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SOFTWARE RELEASE NOTICE

1. SRN Number: **MGFE-SRN-191**

2. Project Title: **Repository Design & Thermal-Mechanical Effects**	Project No.: **20-1402-671**

3. SRN Title: **ABAQUS/Pre Version 5.7**

4. Originator/Requestor: **Bruce Mabrito**	Date: **06/25/1999**

5. Summary of Actions

- ☐ Release of new software
- ■ Release of modified software:
  - ■ Enhancements made
  - ☐ Corrections made
- ☐ Change of access software
- ☒ Software Retirement 8/16/2001

6. Persons Authorized Access

Name	Read Only/Read-Write	Addition/Change/Delete
Goodluck Ofoegbu	**Read Only**	**Change**
Rui Chen	**Read Only**	**Change**
Amitava Ghosh	**Read Only**	**Change**
Simon Hsiung	**Read Only**	**Change**
Doug Gute	**Read Only**	**Change**

7. Element Manager Approval: [signature] Date: 6/25/99

8. Remarks:
Access is not limited for commercial software.

SOFTWARE RELEASE NOTICE

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3. SRN Title: **ABAQUS/Pre Version 5.7**

4. Originator/Requestor: **Bruce Mabrito**	Date: **08/15/2001**

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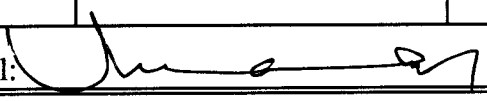
7. Element Manager Approval:  Date: 8-16-01

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SOFTWARE SUMMARY FORM

01. Summary Date: **06/25/99**	02. Summary prepared by (Name and phone) **Bruce Mabrito, (210) 522-5149**		03. Summary Action: **New**
04. Software Date: **06/25/99**	05. Short Title: **ABAQUS/Pre V.5.7**		
06. Software Title: **ABAQUS/Pre Version 5.7**			07. Internal Software ID: **NONE**
08. Software Type: ☐ Automated Data System ■ Computer Program ☐ Subroutine/Module	09. Processing Mode: ■ Interactive ☐ Batch ☐ Combination	10. APPLICATION AREA a. General: ■ Scientific/Engineering ☐ Auxiliary Analyses ☐ Total System PA ☐ Subsystem PA ☐ Other b. Specific:	
11. Submitting Organization and Address: **CNWRA/SwRI** **6220 Culebra Road** **San Antonio, TX 78228**		12. Technical Contact(s) and Phone: **Goodluck Ofoegbu (210) 522-6641**	
13. Software Application: **Used for preprocessing of finite element models for ABAQUS.**			
14. Computer Platform **"Pluto" Server** **(Silicon Graphics)**	15. Computer Operating System: **IRIS 6.5**	16. Programming Language(s): **N/A**	17. Number of Source Program Statements: **N/A**
18. Computer Memory Requirements: **N/A**	19. Tape Drives: **NONE**	20. Disk/Drum Units: **N/A**	21. Graphics: **XWINDOW System**
22. Other Operational Requirements **NONE**			
23. Software Availability: ■ Available ☐ Limited ☐ In-House ONLY		24. Documentation Availability: ■ Available ☐ Inadequate ☐ In-House ONLY	
CNWRA Contact Person:		Date: 6/25/99	

CNWRA Form TOP-4-1

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Date: 6/25/99
Sender: Goodluck Ofoegbu
To: Bruce Mabrito
Priority: Normal
Subject: ABAQUS/PRE Version 5.7

I have performed a verification test of the installation of ABAQUS/PRE Version 5.7 on PLUTO. The result of the test shows that the software has been installed properly. The results are documented in CNWRA Scientific Notebook Number 263, pp. 77-84, a copy of which is attached.

Thanks

Goodluck Ofoegbu

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Two drift-scale models are set up to examine the following:

(1) Shape and size of damaged zone (zone of high plastic strain in the roof area of opening)

(2) Distribution of contact pressure on drift lining

(3) Distribution of the permeability-change ratio R_k

The drift-scale models ~~will be~~ are synchronized with the repository-scale model in terms of (i) coordinates, (ii) spatial variation of mechanical properties, and (iii) Drift number. Results from the repository-scale model are used to set the boundary conditions for the drift-scale models.

Two drift-scale models are analyzed:

(1) Drift #48 of repository-scale model. Boundary x coordinates (middle of the bounding pillars) are.

$$X_{min} = 28(100 - D_n) = 28 \times 52 \quad (D_n = 48)$$
$$= 1456 \text{ m}$$
$$X_{max} = 1456 + 28 = 1484 \text{ m}$$
$$X_o = x \text{ at drift axis} = \tfrac{1}{2}(1456 + 1484) = 1470 \text{m}$$

(2) Drift #85 of repository-scale model

$$X_{min} = 28(100 - 85) = 420 \text{ m}$$
$$X_{max} = 420 + 28 = 448 \text{ m}$$
$$X_o = \tfrac{1}{2}(420 + 448) = 434 \text{ m}$$

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From Scientific Notebook No. 263

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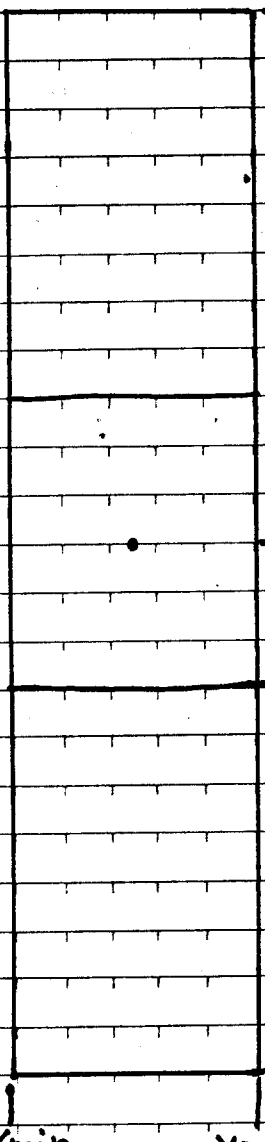
Drift #48 is in the maximum Q area, and #85 in the minimum Q area, of the repository-scale model. Minimum Q actually occurs between drifts 98 and 99 (p. 70) but these drifts lie in the zone of significant lateral temperature gradient and relatively low temperature. Drift #85 was (cf. p. 70) was chosen to represent low-Q areas to avoid the effects of lateral temperature gradient and relatively low temperature on the calculated response.



This figure illustrates schematically the domain of each drift-scale model. The domain extends about 200 m horizontally, i.e. ± 100 m above and below the drift axis. Boundary conditions at the exterior boundaries are set using temperature and x and y displacement histories calculated in the repository-scale model. Such boundary conditions are applied using the ABAQUS SUBMODEL facilities.

Each drift is modeled using as a circular section with external diameter of 5.4 m, including a 0.2 m thick concrete lining.

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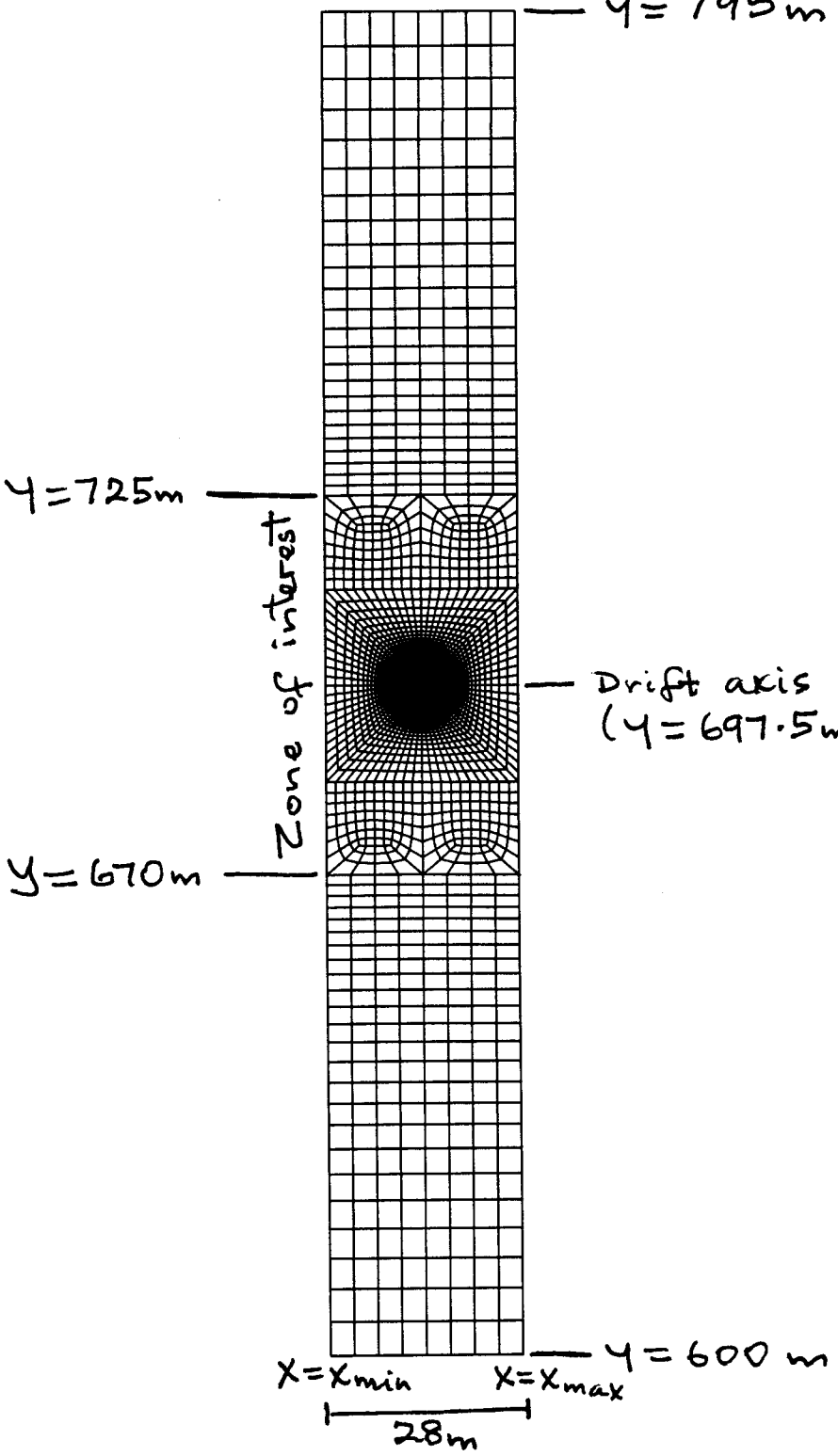

Finite element mesh used for drift-scale models. See p. 80 for more details.

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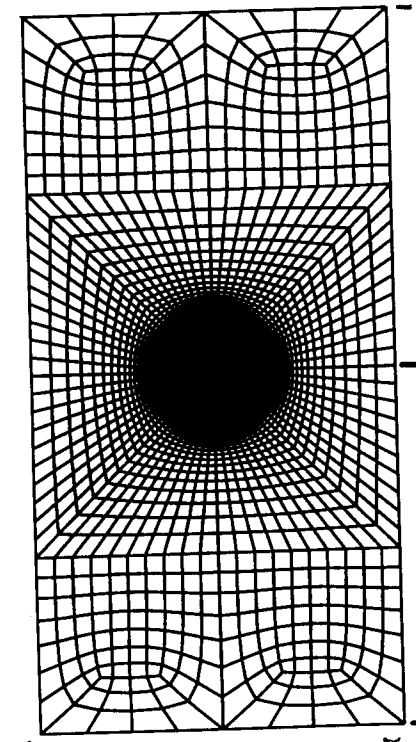
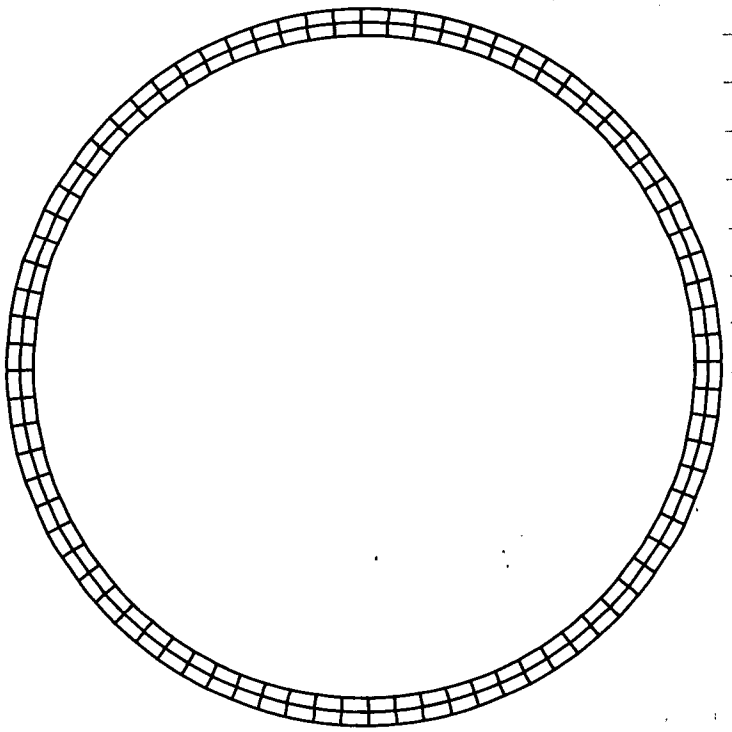


Finite element mesh within the zone of interest, which extends vertically 27.5 m above and below the drift axis. Materials within this zone, except the liner and tunnel section, are modeled as ~~lin~~ elastic-plastic using the Drucker-Prager strength criterion.



Finite element mesh used to model liner. The liner has internal and external diameters of 5.0 and 5.4 m, respectively. Pressure distributions at the exterior surface of the liner is monitored as part of the analysis.

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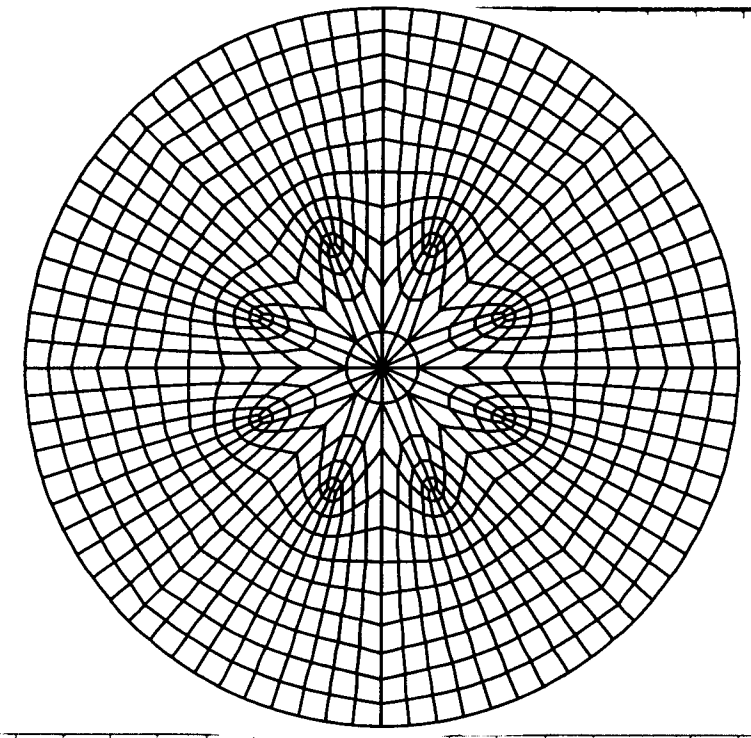

Finite element mesh of the tunnel section. Material within this zone is treated as a uniform volumetric heat source in the thermal analysis. In the mechanical analysis, the tunnel-section elements are removed to simulate excavation. The interior surface of the liner coincides with the exterior surface of the tunnel section.

Material Properties

Zones: (1) Elastic-plastic zone (see p. 80).

(2) Elastic zone: includes the tunnel section, areas above and the upper elastic-plastic zone, and areas below the lower elastic-plastic zone (i.e., areas above y=725m and areas below y=670m on p. 78).

(3) Liner: modeled as linear elastic with concrete properties.

Rock mass thermal and mechanical properties are assigned the same values (some as functions of X) described on p. 18-23. The properties of concrete liner are assigned from literature as follows:

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Properties of Concrete

Density: 2100 kg/m^3 [p. 15 of reference (1) cited on p. 2].

Thermal conductivity: 1.37 J/(s.m.K)

$= 4.32 \times 10^7$ J/(yr.m.K)

[p. 15 of same reference]

Specific heat capacity = 880 J/(kg.K)

[p. 15 of same reference]

Young's modulus: 2.76×10^4 MPa

Poisson's ratio: 0.25 ← Changed to 0.21

↳ [p. 8 of reference (3) cited on p. 15]

Thermal expansivity: 9.9×10^{-6}/K

[p. 8 of same reference].

Input Files

(1) Repository-scale model ~~to~~ m06 (same as m01 described on p. 61) is used to generate histories of x and y displacements required to set drift-scale model boundary conditions.

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Input files for model m06: (Global model)

m06.inp
allNodes.def
mElem01.def and auxiliary files listed on p. 61
d1GmNodes.def defines driver node set for model d1
d2GmNodes.def defines driver node set for d2

② Drift-Scale Models (Submodels).

Model d1 — Drift #48

2.1	d1t.inp	Thermal analysis input files
2.2	d1Nodes.def	Node definitions.
2.3	nodeSets.def	Node set definitions.
2.4	drivenNodes.def	Node sets that get temperature and displacement histories from model m06.
2.5	tElems.def	Element connectivity definitions for thermal model
2.6	elemSets.def	Element set definitions
2.7	contacts.def	Defines liner-to-rock contact sets.
2.8	tProps.def	Thermal property definitions
2.9	iniTemp.def	Initial temperature definitions
2.10	cDrftSrc.def	Heat source definition
2.11	mElems.def	Element connectivity for mechanical model
2.12	mProps.def	Mechanical property definitions
2.13	ndxFld.def	Defines a field variable assigned value of x-coordinate at each node.
2.14	d1m.inp	Mechanical analysis input files
2.15	d1EMat.def	Young's modulus and Poisson's ratio
2.16	d1Friction.def	Drucker-Prager friction properties
2.17	d1Cohesion.def	Drucker-Prager cohesion properties

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Model Ø d2 Drift #85

2.18	d2t.inp	Thermal analysis input file
2.19	d2Nodes.def	Node definitions.
2.20	d2ndxFld.def	Defines a field variable assigned value of x-word at every node.
2.21	d2m.inp	Mechanical analysis input
2.22	d2EMat.def	Young's modulus & Poisson's ratio
2.23	d2Friction.def	Drucker-Prager friction properties
2.24	d2Cohesion.def	Drucker-Prager cohesion properties
2.25	d2mProps.def	Mechanical properties definitions

The following input files ~~are~~ listed for model d1 are also used by model d2.

2.3 thru 2.11

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