2. To: (Receiving Organization) Documentation and Records Management		3. From: (Originating Organization) Technical Integration (FSA 13300)		4. Related EDT No.: 627120	
5. Proj./Prog./Dept./Div.: Spent Nuclear Fuel Project		6. Design Authority/ Design Agent/Cog. Engr.: D. M. Chenault		7. Purchase Order No.: N/A	
8. Originator Remarks: Evaluation of the below grade structures utilities subject to SNF Transport loads.				9. Equip./Component No.: N/A	
				10. System/Bldg./Facility: 100K and 200E (CSB)	
11. Receiver Remarks: 11A. Design Baseline Document? ☒ Yes ☐ No				12. Major Assm. Dwg. No.: N/A	
				13. Permit/Permit Application No.: N/A	
				14. Required Response Date:	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Desig- nator	Reason for Trans- mittal	Origi- nator Dispo- sition	Receiv- er Dispo- sition
1	SNF-5042	N/A	0	Below Grade Assessment of Spent Nuclear Fuel Cask Transport Route	S ^N	1	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
 (See Approval Designator for required signatures)

(G) Rea- son	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Rea- son	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Design Authority	D.M. Chenault	11-18-99	R3-86	3		W. A. Frier			S5-07
		Design Agent				3		O. M. Serrano			R3-86
		Cog. Eng.				3		J. R. Gregory			X3-78
1	1	Cog. Mgr.	D.W. Medford	11-18-99	R3-86	3		W. C. Alaconis			R3-86
		QA				3		P. T. Day			R3-11
1	1	Safety	B.D. Lorenz	11-22-99	R3-26						
		Env.									

18. Signature of EDT Originator D.M. Chenault 11-18-99		19. Authorized Representative Date for Receiving Organization		20. Design Authority/ Cognizant Manager D.W. Medford 11-18-99		21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
--	--	--	--	---	--	---	--

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

EDT/ECN: 627120

UC: 600

Org Code: FSA 13300

Charge Code: 105528

B&R Code: EW7040000

Total Pages: 25

Key Words: SNF, transport, grade, cross-tie, tunnel, utilities

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.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

Release Approval

11/22/99
Date

Release Stamp

Approved For Public Release

SNF-5042
REVISION 0

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. Fritz

Date: 11/11/99

**SNF-5042
REVISION 0**

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

SNF-5042
REVISION 0

ACRONYMS

AEC	Atomic Energy Commission
CSB	Canister Storage Building
CTS	Cask Transportation System
CVDF	Cold Vacuum Drying Facility
GAWR	Gross Axle Weight Rating
GVWR	Gross Vehicle Weight Rating
KE	K-East
KW	K-West
SNF	Spent Nuclear Fuel

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

SNF-5042
REVISION 0

Table 2.1. Identification of Underground Structures and Utilities

Location No.	Location Description	Item Description	Reference Drawing(s)	Soil Overburden (ft)	Soil Dead Load (lb./ft ²)	Transporter Live Load (lb./ft ²)	Total Load (lb./ft ²)	Comments
1	100 K / KW	(2) 60-in. Raw Water (Steel pipe with 1/2-in. walls)	H-1-25540 H-1-25517 H-1-25375 M-1901-K	22	10,780	N/A	10,780	Transporter live load is negligible.
2	100 K / KE	(2) 60-in. Raw Water (Steel pipe with 1/2-in. walls)	H-1-25540 H-1-25521 H-1-25375 M-1901-K	21	10,241	N/A	10,241	Transporter live load is negligible.
3	100 K / KW	105KW to 165KW Tunnel	H-1-25210 H-1-25433 M-1901-K	4.5 - 6	*	*	*	Ref.. AEC (1952)
4	100 K / KW	(2) 10-in. Hot Water (Supply and Return) 4-in. Non-Potable Filtered (Service) Water	H-1-25670 M-1901-K	6	545	158 (1.1%)	703	
5	100 K / 1717K, Cross-Tie Tunnel	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	H-1-25211 H-1-25678 H-1-25664 M-1901-K	1.25 4 8 6 5	* 446 619 545 495	* 245 (1.7%) 58 (0.4%) 115 (0.8%) 144 (1.0%)	• 691 677 660 630	* Ref. Calculation WHC-SD-SNF-FLE-001, Rev. 0
6	100 K / KE	(2) 24-in. Process Water with 30-in. corrugated iron culvert encasement (KE to KW Cross-Tie)	H-1-22310 H-1-21181 H-1-22311 M-1901-K	7	N/A	N/A	N/A	Culvert protects pipe from loads.
7	100 K / KE	3-in. Raw Water 1-in. Pile Effluent Water (PIE) 1-in. Pile Effluent Water (PIEX) 2-in. Pile Effluent Water (PIEX)	H-1-20365KE H-1-24974KE M-1901-K	Unknown	Unknown	Unknown	Unknown	
8	100 K / 183.1KW to 183.1KE	6-in. Sanitary Water	H-1-25524 H-1-25526 M-1901-K	Unknown	Unknown	Unknown	Unknown	

SNF-5042
REVISION 0

Location No.	Location Description	Item Description	Reference Drawing(s)	Soil Overburden (ft)	Soil Dead Load (lb./ft ²)	Transporter Live Load (lb./ft ²)	Total Load (lb./ft ²)	Comments
9	100 K / KW	1 1/4-in. Potable Water (PVC)	H-1-82519	Unknown	Unknown	Unknown	Unknown	
10	100 K / 1702KE	1 1/2-in. Sanitary Water	H-1-23215KE H-1-25061	Unknown	Unknown	Unknown	Unknown	
11	100 K / KW	4-in. Sanitary Water	H-1-25061	Unknown	Unknown	Unknown	Unknown	
12	100 K / KW	Drainage (Process) Sewer 5-ft 6-in. by 5-ft 6-in. Reinforced Concrete Flume	H-1-25074 H-1-25075 H-1-25378 H-1-25534 H-1-25540 M-1904-K	30	3300	N/A	3300	Transporter live load is negligible. Dead load is lb. / ft ² .
13	100 K / KE	Drainage (Process) Sewer 5-ft 6-in. by 5-ft 6-in. Reinforced Concrete Flume	H-1-25074 H-1-25076 H-1-25378 H-1-25534 H-1-25540 M-1904-K	29	3190	N/A	3190	Transporter live load is negligible. Dead load is lb. / ft ² .
14	100 K / 105KE	36-in. Process Sewer (Steel pipe with 1/2-in. walls)	H-1-25384 M-1904-K	15	5225	N/A	5225	Transporter live load is negligible.
15	100 K / 105KE	72-in. Process Sewer (Steel pipe with 5/8-in. walls)	H-1-25072 H-1-25384 M-1904-K	15	10,208	N/A	10,208	Transporter live load is negligible.
16	100 K / Mobile Offices	8-in. Sanitary Sewer (Vitrified Clay)	H-1-25079 H-1-25080 M-1904-K	3.5	396	432 (3.0%)	828	Transporter live load is 109% of soil dead load.
17	100 K / 1717K	(2) 6-in. Sanitary Sewer (Vitrified Clay)	H-1-25079 H-1-25080 M-1904-K	3.5	396	360 (2.5%)	756	Transporter live load is 91% of soil dead load.
18	100 K / 165KW	6-in. Sanitary Sewer (Vitrified Clay)	H-1-25079 H-1-25080 M-1904-K	6	545	115 (0.8%)	660	Transporter live load is 21% of soil dead load.
19	100 K / 105KW	36-in. Process Sewer (Steel pipe with 1/2-in. walls)	H-1-25384 M-1904-K	15	5225	N/A	5225	
20	100 K / 105KW	72-in. Process Sewer	H-1-25071	15	10,208	N/A	10,208	

SNF-5042
REVISION 0

Location No.	Location Description	Item Description	Reference Drawing(s)	Soil Overburden (ft)	Soil Dead Load (lb/ft ²)	Transporter Live Load (lb/ft ²)	Total Load (lb/ft ²)	Comments
		(Steel pipe with 5/8-in. walls)	H-1-25384 M-1904-K					
21	100 K / 1720K	6-in. Sanitary Sewer (Vitrified clay with concrete encasement)	H-1-25079 H-1-25080 M-1904-K	Unknown	Unknown	Unknown	Unknown	Concrete encasement protects pipe from loads
22	100 K / 1706KER	12-in. Sump Drain	H-1-20355KE	Unknown	Unknown	Unknown	Unknown	
23	100K / KE	(2) 2-in. Gas 12-in. Oil	H-1-20365KE	Unknown	Unknown	Unknown	Unknown	
24	100 K / CVDF	8-in. Fire Water (PVC) 2-in. Potable Water (PVC)	H-1-82092	4	446	303 (2.1%)	749	Transporter live load is 68% of soil dead load.
25	600 / CSB	(2) 24-in. Export Water	H-2-117071	6	3872	403 (2.8%)	4275	Transporter live load is 10% of soil dead load.

SNF-5042
REVISION 0

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:

Model	ARTA-35LD
GAWR	20,280 lb.
GVWR	97,280 lb.
Rims	8.25 x 22.5
Tires	275/70R x 22.5 @ 115 psi (cold)

[illegible]

9

SNF-5042
REVISION 0

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 Bridgestone¹ 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 3.1. Road Surface Conditions and Cross-Sections for the SNF Transport Route

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

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.

¹ Bridgestone is a registered trademark of the Bridgestone Corporation, Nashville, Tennessee.

Map of the Hanford Site showing various areas, roads, and landmarks. The map includes labels for '100 Y & OR AREA', 'SADDLE MOUNTAIN NATIONAL BULLFEE REFUGE', '100 K & LA AREA', 'COLUMBIA RIVER', '100 A AREA', 'FEDERAL AVE', 'ROUTE 1', '100 B & C AREA', 'CUT-OFF ROAD', 'ROUTE 4 NORTH', 'SNF CASK TRANSPORT ROUTE', 'CABLE MOUNTAIN', '200 NORTH AREA', '200 WEST AREA', 'ROUTE 3', '200 EAST AREA', 'ROUTE 4 SOUTH', '200 SOUTH AREA', 'ENVIRONMENTAL RECREATION DISPOSAL FACILITY', and '200 Y & OR AREA'. A north arrow is located in the top left corner.

8

Figure 3.3. SNF Cask Transport Route (100 K Area)

**SNF-5042
REVISION 0**

Figure 3.4. SNF Cask Transport Route (CSB)

SNF-5042
REVISION 0

The soil dead loads for the underground utilities were calculated using the Marston Equation:

$$W_c = C_d w B_d^2$$

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./ft³)

B_d = the width of the ditch at the top of the conduit (ft)

The analysis used a density of 110 lb./ft³ 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 9603 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 in²., 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 than 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

- AEC 1952, Contract No. AT(45-1)-624, Project No. CA-512-W, 100-K Water Plant Facilities, *Structural Calculations Concrete Tunnel 165 K to 105 K*, U.S. Atomic Energy Commission, Hanford Operations Office, Richland, Washington.
- Brisbin 1997, *Design Analysis Report for the TN-WHC Cask and Transportation System*, HNF-SD-SNF-FDR-003, Rev. 0, Duke Engineering Services Hanford, Richland, Washington.
- Chenault 1999, *Cask Transportation System-System Design Description*, SNF-3947, Rev. 0, Duke Engineering Services Hanford, Richland, Washington.
- Islam 1995, *Structural Evaluation for the 165K Cross-Tie Tunnel, 100K Area*, WHC-SD-SNF-FLE-001, Rev. 0, ICF Kaiser Hanford Company for Westinghouse Hanford Company, Richland, Washington.
- Kee, A. T., 1995, *Specification for SNF Path Forward Cask and Transportation System*, WHC-S-0396, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- NCPI 1995, *Clay Pipe Engineering Manual*, National Clay Pipe Institute, Lake Geneva, Wisconsin.

**SNF-5042
REVISION 0**

**Appendix A
ARES Corporation Calculation No. 9904500.47-001, Revision 0**

CALCULATION/PROBLEM COVER SHEET

ARES
CORPORATION

Calculation/Problem No: 9904500.47 - 001

Title: KE-KW CROSS TIE TUNNEL EVALUATION

Client: FDH Job No: 9904500.47

Project: SNF CASK TRANSPORT ROUTE ASSESSMENT

Design Input References:

PROVIDED WITHIN CALC.

Assumptions:

PROVIDED WITHIN CALC

Method:

HAND CALCULATIONS USING ROARK'S FORMULAE

Remarks:

THIS CALCULATION DETERMINED THAT THE KE-KW
CLOSE-TIE TUNNEL IS STRUCTURALLY ADEQUATE
TO WITHSTAND CTS TRASPORT TRAILER LOADS.

REV. NO.	REVISION	APPROVED	DATE
0	ORIGINAL ISSUE	<i>R. F. [Signature]</i>	11/10/99

Sheet: 1 of 7

PROJECT No.: 9904000,47 CALC. No.: 001 REVISION No.: 0 SHEET No.: 2/7
 PREPARED BY: A. GHOSE DATE: 11/4/99 REVIEWED BY: C.M. CONSELMAN DATE: 11/9/99

OBJECTIVE: PERFORM A STRUCTURAL EVALUATION OF THE K4-KW CROSS-TIE TUNNEL FOR THE SNF CTS TRANSPORT TRAILER TO DETERMINE STRUCTURAL ADEQUACY.

REFERENCE: 1. US-A.E.C. HANFORD WORKS DWG No. H-1-25211, CROSS-TIE TUNNEL PLANS, SECTIONS & DETAILS, Revision 6, Date (illegible)
 2. WHC-SD-SNF-FLE-001, Rev 0, July 26, 1995, "Structural Eval. for the 165K Cross-Tie Tunnel, 100K Area,"
 3. HNF-SD-SNF-FDR-003, Rev 0, 1997, "Design Analysis Report for the TN-WHC Cask and Transportation System,"
 4. SNF-2947, Rev 0, 1999, "CTS System Design Description,"
 5. POARK'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 STR. EVALUATION (REF. 2) ARE ADEQUATE FOR USE IN THIS CALC. (THEY HAVE BEEN VERIFIED, HENCE WILL NOT BE REPEATED)
 2. THE CRITICAL STRUCTURAL COMPONENT TO BE CHECKED IS THE 10'-SPAN BEAM (SEE FIG. 1). THE CALC. IN REF. 2. VERIFIED THAT THE 6'-SPAN SLAB IS NOT CRITICAL BASED ON SHOWING STRUCTURAL ADEQUACY OF A SIMILAR SLAB WITH 8'-SPAN AT ANCHOR LOCATIONS.
 3. FOR LIVE LOAD CALCULATIONS, A CONCENTRATED WHEEL LOAD WILL BE USED, RATHER THAN THE

PROJECT No.: 9004500.47 CALC. No.: 001 REVISION No.: 0 SHEET No.: 3/7
PREPARED BY: A. GIBSE DATE: 11/4/99 REVIEWED BY: C. M. CONSELMAN DATE: 11/9/99

ASSUMPTIONS: $\equiv$ (cont)
(cont)

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

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

5. IMPACT FACTOR OF 1.25 APPLIED TO LIVE LOADS.

FIG 1: CROSS-THE TUNNEL LAYOUT PLAN (FROM REF. 1)

PROJECT No.: 9904500.47 CALC. No.: 001 REVISION No.: 0 SHEET No.: 4/7
 PREPARED BY: A. GHOSE DATE: 11/4/99 REVIEWED BY: C.M. CONSELMAN DATE: 11/2/99

ANALYSIS OF 10 FT SPAN BEAM.

Load combination $\rightarrow 1.4 (DL) + 1.7 (LL)$

$$1.4 (DL) = 187.8 \#/\text{in} = W \text{ (Ref 2, PA-2)}$$

$$1.7 (LL) = 1.7 \times 9603 = 16,325 \text{ lbs.} = W$$

Ref 5: Roark's Formulas for Stress and Strain, 6th Edition.
 TABLE 3. pp 100-103.

Fixed End Moments (Item 2c, TABLE 3)

$$\begin{aligned} \text{Max } M^+ &= \frac{9Wl^2}{128} = \frac{9 \times 187.8 \times (120)^2}{128} \\ &= 190,143 \#-\text{in} \end{aligned}$$

$$\text{Max } M^- = \frac{wl^2}{8} = 338,040 \#-\text{in}$$

SINGLE AXLE IN SPAN

Live Load Moments (Item 1c, TABLE 3)

$$\begin{aligned} \text{Max } M^+ &= 0.174 Wl = 340,866 \#-\text{in} \\ &\text{with } W \text{ located at } 0.366l \text{ from pinned end} = 43.9' \end{aligned}$$

$$\begin{aligned} \text{Max } M^- &= 0.1924 Wl = 376,922 \#-\text{in} \\ &\text{with } W \text{ located at } 0.577l \text{ from pinned end} = 69.3' \end{aligned}$$

Shear Force

$$\text{Pinned Ends: } V_{\text{max}} = \frac{3}{8} Wl + W = 24,776 \#$$

$$\text{Fixed End: } V_{\text{max}} = \frac{5}{8} Wl + W = 30,410 \#$$

PROJECT No.: 9904500.47 CALC. No.: 001 REVISION No.: 0 SHEET No.: 5/7
PREPARED BY: A. G. HOE DATE: 11/5/99 REVIEWED BY: C. M. CONSELLMAN DATE: 11/9/99

TWO AXLES IN SPAN

LIVE LOAD MOMENTS (Example, Table 3, 1012)

FOR W_1 : $M^+ = 340,866 \text{ #}\cdot\text{in}$

$$M^- = \frac{16,325 \times 44 (120^2 - 44^2)}{2 \times 120^3} = 310,864$$

FOR W_2 : $a = 54 + 44 = 98$
 $l = 120$

$$\begin{aligned} M^+ &= \frac{W_2}{2l^3} (l-a)^2 (2l+a) \\ &= \frac{16,325 \times 98 (22^2 (398))}{2 \times (120)^3} \\ &= 75,730 \text{ #}\cdot\text{in} \end{aligned}$$

$$\begin{aligned} M^- &= \frac{W_2 a}{2l^3} (l^2 - a^2) \\ &= \frac{16,325 \times 98 (120^2 - 98^2)}{2 \times (120)^3} \\ &= 266,419 \text{ #}\cdot\text{in} \end{aligned}$$

$$\text{Max } M^+ = 340,866 + 34,001 = 374,867 \text{ #}\cdot\text{in}$$

$$\text{Max } M^- = 310,864 + 266,419 = 577,283 \text{ #}\cdot\text{in}$$

THREE AXLES IN SPAN

LIVE LOAD MOMENTS

FOR W_1 : $a = 6$ $M^+ = \frac{16,325 \times 6 (114)^2 (246)}{2 \times (120)^3} = 90,610$

$$M^- = \frac{16,325 \times 6 (120^2 - 6^2)}{2 \times (120)^3} = 45,553 \text{ #}\cdot\text{in}$$

FOR W_2 : $a = 60$ $M^+ = \frac{16,325 \times 60 (60)^2 (306)}{2 \times (120)^3} = 306,024 \text{ #}\cdot\text{in}$

$$M^- = \frac{16,325 \times 60 (120^2 - 60^2)}{2 \times (120)^3} = 367,213 \text{ #}\cdot\text{in}$$

PROJECT No.: 9904500.47 CALC. No.: 001 REVISION No.: 0 SHEET No.: 6/7
 PREPARED BY: A. GHOSE DATE: 11/3/99 REVIEWED BY: C. M. CONSELMAN DATE: 11/9/99

THREE AXLES IN SPAN (cont.)

$$\text{For } W_3: a = 114 \quad M^+ = \frac{16,325 \times 114}{2 \times (120)^3} (6)^2 (354) = 6,863 \text{ \#-in}$$

$$M^- = \frac{16,325 \times 114}{2 \times (120)^3} (120^2 - 114^2) = 90,726 \text{ \#-in}$$

$$\begin{aligned} \text{Max } M^+ &= \left[90,610 + 48,853 \right] \frac{60}{114} + \left[306,094 \right] + \left[6,863 \times \frac{60}{114} \right] \\ (\text{at midspan}) &= \underbrace{24549}_{(W_1)} + \underbrace{306,094}_{(W_2)} + \underbrace{3,612}_{(W_3)} = 324,255 \text{ \#-in} \end{aligned}$$

$$\text{Max } M^- = 48,853 + 367,313 + 90,726 = 506,892 \text{ \#-in}$$

Shear Force

$$\begin{aligned} \text{Pinned End: } W + \frac{W}{2l^3} \left[(l-54)^2 (2l+54) + (l-108)^2 (2l+108) \right] \\ = 16,325 + 16,325 \frac{(120-54)^2 (294)}{2 (120)^3} + 16,325 \frac{(120-108)^2 (342)}{2 (120)^3} \\ = 16,325 + 6,049 + 237 = 22,611 \text{ lbs.} \end{aligned}$$

$$\begin{aligned} \text{Fixed End: } \frac{W}{2l^3} \left[12 (3 \times 120^2 - 12^2) + 66 (3 \times 120^2 - 66^2) \right] + W \\ = 2441 + 12,110 + 16,325 = 30,876 \text{ lbs.} \end{aligned}$$

$$\begin{aligned} V_{\text{max}} &= \frac{5}{8} w l + 1.25 \times 30,876 \quad (\text{IL Impact Factor} = 1.25) \\ &= 14,035 + 38,595 = 52,680 \text{ lbs.} \end{aligned}$$

PROJECT No.: 9904500,47 CALC. No.: 001 REVISION No.: 0 SHEET No.: 7/7
 PREPARED BY: A. GALLAGHER DATE: 11/4/99 REVIEWED BY: S.M. CONSKELMAN DATE: 11/9/99

DESIGN CHECK OF 10-FT SPAN SLAB(from Ref 2, pA22 for M_u^+ , p. C10 for M_u^-)Ultimate Moment Capacity, $M_u^+ = 911,736 \text{ #-in}$

$$\begin{aligned} \text{Max. moment in span} &= M_{DL}^+ + 1.25 M_{LL}^+ \quad (\text{LL Impact Factor} = 1.25) \\ &= 658,732 \text{ #-in} < M_u^+ \end{aligned}$$

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

$$\begin{aligned} \text{Max. support moment} &= M_{DL}^- + 1.25 M_{LL}^- \quad (\text{LL Impact Factor} = 1.25) \\ &= 1,059,644 \text{ #-in} < M_u^- \end{aligned}$$

Moment Capacity is OK.

Ultimate Shear Capacity, V_u for 12" Slab

$$V_u = \left(2 + \frac{4}{\beta_c}\right) \sqrt{f'_c} b_o d \quad (\text{Ref. ACI 318-95, Eq. 11-35})$$

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

$$= 163,364 \text{ \#}$$

$$> 52,680 \text{ \#}$$

Shear Capacity is OK.

CONCLUSION: KE-KU CROSS-TIE TUNNEL IS STRUCTURALLY
 ADEQUATE TO WITHSTAND CTS TRAILER LOADS.