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ANACAP-U Software Configuration and Installation Verification on the SECC		ECN No. N/A

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2. To: (Receiving Organization) Component Stress Analysis J. B. Truitt	3. From: (Originating Organization) Component Stress Analysis	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: N/A	6. Cog. Engr.: R. S. Marlow	7. Purchase Order No.: N/A
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Document Number: WHC-SD-SQA-CSWD-30017, Rev. 0

Document Title: ANACAP-U Software Configuration and Installation
Verification on the SECC

Release Date: 1/11/95

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SUPPORTING DOCUMENT		1. Total Pages <u>53</u> <u>145</u>
2. Title ANACAP-U Software Configuration and Installation Verification on the SECC	3. Number WHC-SD-SQA-CSWD-30017	4. Rev No. 0
5. Key Words Software, configuration, ANACAP-U, concrete APPROVED FOR PUBLIC RELEASE <i>V. Burkland 1/11/95</i>	6. Author Name: R. S. Marlow Signature Organization/Charge Code 8D410 / J234A	
7. Abstract ANACAP-U is a preprocessor, postprocessor, and concrete material subroutine used for the analysis of concrete structures. ANACAP-U functions in concert with the ABAQUS general purpose finite-element code. This document describes the Quality Assurance process for ANACAP-U version 9-2.2.7 as installed on the SECC.		
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9. Impact Level SQ		

ANACAP-U SOFTWARE CONFIGURATION
AND INSTALLATION VERIFICATION ON THE SECC

September 1994

Prepared by:

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Component Stress Analysis

10/4/94
Date

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10/4/94
Date

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10/5/94
Date

WESTINGHOUSE HANFORD COMPANY
Richland, Washington
Hanford Operations and Engineering Contractor
for the
U.S. Department of Energy

INDEPENDENT REVIEW

Document Reviewed ANACAP-U Software Configuration and Installation
Verification on the SECC3

Author R. S. Marlow Report No. WHC-SD-SQA-CSWD-30017 EDT No. 142754

The subject document has been reviewed by the undersigned. The reviewer reviewed and verified the following items as applicable [EP.4.1].

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

F. George Abatt

Reviewer

10/4/74

Date

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed ANACAP-U Software Configuration and Installation
Verification on the SECC

Author R. S. Marlow

Yes No N/A

☒	☐	☐	Problem completely defined.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☒	Mathematical derivations checked including dimensional consistency of results.
☐	☐	☒	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors.
☒	☐	☐	Code run streams correct and consistent with analysis documentation.
☒	☐	☐	Code output consistent with input and with results reported in analysis documentation.
☐	☐	☒	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
☐	☐	☒	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.

MANDATORY

Software QA Log Number 94051

F. George Abatt
Reviewer

George Abatt

10/4/94
Date

ENGINEERING ANALYSIS SOFTWARE REPORT FORM

SOFTWARE APPLICATIONANACAP-U
Ver. 92-2.2.7SOFTWARE LOG #

94051

ANALYSTS

R. S. Marlow

EDT #

142754

ANALYST MANAGER

J. B. Truitt

DOCUMENT #

WHC-SD-SQA-CSWD-30017, Rev. 0

DATE PERFORMEDDESCRIPTION OF ANALYSIS:

A QA verification of the Anacap-U
software on the SECC.

SIGNATURE OF ANALYST DATE

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DESIGN VERIFICATION METHOD

The need for design verification has been reviewed with the method selected as indicated below:

✓

Independent Review

Alternative Calculations

Qualification Testing

Formal Design Review

J. B. Truitt
Cognizant Project/Design Manager

SD # WHC-SD-SQA-CSWD-30017

EDT # 142754

DWG(S) # N/A

CONTENTS

1.0	INTRODUCTION	1
2.0	APPROVAL DESIGNATOR	1
3.0	DOCUMENTATION	1
4.0	VERIFICATION AND VALIDATION	2
5.0	INSTALLATION VERIFICATION	3
5.1	BEAM BENDING	3
5.2	PROPERTY DEGRADATION FOR 50 YEARS AT 450 °F	3
5.3	STEPPED TEMPERATURE TEST	3
5.4	VARIABLE TEMPERATURE TEST	4
6.0	CONFIGURATION STATUS	4
7.0	REVISIONS	6
8.0	CONCLUSION	6
9.0	REFERENCES	6
	Attachment 1. ABAQUS Input File for Beam Bending Test	Att1-1
	Attachment 2. Selected Output from the Beam Bending Tests on hp1 and hp2	Att2-1
	Attachment 3. ABAQUS Input File for Property Degradation Test	Att3-1
	Attachment 4. Log File for Property Degradation Test	Att4-1
	Attachment 5. ABAQUS Input File for Stepped Temperature Test	Att5-1
	Attachment 6. Log File for Stepped Temperature Test	Att6-1
	Attachment 7. ABAQUS Input File for Variable Temperature Test	Att7-1
	Attachment 8. Log File for Variable Temperature Test	Att8-1

FIGURES

1.	Beam Profile Position	7
2.	Stress Contour Plot for Beam Bending	8
3.	Strain Contour Plot for Beam Bending	9
4.	Displacement History for Beam Bending	10
5.	Stress History for Beam Bending	11
6.	Crack Surfaces for Beam Bending	12
7.	Modulus Degradation at 450 °F	13
8.	Compressive Strength Degradation at 450 °F	14
9.	Tensile Strength Degradation at 450 °F	15
10.	Modulus Degradation for Stepped Temperature	16
11.	Compressive Strength Degradation for Stepped Temperature	17
12.	Tensile Strength Degradation for Stepped Temperature	18
13.	Temperature History for Stepped Temperature	19
14.	Modulus Degradation for Variable Temperature	20
15.	Compressive Strength Degradation for Variable Temperature	21
16.	Tensile Strength Degradation for Variable Temperature	22
17.	Temperature History for Variable Temperature	23
18.	Total Strain for 1,000 lbf/in/in at Constant Temperature (450 °F) .	24
19.	Total Strain for 1,000 lbf/in/in at Constant Temperature (450 °F) .	25
20.	Total Strain Under a Stepped Temperature	26
21.	Total Strain Under a Variable Temperature	27

TABLES

1.	Section Forces and Moments for Beam Bending Test	28
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ANACAP-U SOFTWARE CONFIGURATION AND INSTALLATION VERIFICATION ON THE SECC

1.0 INTRODUCTION

The purpose of this document is to demonstrate that the ANACAP-U (version 92-2.2.7) concrete analysis computer program module complies with the requirements of the Westinghouse Hanford Company, *Software Practices*, WHC-CM-3-10 (WHC 1993). This document also demonstrates installation verification specifically on the Scientific and Engineering Computing Center (SECC).

ANACAP-U (James 1992a, James 1993a) Version 92-2.2.7, a software product of the ANATECH Research Corporation, is an analysis package for concrete designed to be used in conjunction with the ABAQUS¹ (HKS 1989) finite-element computer code. ANACAP-U is leased to Westinghouse Hanford Company from the ANATECH Research Corporation and is licensed to run on the Hewlett-Packard workstations hp1 and hp2 of the SECC. The main feature of ANACAP-U is a concrete constitutive model called UMAT92. The constitutive model includes such complex phenomena as cracking and creep. Some features of UMAT92 are designed specifically to model the behavior of concrete at the DOE Hanford Site.

ANACAP-U has preprocessing and postprocessing capabilities. The actual problem solution is computed by ABAQUS using UMAT92. ANAGEN is the preprocessing module. It may be used to create the ABAQUS input file. The two postprocessors are called ANAPOST and ANAPLOT. ANAPOST extracts data from the ABAQUS results files. ANAPLOT displays contour plots, crack plots, histories, etc. A complete description of ANACAP-U appears in James 1992a and 1993a.

The following sections of this document are designed to satisfy the requirements of document WHC-CM-3-10 (WHC 1993).

2.0 APPROVAL DESIGNATOR

ANACAP-U is assigned approval designator SQ.

3.0 DOCUMENTATION

The ANACAP-U documentation supplied by ANATECH includes a theory manual (James 1992a), a user's manual (James 1993a), and a verification and validation manual (James 1992b). The vendor-supplied documentation also includes a theory manual supplement (James and Rashid 1993) and a verification

¹ABAQUS is a trademark of Hibbit, Karlsson, and Sorenson, Inc.

manual supplement (James 1993b) covering the software features specific to Hanford concrete.

4.0 VERIFICATION AND VALIDATION

ANATECH has verified and validated ANACAP-U extensively. The results of their tests are documented in the verification and validation manual (James 1992b) and supplement (James 1993b).

The verification tests documented in James 1992b test the tensile cracking behavior, the compressive behavior, the shear behavior, and the thermal behavior of UMAT92. An additional verification test exercises the directed crack option. ANATECH designed the verification tests to show that each capability functions as intended. ANACAP-U successfully passed each test. For a more detailed discussion of the test results, see James 1992b.

Independent verification of the implementation of the equation for tensile strength degradation in Hanford concrete in ANACAP-U exists and is documented in Weis 1993. Independent verification of the implementation of the modulus degradation equation, the compressive strength degradation equation, and the creep strain algorithm are documented in Marlow 1994.

The validation tests documented in James 1992b test the ability of ANACAP-U to solve accurately those engineering problems for which experimental results are available or for which hand-calculated solutions exist. The problems solved and documented include beam bending, one-way reinforced slab loaded symmetrically with line loads, two-way reinforced slab point-loaded in the middle, the University of California, Berkeley knee joint, and a pressurized concrete containment vessel.

The complete results of the ANATECH validation testing should be read by anyone who intends to use ANACAP-U. Although, in general, the performance of ANACAP-U was satisfactory, the test reports contain a significant number of qualifying statements.

5.0 INSTALLATION VERIFICATION

Several test cases supplied by ANATECH to the Westinghouse Hanford Company (WHC) were run on the Hewlett-Packard workstation named hp2 to verify that the installed version of ANACAP-U performs as designed. The beam bending problem was also run on the Hewlett-Packard workstation named hp1. The results on hp1 and hp2 are identical.

The test problems documented here are not as comprehensive as those documented in Marlow 1994. Some of the test problems in Marlow 1994 were designed to verify algorithms rather than the installation. Since the algorithms in the workstation version are identical to those of the Cray version, these test problems are not repeated here.

5.1 BEAM BENDING

The beam bending test case is described in detail in Section 7.1 of James 1993a. A beam 10-in. wide, 22-in. deep, and 240-in. long is simply supported at either end and loaded with a uniform pressure. The tension side of the beam is reinforced with two #9 rebars. The beam contains two #5 stirrup bars at the free ends. Attachment 1 gives the ABAQUS input deck. Attachment 2 is an excerpt from the computer output verifying that the analysis was done on the hp1 and hp2 machines. The ABAQUS input deck in edited form was supplied to WHC by ANATECH. The deck as supplied is identical to the file beam1.abdat documented in James 1993a. The deck given in Attachment 1 contains one extra feature: the variable NFORC is written to the ABAQUS results file to create a print of the section forces. The results of the beam analysis are documented in Figures 1 through 6 and Table 1. Figure 6 is a crack plot at the end of the analysis. As expected, the results are identical to those reported in James 1993a.

5.2 PROPERTY DEGRADATION FOR 50 YEARS AT 450 °F

A test case for property degradation for 50 years at 450 °F was run by ANATECH and is documented in James 1993b; it involves a one-element model with the best-estimate Hanford concrete model number 4, which is degraded for 50 years under a uniaxial compressive stress of 1,000 lbf/in². ANATECH supplied the input deck for this test case, which appears in Attachment 3. Attachment 4 is an excerpt from the computer output verifying that the analysis was done on hp2. The elastic modulus, compressive strength, and tensile strength are plotted in Figures 7, 8, and 9, respectively. Figures 18 and 19 show the history of the compressive strain. The plots are identical to those given in James 1993b.

5.3 STEPPED TEMPERATURE TEST

Marlow ran a stepped temperature test and documented the results in Marlow 1994. The analysis was repeated on hp2. Attachment 5 lists the input deck for this test. Attachment 6 gives an excerpt from the output verifying that the analysis has been done on hp2. The results from the hp2 analysis are documented in Figures 10 through 13. Figure 20 shows the history of the

compressive strain. These plots are identical to the corresponding plots documented in Marlow 1994.

5.4 VARIABLE TEMPERATURE TEST

The variable temperature test is similar to the stepped temperature test. ANATECH documented the results of their analysis for this test in James 1993b. The input deck that ran on hp2 is given in Attachment 7. Attachment 8 gives an excerpt from the hp2 output. The results of this analysis are documented in Figures 14 through 17. Figure 21 shows the history of the compressive strain. The hp2 results are virtually identical to the ANATECH results. Note that the ANATECH results do not include a temperature history plot. See Marlow 1994 for the temperature history. Some data irrelevant to this document is present in the ANATECH plots.

6.0 CONFIGURATION STATUS

Currently, ABAQUS 4.9 and ABAQUS 5.3 are available on the SECC. ANACAP-U version 92-2.2.7 requires ABAQUS 4.9 and will run on hp1 and hp2 only. The current access files and error reporting process are indicated below.

Installation: ANACAP-U 92-2.2.7 -- /p2_hp/anacapu/v2.2/
ABAQUS ---- /p_hp/abaqus/abaqus49

User access: To access ANACAP-U the user must have an SECC account. Running in the SECC environment can be confusing. For more information contact the code custodian or R.S. Marlow.

Code Custodian: L. J. Julyk

Files:

/p/anacapu/v2.2

-rwxr-xr-x	1	e40511	irm_misc	243	Apr	19	11:57	anacap.t44
-rwxr-xr-x	1	e40511	irm_misc	244	Apr	19	11:57	anacap.t44.sv
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-rwxr-xr-x	1	e40511	irm_misc	1823712	Sep	9	14:27	anagen.e
-rwxr-xr-x	1	e40511	irm_misc	1278944	Oct	25	1993	anagen.e.sv
-rwxr-xr-x	1	e40511	irm_misc	1749984	Apr	25	16:20	anagen.e.sv1
-rwxr-xr-x	1	e40511	irm_misc	1823712	Jun	30	14:20	anagen.e.sv2
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-rwxr-xr-x	1	e40511	irm_misc	2534	Jan	4	1994	anapost
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-rwxr-xr-x	1	e40511	irm_misc	118824	Oct 25	1993	umat92.o.sv
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-rwxr-xr-x	2	e40511	irm_misc	188040	Apr 29	08:01	umat92_6.o

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-rwxr-xr-x	1	e40511	irm_misc	545	Aug 11	1992	beam1.ana
-rwxr-xr-x	1	e40511	irm_misc	581	Aug 11	1992	beam1.anp
-rw-rw-rw-	1	e40511	irm_misc	6307	Feb 1	1994	typescript
-rwxr-xr-x	1	e40511	irm_misc	1526	Aug 11	1992	ver41.abdat
-rwxr-xr-x	1	e40511	irm_misc	382	Aug 11	1992	ver41.ana
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-rwxr-xr-x	1	e40511	irm_misc	74	Aug 11	1992	ver44.anp
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-rwxr-xr-x	1	e40511	irm_misc	335	Aug 11	1992	ver45a.ana
-rwxr-xr-x	1	e40511	irm_misc	2523	Aug 11	1992	ver45b.abdat
-rwxr-xr-x	1	e40511	irm_misc	106	Aug 11	1992	ver45b.anp

Permanent storage: Permanent file storage is in the Common File System. Contact L. J. Gannon for additional information.

Error reporting: Perceived errors should be reported in writing to the code custodian. The custodian maintains a log of significant events such as error reports, resolutions, modifications, and changes in operating environment or configuration. The custodian also maintains test input and test output.

7.0 REVISIONS

Version identification appears in the printed output of ANACAP-U.

8.0 CONCLUSION

The version of ANACAP-U installed on the SECC performs as intended.

9.0 REFERENCES

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- Marlow, R. S., 1994, *ANACAP-U Software Configuration and Installation Verification on DOE-RL Cray XMP/232*, WHC-SD-GN-CSWD-30059, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Weis, M. P., 1993, *Verification of Property Degradation Equations*, Letter from M. P. Weis to Dr. R. James of ANATECH Research Corp., Correspondence No. CSA:JBT:ggb:93/7, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1993, *Software Practices*, WHC-CM-3-10, Westinghouse Hanford Company, Richland, Washington.

Figure 1. Beam Profile Position

Figure 2. Stress Contour Plot for Beam Bending

BEAM1; REINFORCED BEAM BENDING UNDER UNIFORM LOAD

Frame 2 beam1.051

ANIPLOT 3.6x 26-Sep-94 11:03:43

Figure 3. Strain Contour Plot for Beam Bending

Figure 4. Displacement History for Beam Bending

ANAPLOT- > ■

HISTORY PLOTS 13,1 TO 13,1

BEAM1; REINFORCED BEAM BENDING UNDER UNIFORM LOAD

Figure 5. Stress History for Beam Bending

Figure 6. Crack Surfaces for Beam Bending

Figure 7. Modulus Degradation at 450 F

Figure 8. Compressive Strength Degradation at 450 F

Figure 9. Tensile Strength Degradation at 450 F

Figure 10. Modulus Degradation for Stepped Temperature

Figure 11. Compressive Strength Degradation for Stepped Temperature

Figure 12. Tensile Strength Degradation for Stepped Temperature

Figure 13. Temperature History for Stepped Temperature

Figure 14. Modulus Degradation for Variable Temperature

Figure 15. Compressive Strength Degradation for Variable Temperature

Figure 16. Tensile Strength Degradation for Variable Temperature

Figure 17. Temperature History for Variable Temperature

Figure 18. Total Strain for 1000 lbf/in/in at Constant Temperature (450 F)

Figure 19. Total Strain for 1000 lbf/in/in at Constant Temperature (450 F)

Figure 20. Total Strain Under a Stepped Temperature

Figure 21. Total Strain Under a Variable Temperature

Table 1. Section Forces and Moments for Beam Bending Test

SECTION FORCES AND NEUTRAL AXIS

STEP= 1 AMP= 1.00

ELEMENT	NODE	FORCE-X	FORCE-Y	ELEMENT AREA-X	ELEMENT AREA-Y	SCALED REBAR AREA-X	SCALED REBAR AREA-Y	ELEMENT MODULUS	REBAR MODULUS
21	1001013	-8.570E+02	.000E+00	9.167E+00	.000E+00	8.182E+00	.000E+00	2.000E+06	3.000E+07
21	1002013	-3.170E+03	-5.383E-10	3.667E+01	.000E+00	2.182E+01	.000E+00	2.000E+06	3.000E+07
21	1003013	-1.039E+02	4.939E+00	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
22	1003013	-2.726E+02	-4.939E+00	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
22	1004013	-3.879E+02	5.918E-10	3.667E+01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
22	1005013	6.147E+01	1.964E+01	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
23	1005013	6.999E+01	-1.964E+01	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
23	1006013	9.088E+02	.000E+00	3.667E+01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
23	1007013	3.941E+02	2.748E+01	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
24	1007013	3.904E+02	-2.748E+01	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
24	1008013	2.242E+03	-1.156E-09	3.667E+01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
24	1009013	7.249E+02	3.333E+01	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
TOTAL		FORCE-X -6.104E-04	FORCE-Y -3.333E+01	AREA-X 2.200E+02	AREA-Y .000E+00	SCALED AREA-X 3.000E+01	SCALED AREA-Y .000E+00		

AMPLITUDE 1.00000E+00	DIRECTION COSINES			NEUTRAL AXIS ORIGIN	SECTION FORCES AND MOMENTS		
	N1	NN	CENTROID		V	P	M
1	.00000E+00	1.00000E+00	1.20000E+02	1.20000E+02	-3.3333E+01	-6.1035E-04	7.20000E+04
	1.00000E+00	.00000E+00	1.10000E+01	9.92000E+00			

SECTION FORCES AND PLASTIC NEUTRAL AXIS

STEP= 1 AMP= 1.00

ELEMENT	NODE	FORCE-X	FORCE-Y	ELEMENT AREA-X	ELEMENT AREA-Y	REBAR AREA-X	REBAR AREA-Y	ELEMENT STRENGTH	REBAR STRENGTH
21	1001013	-8.570E+02	.000E+00	9.167E+00	.000E+00	5.455E-01	.000E+00	1.000E+00	1.000E+00
21	1002013	-3.170E+03	-5.383E-10	3.667E+01	.000E+00	1.455E+00	.000E+00	1.000E+00	1.000E+00
21	1003013	-1.039E+02	4.939E+00	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
22	1003013	-2.726E+02	-4.939E+00	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
22	1004013	-3.879E+02	5.918E-10	3.667E+01	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
22	1005013	6.147E+01	1.964E+01	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
23	1005013	6.999E+01	-1.964E+01	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
23	1006013	9.088E+02	.000E+00	3.667E+01	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
23	1007013	3.941E+02	2.748E+01	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
24	1007013	3.904E+02	-2.748E+01	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
24	1008013	2.242E+03	-1.156E-09	3.667E+01	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
24	1009013	7.249E+02	3.333E+01	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
TOTAL		FORCE-X -6.104E-04	FORCE-Y -3.333E+01	SCALED AREA-X 1.870E+02	SCALED AREA-Y .000E+00	SCALED AREA-X 2.000E+00	SCALED AREA-Y .000E+00		

AMPLITUDE 1.00000E+00	DIRECTION COSINES			NEUTRAL AXIS ORIGIN	SECTION FORCES AND MOMENTS		
	N1	NN	CENTROID		V	P	M
1	.00000E+00	1.00000E+00	1.20000E+02	1.20000E+02	-3.3333E+01	-6.1035E-04	7.20000E+04
	1.00000E+00	.00000E+00	1.10000E+01	1.09048E+01			

SECTION FORCES AND NEUTRAL AXIS

STEP= 20 AMP= 20.0

ELEMENT	NODE	FORCE-X	FORCE-Y	ELEMENT AREA-X	ELEMENT AREA-Y	SCALED REBAR AREA-X	SCALED REBAR AREA-Y	ELEMENT MODULUS	REBAR MODULUS
21	1001013	-1.406E+04	-4.316E+00	.000E+00	.000E+00	8.182E+00	.000E+00	2.000E+06	3.000E+07
21	1002013	-7.904E+04	9.335E+00	2.186E-06	.000E+00	2.182E+01	.000E+00	2.000E+06	3.000E+07
21	1003013	1.072E+04	1.448E+03	1.093E-06	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
22	1003013	5.426E+02	-1.423E+03	.000E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
22	1004013	-2.148E+03	-5.978E+01	2.723E-01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
22	1005013	1.416E+03	2.157E+03	1.361E-01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
23	1005013	-3.600E+03	-2.117E+03	1.002E-01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
23	1006013	1.473E+04	3.043E-02	1.853E+01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00

23	1007013	-6.287E+03	-1.006E+03	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
24	1007013	4.718E+03	1.003E+03	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
24	1008013	5.156E+04	9.871E+00	3.667E+01	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00
24	1009013	2.095E+04	6.606E+02	9.167E+00	.000E+00	.000E+00	.000E+00	2.000E+06	1.000E+00

	FORCE-X	FORCE-Y	AREA-X	AREA-Y	SCALED AREA-X	SCALED AREA-Y
TOTAL	5.001E+02	-6.778E+02	8.321E+01	.000E+00	3.000E+01	.000E+00

AMPLITUDE	DIRECTION COSINES		CENTROID	NEUTRAL AXIS ORIGIN	SECTION FORCES AND MOMENTS		
	N1	NN		V	P	M	
2.00000E+01	.00000E+00	1.00000E+00	1.20000E+02	1.20000E+02	-6.77768E+02	5.00105E+02	1.43965E+06
1	1.00000E+00	.00000E+00	1.10000E+01	1.35120E+01			

SECTION FORCES AND PLASTIC NEUTRAL AXIS

STEP= 20 AMP= 20.0

ELEMENT	NODE	FORCE-X	FORCE-Y	ELEMENT AREA-X	ELEMENT AREA-Y	REBAR AREA-X	REBAR AREA-Y	ELEMENT STRENGTH	REBAR STRENGTH
21	1001013	-1.406E+04	-4.316E+00	9.167E+00	.000E+00	5.455E-01	.000E+00	1.000E+00	1.000E+00
21	1002013	-7.904E+04	9.335E+00	3.667E+01	.000E+00	1.455E+00	.000E+00	1.000E+00	1.000E+00
21	1003013	1.072E+04	1.448E+03	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
22	1003013	5.426E+02	-1.423E+03	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
22	1004013	-2.148E+03	-5.978E+01	3.667E+01	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
22	1005013	1.416E+03	2.157E+03	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
23	1005013	-3.600E+03	-2.117E+03	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
23	1006013	1.473E+04	3.043E-02	3.667E+01	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
23	1007013	-6.287E+03	-1.006E+03	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
24	1007013	4.718E+03	1.003E+03	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
24	1008013	5.156E+04	9.871E+00	3.667E+01	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00
24	1009013	2.095E+04	6.606E+02	9.167E+00	.000E+00	.000E+00	.000E+00	1.000E+00	1.000E+00

	FORCE-X	FORCE-Y	SCALED AREA-X	SCALED AREA-Y	SCALED AREA-X	SCALED AREA-Y
TOTAL	5.001E+02	-6.778E+02	1.870E+02	.000E+00	2.000E+00	.000E+00

AMPLITUDE	DIRECTION COSINES		CENTROID	NEUTRAL AXIS ORIGIN	SECTION FORCES AND MOMENTS		
	N1	NN		V	P	M	
2.00000E+01	.00000E+00	1.00000E+00	1.20000E+02	1.20000E+02	-6.77768E+02	5.00105E+02	1.43836E+06
1	1.00000E+00	.00000E+00	1.10000E+01	1.09048E+01			

ATTACHMENT 1

ABAQUS Input File for Beam Bending Test

*HEADING

BEAM1; REINFORCED BEAM BENDING UNDER UNIFORM LOAD

*NODE,NSET=ALLNODES

1, 0.00000E+00, 0.00000E+00, 0.00000E+00
2, 0.00000E+00, 2.75000E+00, 0.00000E+00
3, 0.00000E+00, 5.50000E+00, 0.00000E+00
4, 0.00000E+00, 8.25000E+00, 0.00000E+00
5, 0.00000E+00, 1.10000E+01, 0.00000E+00
6, 0.00000E+00, 1.37500E+01, 0.00000E+00
7, 0.00000E+00, 1.65000E+01, 0.00000E+00
8, 0.00000E+00, 1.92500E+01, 0.00000E+00
9, 0.00000E+00, 2.20000E+01, 0.00000E+00
10, 1.00000E+01, 0.00000E+00, 0.00000E+00
12, 1.00000E+01, 5.50000E+00, 0.00000E+00
14, 1.00000E+01, 1.10000E+01, 0.00000E+00
16, 1.00000E+01, 1.65000E+01, 0.00000E+00
18, 1.00000E+01, 2.20000E+01, 0.00000E+00
19, 2.00000E+01, 0.00000E+00, 0.00000E+00
20, 2.00000E+01, 2.75000E+00, 0.00000E+00
21, 2.00000E+01, 5.50000E+00, 0.00000E+00
22, 2.00000E+01, 8.25000E+00, 0.00000E+00
23, 2.00000E+01, 1.10000E+01, 0.00000E+00
24, 2.00000E+01, 1.37500E+01, 0.00000E+00
25, 2.00000E+01, 1.65000E+01, 0.00000E+00
26, 2.00000E+01, 1.92500E+01, 0.00000E+00
27, 2.00000E+01, 2.20000E+01, 0.00000E+00
28, 3.00000E+01, 0.00000E+00, 0.00000E+00
30, 3.00000E+01, 5.50000E+00, 0.00000E+00
32, 3.00000E+01, 1.10000E+01, 0.00000E+00
34, 3.00000E+01, 1.65000E+01, 0.00000E+00
36, 3.00000E+01, 2.20000E+01, 0.00000E+00
37, 4.00000E+01, 0.00000E+00, 0.00000E+00
38, 4.00000E+01, 2.75000E+00, 0.00000E+00
39, 4.00000E+01, 5.50000E+00, 0.00000E+00
40, 4.00000E+01, 8.25000E+00, 0.00000E+00
41, 4.00000E+01, 1.10000E+01, 0.00000E+00
42, 4.00000E+01, 1.37500E+01, 0.00000E+00
43, 4.00000E+01, 1.65000E+01, 0.00000E+00
44, 4.00000E+01, 1.92500E+01, 0.00000E+00
45, 4.00000E+01, 2.20000E+01, 0.00000E+00
46, 5.00000E+01, 0.00000E+00, 0.00000E+00
48, 5.00000E+01, 5.50000E+00, 0.00000E+00
50, 5.00000E+01, 1.10000E+01, 0.00000E+00
52, 5.00000E+01, 1.65000E+01, 0.00000E+00
54, 5.00000E+01, 2.20000E+01, 0.00000E+00
55, 6.00000E+01, 0.00000E+00, 0.00000E+00
56, 6.00000E+01, 2.75000E+00, 0.00000E+00
57, 6.00000E+01, 5.50000E+00, 0.00000E+00
58, 6.00000E+01, 8.25000E+00, 0.00000E+00
59, 6.00000E+01, 1.10000E+01, 0.00000E+00

60, 6.00000E+01, 1.37500E+01, 0.00000E+00
61, 6.00000E+01, 1.65000E+01, 0.00000E+00
62, 6.00000E+01, 1.92500E+01, 0.00000E+00
63, 6.00000E+01, 2.20000E+01, 0.00000E+00
64, 7.00000E+01, 0.00000E+00, 0.00000E+00
66, 7.00000E+01, 5.50000E+00, 0.00000E+00
68, 7.00000E+01, 1.10000E+01, 0.00000E+00
70, 7.00000E+01, 1.65000E+01, 0.00000E+00
72, 7.00000E+01, 2.20000E+01, 0.00000E+00
73, 8.00000E+01, 0.00000E+00, 0.00000E+00
74, 8.00000E+01, 2.75000E+00, 0.00000E+00
75, 8.00000E+01, 5.50000E+00, 0.00000E+00
76, 8.00000E+01, 8.25000E+00, 0.00000E+00
77, 8.00000E+01, 1.10000E+01, 0.00000E+00
78, 8.00000E+01, 1.37500E+01, 0.00000E+00
79, 8.00000E+01, 1.65000E+01, 0.00000E+00
80, 8.00000E+01, 1.92500E+01, 0.00000E+00
81, 8.00000E+01, 2.20000E+01, 0.00000E+00
82, 9.00000E+01, 0.00000E+00, 0.00000E+00
84, 9.00000E+01, 5.50000E+00, 0.00000E+00
86, 9.00000E+01, 1.10000E+01, 0.00000E+00
88, 9.00000E+01, 1.65000E+01, 0.00000E+00
90, 9.00000E+01, 2.20000E+01, 0.00000E+00
91, 1.00000E+02, 0.00000E+00, 0.00000E+00
92, 1.00000E+02, 2.75000E+00, 0.00000E+00
93, 1.00000E+02, 5.50000E+00, 0.00000E+00
94, 1.00000E+02, 8.25000E+00, 0.00000E+00
95, 1.00000E+02, 1.10000E+01, 0.00000E+00
96, 1.00000E+02, 1.37500E+01, 0.00000E+00
97, 1.00000E+02, 1.65000E+01, 0.00000E+00
98, 1.00000E+02, 1.92500E+01, 0.00000E+00
99, 1.00000E+02, 2.20000E+01, 0.00000E+00
100, 1.10000E+02, 0.00000E+00, 0.00000E+00
102, 1.10000E+02, 5.50000E+00, 0.00000E+00
104, 1.10000E+02, 1.10000E+01, 0.00000E+00
106, 1.10000E+02, 1.65000E+01, 0.00000E+00
108, 1.10000E+02, 2.20000E+01, 0.00000E+00
109, 1.20000E+02, 0.00000E+00, 0.00000E+00
110, 1.20000E+02, 2.75000E+00, 0.00000E+00
111, 1.20000E+02, 5.50000E+00, 0.00000E+00
112, 1.20000E+02, 8.25000E+00, 0.00000E+00
113, 1.20000E+02, 1.10000E+01, 0.00000E+00
114, 1.20000E+02, 1.37500E+01, 0.00000E+00
115, 1.20000E+02, 1.65000E+01, 0.00000E+00
116, 1.20000E+02, 1.92500E+01, 0.00000E+00
117, 1.20000E+02, 2.20000E+01, 0.00000E+00

*ELEMENT,TYPE=CPS8R,ELSET=BEAM

1	1	19	21	3	10	20	12	2
2	3	21	23	5	12	22	14	4
3	5	23	25	7	14	24	16	6
4	7	25	27	9	16	26	18	8
5	19	37	39	21	28	38	30	20
6	21	39	41	23	30	40	32	22

7	23	41	43	25	32	42	34	24
8	25	43	45	27	34	44	36	26
9	37	55	57	39	46	56	48	38
10	39	57	59	41	48	58	50	40
11	41	59	61	43	50	60	52	42
12	43	61	63	45	52	62	54	44
13	55	73	75	57	64	74	66	56
14	57	75	77	59	66	76	68	58
15	59	77	79	61	68	78	70	60
16	61	79	81	63	70	80	72	62
17	73	91	93	75	82	92	84	74
18	75	93	95	77	84	94	86	76
19	77	95	97	79	86	96	88	78
20	79	97	99	81	88	98	90	80
21	91	109	111	93	100	110	102	92
22	93	111	113	95	102	112	104	94
23	95	113	115	97	104	114	106	96
24	97	115	117	99	106	116	108	98

*MATERIAL,NAME=BEAM

*USER MATERIAL,CONSTANT=4

** BASIC PROPERTIES

3,2.50E+03,1.00E-04,2.00E+06

*DEPVAR

2

*MATERIAL,NAME=STEEL

*ELASTIC

3.00E+07, 3.00E-01

*PLASTIC

40.E3, 0.0

60.E3, .01

*ELSET,ELSET=G1001019

**ELEMENT=CPS8R,MATERIAL=BEAM,SECTION=BEAM

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

16

17 18 19 20 21 22 23 24

*SOLIDSECTION,ELSET=G1001019,MATERIAL=BEAM

1.00E+01

*REBAR,ELEMENT=CONTINUUM,MATERIAL=STEEL,GEOMETRY=SKEW,NAME=TIE

1,3.10000E-01,5.00000E+00,0.00000E+00

5.00000E-02,0.00000E+00,9.50000E-01,0.00000E+00

2,3.10000E-01,5.00000E+00,0.00000E+00

5.00000E-02,0.00000E+00,9.50000E-01,0.00000E+00

3,3.10000E-01,5.00000E+00,0.00000E+00

5.00000E-02,0.00000E+00,9.50000E-01,0.00000E+00

4,3.10000E-01,5.00000E+00,0.00000E+00

5.00000E-02,0.00000E+00,9.50000E-01,0.00000E+00

*REBAR,ELEMENT=CONTINUUM,MATERIAL=STEEL,GEOMETRY=SKEW,NAME=LONG

1,1.00000E+00,5.00000E+00,0.00000E+00

0.00000E+00,3.63636E-01,0.00000E+00,6.36364E-01

5,1.00000E+00,5.00000E+00,0.00000E+00

```

0.00000E+00,3.63636E-01,0.00000E+00,6.36364E-01
9,1.00000E+00,5.00000E+00,0.00000E+00
0.00000E+00,3.63636E-01,0.00000E+00,6.36364E-01
13,1.00000E+00,5.00000E+00,0.00000E+00
0.00000E+00,3.63636E-01,0.00000E+00,6.36364E-01
17,1.00000E+00,5.00000E+00,0.00000E+00
0.00000E+00,3.63636E-01,0.00000E+00,6.36364E-01
21,1.00000E+00,5.00000E+00,0.00000E+00
0.00000E+00,3.63636E-01,0.00000E+00,6.36364E-01
*****
*ELSET,ELSET=ALLELEME
  1    2    3    4    5    6    7    8    9   10   11   12   13   14   15
16
  17   18   19   20   21   22   23   24
*NSET,NSET=UX
  109  110  111  112  113  114  115  116  117
*NSET,NSET=UY
  1
*ELSET,ELSET=MIDSPAN
  21   22   23   24
*****
*AMPLITUDE,TIME=A,NAME=LIVE
0.0,0.00, 22.0,1.0
*RESTART,WRITE,FREQUENCY=10
*****
*STEP,INC=100,CYCLE=3
*STATIC,PTOL=1.00000E+02,DIRECT=NOSTOP
1.0, 22.0
*BOUNDARY
UX,1,1,0.0
UY,2,2,0.0
*DLOAD,AMPLITUDE=LIVE
4,P3,2.20000E+01
8,P3,2.20000E+01
12,P3,2.20000E+01
16,P3,2.20000E+01
20,P3,2.20000E+01
24,P3,2.20000E+01
*ELFILE,FREQUENCY=1,ELSET=ALLELEME
E
S
SDV
NFORC
*ELFILE,FREQUENCY=1,ELSET=ALLELEME,REBAR
E
S
*NODEFILE,FREQUENCY=1,NSET=ALLNODES
U
RF
*ELPRINT,FREQUENCY=5,ELSET=MIDSPAN
E
S
*ELPRINT,FREQUENCY=2,ELSET=ALLELEME,REBAR=LONG
E

```

S
*NODEPRINT, FREQUENCY=2, NSET=ALLNODES, TOTALS=YES
RF
*END STEP

ATTACHMENT 2

Selected Output from the Beam Bending Tests on hp1 and hp2

1

ABAQUS PRODUCTION VERSION 4-9-1

DATE 26-Sep-94

TIME 11:01:36

PAGE

1

FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

BEAM1; REINFORCED BEAM BENDING UNDER UNIFORM LOAD
INCREMENT 1

STEP 1

THIS STEP .000E+00

TIME COMPLETED IN

STEP 1

STATIC ANALYSIS

USER SPECIFIED INCREMENTS OF 1.00 FOR A TIME PERIOD OF 22.0

THE SOLUTION TO EACH INCREMENT WILL BE ACCEPTED WHEN THE ITERATION LIMIT HAS BEEN REACHED
EVEN IF THE EQUILIBRIUM TOLERANCES ARE STILL EXCEEDED.

---WARNING--- INTERPRET ANY OUT-OF-EQUILIBRIUM RESULTS WITH CAUTION

EQUILIBRIUM TOLERANCES -

TOLERANCE ON INDIVIDUAL FORCE COMPONENTS 100.

SMALL DISPLACEMENT THEORY WILL BE USED

MAXIMUM NUMBER OF INCREMENTS ALLOWED IN THIS STEP IS 100

MAXIMUM NUMBER OF ITERATIONS ALLOWED PER INCREMENT IS 3

PRINT OF INCREMENT NUMBER, TIME, ETC., EVERY 1 INCREMENTS

INCREMENT NUMBER 1 ATTEMPT NUMBER 1

TIME INCREMENT = 1.00

ANATECH CONCRETE UMAT92 Version 2.2.7, May, 26, 1994:

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UMAT CONCRETE PROPERTIES 26-Sep-94 11:01:36

CMNAME = BEAM

NPROPS = 4

MODEL = 3 COMPRESSIVE STRAIN HARDENING & SOFTENING

CRUSH = 2.500E+03 (PSI)

EPFRAC = 1.000E-04 (IN/IN)

ECONC = 2.000E+06 (PSI)

XVC = .150

ALFAC = .000E+00 (1/DEG F)

TREF = .000E+00 (DEG F)

TIMREF = .000E+00 (DAYS)

** CREEP, AGE & DEGRADE MODELS NOT ACTIVATED **

** DIRECTED CRACK MODEL NOT ACTIVATED **

** DAMPING MODEL NOT ACTIVATED **

** ROUGH CRACK MODEL NOT ACTIVATED **

** COMPRESSION CURVE MODEL NOT ACTIVATED **

WHC-SD-SQA-CSWD-30017
Rev. 0

```
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
dir = /t_hp1/w84255/ana/15861
START ANALYSIS beam1 on: Mon Sep 26 16:21:20 PDT 1994 on hp1
if ( -e /t_hp1/w84255/.res ) then
if ( -e /t_hp1/w84255/beam1.res ) rm -f beam1.res
endif
ln -s /t_hp1/w84255/beam1.res /t_hp1/w84255/ana/15861/beam1.res
if ( -e /t_hp1/w84255/.fil ) then
ln -s /t_hp1/w84255/beam1.fil /t_hp1/w84255/ana/15861/beam1.fil
echo RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
cd /t_hp1/w84255/ana/15861
setenv TMPDIR /t_hp1/w84255/ana/15861
/p_hp/abaqus/abaqus49/lib/abq49pre.exe
0.7u 0.2s 0:03 27%
echo END OF PRE
END OF PRE
echo Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
/p_hp/abaqus/abaqus49/lib/abq49shr.a
Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
/p_hp/abaqus/abaqus49/lib/abq49shr.a
0.4u 0.2s 0:03 20%
f77 -o beam1.exe beam1.o /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
/p_hp/abaqus/abaqus49/lib/abq49shr.a -lvec
1.4u 0.7s 0:04 52%
chmod +x beam1.exe
echo EXECUTING MAIN
EXECUTING MAIN
ln -s /p2_hp/anacapu/v2.2/anacap.t44 TAPE44
beam1.exe
20.0u 0.4s 0:22 92%
rm TAPE44
if ( -e core ) then
cd /t_hp1/w84255
rm -f /t_hp1/w84255/ana/15861/beam1.023 /t_hp1/w84255/ana/15861/beam1.exe /t_hp1/w84255/ana/15861/beam1.f
/t_hp1/w84255/ana/15861/beam1.fil /t_hp1/w84255/ana/15861/beam1.id /t_hp1/w84255/ana/15861/beam1.inp
/t_hp1/w84255/ana/15861/beam1.lis /t_hp1/w84255/ana/15861/beam1.mpl /t_hp1/w84255/ana/15861/beam1.o
/t_hp1/w84255/ana/15861/beam1.ppl /t_hp1/w84255/ana/15861/beam1.res /t_hp1/w84255/ana/15861/beam1.sta
/t_hp1/w84255/ana/15861/beam1.stp
rmdir /t_hp1/w84255/ana/15861
endif
time
22.6u 1.8s 0:34 71%
echo END OF MAIN
END OF MAIN
exit
22.6u 1.8s 0:34 71%
```

ATTACHMENT 3

ABAQUS Input File for Property Degradation Test

*HEADING

BEST FIT HANFORD PROPERTIES, 450F, 50 YEARS

**

*NODE,NSET=ALLNODES

1, 0.00000E+00, 0.00000E+00, 0.00000E+00

2, 0.00000E+00, 1.00000E+00, 0.00000E+00

3, 1.00000E+00, 0.00000E+00, 0.00000E+00

4, 1.00000E+00, 1.00000E+00, 0.00000E+00

*NSET, NSET = LEFT

1,2

*NSET, NSET = BOTT

1,3

*NSET, NSET = RIGHT

3,4

*NSET, NSET = TOP

2,4

**

*ELEMENT,TYPE=CPS4,ELSET=CPS4

1 1 3 4 2

**

*MATERIAL, NAME=CONCR

*USER MATERIAL, CONSTANTS=25

4, 4000., 100E-6, 4.E6, 0.15, 0., 0., 0.

0., 0., 0., 0., 0., 0., 0., 0.

0., 0., 0., 0., 0., 0., 0., 0.

4.,

*DEPVAR

32

*ELSET,ELSET=ALL

1

*SOLID SECTION, ELSET=CPS4, MATERIAL=CONCR

1.0

*INITIAL CONDITIONS, TYPE=TEMPERATURE

ALLNODES, 450.

*AMPLITUDE, TIME=A, NAME=LOAD

0.,1.0, 1000.,1.0, 10000.,1.0, 20000.,1.0

*RESTART, WRITE, FREQUENCY=1000

**

*STEP, INC=1000, CYCLE=3

*STATIC, PTOL=.01, DIRECT=NOSTOP

1., 100.

*BOUNDARY

BOTT, 2, 2

LEFT, 1, 1

*DLOAD, AMPLITUDE=LOAD

1, P3, 1000.0

*ELFILE, FREQUENCY=2

S

E

SDV

```
*NODEFILE, FREQUENCY=2
NT
*EL PRINT, FREQUENCY=10
TEMP, SDV6, SDV7, SDV8, S22, E11, E22
*NODE PRINT, FREQUENCY=0
U
*END STEP
**
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
10., 900.
*END STEP
**
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
100., 9000.
*ELFILE, FREQUENCY=4
S
E
SDV
*NODEFILE, FREQUENCY=4
NT
*END STEP
**
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
200., 10000.
*END STEP
```

ATTACHMENT 4

Log File for Property Degradation Test

```
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
  dir = /t_hp2/w84255/anaqa/best/ana/18547
  START ANALYSIS best on: Mon Sep 26 11:10:05 PDT 1994  on hp2
  if ( -e /t_hp2/w84255/anaqa/best/.res ) then
  if ( -e /t_hp2/w84255/anaqa/best/best.res ) rm -f best.res
  rm -f best.res
  endif
  ln -s /t_hp2/w84255/anaqa/best/best.res /t_hp2/w84255/anaqa/best/ana/18547/best.res
  if ( -e /t_hp2/w84255/anaqa/best/.fil ) then
  ln -s /t_hp2/w84255/anaqa/best/best.fil /t_hp2/w84255/anaqa/best/ana/18547/best.fil
  echo RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
  RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
  cd /t_hp2/w84255/anaqa/best/ana/18547
  setenv TMPDIR /t_hp2/w84255/anaqa/best/ana/18547
  /p_hp/abaqus/abaqus49/lib/abq49pre.exe
  0.3u 0.3s 0:03 20%
  echo END OF PRE
  END OF PRE
  echo Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
  /p_hp/abaqus/abaqus49/lib/abq49shr.a
  Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
  /p_hp/abaqus/abaqus49/lib/abq49shr.a
  0.4u 0.2s 0:02 31%
  f77 -o best.exe best.o /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
  /p_hp/abaqus/abaqus49/lib/abq49shr.a -lvec
  1.3u 0.6s 0:03 60%
  chmod +x best.exe
  echo EXECUTING MAIN
  EXECUTING MAIN
  ln -s /p2_hp/anacapu/v2.2/anacap.t44 TAPE44
  best.exe
  10.8u 0.5s 0:30 37%
  rm TAPE44
  if ( -e core ) then
  cd /t_hp2/w84255/anaqa/best
  rm -f /t_hp2/w84255/anaqa/best/ana/18547/best.023 /t_hp2/w84255/anaqa/best/ana/18547/best.exe
  /t_hp2/w84255/anaqa/best/ana/18547/best.f /t_hp2/w84255/anaqa/best/ana/18547/best.fil
  /t_hp2/w84255/anaqa/best/ana/18547/best.id /t_hp2/w84255/anaqa/best/ana/18547/best.inp
  /t_hp2/w84255/anaqa/best/ana/18547/best.lis /t_hp2/w84255/anaqa/best/ana/18547/best.mpl
  /t_hp2/w84255/anaqa/best/ana/18547/best.o /t_hp2/w84255/anaqa/best/ana/18547/best.ppl
  /t_hp2/w84255/anaqa/best/ana/18547/best.res /t_hp2/w84255/anaqa/best/ana/18547/best.sta
  /t_hp2/w84255/anaqa/best/ana/18547/best.stp
  rmdir /t_hp2/w84255/anaqa/best/ana/18547
  endif
  time
  13.0u 1.9s 0:39 38%
  echo END OF MAIN
  END OF MAIN
  exit
  13.0u 1.9s 0:39 38%
```


ATTACHMENT 5

ABAQUS Input File for Stepped Temperature Test

```

*HEADING
CREEP AND PROPERTY DEGRADATION TESTS
**
*NODE,NSET=ALLNODES
    1, 0.00000E+00, 0.00000E+00, 0.00000E+00
    2, 0.00000E+00, 1.00000E+00, 0.00000E+00
    3, 1.00000E+00, 0.00000E+00, 0.00000E+00
    4, 1.00000E+00, 1.00000E+00, 0.00000E+00
*NSET, NSET = LEFT
1,2
*NSET, NSET = BOTT
1,3
*NSET, NSET = RIGHT
3,4
*NSET, NSET = TOP
2,4
*ELEMENT,TYPE=CPS4,ELSET=CPS4
    1    1    3    4    2
*MATERIAL, NAME=CONCR
*USER MATERIAL, CONSTANTS=25
    4, 4500., 100E-6, 4.E6, 0.15, 0., 0., 0.
    0., 0., 0., 0., 0., 0., 0., 0.
    0., 0., 0., 0., 0., 0., 0., 0.
    4.
*DEPVAR
32
*ELSET,ELSET=ALL
1
*SOLID SECTION, ELSET=CPS4, MATERIAL=CONCR
1.0
*INITIAL CONDITIONS, TYPE=TEMPERATURE
ALLNODES, 150.
*AMPLITUDE, TIME=A, NAME=LOAD
0.,1.0, 1000.,1.0, 20000.,1.0
*AMPLITUDE, TIME=A, NAME=TEMP
0.,1.5, 10.,2.5, 300.,2.5, 310.,3.5,
600.,3.5, 610.,4.5, 900.,4.5, 1200.,2.5
*RESTART, WRITE, FREQUENCY=1000
**
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
1.0, 100.0
**
*BOUNDARY
BOTT, 2, 2
LEFT, 1, 1
*DLOAD, AMPLITUDE=LOAD
1, P3, 1000.0
*TEMPERATURE, AMPLITUDE=TEMP

```

```
ALLNODES, 100.
**
*ELFILE, FREQUENCY=2
S
E
SDV
*NODEFILE, FREQUENCY=2
NT
*EL PRINT, FREQUENCY=10
TEMP, SDV6, SDV7, SDV8, S22, E22, E11
*NODE PRINT, FREQUENCY=0
RF
*END STEP
*****
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
10., 200.
*END STEP
*****
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
1.0, 10.0
*END STEP
*****
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
10.0, 290.
*END STEP
*****
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
1.0, 10.0
*END STEP
*****
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
10., 290.
*END STEP
*****
*STEP, INC=1000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
10., 300.
*END STEP
```

ATTACHMENT 6

Log File for Stepped Temperature Test

```
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
  dir = /t_hp2/w84255/anaqa/step1/ana/19345
  START ANALYSIS step1 on: Mon Sep 26 12:44:49 PDT 1994  on hp2
  if ( -e /t_hp2/w84255/anaqa/step1/.res ) then
  if ( -e /t_hp2/w84255/anaqa/step1/step1.res ) rm -f step1.res
  rm -f step1.res
  endif
  ln -s /t_hp2/w84255/anaqa/step1/step1.res /t_hp2/w84255/anaqa/step1/ana/19345/step1.res
  if ( -e /t_hp2/w84255/anaqa/step1/.fil ) then
  ln -s /t_hp2/w84255/anaqa/step1/step1.fil /t_hp2/w84255/anaqa/step1/ana/19345/step1.fil
  echo RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
  RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
  cd /t_hp2/w84255/anaqa/step1/ana/19345
  setenv TMPDIR /t_hp2/w84255/anaqa/step1/ana/19345
  /p_hp/abaqus/abaqus49/lib/abq49pre.exe
  0.5u 0.2s 0:03 20%
  echo END OF PRE
  END OF PRE
  echo Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
  /p_hp/abaqus/abaqus49/lib/abq49shr.a
  Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
  /p_hp/abaqus/abaqus49/lib/abq49shr.a
  0.4u 0.2s 0:00 58%
  f77 -o step1.o /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
  /p_hp/abaqus/abaqus49/lib/abq49shr.a -lvec
  1.3u 0.6s 0:05 37%
  chmod +x step1.exe
  echo EXECUTING MAIN
  EXECUTING MAIN
  ln -s /p2_hp/anacapu/v2.2/anacap.t44 TAPE44
  step1.exe
  6.9u 0.6s 0:19 39%
  rm TAPE44
  if ( -e core ) then
  cd /t_hp2/w84255/anaqa/step1
  rm -f /t_hp2/w84255/anaqa/step1/ana/19345/step1.023 /t_hp2/w84255/anaqa/step1/ana/19345/step1.exe
  /t_hp2/w84255/anaqa/step1/ana/19345/step1.f /t_hp2/w84255/anaqa/step1/ana/19345/step1.fil
  /t_hp2/w84255/anaqa/step1/ana/19345/step1.id /t_hp2/w84255/anaqa/step1/ana/19345/step1.inp
  /t_hp2/w84255/anaqa/step1/ana/19345/step1.lis /t_hp2/w84255/anaqa/step1/ana/19345/step1.mpl
  /t_hp2/w84255/anaqa/step1/ana/19345/step1.o /t_hp2/w84255/anaqa/step1/ana/19345/step1.ppl
  /t_hp2/w84255/anaqa/step1/ana/19345/step1.res /t_hp2/w84255/anaqa/step1/ana/19345/step1.sta
  /t_hp2/w84255/anaqa/step1/ana/19345/step1.stp
  rmdir /t_hp2/w84255/anaqa/step1/ana/19345
  endif
  time
  9.2u 1.9s 0:28 39%
  echo END OF MAIN
  END OF MAIN
  exit
  9.2u 1.9s 0:28 39%
```

ATTACHMENT 7

ABAQUS Input File for Variable Temperature Test

```
*HEADING
BEST FIT HANFORD, VARIABLE TEMPERATURE HISTORY OVER 50 YEARS
**
*NODE,NSET=ALLNODES
    1, 0.00000E+00, 0.00000E+00, 0.00000E+00
    2, 0.00000E+00, 1.00000E+00, 0.00000E+00
    3, 1.00000E+00, 0.00000E+00, 0.00000E+00
    4, 1.00000E+00, 1.00000E+00, 0.00000E+00
*NSET, NSET = LEFT
1,2
*NSET, NSET = BOT
1,3
*NSET, NSET = RIGHT
3,4
*NSET, NSET = TOP
2,4
*ELEMENT,TYPE=CPS4,ELSET=CPS4
    1    1    3    4    2
*MATERIAL, NAME=CONCR
*USER MATERIAL, CONSTANTS=25
    4, 4000., 100E-6, 4.E6, 0.15, 0., 0., 0.
    0., 0., 0., 0., 0., 0., 0., 0.
    0., 0., 0., 0., 0., 0., 0., 0.
    4.,
*DEPVAR
32
*ELSET,ELSET=ALL
1
*SOLID SECTION, ELSET=CPS4, MATERIAL=CONCR
1.0
*INITIAL CONDITIONS, TYPE=TEMPERATURE
ALLNODES, 70.
*AMPLITUDE, TIME=A, NAME=LOAD
0.0,1.0, 18000.,1.0
*AMPLITUDE, TIME=A, NAME=TEMP
    0.0,.70, 90.,2.5, 1350.,2.5, 1440.,1.5
1530.,2.5, 2790.,2.5, 2880.,1.5, 3690.,3.0
4320.,3.0, 4500.,3.5, 5130.,3.5, 7380.,1.5
9000.,1.5, 9180.,2.5, 18000.,2.5
*RESTART, WRITE, FREQUENCY=1000
*****
*STEP, INC=5000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
1., 100.
**
*BOUNDARY
BOTT, 2, 2
LEFT, 1, 1
*DLOAD, AMPLITUDE=LOAD
1, P3, 1000.0
```

```
*TEMPERATURE, AMPLITUDE=TEMP
ALLNODES, 100.
**
*ELFILE, FREQUENCY=2
S
E
SDV
TEMP
*NODEFILE, FREQUENCY=2
NT
*EL PRINT, FREQUENCY=10
TEMP, SDV6, SDV7, SDV8, E11, E22, S22
*NODE PRINT, FREQUENCY=0
RF
*END STEP
*****
*STEP, INC=2000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
10., 9000.
*END STEP
*****
*STEP, INC=2000, CYCLE=3
*STATIC, PTOL=.01, DIRECT=NOSTOP
100., 8000.
*END STEP
```

ATTACHMENT 8

Log File for Variable Temperature Test

```
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
stty: : Not a typewriter
dir = /t_hp2/w84255/anaqa/creep2/ana/19710
START ANALYSIS creep2 on: Mon Sep 26 13:05:49 PDT 1994 on hp2
if ( -e /t_hp2/w84255/anaqa/creep2/.res ) then
if ( -e /t_hp2/w84255/anaqa/creep2/creep2.res ) rm -f creep2.res
rm -f creep2.res
endif
ln -s /t_hp2/w84255/anaqa/creep2/creep2.res /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.res
if ( -e /t_hp2/w84255/anaqa/creep2/.fil ) then
ln -s /t_hp2/w84255/anaqa/creep2/creep2.fil /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.fil
echo RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
RUN /p_hp/abaqus/abaqus49/lib/abq49pre.exe
cd /t_hp2/w84255/anaqa/creep2/ana/19710
setenv TMPDIR /t_hp2/w84255/anaqa/creep2/ana/19710
/p_hp/abaqus/abaqus49/lib/abq49pre.exe
0.4u 0.3s 0:02 31%
echo END OF PRE
END OF PRE
echo Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
/p_hp/abaqus/abaqus49/lib/abq49shr.a
Link /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
/p_hp/abaqus/abaqus49/lib/abq49shr.a
0.4u 0.2s 0:00 59%
f77 -o creep2.exe creep2.o /p2_hp/anacapu/v2.2/umat92.o /p_hp/abaqus/abaqus49/lib/abq49main.a
/p_hp/abaqus/abaqus49/lib/abq49shr.a -lvec
1.2u 0.6s 0:05 35%
chmod +x creep2.exe
echo EXECUTING MAIN
EXECUTING MAIN
ln -s /p2_hp/anacapu/v2.2/anacap.t44 TAPE44
creep2.exe
41.5u 1.9s 2:17 31%
rm TAPE44
if ( -e core ) then
cd /t_hp2/w84255/anaqa/creep2
rm -f /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.023 /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.exe
/t_hp2/w84255/anaqa/creep2/ana/19710/creep2.f /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.fil
/t_hp2/w84255/anaqa/creep2/ana/19710/creep2.id /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.inp
/t_hp2/w84255/anaqa/creep2/ana/19710/creep2.lis /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.mpl
/t_hp2/w84255/anaqa/creep2/ana/19710/creep2.o /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.ppl
/t_hp2/w84255/anaqa/creep2/ana/19710/creep2.res /t_hp2/w84255/anaqa/creep2/ana/19710/creep2.sta
/t_hp2/w84255/anaqa/creep2/ana/19710/creep2.stp
rmdir /t_hp2/w84255/anaqa/creep2/ana/19710
endif
time
43.6u 3.3s 2:26 32%
echo END OF MAIN
END OF MAIN
exit
43.6u 3.3s 2:26 32%
```