627 12u

2. To: (Receiving Organization) Documentation and Records Management
3. From: (Originating Organization) Technical Integration (FSA 13300)
5. Proj./Prog./Dept./Div.: Spent Nuclear Fuel Project
6. Design Authority/Design Agent/Cog. Engr.: D. M. Chenault
8. Originator Remarks:
Evaluation of the below grade structures utilities subject to SNF Transport loads.


15. DATA TRANSMITTED

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<th>(C)</th>
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17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

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<td>Design Authority: D.M. Chenault</td>
<td>[Signature]</td>
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<td>S5-07</td>
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<td>Cog Eng.</td>
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<td>X3-78</td>
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<td>Cog Mgr. D.W. Medford</td>
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18. (D. M. Chenault 11-19-99)

Signature of EDT Date

Authorized Representative Date for Receiving Organization

21. DOE APPROVAL (if required)

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BELOW GRADE ASSESSMENT OF SPENT NUCLEAR FUEL CASK TRANSPORT ROUTE

DM Chenault
Fluor Daniel Hanford
P.O. Box 1000
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

Abstract:
The report provides an assessment of the route for the SNF Fuel transport system from the K Basins to the CVDF and to the CSB. Results include the identification of any underground structures or utilities traveled over by the transport, the overburden depths for all locations identified, evaluation of the loading conditions, and determination of the effects of the loads on the structures and utilities.

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BELOW GRADE ASSESSMENT OF SPENT NUCLEAR FUEL CASK TRANSPORT ROUTE

Prepared for

FLUOR DANIEL HANFORD
Contract No. 263 – Release 47

November 1999

Prepared by: C. M. Conselman

Reviewed by: Robert L. Fred

Date: 11/11/99
TABLE OF CONTENTS

1.0 INTRODUCTION .............................................................................................................. 1
2.0 SUMMARY AND CONCLUSIONS ...................................................................................... 1
3.0 APPROACH/EVALUATION .............................................................................................. 5
  3.1 Transport Trailer Description ..................................................................................... 5
  3.2 Routing, Access Control, and Speed Limitations .......................................................... 7
  3.3 Identification of Underground Structures and Utilities .................................................. 7
4.0 ASSUMPTIONS AND UNCERTAINTIES ....................................................................... 12
5.0 REFERENCES .................................................................................................................. 12

APPENDICES

Appendix A
ARES Corporation Calculation No. 9904500.47-001, Revision 0
SNF-5042
REVISION 0

TABLES

Table 2.1. Identification of Underground Structures and Utilities ........................................... 2
Table 3.1. Road Surface Conditions and Cross-Sections for the SNF Transport Route ........... 7

FIGURES

Figure 3.1 SNF Transport Trailer .................................................................................................. 6
Figure 3.2. SNF Cask Transport Route........................................................................................ 8
Figure 3.3. SNF Cask Transport Route (100 K Area) ................................................................. 9
Figure 3.4. SNF Cask Transport Route (CSB) ......................................................................... 10
### ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>AEC</td>
<td>Atomic Energy Commission</td>
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<tr>
<td>CSB</td>
<td>Canister Storage Building</td>
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<tr>
<td>CTS</td>
<td>Cask Transportation System</td>
</tr>
<tr>
<td>CVDF</td>
<td>Cold Vacuum Drying Facility</td>
</tr>
<tr>
<td>GAWR</td>
<td>Gross Axle Weight Rating</td>
</tr>
<tr>
<td>GVWR</td>
<td>Gross Vehicle Weight Rating</td>
</tr>
<tr>
<td>KE</td>
<td>K-East</td>
</tr>
<tr>
<td>KW</td>
<td>K-West</td>
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<tr>
<td>SNF</td>
<td>Spent Nuclear Fuel</td>
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SNF-5042
REVISION 0

BELOW GRADE ASSESSMENT OF SPENT NUCLEAR FUEL CASK TRANSPORT
ROUTE

1.0 INTRODUCTION

The purpose of this report is to provide an assessment of the route for the Spent Nuclear
Fuel (SNF) Cask Transportation System (CTS) transport trailer from the storage basins in the
100 K Area [105-K-East (KE) and 105-K-West (KW)] to the Cold Vacuum Drying Facility
(CVDF), and then to the Canister Storage Building (CSB) in the 200 East Area. This includes
identifying any underground structures or utilities that will be traversed, determining the soil
overburden depths for all locations identified, evaluating the loading conditions at each location,
and determining if the transport trailer will have any adverse impact on any of the structures or
utilities.

2.0 SUMMARY AND CONCLUSIONS

It usually is not necessary to consider the effect of live loads on buried utilities except
where they are exceedingly large or where they occur on objects with very little cover. As can
be seen by examining Table 2.1, the highest percentage of the transport trailer live loads
transmitted to any identified buried utility is 3 percent. This is an insignificant amount of
loading when compared to the soil dead load, with the exception of locations 16, 17, 18, 24, and
25. The live load at these locations varies between 10 and 109 percent of the dead load, but the
total loading is still relatively low. Combined with the fact that all of the utilities have been
subjected to various vehicle live loads over time, this indicates that the transport trailer loads
should have no adverse impact on them.

Due to their importance and configuration, additional evaluation was performed on the
two tunnel crossings (locations 3 and 5). The 105-KW to 165-KW tunnel (location 3) was
designed for a crane loading of 204 kips (AEC 195 - Atomic Energy Commission). The crane
loads were applied using three different configurations running along the tunnel and were
calculated to have an applied load of 14.6 kips per foot. This loading condition is greater than
the loading condition applied by the transporter. Therefore, it can be concluded that the tunnel is
structurally adequate to withstand the transport trailer loading conditions.

The KE to KW cross-tie tunnel (location 5) was evaluated for various crane loadings in
Structural Evaluation for the 165K Cross-Tie Tunnel, 100K Area, WHC-SD-SNF-FLE-001,
Revision 0 (Islam 1995). This document concluded that the tunnel was structurally adequate to
### Table 2.1. Identification of Underground Structures and Utilities

<table>
<thead>
<tr>
<th>Location No.</th>
<th>Location Description</th>
<th>Item Description</th>
<th>Reference Drawing(s)</th>
<th>Soil Overburden (ft)</th>
<th>Soil Dead Load (lbs/ft²)</th>
<th>Transporter Live Load (lbs/ft²)</th>
<th>Total Load (lbs/ft²)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100 K / KW</td>
<td>(2) 60-in. Raw Water (Steel pipe with ½-in. walls)</td>
<td>H-1-25540, H-1-25517, H-1-25375, M-1901-K</td>
<td>22</td>
<td>10,780</td>
<td>N/A</td>
<td>10,780</td>
<td>Transporter live load is negligible.</td>
</tr>
<tr>
<td>2</td>
<td>100 K / KE</td>
<td>(2) 60-in. Raw Water (Steel pipe with ½-in. walls)</td>
<td>H-1-25540, H-1-25521, H-1-25375, M-1901-K</td>
<td>21</td>
<td>10,241</td>
<td>N/A</td>
<td>10,241</td>
<td>Transporter live load is negligible.</td>
</tr>
<tr>
<td>3</td>
<td>100 K / KW</td>
<td>105KW to 165KW Tunnel</td>
<td>H-1-25210, H-1-25433, M-1901-K</td>
<td>4.5 – 6</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>Ref. AEC (1952)</td>
</tr>
<tr>
<td>4</td>
<td>100 K / KW</td>
<td>(2) 10-in. Hot Water (Supply and Return) 4-in. Non-Potable Filtered (Service) Water</td>
<td>H-1-25670, M-1901-K</td>
<td>6</td>
<td>545</td>
<td>158 (1.1%)</td>
<td>703</td>
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</tr>
<tr>
<td>5</td>
<td>100 K / 1717K, Cross-Tie Tunnel</td>
<td>Reinforced Concrete KE to KW Cross-Tie Tunnel (2) 6-in. Fire Water (2) 6-in. Hot Water Supply (2) 6-in. Hot Water Return (2) 4-in. Sanitary Water</td>
<td>H-1-25211, H-1-25678, H-1-25664, M-1901-K</td>
<td>1.25</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>* Ref. Calculation WHC-SD-SNF-FLE-001, Rev. 0</td>
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<tr>
<td>6</td>
<td>100 K / KE</td>
<td>(2) 24-in. Process Water with 30-in. corrugated iron culvert encasement (KE to KW Cross-Tie)</td>
<td>H-1-22310, H-1-21181, H-1-22311, M-1901-K</td>
<td>7</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Culvert protects pipe from loads.</td>
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<td>8</td>
<td>100 K / 183.1KW to 183.1KE</td>
<td>6-in. Sanitary Water</td>
<td>H-1-25524, H-1-25526, M-1901-K</td>
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<td>Unknown</td>
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<tr>
<td>Location No.</td>
<td>Location Description</td>
<td>Item Description</td>
<td>Reference Drawing(s)</td>
<td>L</td>
<td>LD (lb/ft²)</td>
<td>T (lb/ft²)</td>
<td>Comment</td>
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<tr>
<td>9</td>
<td>100 K / KW</td>
<td>1¼-in. Potable Water (PVC)</td>
<td>H-1-82519</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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<tr>
<td>10</td>
<td>100 K / 1702KE</td>
<td>1¼-in. Sanitary Water</td>
<td>H-1-23215KE, H-1-25061</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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<td>11</td>
<td>100 K / KW</td>
<td>4-in. Sanitary Water</td>
<td>H-1-25061</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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<tr>
<td>12</td>
<td>100 K / KW</td>
<td>Drainage (Process) Sewer 5-ft 6-in. by 5-ft 6-in. Reinforced Concrete Flume</td>
<td>H-1-25074, H-1-25075, H-1-25076, H-1-25378, H-1-25534, H-1-25540, M-1904-K</td>
<td>30</td>
<td>3300</td>
<td>N/A</td>
<td>3300</td>
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<tr>
<td>13</td>
<td>100 K / KE</td>
<td>Drainage (Process) Sewer 5-ft 6-in. by 5-ft 6-in. Reinforced Concrete Flume</td>
<td>H-1-25074, H-1-25076, H-1-25378, H-1-25534, H-1-25540, M-1904-K</td>
<td>29</td>
<td>3190</td>
<td>N/A</td>
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<tr>
<td>14</td>
<td>100 K / 105KE</td>
<td>36-in. Process Sewer (Steel pipe with ½-in. walls)</td>
<td>H-1-25384, M-1904-K</td>
<td>15</td>
<td>5225</td>
<td>N/A</td>
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<tr>
<td>15</td>
<td>100 K / 105KE</td>
<td>72-in. Process Sewer (Steel pipe with 5/8-in. walls)</td>
<td>H-1-25072, H-1-25384, M-1904-K</td>
<td>15</td>
<td>10,208</td>
<td>N/A</td>
<td>10,208</td>
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<tr>
<td>16</td>
<td>100 K / Mobile Offices</td>
<td>8-in. Sanitary Sewer (Vitrified Clay)</td>
<td>H-1-25079, H-1-25080, M-1904-K</td>
<td>3.5</td>
<td>396</td>
<td>342 (3.0%)</td>
<td>828</td>
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<tr>
<td>17</td>
<td>100 K / 1717K</td>
<td>(2) 6-in. Sanitary Sewer (Vitrified Clay)</td>
<td>H-1-25079, H-1-25080, M-1904-K</td>
<td>3.5</td>
<td>396</td>
<td>360 (2.5%)</td>
<td>756</td>
<td></td>
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<tr>
<td>18</td>
<td>100 K / 165KW</td>
<td>6-in. Sanitary Sewer (Vitrified Clay)</td>
<td>H-1-25079, H-1-25080, M-1904-K</td>
<td>6</td>
<td>545</td>
<td>115 (0.8%)</td>
<td>660</td>
<td></td>
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</tr>
<tr>
<td>19</td>
<td>100 K / 105KW</td>
<td>36-in. Process Sewer (Steel pipe with ½-in. walls)</td>
<td>H-1-25384, M-1904-K</td>
<td>15</td>
<td>5225</td>
<td>N/A</td>
<td>5225</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>100 K / 105KW</td>
<td>72-in. Process Sewer</td>
<td>H-1-25071</td>
<td>15</td>
<td>10,208</td>
<td>N/A</td>
<td>10,208</td>
<td></td>
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</table>

Transporter live load is negligible. Dead load is lb. / ft².
<table>
<thead>
<tr>
<th>Location No.</th>
<th>Location Description</th>
<th>Item Description</th>
<th>Reference Drawing(s)</th>
<th>Soil Overburden Load (lb/ft)</th>
<th>Soil Dead Load (lb/LF)</th>
<th>Transporter Live Load (lb/lt)</th>
<th>Total Load (lb/LF)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>100 K / 1720K</td>
<td>6-in. Sanitary Sewer (Vitrified clay with concrete encasement)</td>
<td>H-1-25079 H-1-25080 M-1904-K</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Concrete encasement protects pipe from loads</td>
</tr>
<tr>
<td>22</td>
<td>100 K / 1706KER</td>
<td>12-in. Sump Drain</td>
<td>H-1-20355KE</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>100K / KE</td>
<td>(2) 2-in. Gas 12-in. Oil</td>
<td>H-1-20365KE</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>100 K / CVDF</td>
<td>8-in. Fire Water (PVC) 2-in. Potable Water (PVC)</td>
<td>H-1-82092</td>
<td>4</td>
<td>446</td>
<td>303 (2.1%)</td>
<td>749</td>
<td>Transporter live load is 68% of soil dead load.</td>
</tr>
<tr>
<td>25</td>
<td>600 / CSB</td>
<td>(2) 24-in. Export Water</td>
<td>H-2-117071</td>
<td>6</td>
<td>3872</td>
<td>403 (2.8%)</td>
<td>4275</td>
<td>Transporter live load is 10% of soil dead load.</td>
</tr>
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withstand the crane loading conditions, which had uniform applied wheel pressures between 35 psi and 45.5 psi. The applied uniform wheel pressure calculated for the transport trailer is 70 psi.

When comparing the transport trailer loading conditions to the previously evaluated crane loadings using applied wheel pressures, it could not directly be concluded that the tunnel is structurally adequate to withstand the transport trailer loading conditions. Therefore, this tunnel has been evaluated in more detail to determine if it can withstand the loads imposed on it by the transport trailer. This evaluation, which is included as Appendix A, concludes that the KE to KW crosstie tunnel is structurally adequate to withstand the transport trailer loads.

The results of this evaluation indicate that the CTS transport trailer will not have any notable affect on any of the underground structures or utilities that it traverses. It is recommended, however, that the road surfaces within the 100 K Area be treated (cracks sealed, potholes repaired, etc.) prior to use of the CTS.

The section of road between Route 4S and the CSB was not evaluated since this road is relatively new and was built to more current Washington State Department of Transportation and American Association of State Highway and Transportation Officials standards, and the transport trailer live loads fall within the loading conditions used by those standards.

3.0 APPROACH/EVALUATION

In order to evaluate the loading conditions at each of the identified locations, several factors were considered. The evaluations for each of the locations are presented in the following sections. These evaluations include a description of the transport trailer (including wheel loads), a discussion and brief evaluation of the transport route, identification of the underground structures and utilities that will be traversed, and determining the soil overburden depths for the locations identified.

3.1 Transport Trailer Description

The transport trailer is designed to the criteria specified in WHC-S-0396, Revision 1, Specification for SNF Path Forward Cask and Transportation System (Kee 1995). It consists of a tri-axle semi-trailer provided by TransNuclear Inc. and Nelson Manufacturing Company. The trailer will be attached to a standard Hanford Site tractor. The transport trailer loaded with the Multi-Canister Overpack/cask is shown in Figure 3.1. The following information was taken from the identification plate of one of the transport trailers:

<table>
<thead>
<tr>
<th>Model</th>
<th>ARTA-35LD</th>
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<tbody>
<tr>
<td>GAWR</td>
<td>20,280 lb.</td>
</tr>
<tr>
<td>GVWR</td>
<td>97,280 lb.</td>
</tr>
<tr>
<td>Rims</td>
<td>8.25 x 22.5</td>
</tr>
<tr>
<td>Tires</td>
<td>275/70R x 22.5 @ 115 psi (cold)</td>
</tr>
</tbody>
</table>
The weight distribution for the six-axle combination will be approximately 10,000 lb. on the steering axle, 37,250 lb. on the tractor drive axles, and 57,620 lb. on the trailer tri-axle assembly (Chenault 1999). Using a footprint of 11.5-in. by 6-in. for the Bridgestone\(^1\) R294 tires currently on the trailer gives a uniform wheel pressure of 70 psi. The 11.5-in. loaded width is taken from Brisbin (1997), and the 6-in. length is from field measurements.

### 3.2 Routing, Access Control, and Speed Limitations

The cask is authorized for onsite exclusive-use transfer only. The first transfer leg consists of less than 0.5 miles between either the K East or K West Basin and the CVDF. The second leg consists of an 8-mile route following Route 1 out of the 100 K Area, then proceeding on Route 4N to the CSB. The proposed transporter routing is shown in Figures 3.2, 3.3, and 3.4 the transporter must negotiate the proposed route(s) at speeds not to exceed 40 mph. (Kee 1995). Based on the number of assemblies and elements at the K Basins, approximately 400 total shipments are estimated (Chenault 1999).

Based on a field walkdown and document review, the road surface conditions and cross-section for the transport route are as identified in Table 3.1.

<table>
<thead>
<tr>
<th>Portion of Route</th>
<th>Surface Condition</th>
<th>Asphalt Concrete Pavement (In)</th>
<th>Top (Leveling) Course (In)</th>
<th>Case Course (In)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 K AREA</td>
<td>Avg. to Poor</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>CVDF Entrance</td>
<td>New</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>100 K to Rt. 1</td>
<td>Avg. to Poor</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Rt. 1</td>
<td>Avg. to Poor</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Rt. 4S/4N</td>
<td>New overlay</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Rt. 4S to CSB</td>
<td>Good</td>
<td>Good</td>
<td>N/A</td>
<td>8</td>
</tr>
</tbody>
</table>

The original construction documents could not be found for those conditions identified as “unknown.”

### 3.3 Identification of Underground Structures and Utilities

The locations of the underground structures and utilities that will be traversed are given in Table 2.1. This table also gives the soil overburden depth and associated dead loads and the transporter live loads for each location.

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\(^1\) Bridgestone is a registered trademark of the Bridgestone Corporation, Nashville, Tennessee.
Figure 3.2. SNF Cask Transport Route
Figure 3.4. SNF Cask Transport Route (CSB)
The soil dead loads for the underground utilities were calculated using the Marston Equation:

\[ W_c = C_d \cdot w \cdot B_d^2 \]

Where \( W_c \) = the vertical external load on a closed conduit due to fill materials (lb./ft of length)
\( C_d \) = the load calculation coefficient for conduits completely buried in ditches
\( w \) = the unit weight (density) of fill materials (lb./ft^3)
\( B_d \) = the width of the ditch at the top of the conduit (ft)

The analysis used a density of 110 lb./ft^3 for the overburden soil. This is based on data taken from various soils reports prepared for the 100 and 200 Areas of the Hanford Site. The trench width was assumed to be 18-in. for pipes up to 12-in. in diameter. For pipes over 12-in. in diameter, the trench width was assumed to be the diameter plus 2 ft.

The live loads superimposed on the underground utilities by the transport trailer were determined using the "Percentages of Wheel Loads" table from the Clay Pipe Engineering Manual (NCPI 1995). The maximum load occurs when the trailer tri-axle is directly over the utility. The 57,620-lb. load is assumed to be evenly distributed over the three axles, giving an axle load of 19,206 lb. or a load of 9,603 lb. at each set of dual wheels. Each of the five adjacent sets of dual wheels will also impose a load on the buried utilities. These will vary based on the size and depth of the utility, but will typically be about 10 percent of each adjacent wheel load, which would add another 50 percent, or 4,802 lb. for a total applied load of 14,405 lb. This load is then multiplied by the percentage taken from the table to determine the load imposed on the utility. It should be noted that the magnitude of the live load superimposed on the underground utilities decreases considerably as the soil overburden depth increases.

For the reinforced concrete tunnels, the trailer tri-axle weight of 57,620 lb. is also assumed to be evenly distributed over the three axles, giving a load of 9,603 lb. at each set of dual wheels or 4,802 lb. per wheel. The tire contact area was calculated to be 11.5-in. x 6-in. = 71.4 in^2., which gives a uniform wheel pressure of 70 psi.

Impact loads will be generated by the movement of the transporter. These impact loads would normally be approximately 25 percent of the live load. However, the impact loads can be significantly reduced by regulating the speed of the transporter (10 mph or less within 100 K Area) and maintaining a relatively smooth roadway surface. By using these administrative controls, the impact loads can essentially be eliminated. Therefore, they are not considered in this evaluation, with the exception of the KE to KW crosstie tunnel location. Due to its importance and minimal depth, a 25 percent impact factor was considered (see Appendix A).
4.0 ASSUMPTIONS AND UNCERTAINTIES

This report considered all known utilities that will be traversed by the CTS transport trailer, some of which may not be currently in use.

As can be seen in Table 3.1, the soil overburden could not be determined for eight locations. The largest of these lines has a diameter of 12-in. If it was assumed that a 12-in. pipe had a soil overburden of 2 ft, the percentage of the transport trailer load superimposed on the pipe would be 6 percent or 922 lb./lf. Since most of these lines are much smaller that 12-in., and are most likely at least 3 to 4 ft deep, the actual live load imposed is more in the range of 1 to 2 percent, which, as stated in the summary section, is insignificant when compared to the soil dead load already imposed on the pipe.

Since there are no longer any facilities at 100K using oil or gas, it is assumed that the two 2-in. gas lines and the 12-in. oil line (location 23) are abandoned in place.

The reinforced concrete tunnels and sewers were assumed to be in good condition, however, this could not be confirmed. It is not within the scope of this task to determine their condition.

5.0 REFERENCES


Calculation/Problem No: 9908500.47 - 001
Title: KE-KW CROSS-TIE TUNNEL EVALUATION
Client: FDH  Job No: 9908500.47
Project: SNF CASK TRANSPORT ROUTE ASSESSMENT

Design Input References:
Provided within CALC.

Assumptions:
Provided within CALC

Method:
HAND CALCULATIONS USING ROARKS FORMULAE

Remarks:
THIS CALCULATION DETERMINED THAT THE KE-KW CROSS-TIE TUNNEL IS STRUCTURALLY ADEQUATE TO WITHSTAND CTS TRANSPORT TRAILER LOADS.

<table>
<thead>
<tr>
<th>REV. NO.</th>
<th>REVISION</th>
<th>APPROVED</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ORIGINAL ISSUE</td>
<td>RLF</td>
<td>11/14/99</td>
</tr>
</tbody>
</table>

Sheet: 1 of 7
OBJECTIVE: PERFORM A STRUCTURAL EVALUATION OF THE 12-KV CROSS-TIE TUNNEL FOR THE SNF CTS TRANSPORT TRAILER TO DETERMINE STRUCTURAL ADEQUACY.

2. WHC-SD-SNF-FLE-001, Rev 0, July 26, 1975, "Structural Eval. For the 105K Cross-Tie Tunnel, 100K Area,"
4. SNF-2947, Rev 0, 1999, "CTS System Design Description,"
5. FÖRSEK'S FORMULAS FOR STRESS-STRAIN, 6TH EDITION
6. ACI 318-95

ASSUMPTIONS: 1. DEAD LOAD CALCULATIONS AND R.C. CROSS-SECTION CAPACITY CALCULATIONS PERFORMED IN THE PREVIOUS ST. EVALUATION (REV. 2) ARE ADEQUATE FOR USE IN THIS CALC. (THEY HAVE BEEN VERIFIED, HENCE WILL NOT BE REVISITED)

2. THE CRITICAL STRUCTURAL COMPONENT TO BE CHECKED IS THE 12'-SPAN SLAB (SEE FIG. 1). THE CALC. IN REV. 2, VERIFIED THAT THE 6'-SPAN SLAB IS NOT CRITICAL BASED ON SHOWING STRUCTURAL ADEQUACY OF A SIMILAR SLAB WITH 8'-SPAN, AT ANOTHER LOCATION.

3. FOR LIVE LOAD CALCULATIONS, A MONORAIL WHEEL LOAD WILL BE USED, WHICH IS THE
ASSUMPTIONS: 5. (cont.)

SPEARL OF THE LOAD RESULTING FROM TILE CONTACT AREA, AND DRAIN DISTRIBUTION
THROUGH THE 1-FOOT SOIL LAYER.
(CONSERVATIVE ASSUMPTION)

4. THE HAUNCH IN THE 10-FT SPAN BEAM WILL BE DISREGARDED.
   CONSIDERATION OF ELASTIC PROPERTIES OF THE BEAM, I.E.
   A UNIFORM ELASTIC BEAM IS ANALYSED;
   (CONSERVATIVE APPROXIMATION)

5. IMPACT FACTOR OF 1.25 APPLIED TO LIVE LOADS.

Fig. 1: CROSS-THE TUNNEL LAYOUT PLAN (from Ref. 1)
ANALYSIS OF 10 FT SPAN BEAM

Load combination: \( 1.4 \times (DL) + 1.7 \times (LL) \)

1.4(DL) = 187.8 \( \#/\text{in} = W \) (Ref. 2, pA-21)

1.7(LL) = 1.7 \times 9600 = 16,325 \text{ lbs.} = W.


Table 3, pp 100-103.

From Load Moments (Item 2c, Table 3)

\[
\text{Max } M^+ = \frac{9WL^2}{12B} = \frac{9 \times 187.8 \times (120)^2}{120} = 190,143 \text{ #-in}
\]

\[
\text{Max } M^- = \frac{WL^2}{8} = 358,040 \text{ #-in}
\]

SINGLE AXLE IN SPAN

Live Load Moments (Item 1c, Table 3)

\[
\text{Max } M^+ = 0.174 WL = 340,866 \text{ #-in}
\]

with \( W \) located at 5.766 ft from piend end 1 = 69.5 ft

\[
\text{Max } M^- = 0.1924 WL = 370,412 \text{ #-in}
\]

with \( W \) located at 0.5772 from piend end = 69.5 ft

Shear Force

First End: \( V_{\text{max}} = \frac{1}{2}WL + W = 24,776 \# \)

Second End: \( V_{\text{max}} = \frac{1}{2}WL + W = 30,410 \# \)
**CALCULATION SHEET**

**ARES CORPORATION**

**Project No.:** 98045-00-47  **Calc. No.:** 001  **Revision No.:** 1  **Sheet No.:** 5/7

**Prepared By:** A. COHN  **Date:** 11/20/03  **Reviewed By:** C.A. CONNELLMAN  **Date:** 11/20/03

---

**Two Axles in Span**

**Live Load Moments**

For **W1**:  \[ M = \frac{W_1 a}{2} \begin{pmatrix} a^2 - a^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

\[ M^+ = \frac{W_1 a}{2} \begin{pmatrix} a^2 - a^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

For **W2**:  \[ M = \frac{W_2 b}{2} \begin{pmatrix} b^2 - b^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

\[ M^+ = \frac{W_2 b}{2} \begin{pmatrix} b^2 - b^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

\[ M^- = \frac{W_2 b}{2} \begin{pmatrix} b^2 - b^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

---

**Three Axles in Span**

**Live Load Moments**

For **W1**:  \[ M = \frac{W_1 a}{2} \begin{pmatrix} a^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

\[ M^+ = \frac{W_1 a}{2} \begin{pmatrix} a^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

For **W2**:  \[ M = \frac{W_2 b}{2} \begin{pmatrix} b^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

\[ M^+ = \frac{W_2 b}{2} \begin{pmatrix} b^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

\[ M^- = \frac{W_2 b}{2} \begin{pmatrix} b^2 \end{pmatrix} \]

\[ = \frac{16,385 \times 60}{2} \begin{pmatrix} 60^2 \end{pmatrix} = 98,610 \] #.in

---

**Diagram**

- **W1**: 60 ft
- **W2**: 5:7 ft
- **W3**: 60 ft
THREE AXLES IN SPAN (cc A")

For W2: a = 114
\[ M^+ = \frac{16,325 \times 114 \times (6)^2 \times (36^2)}{2 \times (120)^3} = 6,363 \# \text{in} \]
\[ M^- = \frac{16,325 \times 114 \times (120 - 114^2)}{2 \times (120)^2} = 20,726 \# \text{in} \]

\[ \text{Max } M^+ = [\frac{90,610 + 48,553}{114} - 48,553] + [306.094 + 6,863 \times \frac{60}{114}] \]
\[ = 24549 + 306.094 + 3612 = 314925 \# \text{in} \]

\[ \text{Max } M^- = 48,553 + 3612 + 20,726 = 52,090 \# \text{in} \]

Shear Force

Pinned End: \[ W + \frac{W}{2L^2} \left[ (l - 54)^2 (2l + 54) \right] + (1 - 105)^2 (2l + 105) \]
\[ = 16,325 + 16,325 \times \frac{(120 - 54)^2 (294)}{2(120)^3} + 16,325 \times \frac{(120 - 108)^2 (349)}{2(120)^3} \]
\[ = 16,325 + 6049 + 237 = 22,611 \# \]

Fixed End: \[ \frac{W}{2L^2} \left[ 12 \left( 3 \times 12^2 - 12^2 \right) + 66 \times 12^2 \right] + W \times \frac{120}{12} \]
\[ = 2941 + 12,110 + 16,325 = 33,576 \# \]

\[ V = \frac{W}{8} \times 1.25 + 1.25 \times 39,876 \times C \times \text{Impact Factor} = 1.25 \]
\[ = 14,055 + 38,595 = 52,680 \# \]
Calculation Check for 10' F.T. Span Beam

(from Ref 2, EAZZ for $M_u^+$, p. C10 for $M_u^-$)

Ultimate Moment Capacity, $M_u^+ = 911,736 \text{ ft-lb}$

Max. moment in span = $M_{DL}^+ + 1.25 M_{LL}^+$ (4 Impact Factor $= 1.25$)

= $658,732 \text{ ft-lb} < M_u^+$

Ultimate Moment Capacity, $M_u^- = 2,512,674 \text{ ft-lb}$

Max. support moment = $M_{DL}^- + 1.25 M_{LL}^-$ (11 Impact Factor $= 1.25$)

= $1,059,644 \text{ ft-lb} < M_u^-$

Moment Capacity is OK.

Ultimate Shear Capacity, $V_u$ for 12" Slab

$V_u = (2 + \frac{4}{\phi_e}) f'_{cc} b_d d$ (Ref. ACI 318-95, Eq. 11-35)

$= 3.0435 \times 55 \times 98 \times 10$

= 163,364 #

> 92,168 #

Shear Capacity is OK.

Conclusion: Key Run Cross Tie Tonnell is structurally adequate to withstand CTS trailer loads.