically dispersed photovoltaic systems. These systems are powering a refrigerator, highway warning sign, forest lookout towers, remote weather stations, a water chiller at a visitor center, and insect survey traps. Each of these systems is described in terms of load requirements, solar array and battery size, and instrumentation and controls. Operational experience is described and present status is given for each system. The P/V power systems have proven to be highly reliable with almost no problems with modules and very few problems overall. (ERA citation 03:052239) IEEE Photovoltaic Specialists Conference, Washington, D.C., 6 June 1978

DESCRIPTIONS: BATTERIES; DEMONSTRATION PROGRAMS; ELECTRIC BATTERIES; ENERGY AND ENVIRONMENT; ERDA/140501; HYBRID SYSTEMS; LIGHTING SYSTEMS; MODULES; OPERATION; PERFORMANCE; PHOTOVOLTAIC CELLS; POWER SUPPLIES; POWER SYSTEMS; REFRIGERATORS; REMOTE AREAS; ROADS; SOLAR CELL ARRAYS; SOLAR POWER GENERATION; TOWERS; USES; WARNING SIGNS; WATER COOLING; WEATHER STATIONS

185357 DA MEASURES FOR ENSURING THE NORMAL OPERATION OF DIESEL LOCOMOTIVE COOLING SYSTEMS UNDER WINTER OPERATION CONDITIONS

USSR Ministry of Railways; Novo-Basmannaya Ulitsa 2; Moscow B-174; USSR

8 p. 2 Ref. Russian
SUBFILE: RIS
AVAILABLE FROM: Transport Publishing House Basmanenny Tupik, 6a Moscow B-174 USSR

Given are the measures and recommendations developed at TsNII (the All-Union Order of the Red Banner of Labor Scientific Research Institute of Railroad Transport) of the U.S.S.R. Ministry of Railway Transport for the prevention of failures of air-oil cooling systems on paired-unit TE3 diesel locomotives in winter time. Design modifications made on the TE3 diesel locomotive for operating in very low temperatures are described; the principle employed is to raise the temperature of the ambient air around the cooling system by means of mixing cold outside air with air heated in the cooling system and blown by the ventilator. Provided are additional technical requirements developed for the operation of air-oil cooling systems with hydrodynamic and hydrostatic driven fans on 2TE10L and TEP60 diesel locomotives with outside temperatures as low as minus 55 degrees C. Findings from tests on a TE3 diesel locomotive are given; this locomotive is one of a series on which a mechanism is used to reduce rarefaction in the diesel compartment and engine's cab. Full translation available at the Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

SUBFILE: RRIS
AVAILABLE FROM: Transport Publishing House Basmanenny Tupik, 6a Moscow B-174 USSR

(Cont. next page)
THERMAL ANALYSIS OF A TYRE DURING ROLLING OR SLIDING
Yew, Sh; El-Shenbiny, M; Newcomb, TP (Loughborough University of Technology, England)
Elsevier Sequoia SA. Wear Vol. 48 No. 1 May 1978 pp 157-171 12 fig. 1 Tab. 18
Ref:
SUBFILE: TRRL: IRRD: HRIS
A simplified three-dimensional model has been developed to predict the temperature distribution in a tyre during rolling or skidding, allowing the tyre cooling to be calculated for various operating conditions. This is also used to investigate the effects of varying certain parameters and surface temperature measurements during the running of a tyre against a rotating drum. The analysis is also used to indicate present understanding of the mechanisms involved.

DESCRIPTORS: CONTACT (TYRE/ROAD); HEAT; HUMAN FACTORS; MATHEMATICAL MODEL; ROLLING; SLIDING; SURFACING; TEMPERATURE; THERMAL ANALYSIS; THREE DIMENSIONAL; TIRES; TYRE

ESTIMATION OF VEHICLE AERODYNAMIC DRAG
Perings, B; Masaki, M
Aerospace Corporation: 2350 East El Segundo Boulevard; El Segundo; Ann Arbor; California; Michigan; 90245; 48105
Oct 1976 57 pp
REPORT NO: ATTR-77(7389)-1; EPA/460/3-76/025
CONTRACT NO: EPA-68-01-0417; Contract
SUBFILE: NIHIS: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
A simple procedure was developed for the estimation of road vehicle aerodynamic drag based on easily quantifiable vehicle shape parameters. The procedure is applicable to passenger vehicles, station wagons, and vans and is based on a 'drag build-up' method which includes the effects of the basic body shape, underpanning, and cooling drag. Not included are effects of lift, sideward, ground clearance, and certain shape details. The limitations of the procedure are discussed and improvements and areas requiring further study are identified. In a related activity, a brief investigation was made of possible techniques for determining vehicle frontal area from photographs of cars. Planimeter measurements of frontal area were compared with photographs with photographic enlargements of approximately 80 cars. The results of this effort are included as an appendix.

DESCRIPTORS: AERODYNAMIC DRAG; AERODYNAMICS; AIR RESISTANCE AUTOMOBILE BODIES; BIBLIOGRAPHIES; DRAG; DRAG REDUCTION; HUMAN FACTORS; LIFT; MOTOR VEHICLES; STREAMLINING; VEHICLE CHARACTERISTICS; WIND TUNNEL TESTS; WIND TUNNELS

QUARTERLY BULLETIN OF THE DIVISION OF MECHANICAL ENGINEERING AND THE NATIONAL AERONAUTICAL ESTABLISHMENT, OTTAWA, 1 JULY TO 30 SEPTEMBER 1977
National Research Council of Canada; Division of Mechanical Engineering; Ottawa; Ontario K1A ORG; Canada
Sep 1977 74 pp
REPORT NO: OME/NAE-1977(3)
SUBFILE: NTIS; ATRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

DESCRIPTORS: AERODYNAMIC CHARACTERISTICS; AERONAUTICAL ENGINEERING; AERONAUTICS; AIRCRAFT; AUTOMOTIVE ENGINEERING; CONCRETE CONSTRUCTION; COOLING; CURING; DRAG; FUEL CONSUMPTION; HUMAN FACTORS; PERFORMANCE; WEIGHT
ANALYSIS OF ON-ROAD FAILURE DATA

Hatch, W; DeArmon, J
Automation Industries, Incorporated; 14000 Georgia Avenue; Silver Spring, Washington; Maryland; D.C.; 20910; 20590
May 1977 Final Rpt. 47 pp
REPORT NO: DOT-HS-802-360; ASGI-TR-77-36
CONTRACT NO: DOT-HS-6-01388; Contract
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

A statistical analysis of 2300 On-Road-Failure survey responses to define the vehicle systems most frequently responsible for on-road breakdowns of passenger vehicles was conducted. It was found that the fuel system, cooling system, ignition system, starting/charging system and engine were responsible for 64% of the reported on-road failures. Significant differences in system failure distributions between vehicle make/models were also identified.

DESCRIPTORS: BREAKDOWN; CHARGING; CONSUMPTION TABLES; COOLING; SYSTEMS; DISTRICT OF COLUMBIA; ENGINES; FAILURE; FUEL SYSTEMS; HUMAN FACTORS; IGNITION SYSTEMS; MARYLAND; MOTOR VEHICLES; PASSENGER VEHICLES; STARTING; STATISTICAL ANALYSIS; TRAFFIC SAFETY; TRAFFIC SURVEYS; VIRGINIA

INSULATED ROAD STUDY

Penner, E (National Research Council of Canada)
Transportation Research Record N612 pp 80-83 6 Fig. 0 Ref.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The results of a 3-year insulated road study showed that frost penetration inward from the edge of an insulated area is about the same as the downward penetration on a control section. Moisture accumulated in the frost-susceptible subgrade after the frost line penetrated the insulation. During periods of rapid cooling, the temperature of the surface above an insulated pavement may be lowered sufficiently to permit surface icing if atmospheric moisture conditions are suitable. Terminating the insulation without feathering induces abrupt changes in elevation in the roadway as a result of heaving. /Author/ This article appeared in TRB Research Record No. 612, Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification.

DESCRIPTORS: FROST PENETRATION; HEAVING; MOISTURE CONDITIONS; PAVEMENT SUBGRADES; SOIL SCIENCE; THERMAL INSULATION

VEHICLE FUEL ECONOMY: EFFECTS OF AERODYNAMICS AND GEARING

Motor Industry Research Association Watling Street Lindley near Nuneaton Warwickshire England
Feb 1976 Monograph 113 pp Figs. Tabs.
SUBFILE: TRRL; IRRD; HRIS
The five-part report examines the developments in vehicle design aimed at making vehicles more economical. Three of the parts deal with ways of reducing the energy requirement at a given road speed by aerodynamic changes to the body and cooling system, while the other two illustrate the gains in economy obtained by using higher gear-ratios so that the engines operate at more favourable load factors at slower engine speeds and thus have better fuel consumption. The interrelation occurs because changes of gearing should be an integral part of obtaining the maximum benefit from aerodynamic improvements. An example of this is given in the typical engine performance chart which presents typical specific fuel consumption contours for an engine./TRRL/

DESCRIPTORS: AERODYNAMICS; BODY; COOLING; DESIGN (OVERALL DESIGN); ENERGY; FUEL CONSUMPTION; GEARS; HUMAN FACTORS; LOAD FACTORS; OPERATING COSTS; SPEED; TRANSMISSION; VEHICLE DESIGN

MICROWAVE HEATING FOR ROAD MAINTENANCE

Boyko, LL; Lederer, EH; Sawyer, RG
Syracuse University Research Corporation; P.O. Box 26, University Station, Syracuse; Hartford; Springfield; Baltimore; New York; Connecticut; Illinois; Maryland; 13210; 62706 Mar 1976 Final Rpt. 93 pp
REPORT NO: SURC-TR-76-052; FHWA/LSURC-76-052
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

This report describes a two-year program during which a high power microwave generator was designed, fabricated, and tested. The microwave road patch system consists of a microwave power generating system and an associated cooling unit and applicator. This equipment is mounted on a modified 2 1/2-ton dump truck equipped with a hydraulic loader. The theoretical and practical considerations involved in the development and performance of this equipment and in the investigation of the polymer concrete compositions are discussed. Also, a series of field tests was conducted in Syracuse, New York, and in each of the sponsoring states. The system's feasibility for use in repairing bridge decks and pavements was successfully demonstrated, and alternative uses of this equipment are indicated. Sponsored in part by Connecticut Dept. of Transportation; Hartford, Illinois State Dept. of Transportation; Springfield, and Maryland Dept. of Transportation, Baltimore.

DESCRIPTORS: BRIDGE DECKS; CONCRETE PAVEMENTS; CONCRETE POLYMER COMPOSITES; DESIGN; FABRICATION; FIELD TESTS; HIGHWAY (cont. next page)
MAINTENANCE; HIGHWAYS; MAINTENANCE; MAINTENANCE EQUIPMENT; MAINTENANCE; GENERAL; MICROWAVE EQUIPMENT; MICROWAVE HEATING; MICROWAVES; PAVEMENT MAINTENANCE; PERFORMANCE TESTS; POLYMER CONCRETE; POLYMERS; REPAIRS

9000 BTU/HR, GASOLINE-ENGINE-DRIVEN, TYPE I, MOUNTED ON M349A4 REFRIGERATOR SEMITRAILER VAN, 7-1/2 TON

Mohlhenrich, G

Aberdeen Proving Ground MD Material Testing Directorate

Jan 1970 95p

REPORT NO: APG-MT-3371

The temperature history of four small experimental pavements laid adjacent to the full-scale road experiment at Alconbury was studied in detail. The temperature of the pavements was recorded at depths of 20mm, 40mm, 100mm, 200mm and 350mm. There is little major difference in the temperature behaviour of the four constructions. Representative elements of the history of one of the constructions are presented, including temperature variations with depth over 6-6 day periods of uniform hot, warm, and cold weather. Two attempts have been made to predict temperature gradients in the pavements, firstly from theoretical heat-flow considerations and, more empirically, from an assumption that the heating/cooling cycle can be represented by a simple harmonic function of time. The validity and accuracy of these predictions are discussed. The climatological significance of the Alconbury site is briefly considered.

DESCRIPTORS: EXPERIMENTAL PAVEMENTS; HEAT FLOW; PAVEMENT DESIGN AND PERFORMANCE; PREDICTIONS; TEMPERATURE DISTRIBUTION; TEMPERATURE GRADIENT

142112 DA

THE COMPACTION OF BITUMINOUS MATERIALS (PARTS 1 & 2)


Civil Engineering Apr 1976 Serial p 46 10 Fig. 21 Ref.

SUBFILE: TRRL; IRRD; HIRS

The two-part article discusses the importance of compaction to ensure the performance and service life of a bituminous pavement. The mechanical properties which are dependent on the state of compaction include stiffness modulus, fatigue and creep properties. Although bituminous composition and mixing temperatures are specified in the relevant British standards, compaction is, to a large extent, left to the skill of the contractor. Although it is only in rare cases that poor road performance can be attributed to inadequate compaction, it is thought there is a case for giving more specific guidance on the compaction of different types of bituminous mixes. The article reviews compaction costs, the principles of the process and general planning for site operations. It is concluded that there will be a need to develop more economical mixes with improved properties through better compaction. Nomographs are given which relate cooling time with layer thickness, mix temperature and base temperature, and also layer compaction to specified temperatures. /TRRL/

DESCRIPTORS: BITUMINOUS MATERIALS; BITUMINOUS MATERIALS AND MIXES; BITUMINOUS PAVEMENTS; COMPACTION; COMPACTION (STATE OF); COSTS; CREEP (MATER); CREEP PROPERTIES; DURABILITY; FATIGUE (MATER); FATIGUE /MATERIALS/; FLEXIBLE PAVEMENT; LAYERS; MECHANICAL PROPERTIES; PAVEMENT PERFORMANCE SERVICE LIFE; SPECIFICATIONS; STIFFNESS; TEMPERATURE
Federal Germany. The conclusions apply equally to other European countries. Vehicle design changes such as improved aerodynamic shapes or the fitting of spoiler devices can reduce fuel consumption by 5-10 per cent. Reducing engine speed and supercharging can save 10-20 per cent. Other improvements are gained by the use of radial tyres and a more efficient cooling system. Changes in the legal requirements regarding speed and gross vehicle weight could increase economy by about 20 per cent. If all other factors were ignored the author claims that some 35 per cent improvement in fuel consumption alone can be gained by reducing engine speed and power. Adverse effects on national and operating economy make this saving impracticable, but it could be as high as 20 per cent. The diesel engine is regarded as the most efficient for commercial vehicle operation, and its development should be encouraged by economic policies in all countries. /TRRL/

**DESCRIPTORS:** AERODYNAMICS; COMMERCIAL VEHICLES; CONFERENCE; CONSERVATION; DIESEL ENGINE; DIESEL ENGINES; ENERGY; ENERGY CONSERVATION; FREIGHT TRANSPORTATION; FUEL CONSUMPTION; GROSS VEHICLE WEIGHT; HUMAN FACTORS; IMPROVEMENTS; LAWS; LONG DISTANCE TRAFFIC; LORRY; METHODS; MOTOR; RADIAL; RADIAL TIRES REDUCTION; SPEED; SUPERCHARGER; TRAILER; TYRE; UNITED KINGDOM VEHICLE DESIGN; WEIGHT

137462 DA

**CARBON MONOXIDE INTOXICATION AND ISCHAEMIC HEART DISEASES**

Borst, JR

Uitgeversmaatschappij de Tijdstroom BV 11 Balgijnestraat

Lochem Netherlands

1975 88 pp Figs. Tabs. Refs. Dutch

SUBFILE: TRRL; IRRD; HRIS

Carbon monoxide is one of the main causes of cardiac diseases, brain diseases and lung diseases. One of the sources of carbon monoxide is the vehicle. If the exhaust system of the vehicle is defective, the carbon monoxide may come into the interior of the vehicle. Other sources of carbon monoxide are heating apparatus, stoves and the smoke of cigarettes. The exhaust system and heating system in cars must be inspected periodically; in particular in vehicles with air cooled engines carbon monoxide measurements must be made inside the vehicle. /TRRL/

**DESCRIPTORS:** AIR COOLING; BLOOD; CARBON MONOXIDE; CARDIAC DISORDER; CIGARETTE SMOKE; DEFECT (TECH); DEFECTS; DISEASES; ELECTROCARDIOGRAPHY; EXHAUST FUMES; EXHAUST PIPE; EXPERIMENTAL ROADS; HEART; HEATING EQUIPMENT; HIGHWAY SAFETY; HUMAN FACTORS; INTOXICATION; MEASUREMENTS; SAFETY; SMOKING; VEHICLE EXHAUST

134727 DA

**COMMERCIAL ROAD VEHICLE NOISE**

Waters, PE


SUBFILE: HSRI; HRIS

A survey of the characteristics of the noise emitted by commercial vehicles has been made. The most important single parameter determining the noise of a modern diesel-engined vehicle is the engine speed. All of the other parameters such as road speed, engine speed, load, etc., have only a minor effect. It is confirmed by the vehicle modifications reviewed and it is shown that there are two extremes of behaviour, the rolling noise controlled vehicle and the power unit noise controlled vehicle; the engine is currently controlling noise sources. Tyre noise has been investigated in some detail as comparatively little has been published previously on this subject. Empirical relationships between the tyre noise and speed, tyre size and road surface roughness are given. It is concluded that tyre noise is generated by impacting between elements of the tyre tread and elements of the road surface. Modifications have been made to the engine, exhaust, intake and cooling fan of a 5 ton, 6 litre diesel engine truck which have reduced its ISO test noise level from 88 dB(A) to 80 dB(A). However, it is concluded that 80 dB(A) commercial vehicles are not yet feasible for production. In particular, insufficient is known about cooling fan design. Finally cabin noise has been investigated and it has been found that the noise from the same source as the exterior noise, power unit airborne noise. Therefore any modifications to the power unit to reduce exterior noise will have a similar effect on interior noise.

**DESCRIPTORS:** CABS /EXCEPT TAXICABS/; COMMERCIAL VEHICLES; DIESEL ENGINES; ENGINE NOISE; HUMAN FACTORS; NOISE LEVELS; TIRE PAVEMENT INTERFACE; TIRES; TRAFFIC NOISES; VEHICLE SPEED

133557 DA

**THE AIR BAG AS IMPROVEMENT OF THE FUTURE OCCUPANT PROTECTION**

Scholz, H

ATZ - Automobil Technische Zeitschrift N11 Nov 1975 pp 314-319

SUBFILE: HSRI; HRIS

The air bag system described can be regarded as one of the most progressive of its kind. The most important characteristic features are described. Due to the 2-stage arrangement of the co-driver system (Fig. 3), the sound pressure can be kept within tolerable limits (Fig. 15). Its structural features being of advantage as well; the protective office can be excellently adapted to the severity of the accident as well as to the size of the occupant and seating position. Furthermore, the residual combustion gases are non-poisonous and nearly free of particles. As a result of appropriate filtering and cooling of the hot gases which fill the air bag at sufficient speed even at extreme ambient temperatures, the surface temperature of the air bag still remains within acceptable limits. The fully electronic
capable to differentiate exactly between bumps from road irregularities, minor damages and real accidents (Fig. 8). According to its design the release is effected in one or in stages depending on the severity of the accident (Fig. 13). Apart from its releasing function, this sensor also has a controlling function. It ensures that occurring faults within the system are immediately indicated optically. As a result of appropriate development of electric interference factors within the vehicle and high frequency radiation from outside, release errors are practically impossible.

DESCRIPTORS: ACCIDENT SEVERITY; AIR BAGS; ELECTRONIC DEVICES; GASES; HUMAN FACTORS; INFLATABLE DEVICES; OCCUPANT RESTRAINT; SAFETY; SURFACE TEMPERATURE

131832 DA

LIQUID-COOLED DISC BRAKES
Newcomb, TP; E. Esherbiny, M (Loughborough University of Technology, England)

Wear Vol. 34 No. 3 Oct 1975 7 pp 10 Ref.

SUBFILE: HSRI; HRIS

The conventional disc brake can reach very high temperatures that seriously impair the brake performance despite the considerable load of better materials used as friction pairs. Lower temperatures can be obtained by using a fluid to remove much of the heat generated by friction. This paper analyzes the thermal behavior of oil-immersed brakes and discusses the factors that influence the friction surface temperature and performance. Finally, consideration is given to the use of wet brakes in road vehicles.

DESCRIPTORS: DISC BRAKES; FRICTION; HEAT; HUMAN FACTORS; LIQUID COOLING; PERFORMANCE; TEMPERATURE

130262 DA

PROBLEMS OF EVALUATION AND CALCULATION OF THE THERMAL AND FORCE ACTION OF ICE LAYERS ON ARTIFICIAL INSTALLATIONS

Dmitriev, Iu V; Smyshliaev, BN (Institute of Railway Transportation Engineers; Novosibirsk USSR)

User: Proceeding pp 96-109 5 Fig. 11 Ref. Russian REPORT NO: No. 170

SUBFILE: HRIS; RRIS

AVAILABLE FROM: Institute of Railway Transportation Engineers Novosibirsk USSR

The action of ice layers on the condition and operation of artificial constructions can appear in the following aspects: (a) surface coverage of bridges and culverts by ice obstruction of filtering dams leading to a lowering of the water permeable capability of constructions in the spring, as well as the danger of ice escape onto the road and the interruption of traffic; (b) force and mechanical action on the elements of construction in the form of horizontal pressure of the ice during its thermal expansion, vertical pressure (heaving) arising during the development of the hydrostatic pressure of the ice water and the destruction of elements during these ruptures; (c) heat-insulating action on the foundations of constructions in the form of melting or cooling effects leading to the development of general deformations of bridge foundations. The indicated aspects of ice actions to some degree affect the longevity and the reliability of water-permeable constructions and, naturally, must be calculated in the form of special engineering computations and requirements. Abstract only is available in English; original untranslated as of November 1976.

DESCRIPTORS: BRIDGE DESIGN; BRIDGES; CONSTRUCTION PROJECTS; CULVERTS; EMBANKMENTS; FILTER DRAINS; FOUNDATIONS; FOUNDATIONS (SOILS); FREEZING; ICE; ICE PRESSURES; INSTALLATIONS; PERMEABILITY; RIGHT OF WAY; SOIL MECHANICS; SOIL MOISTURE; SOIL SCIENCE; SUBGRADE; THERMAL EXPANSION; THERMAL INSULATION
SUPPLIES: ELECTRIFICATION; HIGH VOLTAGE DC ELECTRIFICATION; MATHEMATICAL MODELS; PROTECTIVE DEVICES; RECTIFIERS; REGENERATIVE BRAKING; SAFETY; SUBSTATIONS; SWITCHGEAR; THYRISTORS; TRACTIVE EFFORT; TRANSFORMERS

DIAL log File B3: TRIS _ 70-92/JUL

PRINTS User: 008102 13may93 P215: PR S8/5/ALL (items 1-142) DIAL og PAGE: 125

Item 100 of 142

127510 DA P A T C H I N G A R O A D W I T H S U L P H U R

Sulphur Institute Journal Vol. 11 No. 2 Jun 1975 pp 2-3 6 Phot.

SUBFILE: HRIS

An experiment was conducted in Boulder City, Nevada using sulfur-asphalt-sand mixture to patch a damaged asphalt pavement. Another base course and fine sand was used in one instance and medium construction sand in another, with mix compositions as follows: (A) asphalt - 6 wt%, sulfur - 17 wt%, and fine sand - 77 wt%; and (B) asphalt - 6 wt%, sulfur - 13.5 wt%, and construction sand - 80.5 wt%. The mixture was shoveled in, smoothed by hoeing and raking to approximate grade, compacted by tamping once with a preheated tamper, and then levelled. After cooling for 6 hours, the road was reopened to traffic. After one year the pavement remains in excellent condition. Another patching experiment with the sulfur-asphalt-sand mixture was conducted in June 1975. A much harder grade of asphalt, AR-6500 grade, was substituted for the AR-2000 grade used in the previous trial. Essentially the same technique as previously was used in placing the patching mixture, except that less compacting was done prior to the levelling. Again the road was reopened to traffic after 6 hours. The performance of these patches is still being observed.


Oeobm, B; Lundgren, N (National Swedish Road & Traffic Research Institute), Engwall and Strahle AG Stockholm-Berglund Stadsbyggnad N1 1974 pp 23-29 7 Fig. 1 Tab. Swedish

SUBFILE: TRRL; IRRD; HRIS

AVAILABLE FROM: National Swedish Road & Traffic Research Institute Drottning Kristinas Vaeg 25 S-11428 Stockholm Sweden

Research and development is in progress to elucidate settlement properties of road embankments constructed in winter. Of the factors governing settlement, subsidence settlement can be influenced by removal of inferior material and vertical drains, and residual settlement by various measures, while deformations due to temperature and moisture are difficult to influence. Field tests comprised examination of borrow pits and embankment subsoil. Compaction of soil is easier, the drier and less cold it is. It must therefore be protected from cooling during excavation, transport, spreading and compaction. As soon as the soil was spread, compaction began. Temperature was continuously measured. Principal object was to find relationship between compaction method and results, and future settlement, under varying conditions. Bulk density determinations were made and embankment surface was monitored by levelling. Settlement in each constructed layer was also determined. Settlement was complete after the second summer season. A formula is proposed for prediction of settlement. Laboratory tests examined the effect of soil temperature and moisture. Requirements to prevent settlement are: 1. low fill moisture content, 2. Removal of large frozen lumps, 3. Protection of fill from cooling before both excavation and compaction, 4. The colder the weather, the thinner the layer or the heavier the vibratory rollers. /TRRL/

DESCRIPTORS: COLD WEATHER OPERATIONS; COMPACTION; CONSTRUCTION; DEFORMATION; EMBANKMENTS; EMBANKMENTS; EQUATION; FROZEN; FROST INDEX; SUBSOIL; TEMPERATURE; METHODS; MOISTURE CONTENT; PREVENTION; SETTLEMENT; SETTLEMENTS; SOIL; SOIL SCIENCE; SUBSOIL; SWEDEN; TEMPERATURE WINTER


SUBFILE: TRRL; IRRD; HRIS

An observation post for studying the behaviour of various road structures and their frost-susceptible subgrade in the presence of freezing-thawing cycles was built in caen, in order to allow laboratory-study observations. Details are given of the installation and of the results of observations made and embankments of the pavement surface caused by frost. Details of the installation, conditions of propagation of the freezing front and the movements of the pavement surface caused by frost. From the point of view of performance of the installation, it was possible to lower the temperature of the road surface to -25.5 degrees; when the temperature of the air inside the shed is -10 degrees, the rate of cooling was estimated to be 10 degrees per day. These performances were considered satisfactory. From the point of view of the use of the measurements made: (1) the existence of a linear relation between frost penetration depth and the square root of the frost index was proved beyond doubt, with breaks corresponding to the pavement/subgrade interface showing the great difference between the thermal characteristics of the pavement and of the subgrade. (2) as regards frost propagation in the subgrade, everything occurred according to the fictitious even temperature of the mass. (3) there exists a linear relation between the square root of the frost index and the square root of the frost index of the surface of the pavement, and the square root of the frost index of the surface of the subgrade. (4) the suction of water due to frost was clearly shown. /TRRL/

DESCRIPTORS: AIR; BELGIUM; COEFFICIENT; CONFERENCE; COOLING DEPTH; EFFICIENCY; FRANCE; FREEZING THAWING CYCLE; FREEZING (cont. next page)
THAWING EFFECTS; FROST; FROST EFFECTS; FROST PENETRATION; INSTALLATION; INSTALLATIONS; MOVEMENT; PAVEMENT; PAVEMENT PERFORMANCE; PENETRATION; SIMULATION; SIMULATIONS; SOIL SCIENCE; SUBGRADE; SUBGRADES; SUCTION; SURFACING; TEMPERATURE WATER

098776 DA

LOCOMOTIVE IN-SERVICE FAILURES/DEFECT ANALYSIS

Smith, SH

Southern Railway System: 99 Spring Street, SW; Atlanta: Georgia: 30303

AVAILABLE FROM: Southern Railway System 99 Spring Street, SW Atlanta Georgia 30303

File name is LOCOMOTIVE FAILURE/DEFECT FILE, CAR MOVEMENT HISTORY FILE. Major objective of computer program is to isolate major causes of locomotive in-service failures. Input consists of: 1. Data on the results of a monthly spectrographic analysis of samples of the cooling water, crank case oil, and air compressor oil from each locomotive. 2. Data on in-service failures (motive power failures which result in either reducing the tonnage of a train or in a train delay.) 3. Diesel shop report on in-service failure giving cause, type to defect, data repaired, etc. 4. Reports of locomotive defects (conditions not causing failure). Monthly output reports include: 1. A raw data tabulation of each failure listing all pertinent data and sorted by locomotive model and within model by cause of failure. 2. A summary of locomotive in-service failures by maintenance points, locomotive model, and failing component for both one month and three-month periods giving number of failures and failures per million miles. 3. Summary of locomotive defects by defective component and by the reporting Road Foremen of Engines. 4. A summary of in-service failures by operating division and by type of service (passenger, freight, or switching). 5. Identification of units which have had repetitive duplicate oil lab findings.

DESCRIPTORS: COBOL; COMPUTER PROGRAMS; DIESEL ENGINE MAINTENANCE; FAILURE INDEXES; IBM 360; IBM 370; INFORMATION SYSTEMS; LOCOMOTIVE COMPONENT ANALYSIS; LOCOMOTIVE RELIABILITY; SPECTROGRAPHIC ANALYSIS

098798 DA

SECTIONS OF ALL-BITUMEN PAVEMENT IN THE LARGEST HIGHWAY IN THE TOWN OF MALMÖ

Byggoferlaget

Byggnadsindustrin N28 1974 pp 30-31 | Fig. 1 Phot. Swedish

SUBFILE: TRRL; IRRD; HRIS

AVAILABLE FROM: National Swedish Road & Traffic Research Institute S-11428 Stockholm Sweden

The largest road construction project so far undertaken in Malmö comprises a 1 km section of all-bitumen (hb) pavement. The cost of this construction is approx. 20% less than that of conventional construction, and owing to the fact that the thickness is about 25% of the conventional one, excavation in embankments and thus road width could be reduced. The all-bitumen section comprises lime-stabilised subgrades where the thickness of pavement is 20 cm, and sections without lime stabilisation where thickness is 35 cm. Bituminous gravel (bg) on the sections without stabilisation has been laid by a spreader in 5-10 cm courses, while on the stabilised sections the whole thickness has been spread in one course by bulldozer. Although the surface is somewhat uneven as a result, better compaction is possible due to slower cooling of the thick layer of bituminous gravel. /TRRL/ DESCRIPITORS: BITUMEN; BITUMINOUS MATERIALS AND MIXES; BITUMINOUS PAVEMENTS; CONSTRUCTION COSTS; COST; GRAVEL; HIGHWAY; LIME; PAVEMENT CONSTRUCTION; PAVEMENT DESIGN; PAVEMENT MATERIALS AND PERFORMANCE; PAVEMENT LAYERS; PAVEMENT THICKNESS; SPREADERS; STABILIZED BASE COURSES/MATERIALS/; SUBGRADE; SWEDEN; THICKNESS

096774 DA

EMBANKMENTS CONSTRUCTED DURING THE WINTER

Gerbom, B; Lundgren, N (National Swedish Road & Traffic Research Institute)

Svenska Byggnadsreproenorsfoereningen Box 27029 Stockholm Sweden 1973 R&D Rot. 68 pp 19 Fig. 9 Tab. 12 Phot. Refs. Swedish REPORT NO: Report 10

SUBFILE: TRRL; IRRD; HRIS; RRIS

The purpose of this investigation was to determine the factors influencing vertical long-term deformations in earth embankments constructed during the winter. Based on this, it was possible to compare laboratory studies to suggest methods of reducing the settlements. Test embankments were constructed, all with filling material of relatively coarse grained fill with a certain content of rock and stone, a common soil in Sweden. The air temperature was between -26 degrees C and -3 degrees C during the time of construction and the thickness of the embankment layer varied between 30 and 120 cm. The settlements were measured by levelling during the two summers following the construction period. The investigation shows that earth embankments can be constructed satisfactorily during the winter if certain performance criteria are fulfilled. The following points should be considered in order to minimize the settlements: the choice of a soil with a low water content; the removal of cooling of earth masses and minimization of cooling before the compaction is performed; the use of thinner layers or heavier vibrating compactors when the temperature is lower. /TRRL/ DESCRIPITORS: BOULDER CLAY; COLD WEATHER; COLD WEATHER OPERATIONS; COMPACTION; CONSTRUCTION PROJECTS; COOLING; DEFORMATION; EARTH FILLS; EMBANKMENT; EMBANKMENT COMPACTION; EMBANKMENTS; FOUNDATIONS (SOILS); FREEZING; FROST; MOISTURE CONTENT; RIGHT OF WAY; ROAD CONSTRUCTION; SETTLEMENTS; SOIL COMPACTING; TEMPERATURE; THAWING; VIBRATORY COMPACTING EQUIPMENT; WATER CONTENT; WINTER
A PILOT-SCALE STUDY OF SLAG/CALCINED - Bauxite Aggregate of High Polishing Resistance
Sweetman, NB
Transport and Road Research Laboratory Crowthorne Berkshire RG11 6AU England
1974 14 pp Fig. 4 Tab. 6 Phot. 9 Ref.
SUBFILE: TRRL; IRRD; HRIS
AVAILABLE FROM: Transport and Road Research Laboratory Crowthorne Berkshire RG11 6AU England
The Transport and Road Research Laboratory is carrying out research into the manufacture of synthetic aggregates with resistance to polishing by traffic which is higher than that normally achieved by naturally occurring aggregates. Such aggregates are required for the surface treatment of difficult road sites where high resistance to skidding is required and where the polishing action of traffic is intense. This report describes work which has been carried out under contract into the manufacture on a pilot scale of an aggregate using blast-furnace slag as a matrix and containing particles of calcined bauxite. This work has shown that the process is not likely to be commercially viable because it would require rapid mixing of the ingredients at a high temperature followed by rapid cooling, which would be incompatible with the needs of commercial production.

CURRICULUM AND PROGRAMS FOR UPGRAADING AUTOMOBILE DRIVER QUALIFICATIONS TO CLASS ONE
Zagajenko, IL
by Committee of the Union of USSR; State Committee of Professional Technical Education; Moscow; USSR
48 pp Russian
SUBFILE: HRIS
The goal of these programs is to widen the driver's technique, stimulate his interest to broaden his knowledge of automobile theory, of the construction of nationally produced heavy-loaders and cross-country vehicles, of the rules of operation, maintenance, and repair of rolling stock, and of traffic safety. Emphasis is upon the most recent models Kr A3-257, GAS-66, ZIL-131. Theoretical lessons utilize visual aids, machinery, models, charts, films, etc. Practical work, (e.g. rolling stock repair is carried out in auto transport concerns as well as in the classroom. The various sections of the pamphlet delineate qualification requirements for drivers of the first class, foundations of automotive construction, the engine (theory of internal combustion engines, crank-shaft mechanisms, cooling system, lubrication, and gas distribution), the supply system (carburetor and diesel engines), electrical equipment, chassis, and transmission. Further chapters cover the operation, maintenance, and repair of the rolling stock, including the new planning system, economic stimulation of automotive transport, the concept of transport plan, the transportation of cargoes, traffic, and wages. Automobile theory includes the forces acting upon the automobile during traffic, the concept of weight balance, deceleration, stability, and trafficability. The section on traffic rules and traffic safety concerns itself with road signs, signals, special conditions, transportation of passengers and cargoes, railroad crossings, and driver's responsibility in regard to traffic regulations.

(Cont. next page)
This collection of programs contains the qualification requirements, curriculum, theoretical information, and production plan for the training of class three drivers in the comprehensive educational schools, the ministerial and departmental auto school the professional-technical and technical secondary level schools; the national and technical schools in the USSR; the state auto clubs and the technical sport clubs. The course lasts five months. Included are sections on the construction of the automobile (e.g., crank-shaft and gas-distribution mechanisms), oil and lubrication, cooling system, carburetor, electrical equipment, batteries, generator, transmission, braking system); automotive vehicle transport operation and maintenance (e.g., repair, stock transportation of cargoes, drivers' wages, tariffs, dispatcher control); traffic safety (e.g., conditions, road signs, precaution measures, safety requirements for transportation of passengers and cargoes, civil defense, driver's responsibility in regard to transposition of traffic regulations). The final chapter on traffic rules and traffic safety covers the driver's general obligations, road signs, road signals, specialized driving conditions, and finally the driver's own responsibility in regard to transposition of traffic regulations.

**CURRICULUM AND PROGRAMS FOR TRAINING CLASS THREE AUTOMOBILE DRIVERS**

Council of Ministers of the Union of USSR; State Committee on Professional Technical Education; Moscow; USSR
78 pp Russian

SUBFILE: HRIS

This collection of programs contains the qualification requirements, curriculum, theoretical information, and production plan for the training of class three drivers in the comprehensive educational schools, the ministerial and departmental auto school the professional-technical and technical secondary level schools; the national and technical schools in the USSR; the state auto clubs and the technical sport clubs. The course lasts five months. Included are sections on the construction of the automobile (e.g., crank-shaft and gas-distribution mechanisms), oil and lubrication, cooling system, carburetor, electrical equipment, batteries, generator, transmission, braking system); automotive vehicle transport operation and maintenance (e.g., repair, stock transportation of cargoes, drivers' wages, tariffs, dispatcher control); traffic safety (e.g., conditions, road signs, precaution measures, safety requirements for transportation of passengers and cargoes, civil defense, driver's responsibility in regard to transposition of traffic regulations). The final chapter on traffic rules and traffic safety covers the driver's general obligations, road signs, road signals, specialized driving conditions, and finally the driver's own responsibility in regard to transposition of traffic regulations.

**CURRICULUM AND PROGRAMS FOR UPGRADING AUTOMOBILE DRIVER QUALIFICATIONS TO CLASS TWO**

Council of Ministers of the Union of USSR; State Committee on Professional Technical Education; Moscow; USSR
46 pp Russian

SUBFILE: HRIS

These materials are intended to raise the driver's technical level and to broaden his knowledge of the construction of nationally produced diesel engine automobiles, buses, and cargo vehicles, particularly models PAZ-672, LAZ-677, and MAZ-500. Visual aids, machinery, details, models, charts, and films are to be used in conjunction with instruction. The pamphlet includes chapters on the qualification requirements of class two drivers, on the construction and maintenance of automobiles (e.g., engine, cooling and lubricating systems, electrical equipment, transmission, steering mechanism), and on diesel engine automobiles (e.g., general construction and working process, crank-shaft and gas distribution mechanisms). Also covered are the basic types of specialized rolling stock: industrial, agricultural, and construction loads, and dangerous and quickly-spooling cargoes. The section on automotive theory covers forces acting upon the vehicle in traffic (e.g., deacceleration, stability, stress distribution, controllability). The final chapter on traffic rules and traffic safety covers the driver's general obligations, road signs, road signals, specialized driving conditions, and finally the driver's own responsibility in regard to transposition of traffic regulations.

**STANDARDIZATION OF AIR CONDITIONING AND HEATING INSTALLATIONS: UNCONVENTIONAL AIR CONDITIONING SYSTEMS FOR RAILWAY SERVICE**

International Union of Railways; Office for Research and Experiments, Oudeoord 60; Utrecht; Netherlands
Apr 1973 26 pp Figs. Tabs. 4 App.

REPORT NO: B107/RP 3/E

SUBFILE: UIe; HRIS

In the present report 5 different air conditioning systems or cooling units, installed either tentatively in railway vehicles or introduced in other fields of application (road transport, vehicles and aircraft) are described. After a short description concerning the design and operation, each of the various systems is compared with the conventional compressor system and the various advantages and drawbacks are demonstrated. No recommendation is made for the general application in RIC coaches, because none of the systems, when considered in their entirety, are more advantageous than the conventional system. In the appendices added to the report, some of these systems are described in detail. Restrictions on the use of this document are contained in the explanatory material.

**DESCRIPTORS:** AUTOMOBILE ENGINES; AUTOMOTIVE ENGINEERING; DIESEL ENGINES; DRIVER TRAINING; FREIGHT TRANSPORTATION; HUMAN FACTORS; MAINTENANCE; SAFETY; TRAFFIC LAWS; TRAFFIC SAFETY; UNCONVENTIONAL TECHNOLOGY
The thaw of permafrost than at preventing seasonal frost penetration. This report summarizes 18 years of study of experimental roadway cut sections which utilized layers of buried peat in an attempt to reduce or prevent differential settlements. The sections were built in a newly realigned section of the Richardson Highway traversing warm permafrost and located about 66 miles southeast of Fairbanks, Alaska.

In 1986 the Alaska Department of Highways constructed its first insulated roadway section over permafrost in North America at a site near Chitina, and the first insulated airfield runway at Kotzebue. Since that time, six additional roadway sections on permafrost, totalling 3.6 lane-miles, have been insulated by the Alaska Department of Transportation and Public Facilities, along with four additional airport installations. Applications of insulation for frost heave control have been numerous, totalling 11 lane-miles. Materials used for subgrade insulation have been primarily extruded-expanded polystyrene foam (Dow's Styrofoam H41 and UC Foamular) with one installation of polyurethane foam and three of molded polystyrene "beadboard." Evaluations of the long-term performance of these installations have included sampling and testing of the insulations to determine the retained thickness, thermal conductivity, and compressive strength properties. Based on these observations, foamed-in-place polyurethane insulation is not accepted for use as a subgrade insulation by the Department, while extruded polystyrene insulation has demonstrated superior performance and longevity. Molded polystyrene beadboard insulation layers have given acceptable performance, but must be installed at a thickness 30 to 50% greater than the extruded polystyrenes to provide comparable thermal performance. Comparisons were made between measured late summer permafrost thaw depths for insulated airfields, and calculated thaw depths using the "Modified Borggren" calculation method and actual site soil and insulation properties. These comparisons demonstrated that this method of calculation results in calculated thaw depths
slightly greater than the actual values, but provides reasonable values for a conservative design.

DESCRIPTORS: AIRPORT RUNWAYS; ALASKA; COLD REGIONS; COMPRESSIVE STRENGTH; FROST HEAVE; GENERAL MATERIALS; HIGHWAY PAVEMENTS; INSULATION; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERFORMANCE EVALUATION; PERMAFROST; POLYSTYRENE; POLYURETHANE; SUBGRADES; TAMPING; THERMAL CONDUCTIVITY; THICKNESS

488197 DA
DALTON HIGHWAY: CHARACTERIZATION OF FOUNDATION SOILS
Vita, CL; Rooney, JW; Riddle, CH; Acomb, AL
Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701
1984 8Ip
REPORT NO: AK-RD-85-28
SUBFILE: HRIS
AVAILABLE FROM: Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701
This report serves to gather together all known test hole information for foundation soils on the Dalton Highway. In addition, it analyzes this data by statistical methods and characterizes foundation soils to be expected all along the route. It identifies thermal state and frost classification for the soil types, and calculates thaw strain and settlement potential due to permafrost degradation. This report shows that nearly all of the foundation soils along the route are in permafrost zones, most of it ice rich, with a potentially high settlement if thawed. Only a few short sections of river bottom and the hill top alignment at miles 95-100 and 105-112 lack permafrost or have any extent of non-frost susceptible soils. Data from this report could be applied toward answering questions on paving of the Dalton Highway. The cold continuous permafrost of the Arctic Foothills and Arctic Coastal Plain Subprovinces should allow paving with no subsequent degradation of the permafrost foundation soils provided the thickness of gravel embankment is sufficient to prevent thawing below the existing permafrost surface. The remainder of the route to the south will require careful analysis and possible strengthening or replacement of foundation soils. Sections of the road having weak base and subbase layers would need rebuilding to obtain thick enough layers of free draining non-frost susceptible material under a pavement. In all cases, route alignment and grades should be improved where needed before any paving is done.

DESCRIPTORS: ALASKA; ARCTIC AREA; EMBANKMENTS; FOUNDATION SOILS; FOUNDATIONS (SOILS); HIGHWAY CONSTRUCTION; PERMAFROST; STRAINS; TAMPING; THICKNESS

488191 DA
WHITE PAINT FOR HIGHWAY THAW SETTLEMENT CONTROL. INTERIM REPORT
Reckard, MK
Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701; Alaska Department of Transp and Public Facilities Pouch Z Juneau Alaska 99811; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590
Mar 1985 34p
REPORT NO: FHWA-AK-RD-85-16
CONTRACT NO: F24572; Contract
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The report discusses the effects of painting roadways over thaw sensitive ground. An experimental program including four test sections on Interior Alaskan roads is described along with the results of two years of settlement and subsurface temperature measurements. The report concludes that the higher albedo of the painted sections resulted in less thaw settlement and lower subsurface temperatures. It is recommended, however, that the technique not be used as a regular road maintenance procedure due to several factors. These include the high cost of painting, the difficulty of pinpointing areas with subsoils favorable to the procedure, and the inability of the paint to reduce heat input through the embankment slopes (an "edge effect"). Road slipperiness was also found to be a major drawback to the technique. The painted sections provided less skid resistance than unpainted pavements; drivers have experienced localized icing such as occurs on bridge decks.

DESCRIPTORS: COLD REGIONS; COSTS; ICING; PAINTING; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENTS; PERFORMANCE EVALUATION; PERMAFROST; PREVENTION; SKID RESISTANCE; SUBSURFACE TEMPERATURE; TEST SECTIONS; TAMPING; WHITE

475440 DA
INSULATION PERFORMANCE BENEATH ROADS AND AIRFIELDS IN ALASKA
Esc, DO
Transportation Research Board
Transportation Research Record N1146 1987 pp 23-27 2 Fig. 4 Tab. 9 Ref.
SUBFILE: HRIS; ATRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2200 Constitution Avenue, NW Washington D.C. 20418
In 1968, the Alaska Department of Highways constructed its first experimental installation of expanded plastic foam for frost heave control at a site 11 mi south of Anchorage. This was followed, in 1969, by construction of both the first insulated roadway section over permafrost in North America at a site near Chitina, and the first insulated airfield runway at Kotzebue. Since that time, six additional roadway sections on permafrost, totaling 3.6 lane-mi, have been insulated by the Alaska Department of Transportation, along with four additional airfield installations. Applications of insulation for frost heave control have been numerous, totaling 11 lane-mi. Materials used for subgrade insulations have been primarily extruded-expanded polystyrene foam (Dow's Styrofoam H1 and UCI Foamular) with one installation of polyurethane foam and three of molded polystyrene beadboard. Evaluations of...
the long-term thermal performance of these installations have included sampling and testing of the insulations to determine the retained thickness, thermal conductivity, and compressive strength properties. Based on these observations, foam-in-place polyurethane insulation is not accepted for use as a subgrade insulation by the Department of Transportation, whereas extruded polystyrene insulation has demonstrated superior performance and longevity. Molded polystyrene beehive insulation layers have given acceptable performance, but must be installed at a thickness 50 percent to 50 percent greater than the extruded polystyrenes to provide comparable thermal performance. Comparisons were made between measured late summer permafrost thaw depths for installed airfield bases and calculated thaw depths using the Modified Berggren calculation method and actual site soil and insulation properties. These comparisons demonstrated that this method of calculation results in calculated thaw depths slightly greater than the actual values, but provides reasonable values for a conservative design. This paper appeared in Transportation Research Record No. 1146, Frost Protection and Insulation for Transportation Facilities.

**DESCRIPTORS:** AIRPORT RUNWAYS; ALASKA; COMPRRESSIVE STRENGTH; DEPTH; DURABILITY; FOUNDATIONS (SOILS); FROST HEAVE; GENERAL MATERIALS; INSULATION; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT MODELS; PAVING PERFORMANCE EVALUATION; PERMAFROST; POLYSTYRENE; POLYURETHANE FOAM; SUBGRADES; THAWING; THERMAL CONDUCTIVITY; THICKNESS

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**464616 DA**

**THAW STABILIZATION OF ROADWAY EMBANKMENTS CONSTRUCTED OVER PERMAFROST. DRAFT FINAL REPORT**

Zarling, JP; Braley, WA

Alaska University, Fairbanks Engineering Research Center, Inst. of Northern Engineering Fairbanks Alaska 99775, Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701, Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

Dec 1986 34p 16 Fig. 8 Tab. 6 Ref. REPORT NO: FHWA-AK-87-20 SUBFILE: HRIS AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The thermal degradation of permafrost beneath Alaskan roads leads to expensive maintenance and repair costs. This project evaluated three methods to stabilize the thaw. Snow covers built along two sections of roadway to shade the ground during the melt season and prevent snow from melting off of the embankment blanket during winter. The second method consisted of removing snow during the winter months to reduce surface temperature. Third, thermosyphon devices were installed along two roadway sections to extract heat over the winter season. The results show that the snow covers were most effective in decreasing the ground surface temperature and, as such, the concept should be further developed.

**DESCRIPTORS:** EFFECTIVENESS; EMBANKMENTS; PERMAFROST REGIONS PREVENTION; SHADING; SNOW REMOVAL; SNOW SHEDS; SOIL SCIENCE; SURFACE TEMPERATURE; THAWING; THERMOSYPHON DEVICES

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**461698 DA**

**ENGINEERING SURVEYS ALONG THE TRANS-ALASKA PIPELINE**

Godfrey, RN; Eaton, RA

Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755; Office of the Chief of Engineers Washington D.C. 20314

Sep 1986 91p 70 Fig. 33 Tab. 4 Ref. REPORT NO: Special Rept. 86-28; DA Proj 44762730AT42 SUBFILE: HRIS AVAILABLE FROM: Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755

During the spring of 1976, environmental engineering investigations along the Alyeska Pipeline Haul Road and TAPS (Trans-Alaska Pipeline System) Road were initiated by CRREL in conjunction with the Federal Highway Administration and the Alaska Department of Highways. The three-year research project had two general objectives: 1) to systematically obtain data on selected highway, airfield and pipeline workpad test sites and adjacent terrain to establish the rate and types of modifications in permafrost-dominated regions, and 2) to provide the basis for improved design criteria and specifications governing road, airfield and workpad construction and restoration in permafrost zones that are influenced by many different seasonal climatic regimes. This report presents the results of 14 test areas not covered in CRREL Report 80-19, "Environmental Engineering and Ecological Baseline Investigations along the Yukon River-Prudhoe Bay Haul Road" (Brown and Berg 1980). The data presented here will be utilized for improving road, workpad and airfield design and construction, and for developing methods of minimizing the impacts on the environment in Alaska. The results show that thaw depths adjacent to the test sites increased each year from 1976 to 1978, causing continued settlement along the embankments. The depths of thaw beneath the gravel surface road and the air thawing index decreased from south to north. Thaw subsidence of the road sideslopes has caused the trafficked surface to become narrower as the sideslopes become wider and flatter. Since the rate of permafrost degradation and resulting thaw settlement has decreased annually, the thermal regime appears to be stabilizing. When the gravel workpads, roadways and runways are graded, any edge berms that would inhibit lateral runoff of water must be removed. Runoff water that ponds on the tundra adjacent to the roadway or workpad or airfield embankment should be avoided to eliminate subsidence caused by heat absorption.

**DESCRIPTORS:** DESIGN CRITERIA; ENVIRONMENTAL ENGINEERING; EXPLORATION CLASSIFICATION (SOILS); FACILITIES DESIGN; MECHANICS (EARTH MASS); PAVEMENT CONSTRUCTION; PERMAFROST REGIONS; RUNOFF; RUNWAYS; SITE SURVEYS; SOIL SCIENCE; SUBSIDENCE; SOIL; THAWING
AIR DUCT SYSTEMS FOR ROADWAY STABILIZATION OVER PERMAFROST AREAS

Zarling, J; Connor, B; Goering, D

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Mar 1984 Final Rpt. 55p

The development of a pavement design evaluation system (PDES), which provides a systematic, consistent, and efficient procedure to evaluate alternative initial designs for paved highways in Alaska on the basis of their total life-cycle costs, is described. The major components of the system include: initial cost of construction, cost of routine maintenance required to keep a pavement serviceable, possible salvage value, and user costs. PDES consists of four subsystems: pavement performance subsystem, cost subsystem, life-cycle cost estimation procedure, and optimization subsystem. Mechanistic procedures tailored to Alaskan conditions and calibrated with empirical data and engineering judgments have been used to predict future physical characteristics of alternative pavement designs. The performance variables for which prediction models are developed are roughness caused by cumulative application of traffic loading, roughness caused by thaw settlement in permafrost regions, fatigue cracking, and major transverse cracking. Uncertainties associated with the prediction of future pavement performance are explicitly considered in PDES to calculate the total expected costs during the specified analysis period and to determine the minimum cost alternative that satisfies desired reliability constraints. As a tool for the designer and decision maker, PDES provides a means of documenting and justifying specific design selections for site-specific projects contemplated for construction in Alaska. This paper appeared in Transportation Research Record N997, Pavement Management Activities.

DESCRIPTORS: CONSTRUCTION COSTS; FORECASTING; HIGHWAY COSTS; HIGHWAY PAVEMENTS; HIGHWAY USER COSTS; LIFE CYCLE COSTING /LCC/; MAINTENANCE COSTS; MAINTENANCE, GENERAL; PAVEMENT CRACKING; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST; ROAD ROUGHNESS; SETTLEMENT /STRUCTURAL/; THAWING; TRAFFIC LOADS

WHITE PAINT FOR HIGHWAY THAW SETTLEMENT CONTROL

Beckard, MK

Alaska Department of Transp and Public Facilities

Research Notes VOL. 4 NO. 7 Jan 1985 2p

The use of white paint to reflect more sunlight measurements of several short painting pavement sections between Fairbanks and Delta, Alaska, show that this does indeed reduce settlement. However, there are some grave drawbacks: the cost of applying
paint, safety (i.e., increase slipperiness and snow sticking and frost forming sooner on the cooler surface), and settlement continuing near unpainted shoulders even though the center of the road is protected.

**General Materials:** Heat; Maintenance, General; Mechanics (Earth Mass); Paints; Pavement Design and Performance; Pavement Maintenance; Permafrost; Reflectivity; Safety; Settlement / Structural; Thawing; White Pigments

387366 DA

**Interaction of Gravel Fills, Surface Drainage and Culverts with Permafrost Terrain**
Brooks V; Brockett, SE; Howe, KE
Cold Regions Research and Engineering Laboratory P.O. Box 282 Hanover New Hampshire 03755; Alaska Department of Transp and Public Facilities Pouch Z Juneau Alaska 99811
Jan 1984 Final Rpt. 4p 13 Fig. 7 Tab. Refs. REPORT NO: AK-RD-84-11
CONTRACT NO: F15631: Contract
SUBFILE: HRIS

During the summers of 1981 and 1982, the thaw regime of gravel roads and the performance of culverts were observed in the Prudhoe Bay and Kuparuk River oilfields, northern Alaska. This relatively flat to gently rolling coastal plain is covered by shallow lakes, drained lake basins and gravel roads up to 2 m thick thaw completely and thawing surface troughs indicate melting of the underlying ice wedges. The permafrost temperature is about -10 deg C. A combination of visual, routine tube readings and temperature measurements were obtained in the roadbed, in an area immediately adjacent to an insulated culvert, and in areas undisturbed by construction. Gravel roads up to 2 m thick thaw completely and thawing penetrates into the consolidated active layer. Where depth of thaw exceeds the thickness of the active layer, ice-rich permafrost begins to thaw. Adjacent to the roads, newly formed surface troughs indicate melting of the underlying ice wedges. Shallow impoundments form on the upslope sides of roads where culverts have not been adequately sited or installed. More standardized practices for culvert placement, installation, and maintenance are desirable to minimize disruption of natural drainage. (Author)

**Descriptors:** Culverts; Fills; Gravel Roads; Hydrology and Hydraulics; Interaction; Permafrost; Soil Science; Surface Drainage; Thawing

376807 DA

**Economic Aspects of High Speed Gravel Roads**
Reckard, M
Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701; Federal Highway Administration P.O. Box 1648 Juneau Alaska 99802
Nov 1982 Final Rpt. 83p
REPORT NO: FHWA-AK-RD-83-20
SUBFILE: HRIS

The report examines the comparative costs of gravel-surfaced and paved roads capable of carrying traffic safely at 55 m.p.h. Gravel surfaces are found to be a practical alternative to asphalt concrete pavement for rural highways in many areas in Alaska. Construction costs are significantly less as a result of the elimination of paving costs and differences in the requirements for embankment material quality and thickness. Maintenance costs are found to favor paved roads where the embankment and original ground conditions are very good, but favor gravel surfaces where these conditions are fair to poor, and especially where permafrost thaw settlement is a maintenance problem. Dust control treatment of gravel-surfaced roads is found to be necessary for providing safe, high speed travel. The expense of such treatment is found to be partially, if not entirely, offset by the resulting reduction in the need for maintenance grading and surfacing gravel replacement. The report recommends that gravel-surfaced roads be given greater consideration in transportation planning for Alaska. It further recommends that the state adopt standard specifications for gravel surface course material, that a regular regraveling program for unpaved highways be initiated, and that Alaskan design limits on road embankment fines content be reexamined where the material is permanently frozen. (FHWA)

**Descriptors:** Alternatives; Asphaltic Concrete; Content; Cost Comparisons; Dust Control; Economic Evaluations; Fines/Materials; Gravel Roads; Ground Conditions; High Speed; Maintenance Costs; Paved Roads; Pavement Design and Performance; Permafrost; Settlement / Structural; Thawing

367043 DA

**Method for Calculation of Frost Heave**
Freden, S
National Swedish Road & Traffic Research Institute Fack 5-581 03 Linkoping Sweden 0347-6049
1981 Monograph 22p 9 Fig. 1 Tab. 23 Ref. SWEDISH REPORT NO: No. 274
SUBFILE: TO RL: IRRD; HRIS

The method presented here makes it possible to calculate the depth of permafrost, frost heave and by that also the water content increase in road constructions. The change of temperature in the road structure is connected to road surface temperature and to a store of heat under the road. This store, which is the stratified heat from the summer period, is described with constant temperature beneath the maximum depth of the permafrost, or as a flow of heat from the subsoil up to the freezing zone. The frost heave properties of the soil are described by frost heave parameters and the heave is a non-linear function of the net heat flow in the freezing zone and the total pressure. The calculation program is in BASIC and PASCAL. In this report calculations of frost depth are compared with measurements in the field. (TRRL)
A BRIEF REVIEW OF FOUNDATION CONSTRUCTION IN THE WESTERN CANADIAN ARCTIC

Thomson, S (Alberta University, Canada) Geological Society
Quarterly Journal of Engineering Geology Vol. 13 No. 2 1980 pp 67-76 Fig. 4 Phot. 12 Ref.

SUBFILE: TRRL; IRRD; HRIS

Problems of design and construction of foundations in permafrost are outlined. If the foundation soil is thawed, normal thermal zone foundation design may be used. If the thawed state is potentially unstable, three possibilities to be considered are: (1) preservation of the permafrost, (2) acceptance of changes in the thermal regime caused by the structure, (3) modification of the foundation conditions prior to construction. Appropriate construction procedures are outlined. Pile foundations, spread footings and highway construction are briefly discussed.

DESCRIPTORS: ARCTIC AREA; CANADA; CONSTRUCTION; CONSTRUCTION PROBLEMS; DESIGN (OVERALL DESIGN); EMBANKMENT; FOUNDATION; FOUNDATION ENGINEERING; FOUNDATIONS (SOILS); FREEZE THAW CYCLE; FREEZING THAWING CYCLE; FROST; FROZEN SOILS; HIGHWAY CONSTRUCTION; LOW COST ROAD; PERMAFROST; PILE; PILE FOUNDATIONS; SHALLOW FOUNDATION; SPREAD FOOTINGS; STABILITY; TEMPERATURE

PAVEMENT DESIGN FOR PERMAFROST CONDITIONS: STRUCTURAL AND THERMAL REQUIREMENTS

Cove Falls, LGC; Haas, R (Research Council of Alberta, Canada; Waterloo University, Canada)
Transportation Research Board
Transportation Research Record N755 1980 pp 30-35 5 Fig. 3 Tab. 13 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The existing Arctic road network is made up almost completely of gravel-surfaced secondary roads for which design, construction, and maintenance procedures are adequate. Proposed reconstruction and paving of the Alaska Highway in the next decade has raised several questions about the adequacy of pavement design technology for permafrost areas. Because of the nature of permafrost terrain the problems of pavement design are twofold: provision of a structurally sound, smooth pavement to allow safe passage of vehicles during critical thaw periods and prevention of thermal degradation of the subgrade and right-of-way. Recent research has concentrated on the evaluation of new materials and design configurations that minimize subgrade thaw settlement. Research into the structural performance of pavements on permafrost has been minimal. Identification of the structural and thermal bases for pavement design in permafrost areas is a key requirement for the development of a design technology that includes economic analysis and evaluation. This paper examines the effects of environment, materials, and loading on the thermal and structural responses of insulated and conventional pavement designs on discontinuous permafrost. The vertical temperature and stress distribution for a range of feasible designs was analyzed by means of two computer programs. Dynamic traffic loading of the structures investigated did not produce excessive subgrade strains. However, the dead load of the structure contributed greatly to thaw consolidation of the subgrade. None of the designs completely prevented subgrade thaw. A trade-off between dead load of the structure and thermal protection of the subgrade was identified. This conclusion provides a new justification for the use of low-density insulating layers in pavements on unstable permafrost. (Author) This paper appeared in Transportation Research Record No. 755 Evaluation and Analysis of Flexible Pavement Components and Properties.

DESCRIPTORS: ARCTIC AREA; ECONOMIC ANALYSIS; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERMAFROST REGIONS; SETTLEMENT/STRUCTURAL/; SOIL MECHANICS; STRUCTURAL DESIGN; SUBGRADE MOISTURE; THAWING; THERMAL CONDITIONS; TRAFFIC LOADS

INSULATING AND LOAD-SUPPORTING PROPERTIES OF SULFUR FOAM FOR EXPEDIENT ROADS IN COLD REGIONS

Smith, N; Pazsint, DA
Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755

4A06212A894 Sep 1979 30 p.

REPORT NO: CRREL-79-18

SUBFILE: NTIS; HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Temperatures of the subgrade and of sulfur foam insulation test sections in an expedient road were monitored with thermocouples to document freezing and thawing conditions. Vehicular trafficking was conducted on a limited basis to determine the load supporting capabilities of the foam. The sulfur foam, placed directly under a prefabricated surface
mat, was found to be unsuitable for use as an expedient thermal insulation and traffic load supporting material primarily because of its low tensile strength and high brittleness. The insulating value of sulfur foam produced by the batch process in the field was about one-half that of extruded polystyrene, meaning double the thickness for equal protection against thaw. (Author)

Descriptors: COLD REGIONS; COLD WEATHER CONSTRUCTION; CONSTRUCTION MATERIALS; FOAM; FOAMS; FOUNDATIONS (SOILS); GENERAL MATERIALS; INSULATION; PAVEMENTS; PERMAFROST; PHYSICAL PROPERTIES; ROADS; RUNWAYS; SUBGRADES; SULFUR; TEMPERATURE; TENSILE STRENGTH; TEST AND EVALUATION; THERMAL INSULATION; TRAFFIC LOADS; TRAFFIC SIGN MATERIALS

237544 DA
FROST ACTION IN ROADS AND AIRFIELDS: A REVIEW OF THE LITERATURE, 1765-1951
Johnson, AL
Highway Research Board Special Reports 1952 No 1, 299 PP, 242 FIG, 79 TAB, 813 REF, 1 APP
SUBFILE: HRIS

The partial differential equation for transient heat conduction is solved by a finite element analog using a quadratic weighting function for the discretized spatial domain. The transient problem is solved by the Crank-Nicolson approximation. Two-dimensional and three-dimensional models incorporated in the same computer program are presented. The finite element method is reviewed, assumptions and limitations upon which the model is based are presented, and a complete

174491 DA
FINITE ELEMENT MODEL OF TRANSIENT HEAT CONDUCTION WITH ISOTHERMAL PHASE CHANGE (TWO AND THREE DIMENSIONAL)
Guymon, GL; Hromadka, TVII
Cold Regions Research and Engineering Lab Hanover N H Nov 1977 167p
REPORT NO: CRREL-SR-77-38
SUBFILE: NTIS

METHODS OF CALCULATING THE THERMAL REGIME FOR THERMAL DESIGN IN PERMAFROST SOILS ARE DISCUSSED, AND A SET OF EXAMPLES PRESENTED TO ILLUSTRATE SOME DESIGN PROCESSES. THE OCCURRENCE OF PERMAFROST IS SCHEMATICALLY SHOWN IN A FIGURE WHERE PERMAFROST IS THAT SOIL WHICH IS NEVER WARMER THAN 32 F DURING THE YEAR. THE ACTIVE LAYER AT THE GROUND SURFACE IS SEASONALLY THAWED AND FROZEN, AND THE SOIL BELOW THE PERMAFROST LAYER HAS VERY LITTLE SEASONAL VARIATION AND IS ABOVE FREEZING. MANY DESIGN PROBLEMS CAN BE PROPERLY SOLVED BY USING RELATIVELY SIMPLE STEADY STATE HEAT FLOW CALCULATIONS. THE GREAT ADVANTAGE TO STEADY STATE ANALYSIS IS THAT SUPERPOSITION CAN BE APPLIED. A USEFUL, ANALYTICAL METHOD USING SUPERPOSITION BY AN EASY GRAPHICAL METHOD IS DESCRIBED. THIS METHOD IS CALLED THE TWO-LANE ROAD CASE BECAUSE HEAT FLOW LINES ARE SEGMENTS OF CIRCLES AND ISOHERMS ARE ODDALLY SPACED RADIAL LINES. TWO SOLUTIONS OF THIS TYPE CAN BE SUPERIMPOSED WHERE THE DIFFERENCE CAUSED BY THE HEATED REGION IS ADDED TO THE ORIGINAL UNIFORM SOIL TEMPERATURE. THE ISOHERMS ARE THEN CONSTRUCTED BY CONTOURING THE MANY INDIVIDUAL POINTS OF EQUAL TEMPERATURE AT INTERSECTIONS OF RADIAL LINES. THIS TYPE OF SOLUTIONS ASSUMES A HOMOGENEOUS SOIL, AND A LAYERED SYSTEM OF SOILS WITH VARIABLE THERMAL CONDUCTIVITY WILL HAVE A DIFFERENT THERMAL REGIME. THE LAYERED CASE CAN BE SOLVED BY SUPERPOSITION, BUT NOT DIRECTLY BY THIS METHOD. ANOTHER STEADY STATE SOLUTION IS THE CASE OF HEATED PIPELINE SUCH AS ONE CARRYING WARM CRUDE OIL. A SOLUTION HAS BEEN ANALYTICALLY SOLVED IN CLOSED FORM. PROBLEMS WHICH REQUIRE A THREE-DIMENSIONAL SOLUTION ARE CONSIDERABLY MORE DIFFICULT TO ANALYZE. AN EXCELLENT ANALYTICAL PROCEDURE WITH MANY APPLICATIONS HAS BEEN DEVELOPED BY LACHENBRUCH, 1958. THIS PROCEDURE ALLOWS A RATHER COMPLETE DETERMINATION OF THE THERMAL REGIME UNDER DISTURBED GROUND SURFACE AREAS OF ANY SHAPE AND IS APPLICABLE TO PROBLEMS ASSOCIATED WITH BUILDINGS, ROADS, AIRFIELDS, LAKES, AND SHORELINES, SEVERAL NUMERICAL TECHNIQUES ARE AVAILABLE FOR SOLVING STEADY STATE PROBLEMS, HOWEVER, ONLY RELAXATION IS DISCUSSED. THE TWO- DIMENSIONAL CASE IS USED AS AN EXAMPLE, AND IT IS SEEN THAT THE THREE DIMENSIONAL CASE IS AS SIMPLE EXTENSION SINCE ROAD CONSTRUCTION INCREASES THE DEPTH OF SEASONAL THAW AND THE VARIATION OF SEASONAL SOIL TEMPERATURE, BOTH OF WHICH INCREASE THE DEPTH OF SEASONAL THAW AND CAN CAUSE PERMAFROST THAWING, THE SOLUTION IS TO APPLY ENOUGH INSULATION BELOW THE ROAD SURFACE TO PREVENT PERMAFROST DEGRADATION.

Descriptors: DESIGN; FOUNDATIONS (SOILS); GRAPHICAL ANALYSIS; HEAT EXCHANGE; HIGHWAY CONSTRUCTION; PERMAFROST; PIPELINES; SOIL SCIENCE; SOIL TEMPERATURE; STEADY STATE; SUPERPOSITION; THERMAL ANALYSIS; THERMAL CONDUCTIVITY; THERMAL INSULATION; THREE DIMENSIONAL
derivation of the system analog is included. Certain problems can only be modeled as a three-dimensional system, e.g. thaw degradation around roadway culverts, embankment dams on permafrost where dam length is short relative to dam width, and thaw and freezeback under buildings. In most cases, however, the more economical two-dimensional model can be used. Numerical tests of both models have been accomplished but field verification has not been attempted. A user's manual and a FORTRAN IV computer listing of the program are presented. (Author)

DESCRIPTORS: COLD REGIONS; COMPUTER PROGRAMS; COMPUTERIZED SIMULATION; CONDUCTION HEAT TRANSFER; DAMS; DEGRADATION; FINITE ELEMENT ANALYSIS; FORTRAN; FROST; HEAT FLUX; MATHEMATICAL MODELS; PARTIAL DIFFERENTIAL EQUATIONS; PERMAFROST; PROGRAMMING MANUALS; ROADS; SOIL MECHANICS; THAWING; THREE DIMENSIONAL; TRANSIENTS; TWO DIMENSIONAL
This article presents an algebraic method for computing the material quantities and the costs for an embankment road section. The symbols used are listed and defined, and a final expression is derived for maximum costs in terms of the three cost functions relating to the two slopes and the complete section. Several diagrams support the mathematical formula.

DESCRIPOTORS: AGGREGATE; CALCULATION; CONSTRUCTION; COST; EMBANKMENT; HIGHWAY; MATHEMATICAL MODEL; QUANTIFICATION OF EARTHWORKS

In two experiments, drivers' ability to identify signs painted on the surface of the road was investigated under simulated conditions employing a model of a road (scale 1:10). Distances to the signs varied between approximately 25 and 45 meters. In Experiment 1 the subjects' task was to identify the letter E and distortions of E. In Experiment 2 the task was to identify digits in speed limits and road numbers as well as to indicate to which category they belonged. A total of 48 drivers, who immediately prior to the experiments had received their driving licenses, participated as subjects. The results supported the following conclusions: 1) The letter E can be identified at a distance of 40 meters or more, given that the horizontal bar is not thicker than normally; 2) Increasing its height above 2.5 meters has a slight effect; 3) Compensation for reduction of the angle of view by distorting the form is probably not effective; 4) White speed limits are somewhat better than the standard colors; 5) A frame surrounding a road number has slight or no effect; and 6) Ease of identification of sign on the road surface varies greatly with how much detail different symbols contain.

DESCRIPOTORS: CARRIAGEWAY MARKING; COLOUR; COMPREHENSION; DESIGN (OVERALL DESIGN); LABORATORY (NOT AN ORGANIZATION); LETTERING; PERCEPTION; SYMBOL; TEST

The recognition value of 25 symbols developed by the International Standard Organization for controls and displays in road vehicles was investigated using 125 subjects (75 males, 50 females) with more than one year of driving experience. The study demonstrated the high recognition value of 20 of the 25 symbols which, in general, is not influenced by sex or additional military driving experience. The five symbols which failed the acceptance criterion of a minimum 75% recognition are: LIGHTER, CHOKE, MASTER LIGHTING SWITCH, REAR FOG LIGHT, AND FRONT FOG LIGHT. It is assumed that the symbol for LIGHTER is of less importance and will be recognized after its initial use. Discrimination between FRONT FOG LIGHT and REAR FOG LIGHT can be improved by rotating the latter symbol 180 degrees. One symbol for FOG LIGHTS would be preferable because under fog conditions both lights will be turned on. The symbol for MASTER LIGHTING SWITCH should be redesigned to avoid confusion with INTERIOR LIGHTING. The symbol for CHOKE should be redesigned, perhaps to replace the pictograph with a verbal label.
Monograph p25-35 6; v14 n 3 p39-41 ( Summer 196 6) REPORT NO: HS-100 093 SUBFILE: HSL AVAILABLE FROM: See serial citation

In the Netherlands a private organization, the ANWB, is responsible for providing road signs. This ensures uniformity of sign design. A brief history of Dutch road signs and an illustrated description of directional and advance direction signs on urban roads, motorways, and traffic circles; touristic route, service, and recreational facility signs; symbols used; and developments in sign lighting are presented.

DESCRIPTOR: DIRECTION SIGNS; NETHERLANDS; RECREATIONAL FACILITY SIGNS; ROUTE SIGNS; SERVICE SIGNS; SIGN DESIGN; SIGN HISTORY; SIGN INSTALLATION; SIGN LEGIBILITY; SIGN LIGHTING; SIGN UNIFORMITY; SIGN VISIBILITY; SYMBOLS; TRAFFIC CIRCLES

525148 DA MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES FOR STREETS AND HIGHWAYS. 1978 ED.


The manual covers standards for all signs, signals, markings, and devices placed on, over, or adjacent to a street or highway by authority of a public body or official having jurisdiction to regulate, warn, or guide traffic. The material includes general provisions, signs (regulatory; warning; guide signs for conventional roads, expressways, and freeways; and signs for civil defense), markings (pavement and curb, object markers, delineation, colored pavements, and barricades and other channelizing devices), signals (traffic controls, warrants for installation, and pedestrian and other highway signals), and islands (design, approach end treatment, illumination, signs, and markings). Separate sections cover traffic controls for construction and maintenance operations, for school areas, for railroad-highway grade crossings, and for bicycle facilities. This edition of the manual incorporates all revisions which have been approved through official rulings, and continues a trend toward broader use of symbols rather than word messages. Prepared in cooperation with the National Advisory Com. on Uniform Traffic Control Devices.

524815 DA DESIGN AND INTERPRETABILITY OF ROAD SIGNS


A clinical study was undertaken to investigate the interpretability of selected European road signs, to determine if stereotypes (preferences) existed for signs, to compare the general characteristics of the European signs with the characteristics embodied in the stereotypes, and to determine if stereotype-based signs enhanced interpretability. In the first phase of the study, subjects wrote the meaning which they thought a sign conveyed, and in the second phase they chose from a list of possible meanings the one meaning which best matched the particular sign being shown. In the third phase, the same subjects from phase two were told the meanings of the signs, and then the signs were presented again and subjects wrote the meaning which they thought the sign conveyed. In the fourth phase, sign meanings were read to subjects, and they designed signs which would convey these meanings; stereotype-based signs were constructed from the results. In the final phase, the interpretability of these signs was determined. It was found that the interpretability of the European signs was partly a function of the method by which it was examined. The mean interpretability score from the first phase was considerably lower than for the second, although the correlation between the two was significant. The European signs were interpreted moderately well on first presentation; The easily-interpreted signs generally were pictorial representations of the sign meanings or were counterparts of American road signs. The signs which were difficult to interpret generally used abstract, unfamiliar symbols or included ambiguous cues. It was found that stereotypes for some road signs exist; the general characteristics found in the stereotypes were the same as those in the easily-interpreted European signs. It is concluded that interpretability is enhanced if signs are stereotype-based but that signs based on stereotypes of only moderate strength (30% to 40%) will not be highly interpretable at all times. It is also concluded that some European road signs could be used efficaciously in the U.S., without prior instruction as to their meaning but that the majority require a minimal degree of familiarization.

521082 DA PERCEPTUAL FACTORS AND MEANINGS OF SYMBOLIC INFORMATION ELEMENTS. VOL. 2. TECHNICAL REPORT


A laboratory evaluation of 108 symbolized and printed message traffic signs representing 19 information situations in which symbols might be effective has been conducted. Measuring sign efficiency by means of flyby and movement variables. Each study situation contained 5 to 15 signs, including, generally, one printed message sign. Thirty-two subjects viewed the signs, and collected data indicated how quickly subjects could identify sign content, how rapidly they could formulate a sign meaning, whether their meaning was (cont. next page)
correct, time required for meaning formulation, and how certain they were that the meaning they supplied was correct. Subjects also ranked signs according to preference. An efficiency index was calculated for each sign based on the summed values of the five variables for that sign. The index permitted a relative comparison of the performance of signs within each message group. Recommendations are made for signs of the following meanings: university, school bus stop ahead, bike lane, no left turn on red, no right turn on red, no turn on red, men working, and information center. Recommendations are also made for the following sign meanings: yield ahead, certain they were that the meaning they supplied was correct, of the following meanings: university, school bus stop ahead, bike lane, no left turn on red, no right turn on red, no turn on red, men working, and information center. Recommendations are also made for the following sign meanings: yield ahead, stop ahead, dip, bump, rough road, base gravel, soft shoulder, truck crossing, flagman ahead, and minimum and maximum speed limits. Usefulness of certainty data in sign efficiency research proved questionable. Meaning latency data reflected the subject's facility for providing logical meanings for the symbols. Study results suggest a set of general symbol signing principles whose use may facilitate optimum sign effectiveness: simplicity, visual contrast, spatial orientation, and dominant elements. Other design considerations are abstract symbolism, physical and temporal orientation, specificity, and message order. Appendices present experimental signs, instructions to subjects, and analysis of variance summaries for mean latency and tachistoscopic data. Final Rept. for 1 May 1977-30 May 1977. Vol. I, Executive Summary, 16 HS-021 099

518529 DA
DRIVER ROAD SIGN INTERACTION
Dewar, Robert E.
University of Calgary, Dept. of Psychology,
HS-017 559, Scientific Conference on Traffic Safet 1974
Monograph y. Proce dings, Ott awa, Canad a, 1974 p2 5-7
REPORT NO: HS-017 563
SUBFILE: HSL
AVAILABLE FROM: In HS-017 559
The complex problem of informing, guiding, and warning the motorist on today's crowded streets and highways is discussed. The major difficulties with current traffic signs are identified: misinformation, missing information, and illegible information. Symbols, either pictographs or abstract designs, are pointed out as perhaps the most widespread example of confusing traffic sign information. It is suggested that near accidents rather than accidents be examined to evaluate traffic signs. The meaning of traffic signs has been shown to be unknown to a large proportion of drivers.

517016 DA
COMMUNICATING TO MOTORISTS WITH ROAD SIGN SYMBOLS
Dewar, R. E.
University of Calgary, Psychology Dept. Alta.
1973 9p
REPORT NO: HS-017 063
SUBFILE: HSL
AVAILABLE FROM: Reference copy only
A study was conducted to determine the extent to which the slash might obscure the symbol of the maneuver being prohibited on traffic signs making use of a slash and a slash. It was divided into two experiments. In the first experiment, 34 (17 male and 17 female) paid volunteer university students, with a mean age of 19.5 years, were presented 60 slides of traffic signs, each for 1/25 of a second. The slides were of 15 different prohibitive symbols and each one was shown under the following conditions: red circle; red circle with a partial slash; red circle with a slash on top of the symbol; and a red circle with a slash under the symbol. All stimuli were presented by a projection tachistoscope and the background on the screen was visual noise consisting of colored wavy lines. Subjects sat 9 feet from the screen and the projector was 6 feet behind them. Stimuli were presented one at a time in a random order and the subject was required to match the stimulus with drawings of 16 symbols on a board in front of him. Performance was found to be best with no slash and worst with the symbol on top of the slash. There was no sex difference. Evidence strongly suggested that the presence of a slash significantly reduced the glance legibility of a symbol. In the second experiment, 13 male and 13 female volunteers with a mean age of 21.2 years were used as subjects. The procedure involved essentially the same experiment as in the first experiment with the following exceptions: subjects sat 33 feet from the screen and the projector was 6 feet behind them. Stimuli were presented one at a time in a random order and the subject was required to match the stimulus with drawings of 16 symbols on a board in front of him. Performance was found to be best with no slash and worst with the symbol on top of the slash. There was no sex difference. Evidence strongly suggested that the presence of a slash significantly reduced the glance legibility of a symbol. In the second experiment, 13 male and 13 female volunteers with a mean age of 21.2 years were used as subjects. The procedure involved essentially the same experiment as in the first experiment with the following exceptions: subjects sat 33 feet from the screen and the projector was 6 feet behind them. Stimuli were presented one at a time in a random order and the subject was required to match the stimulus with drawings of 16 symbols on a board in front of him. Performance was found to be best with no slash and worst with the symbol on top of the slash. There was no sex difference. Evidence strongly suggested that the presence of a slash significantly reduced the glance legibility of a symbol. In the second experiment, 13 male and 13 female volunteers with a mean age of 21.2 years were used as subjects.

515399 DA
SYMBOL STUDY--1972 (ROAD SIGNS)
Heard, E. A.
International Organization for Standardization, Geneva, Switzerland
1974 22p Brefs
REPORT NO: SAE-740304; HS-015 665
SUBFILE: HSL
AVAILABLE FROM: SAE
The International Organization for Standardization, Technical Committee 22, Subcommittee 13, Working Group 5 was given the task of determining which symbols should be proposed for standardization for 15 controls, indicators, and telltale. A test was devised in which three different symbols for each given control, indicator, or telltale could be appraised by licensed drivers in a simulated driving situation. Data from 2593 licensed drivers from France. Germany, the United Kingdom, and the United States were obtained and statistically treated. The procedures and results are reported. On the basis of these results, symbols for 12 controls, indicators, and telltales were proposed as standards. Presented at the Automotive Engineering Congress, Detroit, MI Feb 1-3 Mar 1974.
DESCRIPTORS: FRANCE; GERMANY; INTERNATIONAL SIGNS; SEX FACTORS; SIGN UNIFORMITY; STANDARDIZATION; STATISTICAL (cont. next page)
DIGITAL COMPUTER
1970 35p
REPORT NO: HS-015 770
SUBFILE: HSL
AVAILABLE FROM: NTIS

Applications of the digital computer are examined as part of the Urban Traffic Control System (UTCS) project. Historical background is provided for twentieth century traffic control methods, followed by approaches to improving transportation network flow. In the UTCS system on-street vehicle detectors and a centrally located digital computer regulate traffic control devices within the controlled area, with reliability and cost effectiveness sufficient enough to allow future modification and expansion. The computer has a 69,000 word main magnetic core memory featuring one-microsecond random access. The map display gives the operator real-time information about the system through illuminated symbols superimposed on a map of the UTCS area. The operator can control the kind of information displayed to suit his needs. Prepared for the Bureau of Public Roads, Federal Hwy. Administration.

DESCRIPTORS: BENEFIT COST ANALYSIS; COMPUTERIZED DESIGN; DIGITAL COMPUTERS; GRAPHIC TECHNIQUES; GRAPHS; MAGNETIC LOOP DETECTORS; MAGNETIC TAPES; PHOTOGRAPHS; RELIABILITY; REMOTE CONTROLLED SIGNALS; TRAFFIC CONTROL DEVICES; TRAFFIC FLOW; VEHICLE DETECTORS

INTERSECTION DIRECTION SIGNS--THE EFFECTS OF DESIGN UPON VISUAL PERFORMANCE
Freeman, K. D.; Hills, B. L.; Goldsmith, J. P.
Victoria Country Roads Board, Kew (Australia)
REPORT NO: Paper-944; HS-014 354
SUBFILE: HSL
AVAILABLE FROM: See publication

A series of experiments are reported in which several designs for intersection direction signs having a white legend and border on a black background were examined to determine the relative ease with which drivers could identify the direction to which they point. The designs consisted of signs with either square or pointed ends, containing arrows, chevrons, or other pointer symbols. It was found that for identification of the direction indicated (left or right), signs with pointed ends gave markedly greater recognition distance values than those with square ends, regardless of the pointer symbols used, indicating that the pointed outline of the sign border is a valuable direction indicator in itself. The 70-degree chevron was the best pointer symbol for distinguishing the direction indicated and for indentifying the shape of the pointer symbol. Presented at the Australian Road Res. Board 6th Conference, 1972. Includes discussion by R. A. Chapman, and author’s closure.

DESCRIPTORS: ARROWS; CHARACTER RECOGNITION; DESIGN OF EXPERIMENTS; DIRECTION SIGNS; FIELD TESTS; INTERSECTIONS; LABORATORY TESTS; SIGN COLORS; SIGN DESIGN; SIGN EFFECTIVENESS; SIGN SHAPE; SYMBOLS; TRAFFIC INFORMATION SIGNS

INVESTIGATION OF NEW TRAFFIC SIGNS, MARKINGS AND SIGNALS. VOL. 1. LABORATORY EXPERIMENTS AND ROAD TESTS
Markowitz, J.; Dietrich, C. W.
REPORT NO: BBN-1762-1; HS-014 423
CONTRACT NO: FH-11-6929; Contract
SUBFILE: HSL
AVAILABLE FROM: Corporate author

Recommended new traffic signs, markings, and signals are evaluated, based on recognizability and population stereotypes. Twenty newly proposed, experimental signs were laboratory-tested, each a pictographic sign with no legend. It was found that with education, visual response was greater with the pictographs than with standard signs. In simulated driving situations, the experimental signs without legends were more easily recognized by the average drivers than the standard signs, for five of the seven signs tested. Questionnaires were also used to determine population stereotypes, probing the signals’ meaning, its implication for action, and consumer acceptability of type of device. It was shown that people prefer signs with both symbols and letters, and they recognize the need for standardization in traffic control devices. Prepared for Federal Hwy. Administration.

DESCRIPTORS: CHARACTER RECOGNITION; DIAGRAMATIC SIGNS; DRIVER AID SYSTEMS; DRIVER EDUCATION; DRIVER PERFORMANCE; DRIVER VEHICLE ROAD INTERFACES; DRIVING TASKS; INTERNATIONAL SIGNS; PAVEMENT MARKINGS; PEDESTRIAN EDUCATION; SIGN DESIGN; SIGN EFFECTIVENESS; SIGN LEGIBILITY; SIGN RECOGNITION; SYMBOLS; TRAFFIC CONTROL DEVICES; TRAFFIC SIGNAL MODERNIZATION; TRAFFIC SIGNAL RECOGNITION; TRAFFIC SIGNAL STANDARDS; TRAFFIC SIGNAL UNIFORMITY; WARNING SIGNALS; WARNING SIGNS

INVESTIGATION OF NEW TRAFFIC SIGNS, MARKINGS AND SIGNALS. VOL. 2. DRIVER QUESTIONNAIRE
Jones, G.
1972 207p
REPORT NO: BBN-1762-1; HS-014 424
CONTRACT NO: DOT-FH-11-7960; Contract
SUBFILE: HSL
AVAILABLE FROM: Corporate author

Questionnaire responses to a study of traffic control (cont. next page)
PRINTS User:005102 13may93 P217: PR S14/5/ALL (items 1-99)
DIALOG PAGE: 141 Item 15 of 99

.devices are presented and evaluated. Three areas were assessed: the meaning of the device as a symbol, its implication for driver action, and driver preferences (consumer acceptability) for one control device over another. Surveys were made of driver reaction to warning, regulatory, and construction signs, road markings, highway delineators, and signals. No general, unifying conclusions are reached. Prepared for Federal Hwy. Administration.

DESCRIPTORS: CHARACTER RECOGNITION; CONSTRUCTION SITE SIGNALS; CONSTRUCTION SITE SIGNS; DRIVER AID SYSTEMS; DRIVER ATTITUDES; DRIVER PERFORMANCE; MASSACHUSETTS; PAVEMENT MARKINGS DELINEATORS (TRAFFIC); QUESTIONNAIRES; SIGN RECOGNITION; SIGN VISIBILITY; SIGNAL VISIBILITY; SYMBOLS; TRAFFIC CONTROL DEVICES; TRAFFIC SIGNAL RECOGNITION; VISUAL PERCEPTION; WARNING SIGNALS; WARNING SIGNS

513172 DA
INTERNATIONAL CONFERENCE ON HIGHWAY SIGN SYMBOLOGY.
Pp.8-9 (Jan 1972) Monograph

The expanded use of symbols on U.S. road signs will facilitate driver communication and recognition. In addition, familiarity with symbol signs will help U.S. drivers traveling in other countries as well as foreign visitors in this country. An important change that will be seen as symbols replace some words will be the use of the international red circle and slash as the symbol for no.

DESCRIPTORS: HIGHWAY SIGNS; PAVEMENT MARKINGS; SIGN COLORS; SIGN DESIGN; SIGN EFFECTIVENESS; SIGN LEGIBILITY; SIGN RECOGNITION; SIGN SHAPE; SIGN VISIBILITY; TRAFFIC CONTROL DEVICES; TRAFFIC SIGNS; WARNING SIGNS

510318 DA
LET'S BLACKBALL DANGEROUS DRIVERS!
Gaffney, Warren N. Journal of Insurance Information Monograph

Statistics show that only a minor percentage of accidents are caused by vehicle or roadway defects. The core of the accident problem always has been and still is the driver, and it is only by reaching the mind and curbing the reckless impulses of the individual driver that accidents can be prevented. A plan is proposed wherein all cars would wear either green or red symbols on windshields and rear windows, cars driven by persons convicted of reckless driving being required to wear the red ones. Any motorists sharing the road with a red stickered car would interpret such warning as a signal to drive with extra care, even defensively, until the danger has passed.

DESCRIPTORS: CARELESS DRIVING; COLOR CODING; DEFENSIVE DRIVING; DRIVER IDENTIFICATION; PROBLEM DRIVERS; RECKLESS DRIVING

503009 DA
RECENT CZECHOSLOVAKIAN WORK ON FIGURE LEGIBILITY, COLOR STANDARDS AND ROAD SIGN STANDARDIZATION
Bertone, CM

CZ notation for entire country.

DESCRIPTORS: BACKGROUNDS; CHARACTER RECOGNITION; CZECHOSLOVAKIA; INDUSTRIAL SAFETY; SIGN COLORS; SIGN LEGIBILITY; SIGN STANDARDS; SYMBOLS

502734 DA
COMPARATIVE ACCURACY OF RECOGNIZING AMERICAN AND INTERNATIONAL ROAD SIGNS
Walker, RE; Nicoley, CR
Journal of Applied Psychology Monograph

Hypothesis that symbol road signs (similar to the international signs) could be more accurately recognized than word road signs (typical of the American signs) was supported by this study. Further phase demonstrated the ease with which
the symbol signs were learned and recalled.

DESCRIPTORS: INTERNATIONAL SIGNS; SIGN RECOGNITION; SYMBOLS

496562 DA
A STUDY SERIES ON OFFICE OF TRAFFIC OPERATIONS-SELECTED SIGNING ISSUES. FINAL REPORT
Alcandri, E; Walker, J; Sedney, CA; Roberts, K
Federal Highway Administration Turner Fairbank Hwy Res Ctr., 6300 Georgetown Pike McLean Virginia 22110
Mar 1990 68p
REPORT NO: FHWA-RD-89-222; NCP 353C-0112
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This report details a series of concurrently conducted laboratory studies of the effectiveness of various standard and/or proposed traffic control devices. In comparisons of bicycle symbol designs, lane shift symbol designs, and road closed barricade designs, no model emerged as superior in terms of driver response. Location of a flashing arrow panel relative to the lane channelization split on a three-lane highway, tested in a driving simulation, had no effect on subject behavior; however, presence of tubes extending from the center lane closure delayed subjects crossing from left to center lanes, and resulted in improved lane placement. A one-way design which retains the directional cue when the text is obscured proved equal to the current standard, and may be an improvement under conditions of reduced visibility. The specific arrangement of the elements (i.e., route number, cardinal direction, and directional arrow) of the route shield guide sign appears to affect the speed with which drivers comprehend this information; subjects responded more rapidly to a design with a vertical arrangement of elements separated by horizontal lines, than to the standard route shield. Three of seven motorcycle warning designs (a word sign, and two symbol designs) performed equally in a preliminary evaluation, thus providing a basis for further research.

DESCRIPTORS: BARRICADES; DIRECTIONAL SIGN; EFFECTIVENESS; FLASHING ARROW PANELS; GUIDE SIGNS; LABORATORY TESTS; OPERATIONS AND TRAFFIC FLOW; PERFORMANCE EVALUATION; SIGN LEGEND; SYMBOLS; TRAFFIC CONTROL DEVICES; TRAFFIC SIGNS; TUBES; WARNING SIGNS

496427 DA
TRAFFIC SIGNALLING AND TRAFFIC SAFETY
Schoon, CC
Institute for Road Safety Research SWOV P.O. Box 170 2260 AD Leidschendam Netherlands
1987 43p Dutch
REPORT NO: R-87-12
SUBFILE: HRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Traffic signalling systems are used increasingly to improve road capacity and traffic safety. The report reviews the different systems in different countries, which are used on motorways. The basis of all systems is to stabilize the traffic flow for as long as possible. By an increase of intensity there is generally a decrease of speed. If there is a certain degree of saturation the traffic flow will become unstable, with a greater chance of accidents, and a decreasing capacity. Traffic signalling systems must give information to the driver and to do so he must have certain criteria such as good visibility, good understanding of symbols, good legibility etc. Components of traffic signalling systems are: systems for incident detection; traffic lane signalling; alternative route indicators, warning systems for fog, wind, snow and black ice; and congestion indicators. Beside these traffic signalling systems some traffic control systems, which are more or less linked to the other systems, are discussed. The text in Dutch, summary in English. North American Continent sales only. All others contact Institute for Road Safety Research, S.W.O.V., P.O.B. 170, 2260 AD Leidschendam, the Netherlands.

DESCRIPTORS: HIGHWAY CAPACITY; SAFETY; SAFETY MEASURES; TRAFFIC CONTROL SYSTEMS; TRAFFIC DENSITY; TRAFFIC FLOW; TRAFFIC SAFETY; TRAFFIC SIGN LEGIBILITY; TRAFFIC SIGN VISIBILITY; TRAFFIC SIGNAL NETWORKS; TRAFFIC SIGNALS; WARNING SYSTEMS

495208 DA
PEDESTRIAN SAFETY: DESIGN CONSIDERATIONS ALONG ROADWAYS.
National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Feb 1990 96p
SUBFILE: HRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This bibliography contains citations concerning the enhancement of pedestrian safety along roadways. Coverage includes effects on pedestrian safety of roadways, vehicle traffic and traffic patterns, walkways, crosswalks, footbridges, and sidewalks. The studies include flashing, symbolic, and audible signal designs and signal displays; pedestrian activated signals; and the use of elevated crossings. Evaluation techniques are included for determining pedestrian requirements for safety and the very basic needs are met. (This updated bibliography contains 222 citations, 15 of which are new entries to the previous edition.)

DESCRIPTORS: BIBLIOGRAPHIES; CROSSINGS; CROSSWALK; ELEVATED STRUCTURES; EVALUATION; FACILITIES DESIGN; FLASHING TRAFFIC SIGNAL; FOOT BRIDGES; PEDESTRIAN SAFETY; ROADS; ROADSIDE; ROADSIDE IMPROVEMENTS; ROADSIDE STRUCTURES; SAFETY; SIDEWALKS; SIGNALS; SYMBOLS; TRAFFIC FLOW PATTERN; TRAFFIC SIGN DESIGN; TRAFFIC SIGNALS; TRAFFIC SIGNALS, MANUALLY CONTROLLED; WALKWAYS
Pavement markings are one of the most effective traffic control devices available to the traveling public. They serve to guide, warn, and regulate the motorist in the use of highways and streets during the day and night. For many years traffic paints were the only materials available for pavement markings. Recently, thermoplastic pavement markings or special markings and symbols are providing 5 to 8 years of acceptable service (including reflectivity) when used as long lines on high volume asphalt roadways. Life cycle costs indicate that thermoplastic used in a long line condition is less expensive than paint on high volume asphalt roadways (5,000 to 20,000 ADT). First, currently available long life pavement marking tapes used as special markings or symbols are not performing acceptable due to reflectivity after only two years of service on high volume roadways (5,000 ADT). Second, thermoplastic pavement markings are providing 5 to 8 years of acceptable service (including reflectivity) when used as long lines on high volume asphalt roadways in North Carolina. Third, life-cycle costs indicate that thermoplastic used in a long line condition is less expensive than paint on high volume asphalt roadways (5,000 to 20,000 ADT) and approximately equal in cost to paint on asphalt roads with ADTs over 20,000. Life cycle costs for special markings and symbols shows thermoplastic's life cycle cost is approximately one third that of paint on urban and high volume routes and approximately equal to the cost of paint on low volume routes. These same life cycle costs indicate that the cost of long life tape is 3 to 5 times more expensive than either paint or thermoplastic.

Descriptors: Cost Comparisons; Durability; General Materials; Life Cycle Costing, LCC; Performance; Reflectivity; Thermoplastics; Traffic Marking Materials; Traffic Marking Tapes; Traffic Paints.
DIALOG File 63: TRIS _ 70-82/JUL

AVAILAIBLE FROM: Institute for Road Safety Research SWOV P.O. Box 170 2280 AD Leiden, Netherlands

Traffic signalling systems are used increasingly to improve road capacity and traffic safety. This report reviews the different systems in different countries, which are used on motorways. The basis of all systems is to stabilize the traffic flow for as long as possible; methods of intensity there is generally a decrease of speed. If there is a certain degree of saturation the traffic flow will become unstable, with a greater chance of accidents, and a decreasing capacity. Traffic signalling systems must give information to the driver and do so he must have certain criteria such as good understanding of symbols, good legibility, etc. Components of traffic signalling systems are: systems for incident detection, traffic lane signalling, alternative route indicators, warning systems for fog, wind, snow and black ice, and congestion indicators. Beside these traffic signalling systems some traffic control systems, which are more or less linked to the other systems, are discussed. (TRRL)

DESCRIPTORS: DETECTION; DRIVER INFORMATION; INCIDENTS; OPERATIONS AND TRAFFIC FLOW; SAFETY; TRAFFIC CAPACITY; TRAFFIC CONTROL SYSTEMS; TRAFFIC FLOW; TRAFFIC SAFETY; TRAFFIC SIGNALS; WARNING SYSTEMS

463418 DA

DIAGNOSTIC SYSTEMS FOR ROAD VEHICLES. PART 2 SPECIFICATION FOR GRAPHICAL SYMBOLS FOR DIAGNOSTIC TESTERS

British Standards Institution

British Standard Automobile Series 1986 10p Figs. 6 Ref. REPORT NO: BS AU 206: Part 2 SUBFILE: HRIS; TRRL; IRRD

AVAILABLE FROM: British Standards Institution 2 Park Street London W1A 2BS England

This part of BS AU 206 is identical with ISO 7639-1985 "Road Vehicles - Diagnostic Systems - Graphical Symbols" published by the International Organization for Standardization (ISO). This standard specifies graphical symbols for diagnostic testers: marking of controls, indicators and tell-tales; use for indications on screens and similar variable indicating systems; marking of connections and other input and output openings. (TRRL)

DESCRIPTORS: DIAGNOSTIC TESTING; INTERNATIONAL STANDARDS; MOTOR VEHICLES; SYMBOLS; TESTING EQUIPMENT; VEHICLE CHARACTERISTICS; VEHICLE INSPECTION; VEHICLE TESTING

463212 DA

TOWARDS INTERNATIONAL-FORMAT ROAD SIGNING IN NEW ZEALAND

Forbes, AR Ergonomics Society of Australia and New Zealand P.O. Box 75 Carlton South Victoria Australia 0726-7029 Dec 1985 pp 31-36 2 Fig. 2 Tab. 5 Ref. SUBFILE: HRIS; TRRL; IRRD

AVAILABLE FROM: Ergonomics Society of Australia and New Zealand P.O. Box 75 Carlton South Victoria Australia

Now actively considering a change from its predominantly verbal-format system of road signing to one of the predominantly symbolic international formats, the New Zealand National Roads Board is supporting a series of laboratory and field studies intended to establish which of these achieves the most reliable detectability, the most speedy and accurate recognisability and the greatest degree of comprehensibility. Considerations affecting the design of the research programme in general are described and illustrated with reference to the first two laboratory experiments. Of these, one showed that the international give way, with or without legend, offered greater recognisability than the current New Zealand sign; in contrast, the other showed clearly that the current New Zealand and Australian signs giving warning of pedestrian crossings were more recognisable than that proposed under United Nations convention. Some experimental and operational implications of these findings are discussed. (Author/TRRL From the Proceedings of the 22nd Annual Conference of the Ergonomics Society of Australia and New Zealand entitled, Ergonomics in the Tourist, Agricultural and Mining Industries, General Ergonomics.

DESCRIPTORS: COMPREHENSION; FIELD STUDIES; INTERNATIONAL SYMBOL SIGNS; LABORATORY STUDIES; OPERATIONS AND TRAFFIC FLOW PEDESTRIAN CROSSINGS; RECOGNITION; SYMBOLS; TRAFFIC SIGN (cont. next page)
CONTRAST SENSITIVITY PREDICTS AGE-RELATED DIFFERENCES IN HIGHWAY-SIGN DISCRIMINABILITY

Evans, DW; Ginsburg, AP
SUBFILE: HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017
This study was conducted to determine if contrast sensitivity could predict age-related differences in the ability to discriminate simple road signs, as these differences have not been predicted by Snellen visual acuity. Contrast sensitivity, Snellen visual acuity, and discrimination distances for projected images of highway signs were measured for 7 older observers, ages 55 to 79, and 13 younger observers, ages 19 to 30. All subjects had 20/20 visual acuity or better, but the older group had significantly lower contrast sensitivity than did the younger group at three spatial frequencies: 3, 6, and 12 cycles/deg of visual angle. The older group required a significantly larger sign symbol in order to determine if it denoted a + or - intersection. Correlations between measures showed that highway-sign discrimination was significantly related to contrast sensitivity at two spatial frequencies, 1.5 and 12 cycles/deg, but discrimination distance was not related to visual acuity. Implication for highway-sign design and driver vision standards are discussed. (Author abstract)

DESCRIPTORS: AGE; CONTRAST SENSITIVITY; DISCRIMINATION DISTANCE; DRIVER VISION; HUMAN FACTORS; HUMAN SUBJECT TESTING; OPERATIONS AND TRAFFIC FLOW; STANDARDS; SYMBOLS; TRAFFIC SIGN DESIGN; VISUAL ACUITY

SOURCE BOOK FOR AUSTRALIAN ROADS. THIRD EDITION
Lay, MG
Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0-86910-173-0 1984 Monograph 162p Figs. Tabs. Refs.
SUBFILE: TRRL; ISSD; HRIS
AVAILABLE FROM: Australian Road Research Board P.O. Box 158, Bag 4 Nunawading Victoria 3131 Australia
A preliminary analysis of a survey of drivers' understanding of traffic control devices (TCDs) and associated road rules is reported. Fifty metropolitan and non-metropolitan clusters of six drivers each were selected in each of three States (Victoria, New South Wales (NSW) and South Australia (SA)) to ensure a socio-demographically representative sample, and quotas applied to each sample ensured an adequate number of young drivers and equal numbers of men and women respondents. There were considerable differences between States in the items which were poorly understood, and understanding of the system was more closely related to age than to current driving experience. Understanding of the symbolic component of regulatory signs was better than previous work suggested, although the understanding of the shape-colour code for different types of signs was poorly understood. The meanings of combinations of signal arrows and through signals were well understood, but there was confusion over whether a green arrow was necessary before making turns. Many drivers still believe that the Give Way to the Right rule applies at T-junctions, and there is considerable confusion as to where overtaking on the left is permitted. Published in 12th ARRB Conference Proceedings, Traffic Behaviour.
DESCRIPTORS: ARROW / TRAFFIC CONTROL / AUSTRALIA; COLOR; (cont. next page)
The Baltimore Region Transportation Improvement Program (TIP) documents the anticipated timing, cost, and rationale for transportation improvements to be made in the Baltimore Region over the next three years. It is a program of specific projects, not a plan. In accordance with Federal guidelines, the TIP is a translation of recommendations from the transportation plan for the Baltimore Region (long-range and short-range elements) into a short-term program of improvements such that the TIP establishes a link between plan recommendations and project implementation in the region. The TIP also serves as a multi-modal listing of transportation projects in the region for which expenditures have been programmed between fiscal year 1985-1987. Only projects for which certain Federal funds have been programmed are required to be contained in the TIP, but an attempt is made to include all of the region's transportation projects, not just the ones that receive Federal aid. The integration of the TIP with other transportation plans and programs in the region, its fulfillment of Federal requirements, its regional review function, and the procedures for amending it are described in Chapter II. Chapter III explains the terms and symbols used in the project listings. The F.Y. 1985 Annual Element is presented in Chapter IV. A summary of the amount and source of Federal funds requested in the Annual Element is presented at the end of Chapter IV. All projects in the TIP are listed in Chapter V. They are grouped first according to the jurisdiction or state agency responsible for their implementation. Within those sections they are then grouped by major category: TSM improvements, road and street upgrading, highway projects that increase capacity or provide amenities, improvements related to the Port of Baltimore, transit improvements, improvements to the region's airport facilities, and commuter rail projects. A timetable for anticipated expenditures is presented for each project. Tables on pages 177-180 of Chapter V summarize the level of funding and timing for all projects in the TIP, grouped by project type, implementing agency, and jurisdiction. (Author)

Search and attention conspicuity of road traffic control devices

 Hughes, PK; Cole, BL (Victorian College Of Optometry) 
 Australian Road Research Board 
 Australian Road Research Board Mar 1984 pp 1-9 2 Fig. 6 Tab. 26 

It is argued that conspicuity cannot be regarded simply as an object property determined by the physical properties of the object and its background but that the state of arousal and attention of the observer must be taken into account. Two kinds of conspicuity are defined: attentional conspicuity, which is the capacity of the target object to attract attention when the observer's attention has not been specifically directed to the likely occurrence of the target object, and search conspicuity, which refers to the ease with which a target object is located when the observer is directed to search for it. A field trial was conducted to estimate the attention and search conspicuity of road traffic control devices. The two measures were correlated and related by a curvilinear function such that search provided greatest gains for objects of low

(cont. next page)
attention conspicuity and least gains for objects of high attention conspicuity. The road environment is shown to have a profound effect on both kinds of conspicuity such that conspicuity is least in shopping centres and greatest in residential roads. It is argued that this is most likely due to visual clutter rather than increased pre-occupation with the driving task in arterial and shopping centre roads. Increasing the size of the traffic control devices, the use of colour and the use of symbolic rather than alphanumeric graphics are shown to be associated with enhanced conspicuity. 

A method was used to identify key landmarks along the route and to present overall results by route and by county. A method was developed which makes it possible to identify a vehicle's location, load distribution; (5) test methods: noise, power, wheels, exhaust gas, braking components, towing brackets, rear view mirrors, drive belt fatigue, filters, electrical connections; (6) terminology: vocabulary covering essential aspects of the automotive product. (TRRL) 

DESCRIPTORS: ATENTION; CARRIAGEWAY MARKING; COLOR; COLOUR; CONSPICUITY; CONTRAST (VISUAL); DRIVER PERCEPTION; ENVIRONMENT; EXPERIMENT; FIELD TESTS; HIGHWAY; HUMAN FACTORS; IN SITU; LEGIBILITY; OPERATIONS AND TRAFFIC FLOW; RESIDENTIAL AREAS; SHOPPING CENTERS; SYMBOL; SYMBOLS; TEST; TRAFFIC SIGN; TRAFFIC SIGN DESIGN; TRAFFIC SIGN VISIBILITY; TRAFFIC SIGNAL; VISIBILITY 

381159 DA 
ROAD VEHICLES - SYMBOLS FOR CONTROLS, INDICATORS AND TELL-TALES. FOURTH EDITION
International Organization for Standardization
REPORT NO: ISO 2575-1
SUBFILE: TRRL; IRRD; HRIS
This international standard specifies the symbols, i.e. conventional signs, with which certain controls, indicators and tell-tales of a road vehicle are to be provided in order to ensure their identification and facilitate their utilization. This standard is applicable to those controls, indicators and tell-tales fitted on the instrument panel, or in the immediate vicinity of the driver. This standard is also published in French. (TRRL) Structural improvement is provided by the grouch. (TRRL)
DESCRIPTORS: COLOUR; CONTROLS; DASHBOARD; DESIGN (OVERALL DESIGN); EQUIPMENT; INDICATORS / INSTRUMENTATION; INSTRUMENT PANEL; INTERNATIONAL; MOTOR VEHICLES; SPECIFICATION (STANDARD); SPECIFICATIONS; STANDARDS; SYMBOL; SYMBOLS; THIN WALL STRUCTURES; VEHICLE; VEHICLE CHARACTERISTICS; WARNING 

377325 DA 
NATIONAL PRIMARY ROUTES: SKID RESISTANCE (1981)
Curran, A; Marry, A
National Institute for Phys Planning & Constr Res St Martin's House, Waterloo Road Dublin 4 Ireland
Apr 1982 40p 2 Fig. 3 Tab. 11 Ref. 3 App.
SUBFILE: HRIS
Since 1974 the skid resistance of the 2630 km of national primary roads have been measured annually by An Foras Forbartha using Scrim. Most of the 2630 km of national secondary roads and the most important "other main roads" have also been measured at intervals of three to four years. Detailed reports giving the results of these measurements are sent to the Road Authorities in respect of the roads measured in their areas. Special reports summarising the results for each county were also prepared in 1976-78. However, the latter had to be discontinued due to financial and other constraints. Research was carried out (4) to find improved methods of analysis and to present overall results by route and by county. A method was developed which makes it possible to display the test results for a complete route in a condensed format, giving the results for an entire route in about five to ten pages. This is taken further in the present report, and national routes, with the position of long sections where the skid resistance is low, are shown here on one page for most routes, with the locations of key landmarks along the route shown against the symbols for each band of skid resistance. (Author)
DESCRIPTORS: ARTERIAL HIGHWAYS; MEASURING; PAVEMENT DESIGN AND PERFORMANCE; SKID RESISTANCE; SURVEYS
PRINTS 13may93 P217: PR S14/5/ALL (items 1-99) PAGE: 148 Item 39 of 99

DIALOG File 63: TRIS _ 70-92/JUL

370714 DA SAFER FOR THE ELK; THE WARNING EQUIPMENT IS EFFICIENT
Mynstad, B. Vegdirektoratet
NORWEGIAN
SUBFILE: TRRL; IRRD; HRIS
The public roads authorities have in operation three warning devices for drivers in areas where elk cross roads. They have shown themselves to be effective. Video-recordings of elk crossing at these locations show that the animals have a low reaction to sound and light, several crossing while cars are nearby. This underlines the fact that game mirrors have little influence on the animals. The new warning installations have been established in places where the elk have permanent passages, and consists of photocells which detect the animals 25-30 metres from the roadside, and make video recordings when they cross the road. At the same time yellow warning lights with elk symbols start flashing at the roadside to warn drivers. Another experiment in progress at present includes building underpasses for smaller animals (deer, etc.). (TRRL)

DESCRIPTORS: ACCIDENT PREVENTION; ANIMAL; ANIMALS; CINEMATOGRAPHY; COLLISIONS; CROSSING THE ROAD (PEDESTRIAN); CROSSINGS; DETECTORS; EQUIPMENT; FLASHING LIGHT; MOTOR VEHICLES; PHOTOELECTRIC CELLS; PHOTOELECTRICAL; RECORDING; SAFETY; TELEVISION; TUNNEL; UNDERPASSES; WARNING; WARNING SYSTEMS

368517 DA HYBRID TURN RESTRICTION SIGNS - COMPREHENSION OF SOME ALTERNATIVE FORMS
MacDonald, WA; Hoffmann, ER (Melbourne University, Australia)
Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0572-1431 1982 111-26 1 FIG 8 TAB 0 19 REF
SUBFILE: TRRL; IRRD; HRIS
Two experiments were carried out to investigate the accuracy of initial comprehension of some alternative forms of hybrid turn restriction signs. A hybrid sign is one in which the message is presented in both symbolic and verbal form. In the first experiment it was found that: (1) hybrid signs were better understood than semi-hybrids; (2) hybrid signs with a prohibitory verbal component were better understood than those with a mandatory verbal component; (3) best of those tested were hybrids with both symbol and words in prohibitory form. In view of the known advantages of mandatory sign forms in terms of most other criteria of sign effectiveness, a second experiment was carried out to investigate initial comprehension of signs displaying combination (mandatory plus prohibitory) symbols. It was found that such symbols were better understood than both mandatory and prohibitory symbols. Comprehension of hybrid signs consisting of a combination symbol and a prohibitory verbal component was as good as that of completely prohibitory hybrids, and their use is therefore recommended (a). The number of the covering abstract of the conference is TRIS no. 368448. (TRRL)

368512 DA COMPREHENSION OF SOME ALTERNATIVE FORMS OF REGULATORY TRAFFIC SIGNS
Hoffmann, ER (Melbourne University, Australia)
Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0572-1431 1982 111-26 1 FIG 8 TAB 0 19 REF
SUBFILE: TRRL; IRRD; HRIS
Some alternative forms of symbolic regulatory sign formats, including the major international ones, were compared in two laboratory studies with each other and with current Australian standard signs in terms of their comprehension by a broad range of Australian drivers. For turn restriction signs, mandatory and prohibitory signs were compared. The best form of symbolic regulatory signs is the green annulus with the word "only" appended; for turn restrictions this form was superior both to prohibitory and to simple mandatory forms. It was also the best of the bus lane signs tested. The best form of symbolic prohibitory signs had a red annulus and red diagonal slash. To convey a limit, a red annulus without a diagonal slash was better. However, it was found that the best comprehended and most often preferred signs were those currently used in Australia, almost all of which include a verbal statement of the sign meaning. It was suggested that the optimum form of regulatory sign is the "hybrid" combining the advantages of both symbolic and verbal information coding (a). This paper was also published as Australian Road Research Board Internal Report AIR 348-1. The number of the covering abstract of the conference is TRIS no. 368448. (TRRL) Proceedings of the Eleventh Australian Road Research Board Conference, held at the University of Melbourne, August 23-27, 1982

DESCRIPTORS: AUSTRALIA; BUS; COLOR CODES; COLOUR; COMPREHENSION; CONFERENCE; DRIVER; ERROR; HUMAN FACTORS; LABORATORY (NOT AN ORGANIZATION); LETTERING; OPERATIONS AND TRAFFIC FLOW; RED; SYMBOL; SYMBOLS; TEST; TRAFFIC SIGN; TRAFFIC SIGN DESIGN; TURN; WARNING

368511 DA THE DESIGN OF SYMBOLIC SIGNS TO ENSURE LEGIBILITY
Bryant, JFM
Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0572-1431 1982 pp 161-171 8 Fig. 11 Tab. 30 Ref.
SUBFILE: TRRL; IRRD; HRIS

(cont. next page)
Design procedures to ensure the legibility of symbolic signs have not been developed to the extent that similar procedures have for verbal signs. The three parameters of luminance, contrast, and size are considered in the light of recent research into the visibility of symbolic signs and a procedure is developed which will ensure that significant detail, necessary for the comprehension of the symbolic image incorporated in the sign, is sufficiently legible for defined populations under the intended conditions of use. The procedure has been incorporated into standards for the design and use of graphic symbols and public information symbol signs by the Standards Association of Australia and similar methods are under consideration by the International Standards Organization. The number of the covering abstract of the conference is TRIS 70-92/23. The different sets of uniform roadside information sign symbols proposed by NAASRA for inclusion in Australian standard as TRIS 70-92/23 were evaluated in a recognition test and a later recall test. In the two tests, the five groups of respondents, who differed widely in their driving experience, differed in the proportion of correct answers given. There was a moderate degree of consistency as to how well signs were understood. While the "youth hostel" and "petrol and repair" signs gave rise to particular difficulty on the recognition test, only the latter was poorly identified on the recall test. Between group differences in per cent correct identification in both tests were apparently related to driving experience, with the group of elderly respondents giving fewest correct answers. Signs differed in the extent to which prior experience aided correct identification. The sources of the difficulties experienced by the elderly are discussed in terms of expectations about symbolic signing systems and difficulties in translating unfamiliar symbolic material. (Author/TRRL)

In this report, a survey is presented of traffic sign visibility problems, visibility of road markings and traffic signals, mainly based on investigations carried out during the seventies in the Institute for Perception and the Netherlands. The report is divided into chapters: properties of the drivers, properties of road markings and traffic signs and the influence of external conditions. In the first chapter it is concluded that no test exists which reliably selects the potentially hazardous driver. Apparently, the driver's task is too complicated for such a test. Some detail the following subjects are treated: visual acuity, visual field, colour vision, dark adaptation, night myopia, eye movements, attention, and reading time. The second chapter consists of a discussion of conspicuity, the distinction between signs with text or with symbols and the influence of spacing and stroke width on legibility. In connection with the phenomenon of retroreflection the influence of dew, rain, dirt, and the distinction between the different types of retroreflective materials are treated. Additionally, the subjects of matrix signs, road markings and traffic signals are discussed. In the last chapter the influence of fog, rain and public lighting on visibility of information carriers is surveyed. (Author/IRRD)

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Evaluating the understanding of symbolic roadside information signs

Cairney, P.T.; Sless, D. (Flinders University of South Australia)

A set of uniform roadside information sign symbols proposed by NAASRA for inclusion in Australian standard as TRIS 70-92/23 were evaluated in a recognition test and a later recall test. In the two tests, the five groups of respondents, who differed widely in their driving experience, differed in the proportion of correct answers given. There was a moderate degree of consistency as to how well signs were understood. While the "youth hostel" and "petrol and repair" signs gave rise to particular difficulty on the recognition test, only the latter was poorly identified on the recall test. Between group differences in per cent correct identification in both tests were apparently related to driving experience, with the group of elderly respondents giving fewest correct answers. Signs differed in the extent to which prior experience aided correct identification. The sources of the difficulties experienced by the elderly are discussed in terms of expectations about symbolic signing systems and difficulties in translating unfamiliar symbolic material. (Author/TRRL)

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impression and general significance of road signs show long interpreting times (on an average 5-20 seconds) and great uncertainties especially as regards road signs concerning opposing traffic and overtaking. However, by the design of the new sign indicating lane change maneouvre where the road work (the obstacle) is indicated symbolically by quadratic, black squares, and the driving directions by black arrows in pairs short/long, 97% of the test subjects show correct understanding of the meaning of the sign and the give way instructions. (TRRL)

DESCRIPTORS: ATTITUDE (PSYCHOL); COMPREHENSION; CONSTRUCTION SITE; DESIGN; DESIGN (OVERALL DESIGN); DIRECTION (TRAFFIC); DRIVER REACTION; HUMAN FACTORS; LANE CHANGE; OPERATIONS AND TRAFFIC FLOW; PRIORITY (TRAFFIC); SYMBOLS; TEST METHOD; TRAFFIC LANE; TRAFFIC SIGN; TRAFFIC SIGNS

362153 DA SOURCE BOOK FOR AUSTRALIAN ROADS

Lay, MG

Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0 86910 045 9


SUBFILE: TRRL; IRDD; HRIS

The book attempts to cover the entire range of road topics from a technical viewpoint, with a strong Australian bias and using a source book approach. This last aspect means that the book refers readers to other sources of information in many areas rather than repeating the data given in the key references. To aid this task, the title and contents pages of the key references are included as exhibits at the end of each chapter. The book includes chapters on definitions and terms, history of roads, organisation of roads, road needs, road pavement markings, traffic signals, lighting, construction, classification guides, kinds of signs, signals, the meaning of various colors, graphic symbols, words and other messages. Traffic signs are self-explanatory for road aids, but can become complex for rail, marine and aviation aids. The third and fourth parts of the book begin a study of international transportation aids. Such aids include buoys, lighthouses, small lights and beacons, fog and electronic signals. Included is the new international buoyage system (approved at Tokyo in 1980), and a discussion of daybeacons (unlighted signals), a little known part of marine navigation. There is an extensive bibliography and several indexes. A treatment of international rail, road, and aeronautical transportation aids is planned for a future volume in preparation. This book is available from the Author, Mount Angel Abbey Saint Benedict, Oregon.

DESCRIPTORS: AUDIBLE WARNING DEVICES; BEACON LIGHTS; BIBLIOGRAPHIES; CLASSIFICATION; COMMUNICATION SYSTEMS; GENERAL MATERIALS; INDEXES; INVENTORIES; OPERATIONS AND TRAFFIC FLOW; REVIEWS; SYMBOLS; TRAFFIC MARKINGS; TRAFFIC SIGNALS; TRAFFIC SIGNS; WARNING SYSTEMS

349807 DA ALTERNATIVE SIGN SEQUENCES FOR WORK ZONES ON RURAL HIGHWAYS

ABRIDGMENT

Lyle, MW (Lyles (Richard) Associates) Transportation Research Board Transportation Research Record N933 1981 pp 13-17 4 Fig. 10 Ref.

SUBFILE: HRIS (cont. next page)
DIALOG File 63: TRIS _ 70-92/JUL

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

Two experiments were done on a two-lane rural road (US-2) in central Maine to evaluate the effectiveness of alternate signing sequences for providing warning to motorists of construction and maintenance activities that require a lane closure on the road ahead. The signs tested included a standard Manual on Uniform Traffic Control Device (MUTCD) warning sequence, the same sequence on both sides of the road augmented with continuously flashing beacons, and a sequence of symbol signs. Data were collected covertly on random motorists by using a combination of inductance loops imbedded in the roadway and piezoelectric cable that (a) the most effective sign sequence was the MUTCD sequence augmented with flashing beacons, (b) the symbol sign sequence appeared to be at least as effective as the standard sequence, and (c) in no instance did the sign sequence appear to cause confusion or potentially dangerous abrupt motorists reaction. This paper appeared in Transportation Research Record No. 833, Work Zone Safety, Maintenance Management and Equipment, and Transportation of Hazardous Materials.

DESCRIPTORS: CONSTRUCTION ZONE TRAFFIC CONTROL; DESIGN; DRIVER REACTION; FLASHING BEACON; INDUCTION LOOP DETECTORS; MAINTENANCE; GENERAL; OPERATIONS AND TRAFFIC FLOW; RURAL HIGHWAYS; SAFETY; SEQUENCES; SYMBOLS; TRAFFIC SIGNS; TWO LANE HIGHWAYS; WARNING SIGNS

348820 DA
AN ANALYSIS OF WRONG RESPONSES TO SOME PROPOSED SYMBOLS FOR TRAFFIC SIGNS
Cairney, PT
Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia GRATIS
Aug 1980 Monograph 26p 19 Tab. 10 Ref.
REPORT NO: No. 1106-2
SUBFILE: TRRL; IRRD; HRIS

Responses to alternative symbolic versions of 18 current legend road signs were analysed in terms of the logical relation between the image content and the response. The data came from an investigation by Johnston (1980). Most wrong responses stemmed from regarding the image content as a literal representation of the referent, rather than the whole-structure relationship intended. The inclusion of arrows in the image content was effective when used as an indicator, but generally ineffective when used to represent traffic flow. Lack of knowledge of the shape_FINAL CODE was most evident when the image content itself was not readily interpretable. It is suggested that the prevalence of the literal interpretation of image content may be due to expectations about what road signs represent generated by existing symbolic road signs. It is proposed that a similarity between existing road signs be carried out, along with investigations into the cognitive processes involved in interpreting symbolic signs and the graphic elements that lead users to adopt one interpretation rather than another. (Author/TRRL)

DESCRIPTORS: COMPREHENSION; DRIVER; DRIVER PSYCHOLOGY; DRIVING REACTION; EVALUATION (ASSESSMENT); HUMAN FACTORS; LABORATORY (NOT AN ORGANIZATION); OPERATIONS AND TRAFFIC FLOW; SYMBOL; SYMBOLS; TEST METHOD; TRAFFIC SIGN; TRAFFIC SIGN DESIGN

345568 DA
EUROPEAN PROJECT ON ELECTRONIC TRAFFIC AIDS ON MAJOR ROADS
Baang, K; Peterson, B (Transport Research Commission, Sweden Vbb-Sweco Consulting Engineers, Sweden)
Svenska Vagfoereningen Box 27115 S-102 52 Stockholm Sweden 1981 pp 123-134
SUBFILE: TRRL; IRRD; HRIS

Eleven European countries and the European commission have 1977-1980 accomplished a cooperative study on the possible application of electronic aids to traffic problems on busy, high-speed roads. Specialist working groups have investigated nine major topics: (1) in-vehicle communication with the driver by spoken words; (2) in-vehicle communication by visual presentation; (3) variable signs or signals; (4) radio broadcasting of traffic information; (5) information needs of drivers and road authorities; (6) automatic or manual detection of incidents affecting traffic; (7) clear, correct and unambiguous terms for use in messages and different languages; (8) equipment for control centres and control strategies, data transmission, proposals for an international demonstration. The study concludes that the most appropriate control system should include changeable message signs, variable direction signs, automatic detection of traffic incidents and bad weather, supplemented by area broadcasts of traffic information. To ensure that information for drivers is always given in the same manner, it is proposed that new symbols should be adopted to warn drivers of hazards encountered on high-speed roads, that light-matrix changeable message signs should be sanctioned, and that radio messages should always have the same sequential structure, although they need only be broadcast in the local language(s). An international demonstration of the system, to be decided by 1981 on an action concertee basis, is proposed for a site in the Netherlands. (Author/TRRL) Papers from the 9th IRF World Meeting, Roads Into the Future-Road Design and Safety--TS3, held in Stockholm, June 1-5, 1981.

DESCRIPTORS: CHANGEABLE MESSAGE SIGN; CONFERENCE; CONFERENCES; CONTROL (SURVEILLANCE); DATA TRANSMISSION SYSTEMS; DETECTOR; DRIVER INFORMATION; DRIVER INFORMATION SYSTEMS; ELECTRONIC TRAFFIC DEVICES; ELECTRONICS; EUROPE; NEAR MISS; OPERATIONS AND TRAFFIC FLOW; RADIO; RADIO COMMUNICATION SYSTEMS; RECOMMENDATIONS; TRAFFIC CONTROL; TRAFFIC SIGN; VARIABILITY; WEATHER
LIGHT SIGNALS FOR ROAD TRAFFIC CONTROL
Schreuder, DA
Printershall Limited
Traffic Engineering and Control VOL. 22 NO. 6 Jun 1981 pp 370-371 1 Tab. 7 Ref.

The author describes the 1980 technical report no 48 (TC 1.6) issued by the Commission Internationale de l'Eclairage, which attempts to standardise road traffic control signal lights. The aim of the report is to bring together current knowledge and experience, giving suggestions on which future recommendations may be based. Colour boundaries have been chosen in person with colour defective vision, namely a blueish green, an amber yellow and a light (nearly orange) red. Values of peak intensity and light distribution are derived so that signals can be perceived clearly at considerable distance (about 100 M). The shape of symbols is discussed. It is recommended that the signal is presented as a light-emitting cut-out on a black background. Suggestions are given for dimensions for the different symbols. Methods of reducing adverse “sun phantom” effects are discussed. This can be achieved, either by hoods or louvres, by additional internal shields or by ensuring that operating signals are always brighter than the phantom. Background screens are considered essential; suggestions are given for their shape, colour, dimension and location. (TRRL)

DESCRIPTORS: COLOR; COLOUR; DESIGN (OVERALL DESIGN); HUMAN FACTORS; OPERATIONS AND TRAFFIC FLOW; SHAPE; SPECIFICATIONS; STANDARDS; SYMBOLS; TRAFFIC SIGNAL; TRAFFIC SIGNALS; VISIBILITY

DEVELOPMENT OF A RADIO EMERGENCY CALL UNIT FOR MOTORWAYS INCLUDING THE NECESSARY CONTROL CENTRE EQUIPMENT
Vosta, K
Ministry of Building and Technology, Austria
Strassenforschung N118 1979 pp 13-23 1 Fig. 6 Phot. German

Operation and servicing of motorways requires an increasing volume of low voltage equipment, especially for means of communication between the road users and the service centres of the various aid and rescue organisations. The disadvantage of cable-bound emergency telephone units on motorways is the high cost of installing the cables, which is often not carried out until after completion of the highway. Therefore the firm Elin-Union in connection with research promotion contract has developed a radio emergency call unit which permits wireless communication. The new equipment allows four directed emergency calls (ambulance, fire brigade, police, breakdown service), which can be actuated by means of push buttons marked with internationally recognised symbols. After activating the call, it is also possible to speak to the control centre. In addition the unit contains a warning system, in which a flashing light can be switched on and off by remote control from the control centre, which will serve to warn road users of critical conditions in the vicinity of the call unit. The emergency call units are powered by rechargeable batteries. In order to maintain the unit operational over as long a period as possible on one charge of the cells, the power consumption is extremely low. An experimental series of emergency units using solar generators for the power supply shows very positive results, which in the near future may make battery replacement totally unnecessary. (TRRL)

DESCRIPTORS: BATTERIES; BATTERY; BREAKDOWN (VEH); COMMUNICATION; COMMUNICATION SYSTEMS MAINTENANCE; DANGER: EMERGENCY; EMERGENCY CALL SYSTEMS; ENERGY; GUIDANCE; MAIN ROAD; MOTORIST AID SYSTEMS; OPERATIONS AND TRAFFIC FLOW; ORGANIZATION (ASSOCIATION); RADIO; RADIO COMMUNICATION SYSTEMS; RESEARCH REPORT; SAFETY; SOLAR POWER GENERATION; SUN; TELEPHONE; WARNING; WARNING SYSTEMS

AGE EFFECTS ON SYMBOL SIGN RECOGNITION
Allen, RW; Parseghian, Z; Van Valkenburgh, PG
Systems Technology, Incorporated 13766 South Hawthorne Boulevard Hawthorne California 90250; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

Dec 1980 Final Rpt. 121p

The use of symbolic road signs is proliferating on the highways, and the Federal Highway Administration is concerned with their effective use, particularly by the elderly driving population. This report describes an experimental study of problems encountered by a broad age range of drivers in learning and retaining symbolic information. A driving simulator was used to present 72 symbol signs to subjects during 25 minute “drives.” Performance measures included the correctness of sign recognition, and the distance from the signs at which recognition took place. The experimental design looked at the effects of age, training, and sign format on the learning and retention of symbol knowledge. Subjects received three simulator trials, the first to determine initial symbol knowledge, a second immediately after symbol training to determine the amount of learning, and a final trial week or so later to measure symbol knowledge retention. Sixty subjects were divided into four age groups (age range 20-79 years). The age groups were further subdivided into three training subgroups, each receiving a different symbol training treatment. The overall results showed strong age effects, but no influence due to the type of symbol training employed. All age groups learned and retained roughly the same number of symbols, but the older age groups started off with less symbol knowledge initially. Data interpretation also indicates the older subjects required longer recognition and response times.
Recognition performance differences between signs were also analyzed. The 72 symbol signs were equally subdivided into six MUTCD sign categories of 12 signs each, with each category representing a different color code. Recognition response differences were apparent between sign categories and were attributable in part to differences in requiring processing time. Symbology appeared to lead to appreciable differences in both response distance and correctness, with simple, bold, unique symbols giving the best performance. (FHWA)

Signalization has existed for centuries in many forms. All of these forms of signalization have the aim of guiding people to their destination by the easiest and quickest route. Each system tries to give information which must be understood by the user. The road user must translate symbols into actions: symbols such as signs, letters, ciphers, forms, colours and sounds. This requires a certain skill. While the system of roads and traffic becomes more and more complicated and busy, errors in signalization systems occur. New simple complete systems are assiduously sought, but the users' understanding of them is a problem. In this report some elements of a theoretical model which play a role in the design of signalization systems are discussed. The model places signalization as a means for route guidance in a wider context. (TRRL)

User:005102 13Aug93 P217: PR 514/5/ALL (items 1-99)
used. It was found that symbolic signs were better than verbal signs in perception time, and equal in accuracy of retention. There was no difference between positive and negative signs in perception time, but negative symbolic signs were worse than positive and combination (positive plus negative) signs in terms of response time and errors. Combination signs were marginally superior overall, but the result was significantly affected by the subject's target direction and form of response. (TRRL) Proceedings from the Ninth Australian Road Research Board Conference, Brisbane, August 21-25, 1978.

308953 DA TRAFFIC SAFETY OF CHILDREN. APPENDIX 7: EDUCATIONAL AIDS IN TRAFFIC

Kommunikationsdepartementet Fack Stockholm Sweden

In this report, a number of educational aids in traffic have been examined and analyzed. The educational aids (ea) have been examined from demands which have been formulated out of following starting points: (a) research result concerning learning and development of children, (b) investigations concerning children traffic environment, (c) the aim the guidelines of the curriculum, (d) the importance of environment for children's development, (e) the result of examination can be summarized as follows: (1) the ea do not touch upon the most important problems out of safety point of view and what they imply for the safety of children, (2) the ea lack the necessary traffic environment for themselves, (3) the ea only take on a small interest in a child's limited skill to interpret, learn and understand symbols, i.e. traffic signs and traffic regulations, (4) the ea describe to a low extent how pupils can work with traffic in real traffic environment, (TRRL)

DESCRIPTORS: BEHAVIOR; BEHAVIOUR; CHILD; COMPREHENSION; EDUCATION; ENVIRONMENT; METHOD; MINORS; SAFETY; SAFETY EDUCATION; SCHOOL; SCHOOL CHILD TRAFFIC SAFETY; TRAFFIC REGULATION; TRAFFIC SAFETY; TRAFFIC SIGNS; TRAINING AIDS

262552 DA HUMAN FACTORS IN HIGHWAY TRAFFIC SAFETY RESEARCH. CHAPTER 6. DRIVER INFORMATION SYSTEMS

Wiley (John) and Sons, Incorporated 605 Third Avenue New York New York 10016

1972 Textbook pp 110-132 9 Fig. Refs.

SUBFILE: TRRL; IRRD; HRIS

In this chapter, the author reviews the research undertaken to evaluate current and future systems for communicating to the driver the information he needs using methods and traffic control devices that are based on awareness of man's ability to process information. Motorway information requirements are outlined (the need for accurate interpretation, continuity between devices, notice of approaching events, danger, prediction and realization of signs and symbol signs to other sources of information such as maps, prominence of signs, and signing for unusual maneuvers). Together with traffic control devices at road-railway crossings, including rubber strips, a number of combined symbols or pictographs are discussed, and the design of information from traffic signals are discussed, and their and presented. The design is assessed. Details are given of detours and construction zone warning principles, information functions of highway markings, changeable message signs, radio messages to
drivers, roadway aesthetics, and holographic images. /TRRL/

DESCRIPTORS: CHANGEABLE MESSAGE SIGN; CONSTRUCTION ZONEs;
DETENTION; ROADWAY INFORMATION SYSTEMS; DRIVER;
PSYCHOLOGY; RADIO; COMMUNICATION SYSTEMS; RAILROAD GRADE CROSSINGS; RUMBLE STRIPS;
SAFETY; SYMBOLS; TRAFFIC CONTROL DEVICES; TRAFFIC SIGN
DESIGN; TRAFFIC SIGNALS

230089 DA

DEVELOPMENT OF A PROCEDURE FOR THE DESIGN OF FLEXIBLE BASEs
Swanberg, JH; Hansen, CC
Highway Research Board Proceedings 1946 Vol 26, pp 44-57, 10
FIG. 2 TAB. 4 REF
SUBFILE: HRIS

The design procedure described in this paper is the result of
an investigation, still in progress, set up to establish a
relationship between field performance of granular bases and
bearing values obtained in the laboratory by means of the
California bearing test, or modifications thereof. The field
investigation involved condition surveys of bituminous
surfaces placed on granular bases, the determination of
thickness, density and moisture content, and North Dakota cone
bearing value of the subgrades. Samples of the base materials
and subgrades were sent to the laboratory for analysis and
bearing values. Laboratory field moisture and density determinations were
also made to determine seasonal and annual fluctuations in
base and subgrades. The field studies revealed that failures
had occurred within practically the entire range of moisture
contents and densities found in the road, which would indicate
generally inadequate thickness of base on plastic soil
subgrades. There was some relation between moisture content
and the plastic limit of subgrade soils. Laboratory tests were
made using the California bearing test procedure on specimens
molded as described in the 1938 proceedings and on specimens
compacted to standard AASHO and modified AASHO densities. It
was concluded that, for all methods of compaction used,
soaking of the specimens from the top resulted in moisture
conditions more severe than were found in the field and that
some modifications of the soaking procedure was desirable. On
the basis of considerable laboratory data it was decided that
the California bearing test offers a practical method for
evaluating drainage and granular material properties. The samples are tested at moisture contents and densities such as
exist or are anticipated on Minnesota roads. Plastic subgrade
soils are compacted to 97 percent of AASHO maximum density and
at moisture contents equal to a percentage of saturation
determined from the relationship established between plastic
limit and percentage of saturation. Bearing tests are made on
plastic soils without soaking or using a surcharge on the
specimens. For granular materials design bearing values are
determined from tests on specimens compacted to AASHO maximum
density and subjected to four days soaking from the bottom. A
surcharge is used during the soaking and bearing tests. A
curve was developed by plotting the bearing values obtained in
the modified California bearing tests described above against the
combined thickness of base and mat found at the test point
in the field. By use of distinctive symbols representing

failure and non-failure, it was found that the curve could be
drawn in such a position as to indicate minimum thicknesses
above which practically no failure occurred. This curve and
the above described test procedure form the basis of design of
flexible bases in Minnesota. /author/

DESCRIPTORS: BASES; CBR; DENSITY; FIELD PERFORMANCE;
FLEXIBLE BASE PAVEMENTs; FOUNDATIONS (SOILs); GRANULAR
MATERIALs; LABORATORY TESTs; MOISTURE CONTENT; PAVEMENT DESIGN
AND PERFORMANCE; SEASONAL VARIATIONS; SUBGRADES; THICKNESS

230129 DA

FIELD IDENTIFICATION OF SOILs AND AGGREGATES FOR COUNTY ROADS
Purdue University; Shurig, DG; Hittle, JE
Dec 1971 57 pp 29 Fig COUNTY HWY SERIES NO 13
SUBFILE: HRIS

The primary purpose is to provide instruction to Indiana
county road personnel on rating the quality of soils and
pit-run materials used in the construction and maintenance of
county roads. A system of soil classification is presented
with a common language for identifying soil types properties
and problems. Chapter II, soil components, properties and
identification tests, provides instructions on the
identification of soil components, based on their physical
properties as determined by visual examination and simple hand
tests. Five soil components are defined, along with their size
ranges, properties and simple hand tests for identification.
The unified soil classification system is presented in chapter
III: the classification recognizes 15 basic soil groups,
however, only seven or eight of these commonly occur here in
Indiana. Definitions, word descriptions and classification
symbols are summarized in tabular form. Chapter IV, field
identification procedure, outlines instructions and procedures
for identifying each of the 15 soil groups, using visual
examination and simple hand tests. The soil identification
process is summarized in tabular form. Chapter V, field tests
for aggregate materials, outlines additional field
identification tests. These "indicator" tests are mainly for
pit-run gravels and sands but can serve for both
identification and general quality evaluation tests. Guide
gradings are presented for gravel base and surfacing
aggregates. Tests to indicate the relative amount of fines
and relative plasticity of fines are also outlined. Chapter VI,
rating soils and aggregates as road materials, the 15 soil
groups are rated with respect to their inherent properties as
road-building materials. Each soil group is rated for its:
(1) load-carrying properties as road-building materials. Each soil
group is rated for its: (1) load-carrying properties, (2)
drainage properties, (3) frost properties, and (4) compaction
properties. /author/

DESCRIPTORS: COMPONENTS; COUNTY ROADS; EXPLORATION
CLASSIFICATION (SOILs); FIELD IDENTIFICATION; FINES
/MATERIALs; FOUNDATIONS (SOILs); PIT RUN MATERIALs; SOIL
CLASSIFICATION SYSTEMS; SOIL GROUPs; SOIL PROPERTIES; SOILS
229962 DA
THE IMPORTANCE OF SUPPLEMENTING RESULTS OF GEOPHYSICAL PROSPECTING FOR ROAD PURPOSES WITH GEOLOGICAL AND CORRELATED DATA
Road Research Institute /Brazil/; Nogami, JS
1970
SUBFILE: HRIS
Based on experience obtained by the Sao Paulo highway department, it was proposed that the results of geophysical tests for road purposes be supplemented by data referring to general genetic classification, to the geological origin, to the color, to the macro-structure and to the mineralogical peculiarities of the sand content. Since little consideration was given to such data in the specialized literature, a summary of the principal data and symbols is presented, accompanied by a discussion of their importance from the practical point of view. In this discussion special emphasis was given to problems related to (1) representativeness of the samples tested, (2) the interpretation of abnormalities of behavior not revealed by the results of the tests carried out, and (3) the utilization of the results of routine geotechnical studies, aimed at the eventual development of a systematization more adapted to the peculiarities of Brazilian soils. A system of symbols and conventions of the data under consideration was adopted to facilitate the presentation of the results of the geotechnical tests in the summary tables. A tentative nomenclature of the principal morphological types of the macro-structure of soils was also presented. /rr/ DESCRIPTORS: BEHAVIOR; CLASSIFICATION; COLOR; EXPLORATION CLASSIFICATION (SOILS); GEOLOGY; GEOPHYSICAL PROSPECTING; GEOPHYSICAL EXPLORATIONS; MATERIALS; MINERALOGY; MORPHOLOGY; SAMPLES; SANDS; SOIL STRUCTURE; SOILS; SYMBOLS

229885 DA
CLASSIFICATION AND ENGINEERING PROPERTIES OF LATERITIC MATERIALS
Vallegra, BA; Van, TIL Cj
Highway Research Record, Hwy Res Board
SUBFILE: HRIS
THE RESULTS OF A 2-YEAR STUDY OF LATERITES AND LATERITIC SOILS IN SOUTHEAST ASIA ARE PRESENTED. INCLUDED IS AN ENGINEERING DEFINITION OF VARIOUS TYPES OF LATERITIC MATERIALS TOGETHER WITH A RECOMMENDED CLASSIFICATION SYSTEM THAT IS AN EXTENSION OF THE UNIFIED CLASSIFICATION SYSTEM. APPROPRIATE SYMBOLS REPRESENTING THE DURABILITY CHARACTERISTICS OF LATERITIC GRAVELS AND SANDS AND THE DEGREE OF PLASTICITY OF THEIR FINES ARE INCLUDED WITH SUGGESTED TEST PROCEDURES. A PAVEMENT EVALUATION STUDY WAS CONDUCTED ON 101 TEST SECTIONS ON THE THAILAND ROAD SYSTEM. THE EXPERIMENT DESIGN INCLUDED THE VARIABLES OF SUBGRADE STRENGTH, RAINFALL, DRAINAGE, AND TRAFFIC LOADING. BASE AND SUBBASE COURSES OF BOTH LATERITIC AND NONLATERITIC MATERIALS WERE INCLUDED IN THE STUDY. FIELD AND LABORATORY TESTS WERE PROGRAMMED TO OBTAIN DATA FOR RELATING ENGINEERING PROPERTIES OF LATERITIC MATERIALS TO OBSERVED PERFORMANCE. AN EQUATION RELATING ENGINEERING PROPERTIES OF MATERIALS TO PAVEMENT GEOMETRY IS PRESENTED. /AUTHOR/
DESCRIPTORS: BASE COURSES; DURABILITY; ENGINEERING PROPERTIES; EXPLORATION CLASSIFICATION (SOILS); GRAVELS; LATERITIC GEOLOGY; GEOLOGICAL PROSPECTING; GEOPHYSICAL EXPLORATION; MATERIALS; MINERALOGY; MORPHOLOGY; SAMPLING; SANDS; SOIL PLASTICITY; SOIL TESTING; SUBBASE; SUBGRADES

223685 DA
GEOTECHNICAL SUBSURFACE EXPLORATION - GLOSSARY /IN PORTUGUESE/
Kollsman Instrument Corporation /Systems Division
REPORT NO: 7 pp
SUBFILE: TRRL; IRRD; HRIS
NATIONAL LABORATORY FOR CIVIL ENGINEERING
THE EXPERIMENTAL ROUTE GUIDANCE SYSTEM IS NOW BEING CONSTRUCTED AT THE NATIONAL LABORATORY FOR CIVIL ENGINEERING. THE INSTRUMENT PANEL AND THE DISPLAY UNIT ARE SPECIFIED. THE INSTRUMENT PANEL CONTAINS SIXTEEN 5 X 8 PRINTED LAMPS. EACH LAMP CAN BE ELECTRICALLY CONNECTED TO A DC MOTOR AND A LENS/MIRROR SYSTEM TO REFLECT A VIRTUAL IMAGE FROM THE WINDSHIELD. THE VIRTUAL IMAGE IS BASED ON THE DRIVER'S EYE. IT IS BRIGHT ENOUGH TO BE SEEN IN VIRTUALLY ALL KINDS OF OUTSIDE BRIGHTNESS AND BY DRIVERS WITH SOME IMPAIRMENT OF VISION SUCH AS COLOR BLINDNESS. /BPR/
DESCRIPTORS: DISPLAYS; DRIVER VISION; GUIDANCE; IMAGES; PROJECTIONS; REFLECTIONS; ROUTES; TRAFFIC FLOW, CAPACITY, AND MEASUREMENTS; WINDSHIELDS

2237945 DA
ROUTE GUIDANCE HEAD-UP DISPLAY
Kollsman Instrument Corporation /Systems Division
1968
SUBFILE: HRIS
THE ROUTE GUIDANCE HEAD-UP DISPLAY IS A MEANS FOR PROJECTING ONE OF SIXTEEN SYMBOLS (STANDARDIZED AND SPECIFIED BY THE BUREAU OF PUBLIC ROAD) SO THAT THEY CAN BE EASILY VIEWED BY A DRIVER WHO HAS HIS ATTENTION ON THE ROAD AHEAD (THAT IS, HE NEED NOT DROP HIS EYES TO THE INSTRUMENT PANEL NOR TAKE THEM OFF THE ROAD). THE SYSTEM USES A 12V LAMP, A Rotating screen Driven BY A DC MOTOR AND A LENSMIRROR SYSTEM TO REFLECT A VIRTUAL IMAGE FROM THE WINDSHIELD. THE VIRTUAL IMAGE IS BASED ON THE DRIVER'S EYE. IT IS BRIGHT ENOUGH TO BE SEEN IN VIRTUALLY ALL KINDS OF OUTSIDE BRIGHTNESS AND BY DRIVERS WITH SOME IMPAIRMENT OF VISION SUCH AS COLOR BLINDNESS. /BPR/
DESCRIPTORS: DISPLAYS; DRIVER VISION; GUIDANCE; IMAGES; PROJECTIONS; REFLECTIONS; ROUTES; TRAFFIC FLOW, CAPACITY, AND MEASUREMENTS; WINDSHIELDS

2237942 DA
ROUTE GUIDANCE POINTS THE WAY
Public Safety Systems /Traffic Control Systems Division
1971
SUBFILE: HRIS
AN EXPERIMENTAL ROUTE GUIDANCE SYSTEM IS NOW BEING TESTED BY THE PUBLIC SAFETY SYSTEMS. (cont. next page)
THE BUREAU OF PUBLIC ROADS. A PART OF THIS SYSTEM IS THE HEAD-UP DISPLAY, WHICH PROJECTS ANY OF 16 DIRECTIONAL SYMBOLS ONTO THE CAR WINDSHIELD. THE DISPLAY SYSTEM IS COMPRISED OF OPTICAL ELEMENTS, A SYMBOL SELECTION SUB-SYSTEM AND A LIGHT SOURCE MOUNTED INTEGRALLY WITH THE DASHGARD, WHICH CAUSES THE DIRECTIONAL SYMBOL TO APPEAR AND SUPERIMPOSES IT ON THE ROAD SCENE. THIS DISPLAY IS FOCUSED INFINITY SO THAT THE DRIVER CAN OBSERVE BOTH THE ROAD SCENE AND THE SYMBOL SIMULTANEOUSLY WITHOUT REFOCUSING HIS EYES ON THE WINDSHIELD. A NATIONWIDE ROADSIDE COMPUTER NETWORK, AN IN-VEHICLE COMPUTER-DECODER AND THE WINDSHIELD DISPLAY SYSTEM WOULD CONSTITUTE THE EXPERIMENTAL ROUTE GUIDANCE. A DRIVER USING THE PROPOSED SYSTEM WOULD SELECT FROM A DIRECTORY A CODE SYMBOL FOR HIS DESTINATION. THE SYMBOL WOULD BE ENTERED INTO THE IN-VEHICLE COMPUTER-DECODER, AS THE VEHICLE ACHIEVES AN EQUIPPED INTERSECTION, A CODED SIGNAL FROM THE COMPUTER-DECODER WILL BE PICKED-UP BY A LOOP ANTENNA BURIED IN THE ROADWAY AND FED INTO A ROADSIDE COMPUTER. THE COMPUTER THEN DECODES THE VEHICLE DESTINATION CODE AND TRANSMITS DIRECTIONAL INSTRUCTIONS BACK TO THE VEHICLE TO ACTIVATE THE WINDSHIELD DISPLAY. AN AUDIBLE "BEEP" WARNS THE DRIVER THAT INSTRUCTIONS ARE ABOUT TO BE GIVEN. SHOULD THE KOLLSMAN SYSTEM BE APPROVED BY THE BUREAU OF PUBLIC ROADS, INSTALLATION OF THE COMPUTER-DECODER IN THE CAR WOULD BE COST COMPARABLE TO THAT OF AUTOMOBILE AIR CONDITIONING OR A STEREO TAPE SYSTEM. DESCRIPTORS: CODING; DESTINATION; DIGITAL COMPUTERS; DISPLAYS; DRIVERS/VEHICLE/; GUIDANCE; MOTOR VEHICLES; OPTICAL INSTRUMENTS; ROUTES; TRAFFIC FLOW, CAPACITY, AND MEASUREMENTS WINDSHIELDS

226923 DA SPECIFICATION FOR ROAD TRAFFIC SIGNALS British Standards Institution Nbs5 1971 43 pp Figs 4 Tab SUBFILE: TRRL; IRRD; HRIS THIS STANDARD SPECIFIES REQUIREMENTS FOR FIXED AND PORTABLE ELECTRIC LIGHT SIGNAL INSTALLATIONS, OPERATED FROM A MAINS, GENERATOR, OR BATTERY SUPPLY, FOR CONTROLLING ROAD TRAFFIC. INFORMATION TO BE GIVEN WITH ENQUIRIES AND ORDERS FOR EQUIPMENT AND THE TYPICAL SYMBOLS TO BE USED IN DRAWING UP PLANS ARE GIVEN IN THE APPENDICES. /TRRL/ DESCRIPTORS: BATTERIES; GENERATORS; OPERATIONS AND TRAFFIC FLOW; SPECIFICATIONS; TRAFFIC SIGNALS

226685 DA INVESTIGATION OF NEW TRAFFIC SIGNS, MARKING AND SIGNALS Bolt Beranek and Newman, Inc.; ND SUBFILE: HRIS AN EVALUATION OF NEW DEVICES RECOMMENDED FOR THE 1971 EDITION OF THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES WAS BASED ON TWO MEASURES, RECOGNIZABILITY AND POPULATION STEREOTYPES. THE MEASUREMENT PROCESS SHOWED THAT THE RESEARCHER ON TRAFFIC CONTROL DEVICES CAN USE ROAD TESTING AND LABORATORY TESTING TO COMPLEMENT ONE ANOTHER. A DRIVER QUESTIONNAIRE WAS USED TO PROVIDE INFORMATION ABOUT POPULATION STEREOTYPES, OR THE RESPONSE AN UNTUTORED OBSERVER ATTACHES TO A PARTICULAR DEVICE. WHILE PEOPLE GENERALLY PREFER LETTERED SIGNS TO UNLETTERED SIGNS, THEIR STRONG PREFERENCE IS FOR SIGNS THAT CARRY BOTH SYMBOLS AND LETTERS. UNDERSTANDING AND PREFERENCE DO NOT NECESSARILY GO HAND-IN-HAND. FOXY-ONE PERCENT OF THOSE RESPONDING TO THE QUESTIONNAIRE INDICATED THE NEED FOR STANDARDIZATION IN TRAFFIC CONTROL DEVICES. /dot/ DESCRIPTORS: DRIVER BEHAVIOR; LABORATORY TESTS; MEASURING; OPERATIONS AND TRAFFIC FLOW; POPULATION /STATISTICAL/; PREFERENCE; RECOGNITION; ROAD TESTS; SIGNS; TRAFFIC CONTROL DEVICES

225966 DA IDENTIFICATION SYMBOLS OF THE STATE HIGHWAYS Road Research Institute /Brazil/; ND SUBFILE: HRIS THE STATE HIGHWAYS WILL BE IDENTIFIED BY A SHIELD ON WHICH WILL BE WRITTEN THE SYMBOLS OF THE STATE WITH THE CORRESPONDING ROAD CODE NUMBER. THE FOLLOWING ASPECTS OF THESE SIGNS ARE Discussed: SIZES AND APPLICATIONS, COLORS, Implantation, directional signs, placement, and materials. /rrl/ DESCRIPTORS: DIRECTIONAL SIGN; IDENTIFICATION; MATERIALS; OPERATIONS AND TRAFFIC FLOW; PLACEMENT; STATE HIGHWAYS; SYMBOLS; TRAFFIC SIGNS

225964 DA PAVEMENT MARKINGS Road Research Institute /Brazil/; Lara, EM SUBFILE: HRIS THIS MANUAL TREATS A VARIETY OF TOPICS RELATED TO PAVEMENT MARKINGS AND CONTAINS STANDARDS RESPECTING THEIR FUNCTIONS AND LIMITATIONS. IN SOME CASES THEY ARE USED TO SUPPLEMENT OTHER SIGNALLING SYSTEMS, IN OTHERS THEY TRANSMIT THEIR OWN MESSAGES WHICH WOULD NOT BE POSSIBLE WITH THE USE OF OTHER EQUIPMENT. PAVEMENT MARKINGS (PM) HAVE DEFINITE LIMITATIONS, E.G., THEIR SHORT DURABILITY WHEN INSTALLED TO SURFACES EXPOSED TO HEAVY TRAFFIC AND THEIR POOR VISIBILITY ON WET ROADS. HOWEVER, THESE LIMITATIONS ARE AMPLY OWEIGHED BY THE ADVANTAGE, IN FAVORABLE CONDITIONS, OF transmitting messages to drivers without distracting their attention from the road. THE FOLLOWING ITEMS ARE DISCUSSED: LEGAL AUTHORITY TO INSTALL PM, STANDARDIZATION OF PM IN ORDER TO BE RECOGNIZED AND UNDERSTOOD BY THE USERS, TYPES, COLORS (THE SPECIFIC USE OF YELLOW AND WHITE), REFLECTORIZATION AND ITS APPLICATIONS, MAINTENANCE, CENTER LINES, LANE LINES, "NO OVERTAKING" MARKINGS ON ASPHALTED SHOULDERs, ROAD WIDTH TRANSITION MARKINGS, CHANNELLING LINES, "APPROACHING-OBSTRUCTION" MARKINGS, STOP LINES, PEDESTRIAN CROSSING LINES, "APPROACHING-INTERSECTION" MARKINGS, PARKING LIMITING LINES, AND WORDS AND SYMBOLS. /rrl/ DESCRIPTORS: CENTER LINES; COLOR; INTERSECTIONS; LEGAL ASPECT; MAINTENANCE; OPERATIONS AND TRAFFIC FLOW; OVERTAKING; PARKING; PEDESTRIAN CROSSINGS; REFLECTORIZATION; SHOULDERS; (CONT. NEXT PAGE)
COMMUNICATION SYSTEMS FOR TODAY'S AND TOMORROW'S MOTORISTS

Communication systems developed by General Motors research laboratories to aid the motorist in driving tasks are covered. A review of the research laboratories' programs includes roadway channel facilities, visual signing, driver aid information and routing, and recent work for the federal highway administration, bureau of public roads involving an electronic route guidance system, in addition, a nationwide community program for coordinating citizens two-way radio facilities in local emergencies along with the city of Detroit driver aid network is described. One of the earliest electronic driver aids was the roadside low frequency signalling system. This experimental system was later produced by the delco radio division under the name hy-com. Today this system is called audio signing. The transmitter output fed a wire loop adjacent to the roadway. The length of the loop was adjusted so that a motorist travelling at the speed limit would receive two complete messages. The messages were either recorded on a continuous tape loop or could be controlled from a master station. Messages would be heard through the car radio receiver only when passing a hy-com transmitter, while the entertainment audio was automatically muted. This was accomplished by placing a trigger loop ahead of the message loop to signal the presence of a hy-com transmitter. The hy-com system was tested and the results documented in a 1967 report by the Georgia institute of technology. Interestingly, a system such as described is now being installed on route M-4 in England. The system will operate at 100 kHz with loops 3/4 mile long to provide two complete messages at 70 mph. Two channels will be employed, one for directions and the other for emergency messages. The use of two channels was first proposed in 1959. The possibility of an in-car display of road signs such as speed limits, curves, stop, railroad, etc., led to the development of visual signing. A general motor's system employed cylindrical magnets buried in the roadway to establish a coded sequence of north-south magnetic fields corresponding to the code assigned to the message on the adjacent roadside sign. Techniques other than the magnets can be employed to generate the displayed symbols but the magnets offer a maintenance-free scheme which should be attractive to highway authorities.

EXPERIMENTAL ROUTE GUIDANCE HEAD-UP DISPLAY RESEARCH

Benzinger, RW; Bell, E

Highway Research Record, Hwy Res Board 1969 No 265, pp 62-70, 7 fig, 1 tab, 7 ref

An experimental route guidance head-up display is a new technique developed by the industry as a pilot landing aid. This concept provides a virtual image symbolic representation of the visual scene projected on the windshield of the aircraft and superimposed on the real world. The symbolology is focused at infinity and permits the pilot to observe both the real world, the superimposed image and other visual cues without lowering his head to look at the instrument panel. The term 'head-up display' was coined to describe this feature. This technique has been adapted to present directional symbols to the driver in the same manner so that he need not take his eyes off the road. The design of the vehicle display unit is derived from evaluation and tradeoff of the various optical and electronic techniques developed for an aircraft application. Design criteria were established to meet the objectives of optimum image quality, minimum package size, and most economical cost. Several alternative approaches to display design were investigated that involved various types of lenses, reflecting surfaces, and symbol production techniques. Other engineering considerations involved included temperature and vibration environment, vehicle design, and safety. A feasibility model of the selected approach was built and delivered to the bureau of highway administration for road testing in their experimental vehicle and subsequent incorporation in the route guidance test network.

A COMPARATIVE EVALUATION OF SPEED CONTROL SIGNS

Cameron, C; Mcgil11, WA

Australian Road Research Dec 1968 Vol 3, No 8, PP 3-11, 1 fig, 3 tab, 9 ref

An experiment was carried out to compare the effectiveness of different types of road sign used for the imposition of speed and for the removal of restrictions on traffic speeds. The time required to classify each sign into one of four categories was the primary measure used for comparison. Significant differences were found among the signs and the conclusions which may be drawn are summarized. (1) Symbolic signs were found to be superior to signs displaying verbal messages. (2) Of those examined the most effective type of speed restriction sign was found to be the type of circular sign recommended in the draft u.n. Portocol. (3) Of those examined the most effective type of de-restriction sign was (cont. next page)
PRINTS  User:005102  13may93 P217: PR S14/5/ALL (items 1-99)  PAGE: 159  Item 74 of 99

DIALOG File B3: TRIS _ 70-92/JUL

found to be a white sign bearing a black oblique bar. (4) A blue circular sign bearing white numerals was found to be superior to a verbal sign for the imposition of a minimum speed. (5) A blue circular sign with white digits cancelled by means of an oblique red bar was found to give faster responses than a verbal sign for the termination of a minimum speed zone. (6) In only one case was it possible to discriminate between signs on the basis of errors. And (7) the experimental method used proved sensitive to differences among signs and is considered suitable for further use in similar studies. /Author/

DESCRIPTORS: COMPARISONS; EFFICIENCY; OPERATIONS AND TRAFFIC FLOW; SPEED CONTROL SIGNAL; SYMBOLS; TRAFFIC SIGN LEGIBILITY; TRAFFIC SIGNS; TRAFFIC SPEED

224357 DA

VISUAL ASPECTS OF ROAD ENGINEERING
Cole, BL
Australian Road Research Board Conference Proce Vol. 6 Pt 1
REPORT NO: Paper No 820
SUBFILE: HRIS

About one in every five drivers will have a deficient capability for one or more of the following visual tasks: detection of obstacles, delineation and signal lights, temporal resolution of flashing and flickering lights, spatial resolution of road sign legends and symbols, color discrimination, and spatial relationships (the perception of direction, depth and movement). It is argued that the visual requirements imposed by licensing authorities do not (and should not) exclude these drivers from holding a license to drive; rather, road design should compensate for defective vision. /Author/

DESCRIPTORS: COLOR PERCEPTION; DRIVER LICENSING; DRIVER VISION; DRIVERS /VEHICLE/; HIGHWAY DESIGN; HUMAN FACTORS; VISUAL PERCEPTION

220822 DA

THE USES OF COORDINATES FOR ACCIDENT LOCATION AND AS A TOOL FOR ANALYSIS
Stoner, JE; Johnson, PC
Indiana University
1966
REPORT NO: 15 pp
SUBFILE: NSC; HRIS

THE STUDY WAS UNDERTAKEN TO FIND A WAY OF REPORTING THE LOCATION OF HIGHWAY TRAFFIC ACCIDENTS. THE SYSTEM SETTLED UPON IS THE USE OF COORDINATES BASED UPON UNITED STATES GEODETICAL SURVEY (USGS) 7.5 MINUTE MAPS, WHICH ARE RELATIVELY UP TO DATE, COVER THE ENTIRE STATE, ARE CONSTANTLY BEING UPDATED, AND ARE THE MOST ACCURATE OF ANY MAPS. THEY CONTAIN THE SYMBOLS FOR PRACTICALLY ALL OF THE RURAL CULTURE AND A GREAT MANY FOR THE PHYSICAL FEATURES, WOODED AREAS, DRAINAGE SYSTEMS, DIFFERENCES IN ELEVATION AND THE TOWNSHIP, RANGE, AND SECTION LINES. AFTER FINDING THE REPRESENTATIONS OF THE CULTURE AND LAND ON THE MAP, AN OFFICER CAN REPORT THE POINT

BY SETTING DOWN THE NUMBER OF FEET IT IS EAST AND NORTH OF 2 LINES. IN URBAN AREAS THE OFFICER WAS ASKED TO REPORT THE PLACE IN TERMS OF HOUSE NUMBERS, STREET INTERSECTIONS OR ALLEYS. A CLERK WHO HAD THE MAP BOOK THE SYSTEM WAS TESTED IN MONROE COUNTY, INDIANA FOR 3 MONTHS. SIX HUNDRED TWENTY-NINE ACCIDENTS WERE REPORTED AND THE REPORTS WERE ADEQUATE TO LOCATE ALL BUT 6. THE AMOUNT OF TRAINING GIVEN THE OFFICERS WAS MINIMAL. VISUAL AIDS FOR TRAINING WILL FOLLOW BEFORE THE SYSTEM IS INSTALLED FOR THE STATE, AND A MECHANICAL TEST WILL BE BUILT IN FOR ERRORS OFF THE ROAD. THE ATTITUDE OF THE POLICE TOWARD SUCH REPORTING IS DISCUSSED. THERE ARE 2 THINGS WHICH COULD BE DONE TO GREATLY IMPROVE THE ACCURACY OF OFFICE PLOTTING OF COORDINATES: AN EDUCATIONAL PROGRAM DESIGNED TO REACH OFFICERS FILLING OUT REPORTS AS TO THEIR SIGNIFICANCE, AND TO REACH THE PUBLIC, AND THE PREPARATION OF BETTER LOCAL MAPS. IT IS STRESSED THAT TO BE ABLE TO RELATE THE PLACE TO THE ACCIDENT OPENS THE DOOR TO IDENTIFYING THE SIZE OF THE ROAD FACTOR IN THE ACCIDENT. THE COORDINATE SYSTEM IS SUITABLE. /Author/

DESCRIPTORS: COORDINATES; GEOLIGIC MAPS /AERIAL/; HIGH ACCIDENT LOCATIONS; LOCATIONS; PERSONNEL TRAINING; POLICE; SAFETY; TRAFFIC ACCIDENT REPORTING; TRAFFIC ACCIDENTS

200974 DA

EVALUATING CONTRACT COSTS IN HIGHWAY NEEDS STUDIES
Jordan, RD
Highway Research Board Bulletin 1957 No 158, pp 98-103, 1
FIG. 1 TAB
SUBFILE: HRIS

DIALOOG File 63: TRIS - 70-92/JUL

198386 DA
AN EVALUATION OF PICTOGRAPHIC SYMBOLS FOR CONTROLS AND DISPLAYS IN ROAD VEHICLES
Wiegand, D; Glumm, MM
Human Engineering Laboratories Aberdeen Proving Ground
Aberdeen Maryland 21005
REPORT NO: HEL-TM-1-79
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285
Port Royal Road Springfield Virginia 22161

This study investigates the recognition value of 25 symbols developed by the International Standard Organization (ISO) for controls and displays in road vehicles. A sample of 125 native US citizens (75 males and 50 females) with more than one year of driving experience served as subjects. The results demonstrated a remarkable recognition value of 20 symbols. Only 5 symbols failed the acceptance criterion of a minimum 75 percent recognition. It was found that identification of the symbols was, in general, not influenced by sex or additional military driving experience. (Author)

DESCRIPTORS: AUTOMOTIVE ENGINEERING; DISPLAY SYSTEMS;
EVALUATION; HUMAN ENGINEERING; HUMAN FACTORS ENGINEERING;
INDICATORS; INSTRUMENTATION; MILITARY; MILITARY VEHICLES;
MOTOR VEHICLES; PASSENGER VEHICLES; RECOGNITION; ROAD TESTS;
SAFETY; SEX; STANDARDS; SYMBOLS; TEST AND EVALUATION; VEHICLE
CHARACTERISTICS; VEHICULAR SAFETY

196917 DA
ERGONOMICS STANDARDS FOR ROAD VEHICLES
Simmonds, G (Ford Motor Company)
Taylor and Francis Limited
Ergonomics VOL. 22 NO. 2 Feb 1979 pp 135-144 8 Fig. 1 Phot.
17 Ref.
SUBFILE: TRRL; IRRD; HRIS

Work on producing ergonomics standards for road vehicles has been co-ordinated by ISO. This is improving the compatibility between drivers and vehicles. It has also been influential in harmonising the technical bases of different sets of regulations. The scope, content and technical approaches are reviewed and a case is made for the need for high standards of experimental work in the key areas. Symbols have been developed to identify many car controls and displays. A major feature in their development has been the use of common experimental evaluations in different countries. These covered both the initial recognition of symbols and their retention. These symbols have been developed to identify many car controls and displays. A major feature world; as well as for related classes of vehicles. Control identification is catered for by standards for location. mode of operation, and combination of function. A sophisticated tool has been produced to permit assessments of functional hand reach. This makes allowance for the presence of the steering wheel and the effects of different driver populations. A novel feature is the introduction of a "package factor" to cater for differences in seating architecture. The basic seating position provides the reference for many other parameters. Unfortunately the degree of standardisation which should have been achieved by the use of manikins, based on SAEJ826, has not been realised. Many variations have appeared. A recent meeting attended by 10 manikins showed up some of the differences within the UK. Efforts are being directed toward achieving convergence of technique. A standard exists as a guide to designers against a tendency for the drivers' feet to be obstructed. Also, a joint international experiment has been designed to measure pedal efforts and present data in a usable form.

DESCRIPTORS: ACCELERATOR (VEH); BRAKE; CAR; CLUTCH;
COMPATIBILITY; CONTROL SYSTEMS; DASHBOARD; DESIGN (OVERALL DESIGN);
DIMENSION; DRIVERS /VEHICLE/; ERGONOMICS; HUMAN FACTORS;
LOCATION; SEAT (CAR); SEATING; STANDARDIZATION;
STANDARDS; STEERING WHEEL; SWITCH; VEHICLE; VEHICLE
CHARACTERISTICS; VEHICLE DESIGN

192241 DA
VERMONT TRAVEL INFORMATION STUDY: AN EVALUATION OF THE STATEWIDE TRAVEL INFORMATION PROGRAM
Vermont Agency of Transportation; State Administration Building; Montpelier; Washington; Vermont; D.C.; 05602; 20590
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285
Port Royal Road Springfield Virginia 22161

The purpose of the study was to evaluate the system of informational signs and map plazas which has replaced conventional billboard advertising in the State of Vermont. To evaluate the effectiveness of the program, self-administered questionnaires were sent to selected businesses throughout the state. In addition, self-administered questionnaires were sent to all chambers of commerce or similar community organizations. Self-administered questionnaires for travelers were distributed at participating businesses and information plazas. Selected roadside interviews of travelers were also conducted. The results of the survey are presented in tabular form by type or station with a list of comments received following each section. The data obtained in the survey indicated that the reaction to the uniform color coded (cont. next page)
The symbols were generated at 1/4 scale in the laboratory, using a computer driven 30 x 30 lamp matrix. Three different task environments were used: one requiring the subjects to name the symbols whilst performing another complex task, the second a simple naming of the symbol and a third, discriminating and then responding with a 6 choice keyboard. In each case the response latency was measured, and whilst some significant differences between symbols were found, it is concluded that response latency is not sufficiently sensitive to discriminate reliably between the perceptual features of the symbols.

Descriptors: changeable message sign; driver perception; driver reaction; operations and traffic flow; reaction time

181184 DA

An interview survey of motorway driver information requirements and signal understanding


Descriptors: Design; divided highways; evaluation; highway bridges; narrow bridges; operations and traffic flow; rural areas; rural highways; symbols; tests; traffic safety; traffic signs; two lane highways; vehicular traffic control; warning signs; warning systems.
Berkshire (including the County Borough of Reading) was chosen as being a suitable catchment area and the drivers were selected at random from driving license records. 523 interviews were successfully completed. The results from these were weighted according to each respondent's frequency of travel on these stretches of road, so as to give data representative of all the drivers living in Berkshire who used these roads. In the first part of the interview the drivers were questioned about their use of M4 and A4, and about factors they thought were important concerning their choice of route, bad weather, delays and hazards. Questions were also asked about their requirements for traffic information and about methods of providing it. In the second part of the interview the drivers were shown diagrams of standard, and non-standard, motorway matrix-signals to test their understanding of them. One finding was that the red 'STOP' lights were poorly understood and often treated only as hazard warnings. (Copyright (c) 1977 Crown Copyright.) (Figures are reproduced in black and white) Also pub. as ISSN 0305-1293.

DESCRIPTORS: GREAT BRITAIN; HAZARDS; INTERVIEWS; MOTOR VEHICLE OPERATORS; PERCEPTION; ROADS; ROUTES; SURVEYS; SYMBOLS; TRAFFIC ENGINEERING; TRAFFIC SIGNALS; VEHICULAR TRAFFIC CONTROL

The technical side of the man-machine system "traffic" has undergone many developments, but the latter has reached an inflexibility and complexity, so that psychological stresses have greatly increased. Acquisition by drivers of information concerning traffic, road characteristics and vehicle movements is of vital importance, and to improve transmission of information it is essential to know the information needs, collection strategies and information effectiveness. Tests were made involving systematic recording of eye and head movements and verbal reports of perception and reactions, correlated with recording of traffic environment. Use and effectiveness of peripheral vision was the common denominator in field tests. Tests on drivers' ability to follow a course using only peripheral vision showed performance to be inversely proportional to angle between course and eye direction, with large individual variations. Eye movement recording, although prone to weaknesses, was found satisfactory for measurement and analysis of information acquisition. Peripheral vision can record the colour and shape of road signs, but identification of text and symbols needs practically central vision. Tests to find, by head movement recording and verbal reports, whether information collection strategy is based on abstract information or concrete environmental information showed that drivers mostly react on the basis of the latter. /TRRL/
149866 DA
TARA: AN AID TO TRAFFIC MANAGEMENT AND TRANSPORTATION ENGINEERS
Slatter, DA (Oxfordshire County Council)
Printerhall Limited
SUBFILE: TRRL; IRRD; HRIS
Gives an account of TARA, a computer based system for recording and analysing traffic and other highway and transportation information, that allows cross-referencing of the specific applications. A link and node system is used to define the network in the form of a four file model. File-accessing and file-handling routines extract the required information. Linked to these are the data files and interrogation programs. Details are given of the network modelling system which is kept up-to-date by means of an edit program, and of the plotting programs which include a range of options such as the inclusion of drawing frame details, legend details, the use of prescribed symbols and lines, labelling facilities, and different sizes and scales. Information is given on the two levels of operation of the road traffic system programs. Traffic information (counts and speed) data are processed and stored on raw data files which up-date a master file. The level 1 program interrogates the master file according to appropriate parameters to obtain the required information. The level 2 program produces a file of summarized level 1 information. Reference is made to the need for the system to accommodate circumstances where no data (or limited data) exist. Information is also given on the accident system which has been designed to make use of (but not duplicate) existing local authority accident systems. The main use of the system is to provide details of roads where the accident rate is reaching an intervention level. Details are given of the formula developed for this purpose using a moving cursor technique. /TRRL/.

148760 DA
METHODS FOR THE EVALUATION OF TRAFFIC SIGNS
Dewar, RE; Elis, JG
Calgary University, Canada; Institute for Transportation Studies; Calgary; Alberta T2N 1N4; Canada
CONTRACT NO: 97096; Contract
SUBFILE: NSC; HRIS
A series of experiments was carried out to measure comprehension, or intrinsic meaning, of traffic sign symbols under a variety of conditions. In addition, the preferences for symbolic representation of traffic sign messages were measured by determining population stereotypes, and subjective meaning of signs was measured using the semantic differential technique. Three questionnaire techniques were developed and compared for use in measuring intrinsic meaning, preference, and clarity of symbolic messages. Learning and memory for the meanings of unfamiliar symbols was examined in two experiments. Laboratory techniques included the measurement of glance legibility using a relatively simple tachistoscopic method, and the measurement of the speed with which subjects could extract information from signs, using a reaction time technique. Several of these methods, with which the same series of signs was examined, were compared for their relative ability to predict results obtained in the initial on-the-road study. Conclusions and recommendations are made on the basis of this series of experiments. /Author/ Sponsored by Ministry of Transport, Canada
SUBFILE: TRIS
DIRECTORS: AUTOMATIC CONTROL; DRIVER INFORMATION SYSTEMS; HIGHWAY SIGNS; OPERATIONS AND TRAFFIC FLOW; OVERHEAD TRAFFIC SIGNS; SPEED; TRAFFIC SIGNALS

DIALOG File 63: TRIS _ 70-92/JUL

DESCRIPTIONS: AUTOMOBILE DRIVERS; AUTOMOBILES; CONTROLS; DRIVER REACTION; DRIVERS /VEHICLE/; HIGHWAY ACCIDENTS; INSTRUMENT PANEL; INSTRUMENT PANELS; LABORATORY STUDIES; SAFETY; TESTING; TRAFFIC ACCIDENTS

149932 DA
HIGHWAY SIGNALING
Traffic Engineering VOL. 47 NO. 2 Feb 1977 p 54
SUBFILE: HRIS
The Dutch Ministry of Public Works and Philips Telecommunication Systems have agreed to work together for a period of five years on the development, manufacture and installation of a new highway signaling system which will inform motorists of road conditions by means of variable advisory speed indicators. The virtually automatic system will warn of slow-moving or stationary traffic or road work; in bad weather, it will inform of speed restrictions. Also, the possibility of reducing queue formation at times of particularly heavy traffic will be investigated. The traffic signals are of an illuminated matrix-type (numbers of symbols) and are mounted on overhead stands at intervals of 500 to 1,000 meters.

DIALECT: TRIS
DESCRIPTIONS: EVALUATION; LEARNING; LEGIBILITY; MEMORY; OPERATIONS AND TRAFFIC FLOW; PREFERENCES; QUESTIONNAIRES; REACTION TIME; SAFETY; SYMBOLS; TACHISTOSCOPY; TRAFFIC SIGNS
Forest road classification in Canadian industry in the late 1960s was uncoordinated and chaotic. Local requirements varied so widely that there were no common grounds for industry-wide standardization. Study showed significant differences underlying the design philosophies of public and forest roads. In particular, forest road design was closely linked to production requirements wherein the roads have a finite life and the objective is clearly lowest cost. A new system of describing forest roads was proposed that consists of five-part designations assembled from symbols representing the design conditions or service requirements of these roads. The symbols represent maximum axle load, desired vehicle speed, availability, daily traffic, and anticipated life. Through assembling to describe almost any type of service a forest road (or public highway) might provide. The system was critically reviewed and subsequently accepted as a standard by the Logging Operations Group of the Canadian Pulp and Paper Association. Proceedings of a workshop held June 16-19, 1975, in Ottawa,Ontario by the Transportation Research Board.

THE VISIBILITY OF ALPHABETIC AND SYMBOLIC TRAFFIC SIGNS

Jacobs, RJ; Johnston, AW; Cole, BL (Melbourne University, Australia)

Australian Road Research Vol. 5 No. 7 May 1975 pp 68-86

SUBFILE: HSR1; HRS

The techniques used in this study permit the determination of sign visibility under controlled conditions for observers with both normal and reduced visual acuity. Sixteen familiar road sign messages (regulatory and warning) were examined in both alphabetic and symbolic form for observers with visual acuities from normal to as low as 6/21. Threshold legibility distances were calculated using probit analysis for individual signs and groups of signs. The experiments show that: (a) the average 50 percent threshold legibility distance for symbolic signs is about twice that for alphabetic signs for all levels of visual acuity; (b) the shape coding included on the signs does not enhance their legibility among a set of signs; (c) the sign size required for 0.95 probability of correct identification is approximately 1.7 times larger than the size giving 0.50 probability of correct identification; and (d) reduced visual acuity has a predictable effect on legibility distance, e.g. a change in visual acuity from 6/6 to 6/12 halves the 50 percent threshold legibility distance. Practical sign design for the actual driver population is discussed and, it is concluded that the use of symbolic sign messages and larger alphabetic sign messages is required.

SUBFILE: TRRL; IRRD: HRIS

Some road safety teaching aids show traffic situations from above using an oblique or composite plan view. These viewpoints are useful for showing distances between vehicles and their relative positions and courses, but might be

(132912 DA)

CURRENT PRACTICES IN USE OF RETRO REFLECTIVE SIGNING MATERIALS

NCHR Research Results Digest 1976 5 pp 3 Tab.

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The major findings are presented of a questionnaire survey (of what material combinations are being used and the basis for their selection) which was part of a research effort to define the optimum relationship between sign background and legend luminance as a function of several pertinent variables. The questionnaire elicited information on the types of signing material; paractices relating to illumination; inspection and maintenance practices; criteria and methods for refurbishing existing signs, and determining the time of replacement; and the useful life of various sign face materials. Material combinations must frequently used are summarized in a table. The combinations must frequently mentioned were button copy on porcelain enamel and button copy on engineer-grade sheeting. With reference to sign employing direct-applied letters, symbols, or legends, material use was evenly divided between engineer grade and high-intensity sheeting. Findings related to illumination of road signs, photometric specifications, quality control, maintenance and replacement are also discussed.
difficult for young children to understand. Children of 6, 7 and 8 years of age were asked to interpret some of these pictures. Recognition of objects was at a high level for both viewpoints, though better for oblique views. Sight-lines for road users were usually interpreted correctly. Symbols used to indicate movement of direction of movement caused more difficulty and children were not always able to predict successfully the outcome of some of the situations shown.

/TRL/

DESCRIPTORS: AERIAL PHOTOGRAPHY; AGE; CHILD; COMPREHENSION; DIRECTION; DIRECTION (TRAFFIC); EDUCATION; HEADING; LOCATION; METHOD; MINORS; RECOGNITION; SAFETY; SAFETY EDUCATION; SCHOOL CHILD TRAFFIC SAFETY; TRAFFIC; TRAFFIC SAFETY EDUCATION; VEHICLE SPACING

127501 DA

STANDARDISED FLEXIBLE PAVEMENT DESIGN FOR RURAL ROADS WITH LIGHT TO MEDIUM TRAFFIC

Mitchell, RL. Vander Marwe, CP; Geel, HK
Ministry of Roads and Road Traffic, Rhodesia; Coghlan Building, Fourth Street; Salisbury; Rhodesia
Jun 1975 70 pp 11 Fig. 3 Tab. Photos. Refs.
REPORT NO: SR 1
SUBFILE: HRIS
AVAILABLE FROM: Ministry of Roads and Road Traffic, Rhodesia Coghlan Building, Fourth Street Salisbury Rhodesia

An empirical approach to pavement design is presented together with introductory notes on the standard specifications of the Rhodesian Ministry of Roads and Road Traffic. Definitions are presented and aspects such as design economics, essential geology, expansive soils, collapsing soils and drainage are covered. The specifications also cover soil grouping classification for design purposes, compaction, climate, design traffic, and construction materials. Other aspects included in the specifications are: termite workings and rock bars, and barriers; surfacings; urban roads; use of symbols for roadbed and subgrade preparation; and design cuts and fills. The preparation of the roadbed and subgrade and the pavement design of minor rural roads with single and major rural roads with at least 2 bituminous traffic lanes are detailed Tables and figures are presented and design examples are described.

DESCRIPTORS: CONSTRUCTION MATERIALS; ECONOMICS; FLEXIBLE PAVEMENT DESIGN; HIGHWAY DRAINAGE; LOW VOLUME ROADS; PAVEMENT DESIGN AND PERFORMANCE; ROADBEDS; RURAL HIGHWAYS; SINGLE LANE TRAFFIC; SOIL CLASSIFICATIONS; SPECIFICATIONS; STANDARDS; SUBGRADES; TWO LANE HIGHWAYS

095399 DA

CONDITIONS FOR THE TRANSPORT OF DANGEROUS GOODS - PROBLEMS AND SOLUTIONS

Koppel, G
Chemische Rundschau VOL. 27 NO. 25 pp 1-7 6 Fig. German
SUBFILE: UIC; RRIS
AVAILABLE FROM: Chemie-Verlag Vogt-Schild AG 4500 Solothurn Switzerland

The author summarizes several aspects of the conditions for the transport of dangerous goods from the railway point of view, mentions the problems involved and proposes optimal solutions. He also presents the standard symbols used for the transport of dangerous goods to show the first results of work for the harmonization and unification of both road and railway transport conditions.

DESCRIPTORS: CHEMICALS; EXPLOSIONS; FIRES; GERMAN FEDERAL RAILWAY; HAZARDOUS MATERIALS; SAFETY; WARNING SYSTEMS

043682 DA

INVESTIGATION OF NEW TRAFFIC SIGNS, MARKINGS AND SIGNALS. VOLUME 1. LABORATORY EXPERIMENTS AND ROAD TESTS

Dietrich, CW; Markowitz, J bolt, BN, and Newman, Incorporated 50 Moulton Street; Cambridge; Massachusetts; 02138
VOL. 1 Dec 1972 87 pp
REPORT NO: BBN-1792 Vol-I
SUBFILE: NTIS AGGREGATE; CLASSIFICATION; CONSISTENCY; CRITERIA; DENSITY; DETERMINATION; DRYING OVEN; EXPLORATION CLASSIFICATION (SOILS); HEAVE; IDENTIFICATION (SOILS); LIQUID LIMIT; LIQUID LIMITS; METHODS; MOISTURE CONTENT; PARTICLE SIZE DISTRIBUTION; PLASTIC LIMIT; SIEVE ANALYSIS; SOIL; SOIL AGGREGATE MIXTURES; SOIL CLASSIFICATION SYSTEMS; SOIL MECHANICS; SPECIFICATION; STANDARDS; TEST; TESTING; WEIGHT MEASUREMENT; WORKABILITY
Traffic signs, markings and signals recommended for a manual on uniform traffic control devices were evaluated both in the laboratory and on the road to measure the recognizability of both standard and experimental signs. Visual presentation was chosen as the independent variable. An important conclusion is that road testing and laboratory testing can complement one another. A questionnaire was designed to provide information about population stereotypes as to the meaning of the traffic control device as a symbol, the implication of this meaning for action, and, the preference for one control device over another. The document is volume one of a two volume report.

See also Volume 2, PB-213 886.

DESCRIPTORS: COLOR CODES; EFFECTIVENESS; FLASHING SIGNALS; LABORATORIES; MARKING; PUBLIC OPINION; QUESTIONNAIRES; RECOMMENDATIONS; REGULATIONS; ROAD TESTS; SIGNAL LIGHTS; SYMBOLS; TRAFFIC LANE MARKINGS; TRAFFIC SAFETY; TRAFFIC SIGNALS; TRAFFIC SIGNS; VEHICULAR TRAFFIC CONTROL; WARNING SYSTEMS; WORDS LANGUAGE

INVESTIGATION OF NEW TRAFFIC SIGNS, MARKINGS AND SIGNALS. VOLUME 2. DRIVER QUESTIONNAIRE.  
Jones, G. Bolt, Beranek and Newman, Incorporated Cambridge; Massachusetts  
VOL. 2 Dec 1972 207p  
REPORT NO: BBN-1762-Vol-2  
CONTRACT NO: DOT-FH-11-7960; Contract  
SUBFILE: NTIS  
AVAILABLE FROM: National Technical Information Service 5285  
Port Royal Road Springfield Virginia 22151

Traffic signs, markings and signals recommended for the 1971 Manual on Uniform Traffic Control Devices were evaluated both in the laboratory and on the road to measure the recognizability of both standard and experimental signs. The strong preference of people tested is discussed for signs that carry both symbols and letters. The document is Volume 2 of a two volume report. See also Volume 1, PB-213 885.

DESCRIPTORS: ABBREVIATIONS; CLASSIFICATIONS; COLOR CODES; DATA ACQUISITION; EVALUATION; FLASHING SIGNALS; HIGHWAY SIGNS MARKINGS; PUBLIC OPINION; QUESTIONNAIRES; RECOMMENDATIONS; REGULATIONS; ROAD MARKINGS; ROADS; TRAFFIC SAFETY; TRAFFIC SIGNALS; TRAFFIC SIGNS; VEHICULAR TRAFFIC CONTROL; WARNING SYSTEMS