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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

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		Design Authority									
1	1	Design Agent L.J. Julyk	L.J. Julyk	6/17/03	R1-14						
		Cog. Eng.									
1	1	Cog. Mgr. C. Defigh-Price	C. Defigh-Price	6-19-03	R2-58						
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L.J. Julyk 6/17/03	T.C. Mackey 6/19/03	C. Defigh-Price 6-19-03	Ctrl No. N/A
Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	Design Authority/ Cognizant Manager / Date	○ Approved ○ Approved w/comments ○ Disapproved w/comments

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Design Engineering	Date 6/17/03
Project Title/Work Order		EDT No. 637313
Development of ANSYS Finite Element Models for SST and DST Tanks (RPP-16414 Rev. 0)		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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T.C. Oten	S5-07				x
E.R. Hamm	R1-31				x
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RPP-16414
Revision 0

Development of ANSYS Finite Element Models for SST and DST Tanks

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.
Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

Development of ANSYS Finite Element Models for SST and DST Tanks

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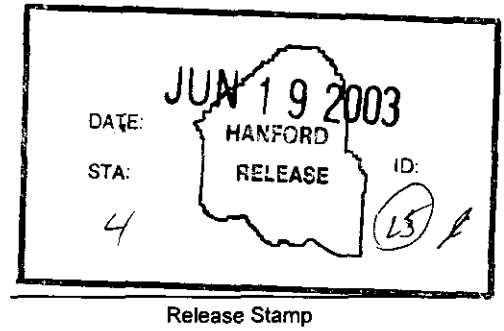
Key Words: single-shell tanks, finite element, dome load, double-shell tanks, ANSYS

Abstract: Summary report of ANSYS finite element models developed for dome load analysis of Hanford 100-series single-shell tanks and double-shell tanks. Document provides user interface for selecting proper tank model and changing of analysis parameters for tank specific analysis.

6/19/03
Release Approval Date



Release Stamp

Approved For Public Release

RPP-16414
Revision 0

Development of ANSYS Finite Element Models for SST and DST Tanks

L. J. Julyk / T. C. Mackey
CH2MHILL Hanford Group, Inc.

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JLR The Engineering Solutions Company

Date Published
May 2003

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Office of River Protection under Contract DE-AC06-99RL14047

RPP-16414
REV 0

The subject document has been reviewed by the undersigned.
The reviewer reviewed and verified the following items as applicable.

Document Reviewed: RPP-16414, Rev. 0, Development of ANSYS Finite Element Models for SST and DST Tanks

Analysis performed by: Xianghong Li / Jim Radochia
JLR The Engineering Solutions Company

- Design Input*
- Basic Assumption
- Approach/Design Methodology
- Related Information
- Conclusion/Result Interpretation

*Default values of changeable parameters in model are for example only. User of model must confirm proper input of parameter values for specific application of model.

An electronic version of model is available from undersigned. See attached ERATA sheet for any known problems with model.

Reviewer/Approver (print) L. J. Julyk / Design Engineering

Reviewer/Approver (signature) 4/17/03
Date

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: RPP-16414, Rev. 0, Development of ANSYS Finite Element Models for SST and DST Tanks

Author: Xianghong Li / Jim Radochia
JLR The Engineering Solutions Company

Yes	No	N/A	
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors.
[X]	[ ]	[ ]	Code run streams correct and consistent with analysis documentation.
[X]	[ ]	[ ]	Code output consistent with input and with results reported in analysis documentation.
[ ]	[ ]	[X] *	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[ ]	[ ]	[X] *	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.

* Sample Calculation / Model Development

B. V. Winkel (M&D) B. V. Winkel 6-10-03
Reviewer Date

L. J. Julyk (CHG) L. J. Julyk 6/17/03
Reviewer Date

ERRATA

ANSYS Macro	Tracking #	Issue Description	Recommended Action
See specific model	1	Material properties are set at default values that may or may not be appropriate for specific analysis.	Verify material input values appropriate for specific analysis.
	2	Concrete creep coefficients not listed or incorrectly specified for implicit user-defined creep. Solid65 elements can only use explicit creep.	See RPP-13990 for proper creep coefficient specification and usage.
	3	Resulting section force and moment plot/list may only be valid for 0 degrees in 360 degree full model. Path distances may not be correct; short by the sine of the angle at which the results are requested.	Verify proper operation for other than 0 degree position.

ANALYTICAL CALCULATIONS

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Checker	Jim Radochia	Date	5/16/03

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Checker	Jim Radochia	Date	5/16/03

1.0 INTRODUCTION

Current dome load restrictions for the Hanford Site underground waste storage tanks are based on existing analyses of record (AOR) that evaluated the tanks for a specific set of design load conditions. However, greater flexibility is required in controlling dome loadings applied to the tanks due to day-to-day operations and waste retrieval activities. This requires the development of an analytical model with sufficient detail to evaluate various dome loading conditions not specifically addressed in the AOR.

2.0 Parametric ANSYS Finite Element Models

Parametric ANSYS finite element models for five 100-Series Single-Shell Tank (SST) designs and one Double-Shell Tank (DST) design are developed and verified with sample AOR loadings. The five SSTs include the million gallon tanks A, AX, and SX; the three-quarter million gallon tank S (same as TX, BY, and TY tank designs); and the half-million gallon tank BX (same as B, C, T, and U tank designs). The DST model is for the AY tank design (similar to AN, AW, AP, AZ, and SY tank designs). Differences between the DST designs can be accounted for by modifying parameters in the AY model macros.

Three different models, axisymmetric linear model, slice model, and full 360-degree model, are available based on the tank analyzed. The axisymmetric linear model assumes a) no liner or waste present in the tank, b) no friction/contact at the soil/tank interface, c) no rebar, d) elastic soil modulus, and e) Poisson's ratio of 0.27 for soil. These assumptions are verified in document RPP-14249 [Ref-1] to be reasonable for the purpose of the linear model, which is to provide a quick evaluation of the effect of axisymmetric loading conditions on the global behavior of the tanks. A more accurate evaluation of the tank behavior under axisymmetric loading conditions can be achieved using the slice model by including the contact effect between the tank and soil, and the soil plasticity. For arbritary loading conditions, the full 360-degree model should be used. The full model also takes the contact and soil plasticity into consideration. The availability of the models for each tank is listed in Table 1, and the detailed information about the model can be found in the report for each individual model, which is also listed in Table 1.

Table 1. Summary of CHG Tank Analyses

Tank	Available Model	Report of AOR Loading
SST-A	Linear Model	RPP-13997 [Ref-2]
	Slice Model	RPP-13995 [Ref-3]
SST-AX	Linear Model	RPP-13998 [Ref-4]
	Slice Model	RPP-13996 [Ref-5]
SST-S (BY, TX, TY)	Linear Model	RPP-14000 [Ref-6]
	Slice Model	RPP-14002 [Ref-7]
SST-SX	Linear Model	RPP-13991 [Ref-8]
	Slice Model	RPP-13992 [Ref-9]
	360-degree Model	RPP-14004 [Ref-10]
SST-BX (B, C, T, U)	Slice Model	RPP-13999 [Ref-11]
DST-AY (AN, AP, AW, AZ, SY)	Slice Model	RPP-13990 [Ref-12] * RPP-14001 [Ref-13]
	360-degree Model	RPP-13990 [Ref-12] *

* See RPP-14001 for AOR loading.

For SSTs, the parameters defining the model dimensions and the magnitude of loads are stored in a parameter file with name of **parm_xx.mac**, where xx indicates the tank to which the parameter file is applid. Parameter file **set_parms.mac** is for the DST-AY tank. For each model, many parameters can be redefined by the user through a MS Windows Interface. There are three group of parameters, namely, parameters for soil size surrounding the tank, parameters for material properties, and parameters for common loadings. By default, the loading conditions and soil dimensions are set for AOR loadings.

Because all analyses will be run via a Windows interface using the ANSYS batch mode, the SST postprocessing macros were modified from those used in the original reports. Table 2 lists all modified/new macros. These will generate proper plots from the batch mode.

Table 2. Modified and Additional Files

File Name	Status	Notes
Plpng.mac	Updated	Rewritten to output png image file under batch mode
Pst_proc_a.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_proc_ax.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_proc_s.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_proc_sx.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_a_slice.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_ax_slice.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_s_slice.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_sx_slice.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_bx_slice.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Pst_sx_360.mac	Updated	Modified for plot positioning and using new plpng.mac file in batch mode
Soil.plt	Added	Position setting for SST-A tank
Tank.plt	Added	Position setting for SST-A tank
Soil_ax.plt	Added	Position setting for SST-AX tank
Tank_ax.plt	Added	Position setting for SST-AX tank
Soil_s.plt	Added	Position setting for SST-S tank
Tank_s.plt	Added	Position setting for SST-S tank
Soil_sx.plt	Added	Position setting for SST-SX tank
Tank_sx.plt	Added	Position setting for SST-SX tank
Soil_sx_360.plt	Added	Position setting for SST-SX full model
Tank_sx_360	Added	Position setting for SST-SX full model
Soil_bx.plt	Added	Position setting for SST-BX tank
Tank_bx.plt	Added	Position setting for SST-BX tank

3.0 WINDOWS INTERFACE

3.0.1 Introduction to Windows Interface

A Windows interface was written by JLR using Visual Basic.Net. The Visual Basic interface allows users who are not familiar with the ANSYS finite element analysis package to easily selct the tank of interest and modify key input parameters such as soil dimensions, material properties, analysis options, and loads. The interface in its initial stage is shown in Figure 1.

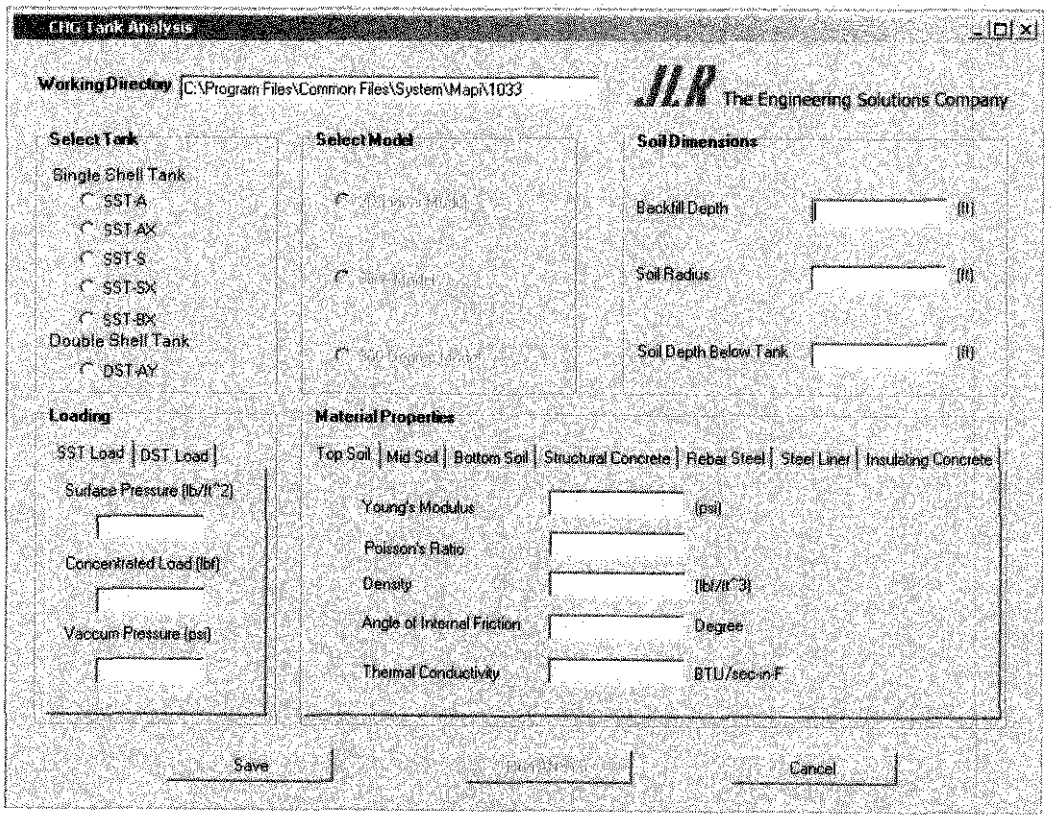

Figure 1. Windows interface in its initial format

The interface is divided into six regions, the working directory, tank selection, model selection, soil dimension definition, loading definition, and material property definition. The directory shown in the initial format is the directory from which the interface is launched. The procedure to run an ANSYS analysis using the Windows interface is detailed in the following section.

3.0.2 Using the Windows Interface

Setting up an analysis is straightforward with the Windows interface. It involves the following steps.

A. ***Installation***

The installation consists of two part, one is for ANSYS macro files, and the other is for the actual Windows interface.

Installation of Macros

The deliverable package includes the macros.zip file which includes all ANSYS macros zipped within appropriate folders. Users need to create a working directory, say D:\CHG Tank, for these macros, then extract all files to the directory. When unzipping, remember to set the WinZip configuration so that the macros will be extracted to individual folders for a specific tank. To do this, click "***option***" in WinZip interface, select "***Configuration***", ***set Extract folder*** to ***Open archive folder.*** Noting that the **parm_xx.mac** (for SST) or **set_parms.mac** (for DST) file are renamed to **parm_xx_def.mac** or **set_parms_def.mac** compared with the macros in early versions, these files contain all parameters needed for the specific analysis in their default values. Once the parameters are modified in the windows interface, the interface program will look for **parm_xx_def.mac** or **set_parms_def.mac** file, append the modified parameters at the end of the file, and save the file as **parm_xx.mac** or **set_parms.mac**, which will then be loaded into an ANSYS analysis. This will ensure that the original parameter values will not be changed to avoid potential modeling problems that could result from modifying these original values. A new file **runall.mac** is added to the deliverable package for each model of each tank. **Runall.mac** is the input file for the ANSYS batch run, including all commands to carry out the analysis, and post processing if needed. The **runall.mac** file can be changed manually by users, and serves as a dividing line between the Windows interface and actual ANSYS analysis.

Installation of Windows Interface

Included in the deliverable package is a zip file called CHGSetup.zip. Make sure that WinZip is installed on the user's computer, then double click the CHGSetup.zip. In the WinZip interface, double click setup.exe, the setup wizard will guide you through the installation of the Windows interface. Once the interface is installed, make sure the ANSYS launch command (ansys70 for ANSYS70) is in the search path

of the operating system. One way to check is to type "ansys70" in a DOS window. If the path is set up right, ANSYS should run no matter where ANSYS is launched.

B. Load the interface

The interface can be launched by running the program CHG Tank Analysis.exe.

C. Define Working Directory

Type or copy-and-paste the working directory containing all ANSYS macros for the tank to be analyzed if the interface is not launched there. The initial directory shown is the directory the interface is launched from.

D. Select a tank

Select a tank to be analyzed by clicking a proper radio button. Once a tank is selected, the finite element models available for the selected tank are shown, and the parameters are set to values for its AOR loading condition. Note that every time you click a tank, the parameters are set to its AOR values, even after you have changed the values for the specific tank. Figure 2 shows the interface after selecting a tank.

E. Select a model

After selecting a tank, select a finite element model for the tank by clicking one of the available models, 2-D model, slice model, or 360-degree model.

F. Define Soil Dimensions

The volume of soil included in the analysis can be defined by setting the backfill depth, soil radius, and soil depth below the tank. Values for AOR loadings are loaded when a tank is selected.

G. Define Loadings

Common loads can be defined, including a uniform pressure load, a concentrated load, and a vacuum pressure. The AOR loadings are the default values.

H. Define Material Properties

Material properties for soil, structural concrete (including creep, cracking, and crushing), rebar, insulating concrete, and liner steel can be specified.

I. Save The Parameters

After verifying the parameter values, click the SAVE button. The newly modified parameters will be appended to a file containing all default parameter values and saved as the parameter file which will be loaded into ANSYS later. Once the parameters are saved, the Run ANSYS button will be lit, as shown in Figure 4.

J. Run ANSYS

After saving the parameters, click the Run ANSYS button to start the tank analysis. By clicking the Run ANSYS button, ansys70 will be called and run in batch mode. The ANSYS input file is **runall.mac**, and the ANSYS output file is **output.txt**. Upon normal termination, a message box with "The job is complete!" will appear.

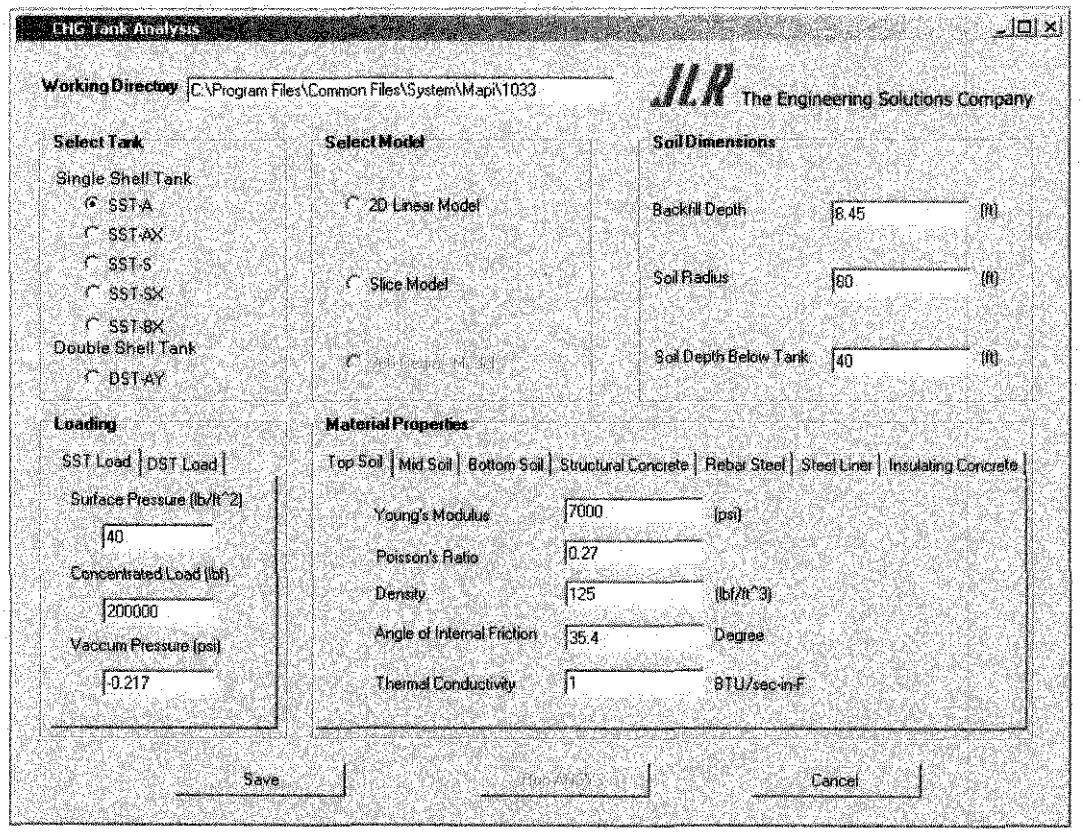

Figure 2. Interface after selecting a tank; only the 2D linear model and slice model are available for SST-A tank

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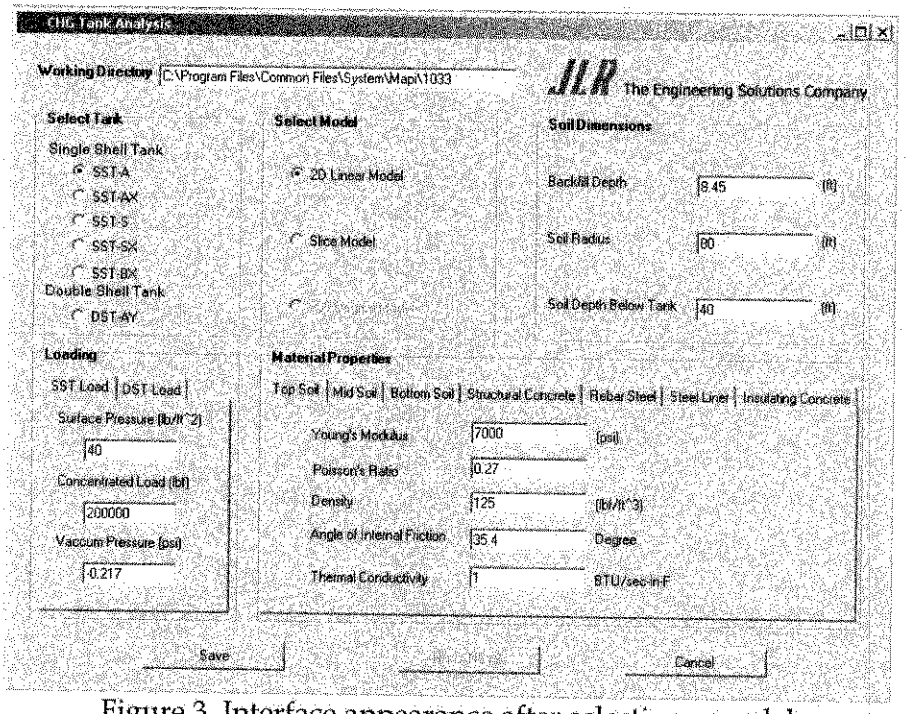

Figure 3. Interface appearance after selecting a model

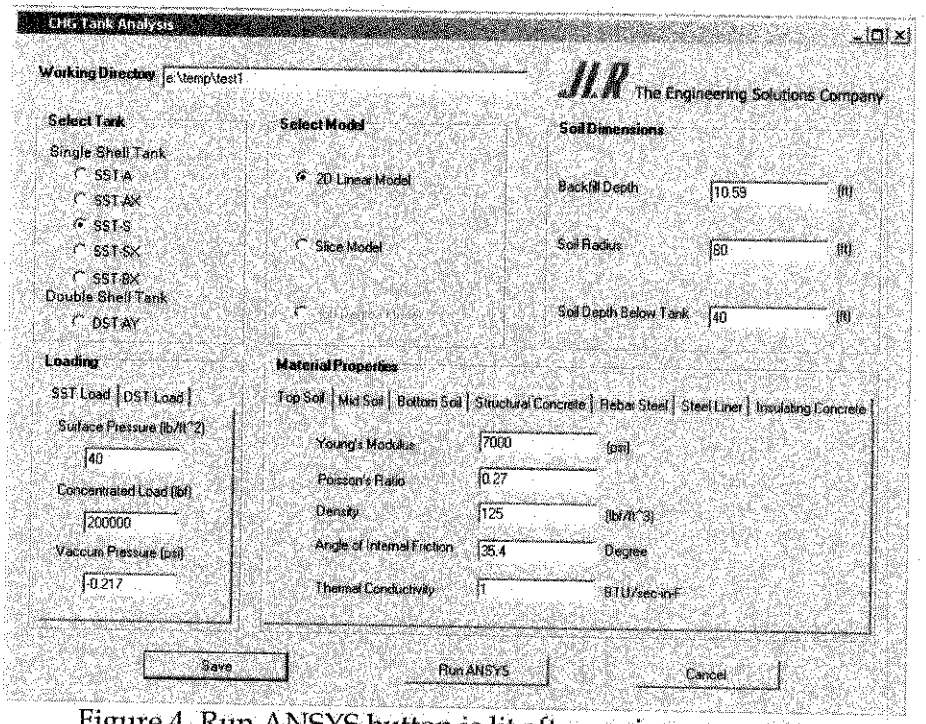

Figure 4. Run ANSYS button is lit after saving parameters

4.0 REFERENCES

Ref-1 M&D Professional Services, "Dome Load Evaluation for Hanford 241-C Farm 100-Series Tanks", Document Number RPP-14249, January 14, 2003.

Ref-2 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Axisymmetric Parametric Model for Tank SST-A", Document Number RPP-13997, March 11, 2003

Ref-3 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Slice Parametric Model for Tank SST-A", Document Number RPP-13995, May 1, 2003

Ref-4 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Axisymmetric Parametric Model for Tank SST-AX", Document Number RPP-13998, March 11, 2003

Ref-5 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Slice Parametric Model for Tank SST-AX", Document Number RPP-13996, April 28, 2003

Ref-6 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Axisymmetric Parametric Model for Tank SST-S", Document Number RPP-14000, March 11, 2003

Ref-7 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Slice Parametric Model for Tank SST-S", Document Number RPP-14002, April 25, 2003

Ref-8 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Axisymmetric Parametric Model for Tank SST-SX", Document Number RPP-13991, March 11, 2003

Ref-9 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Slice Parametric Model for Tank SST-SX", Document Number RPP-13992, April 11, 2003

Ref-10 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-A", Document Number RPP-14004, April 23, 2003

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Ref-11 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Slice Parametric Model for Tank SST-BX", Document Number RPP-13999, April 23, 2003

Ref-12 JLR The Engineering Solutions Company, "ANSYS Parametric Model for Tank DST-AY", Document Number RPP-13990, May 19, 2003

Ref-13 JLR The Engineering Solutions Company, "Sample AOR Calculation using ANSYS Parametric Model for Tank DST-AY", Document Number RPP-14001, April 18, 2003