

SCHOOL OF
CIVIL ENGINEERING

INDIANA

DEPARTMENT OF TRANSPORTATION

Joint Highway Research Project

Interim Report FHWA/JHRP/IN 92/1

A Sensitivity Analysis of
the Parameters for a Cap
Plasticity Model

Philippe Bourdeau

Wai-Fai Chen

C. William Lovell

Scott Ludlow



PURDUE UNIVERSITY



Joint Highway Research Project

Interim Report FHWA/JHRP/IN 92/1

A Sensitivity Analysis of
the Parameters for a Cap
Plasticity Model

Philippe Bourdeau
Wai-Fai Chen
C. William Lovell
Scott Ludlow



**Interim Report: "A Sensitivity Analysis
of the Parameters for a Cap Plasticity Model"**

by

Scott J. Ludlow
Graduate Research Assistant

Wai-Fah Chen
Professor of Civil Engineering

Philippe L. Bourdeau
Assistant Professor of Civil Engineering

and

C. William Lovell
Professor of Civil Engineering

Joint Highway Research Project
HPR 2031

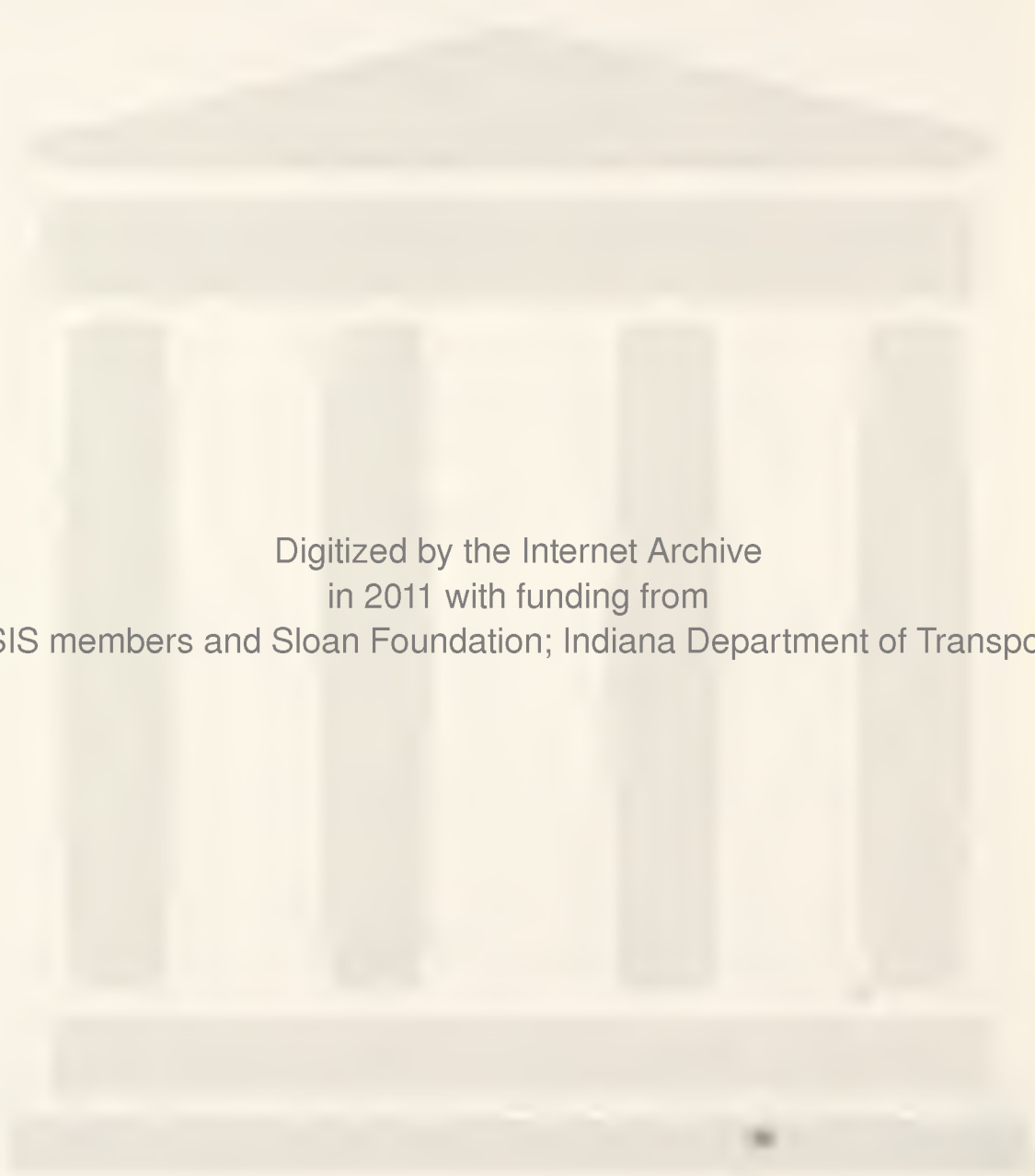
Project No.: C-36-36U
File No.: 6-14-21

This study is proposed to be conducted by
the Joint Highway Research Project
in Cooperation with
the Indiana Department of Highways
and the
U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein.

Purdue University
West Lafayette, Indiana 47907

Date: January 23, 1991



Digitized by the Internet Archive
in 2011 with funding from
LYRASIS members and Sloan Foundation; Indiana Department of Transportation

TABLE OF CONTENTS

	Page
LIST OF TABLES	i
LIST OF FIGURES	i

APPENDICES

APPENDIX A -	A.1 -	Case 1
	A.2 -	Case 2
	A.3 -	Case 3
	A.4 -	Case 4
	A.5 -	Case 5
	A.6 -	Case 6
	A.7 -	Case 7
APPENDIX B -	Computer disk with input data files	
APPENDIX C -	List of References	

LIST OF TABLES

Table	Page
1. Summary of Sensitivity Analysis of the Cap Plasticity Model Parameters	1

LIST OF FIGURES

Figure		
A.1.1	Case 1 - Effect of Poisson's Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain ..	2
A.1.2	Case 1 - Effect of Poisson's Ratio on the Principal Stress Ratio vs. Axial Strain	3
A.1.3	Case 1 - Effect of Poisson's Ratio on the location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram	4
A.2.1	Case 2 - Effect of the Compression Index on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain ..	5
A.2.2	Case 2 - Effect of the Compression Index on the Principal Stress Ratio vs. Axial Strain	6
A.2.3	Case 2 - Effect of the Compression Index on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram	7
A.3.1	Case 3 - Effect of the Recompression Index on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain ..	8
A.3.2	Case 3 - Effect of the Recompression Index on the Principal Stress Ratio vs. Axial Strain	9
A.3.3	Case 3 - Effect of the Recompression Index on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram	10
A.4.1	Case 4 - Effect of the Pore Pressure Response Factor on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain	11
A.4.2	Case 4 - Effect of the Pore Pressure Response Factor on the Principal Stress Ratio vs. Axial Strain	12
A.4.3	Case 4 - Effect of the Pore Pressure Response Factor on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram ..	13

LIST OF FIGURES cont'd

Figure		Page
A.5.1	Case 5 - Effect of the Angle of Internal Friction on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain	14
A.5.2	Case 5 - Effect of the Angle of Internal Friction on the Principal Stress Ratio vs. Axial Strain	15
A.5.3	Case 5 - Effect of the Angle of Internal Friction on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram ..	16
A.6.1	Case 6 - Effect of the Undrained Shear Strength Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain	17
A.6.2	Case 6 - Effect of the Undrained Shear Strength Ratio on the Principal Stress Ratio vs. Axial Strain	18
A.6.3	Case 6 - Effect of the Undrained Shear Strength Ratio on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram ..	19
A.7.1	Case 7 - Effect of the Over-consolidation Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain	20
A.7.2	Case 7 - Effect of the Over-consolidation Ratio on the Principal Stress Ratio vs. Axial Strain	21
A.7.3	Case 7 - Effect of the Over-consolidation Ratio on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q-p' Diagram ..	22

APPENDIX A

A.1 - Case 1

TABLE 1. SUMMARY OF SENSITIVITY ANALYSIS OF THE CAP PLASTICITY MODEL PARAMETERS

PARAMETER CASE	ν	C_c	C_r	β	ϕ	USR	OCR
1A	0.15	0.162	0.044	10	24	0.22	1.49
1B	0.30						
1C	0.45						
2A	0.45	0.107	0.044	10	24	0.22	1.49
2B		0.162					
2C		0.240					
3A	0.45	0.162	0.029	10	24	0.22	1.49
3B			0.044				
3C			0.066				
4A	0.45	0.162	0.044	1	24	0.22	1.49
4B				5			
4C				10			
5A	0.45	0.162	0.044	10	19	0.22	1.49
5B					24		
5C					30		
6A	0.45	0.162	0.044	10	24	0.22	1.49
6B						0.31	
6C						0.43	
7A	0.45	0.162	0.044	10	24	0.22	1.0
7B							1.49
7C							2.25

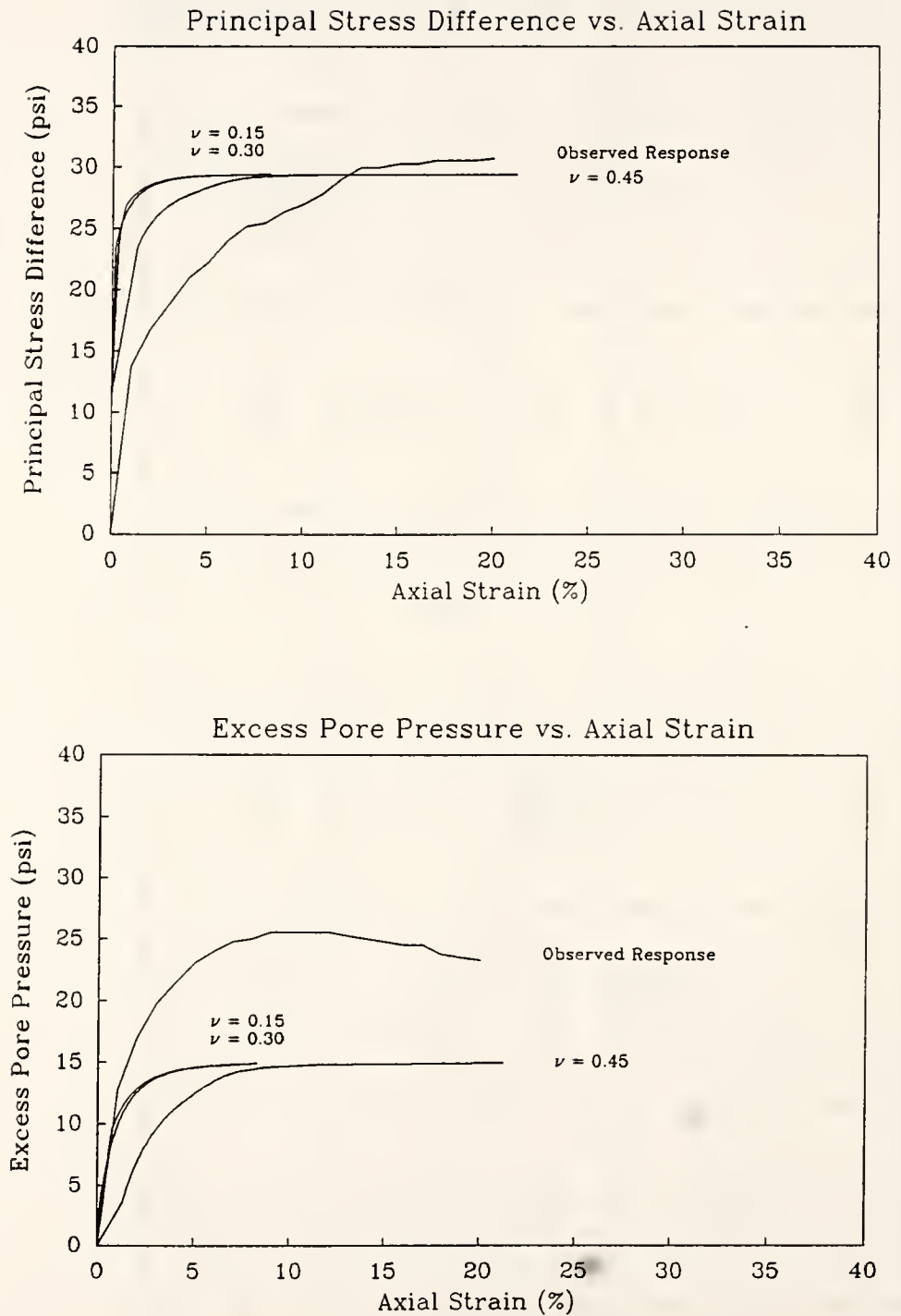


Figure A.1.1 - Effect of Poisson's Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

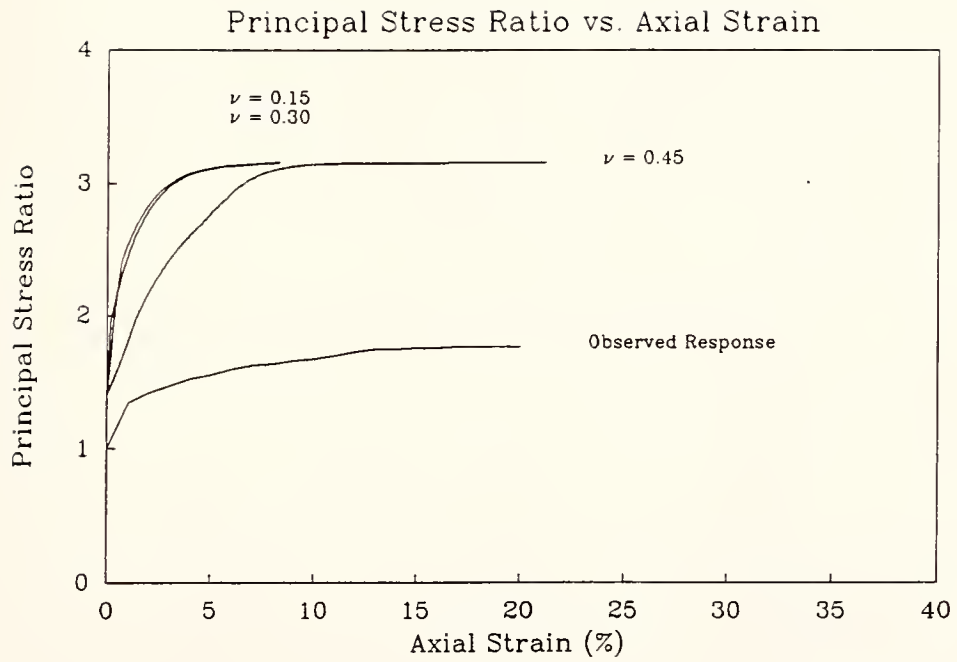


Figure A.1.2 - Effect of Poisson's Ratio on the Principal Stress Ratio vs. Axial Strain

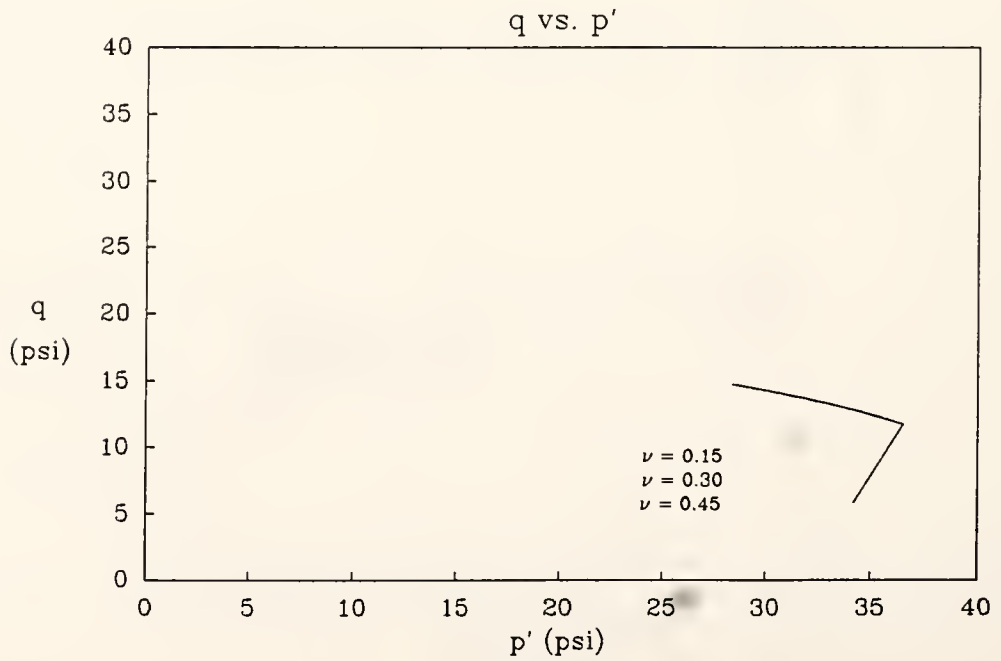
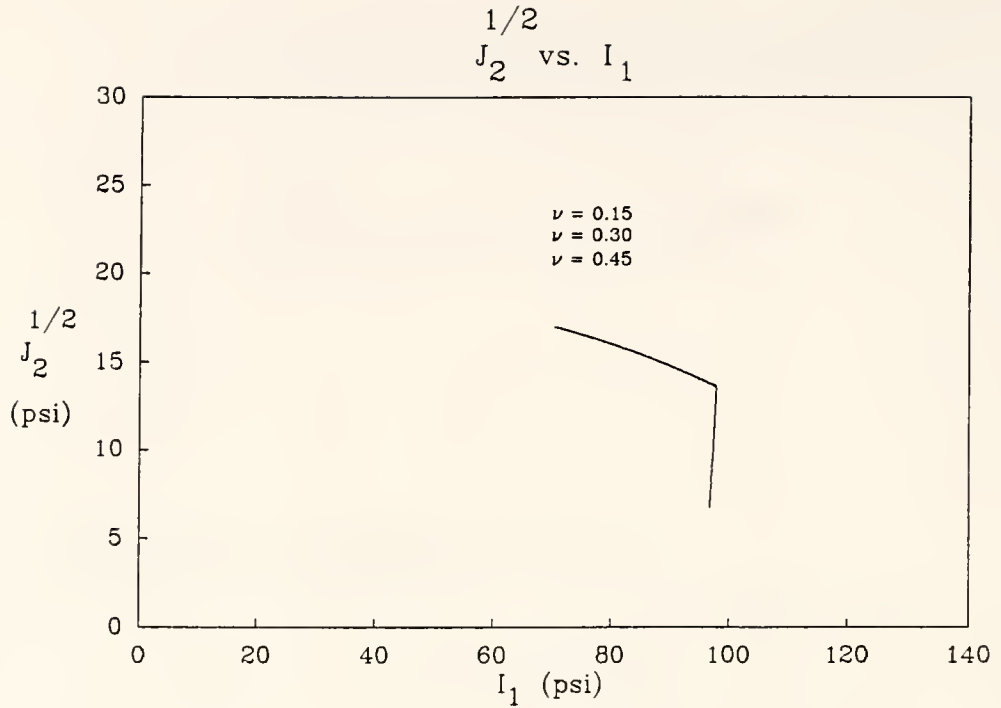


Figure A.1.3 - Effect of Poisson's Ratio on the location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

A.2 - Case 2

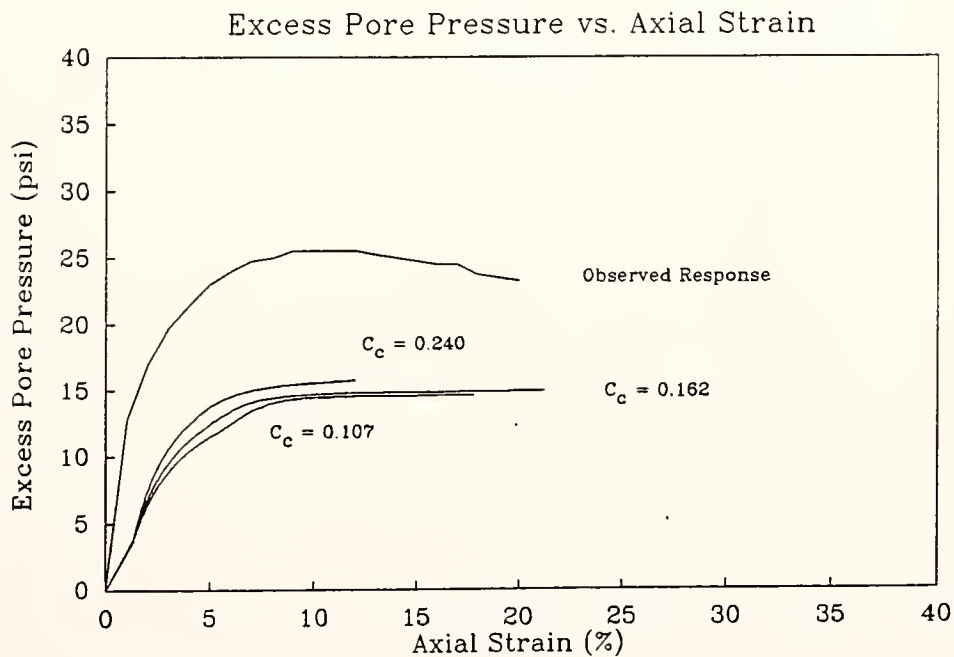
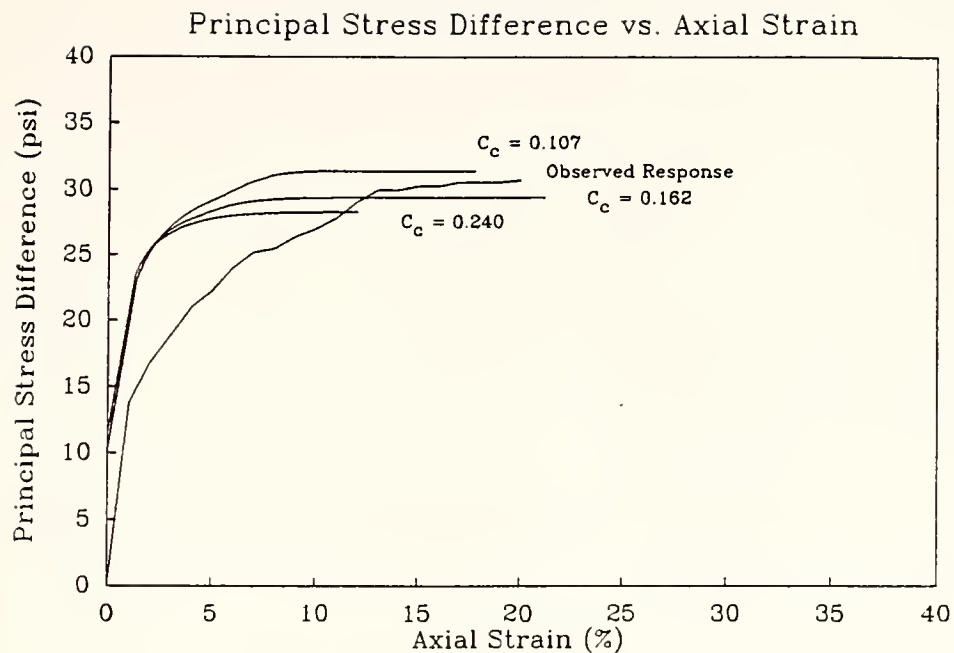


Figure A.2.1 - Effect of the Compression Index on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

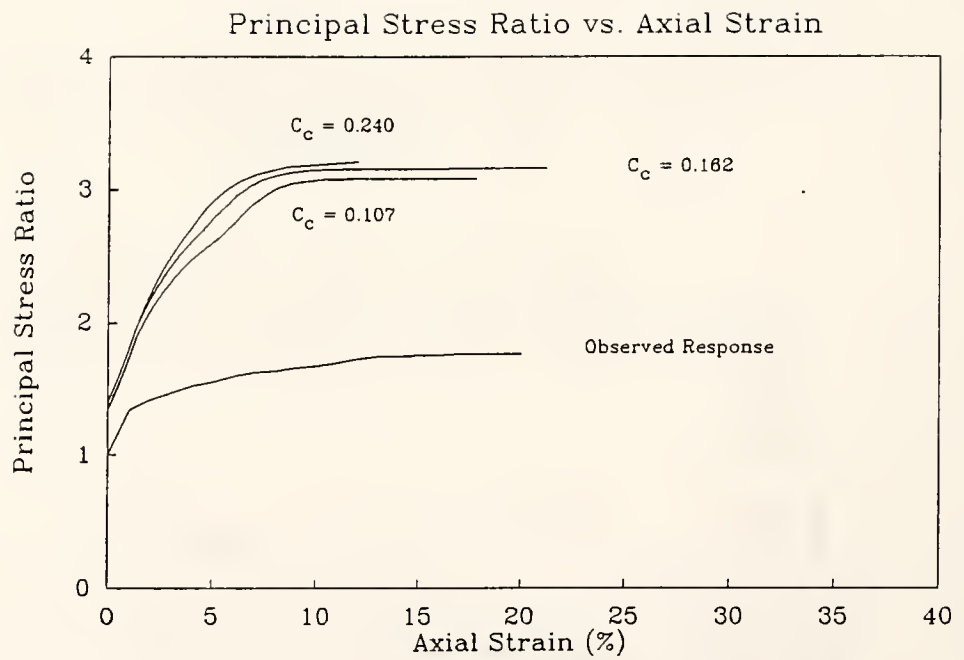


Figure A.2.2 - Effect of the Compression Index on the Principal Stress Ratio vs. Axial Strain

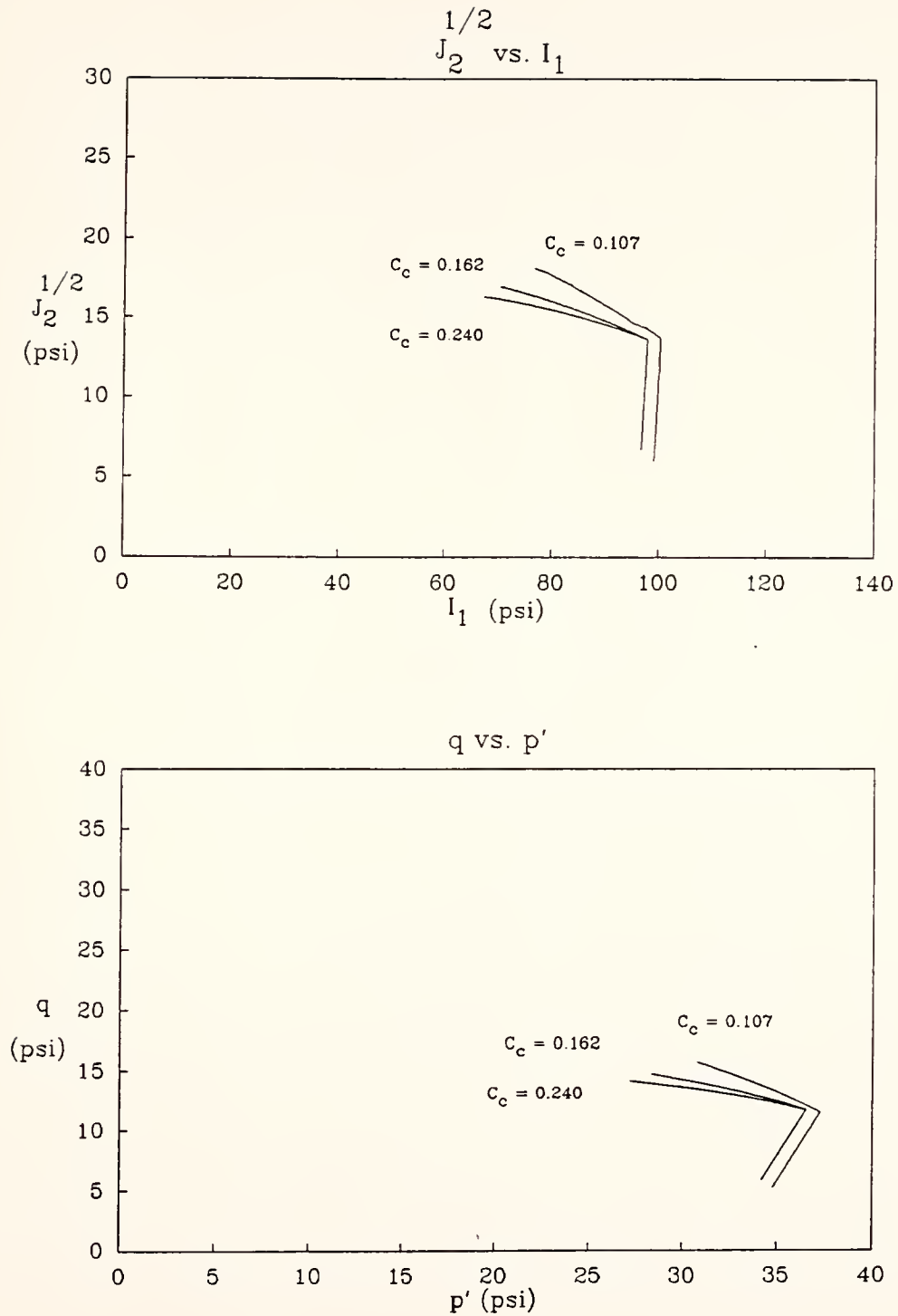


Figure A.2.3 - Effect of the Compression Index on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

A.3 - Case 3

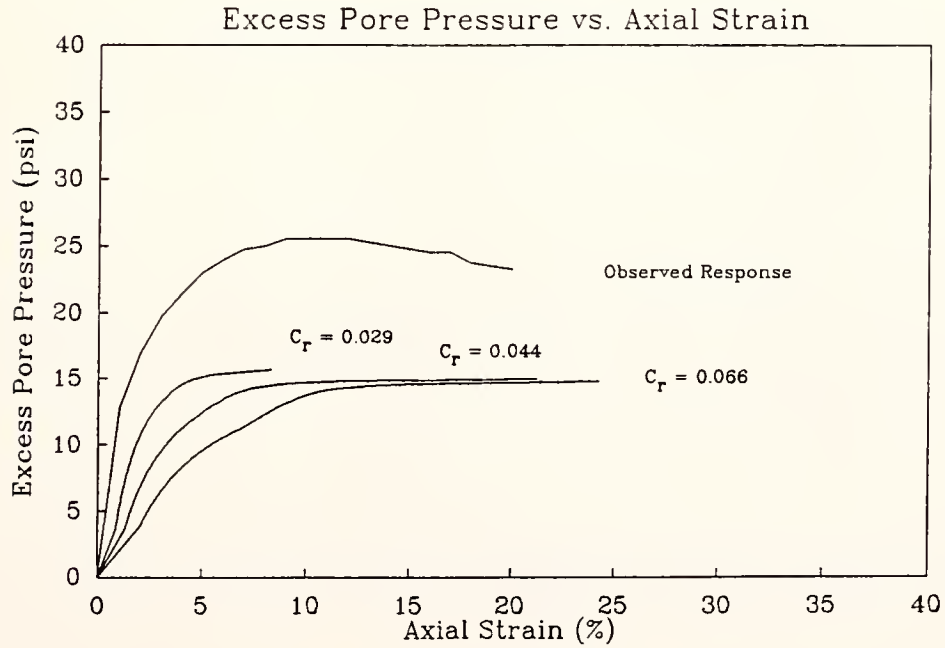
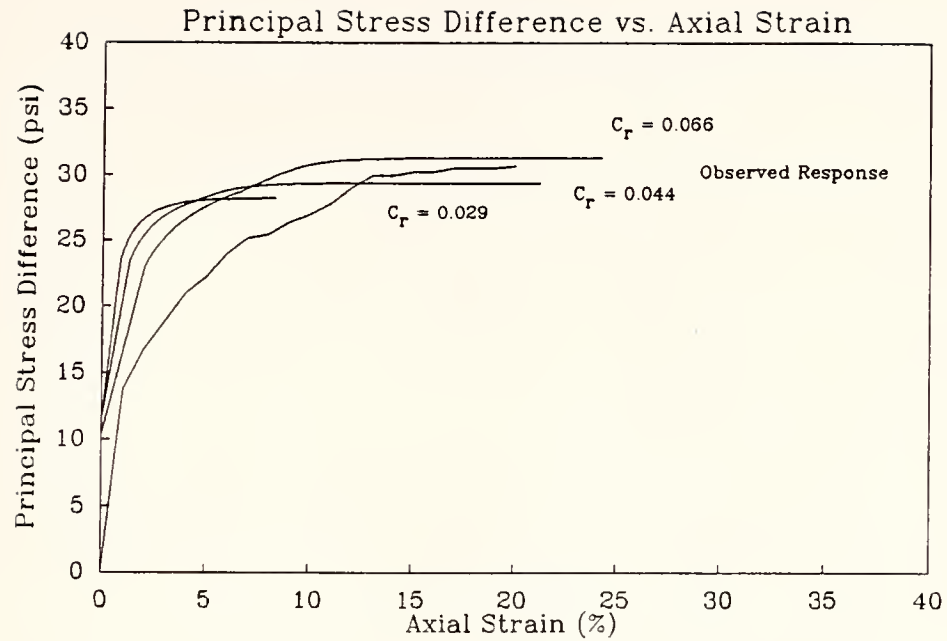


Figure A.3.1 - Effect of the Recompression Index on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

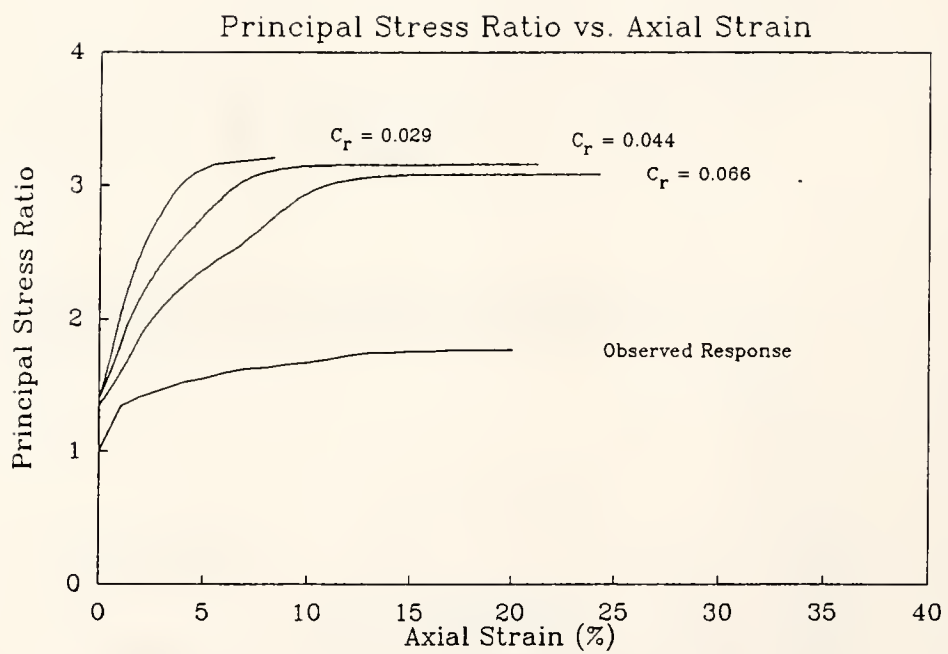


Figure A.3.2 - Effect of the Recompression Index on the Principal Stress Ratio vs. Axial Strain

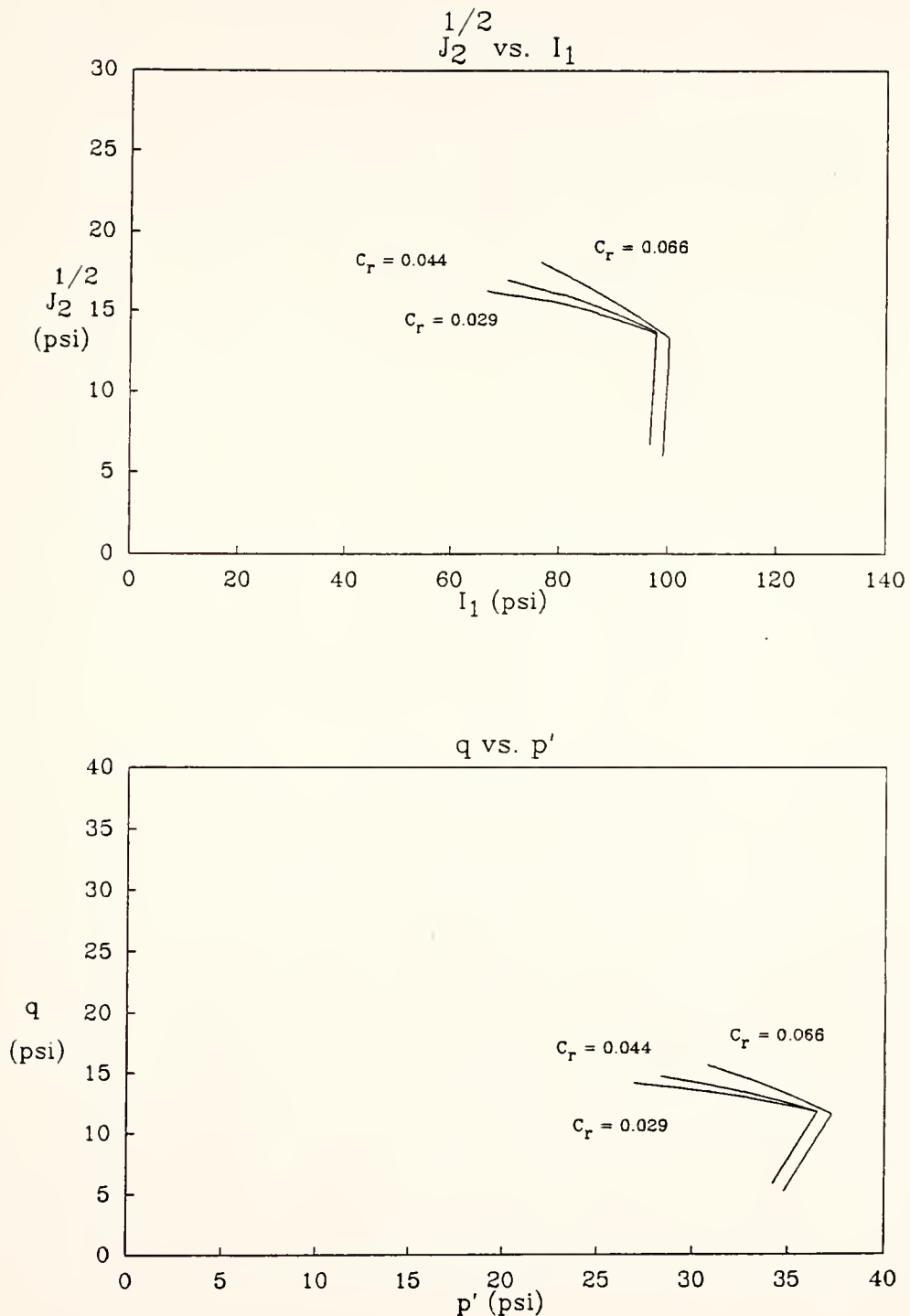


Figure A.3.3 - Effect of the Recompression Index on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

A.4 - Case 4

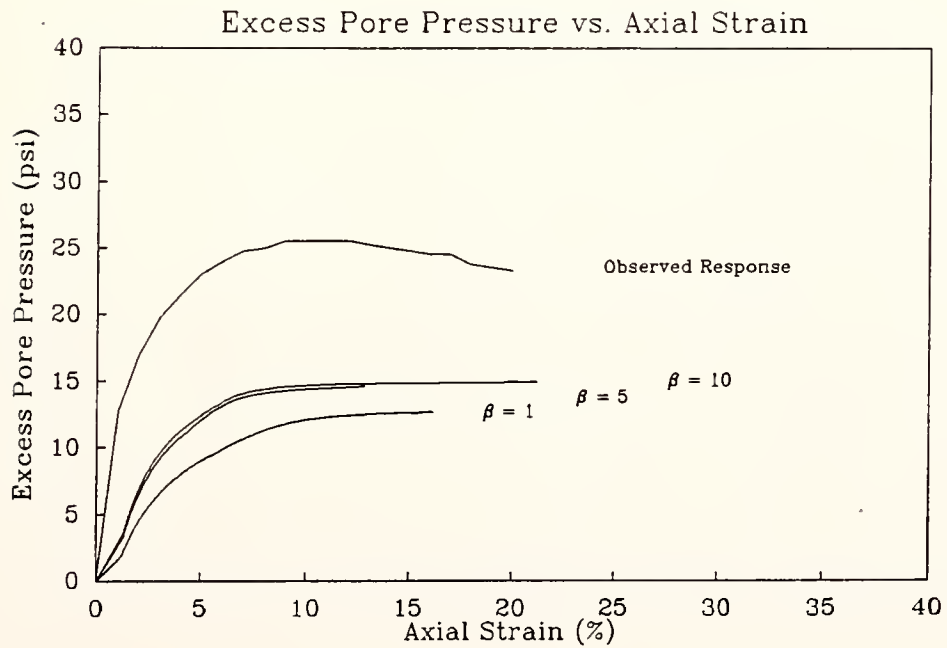
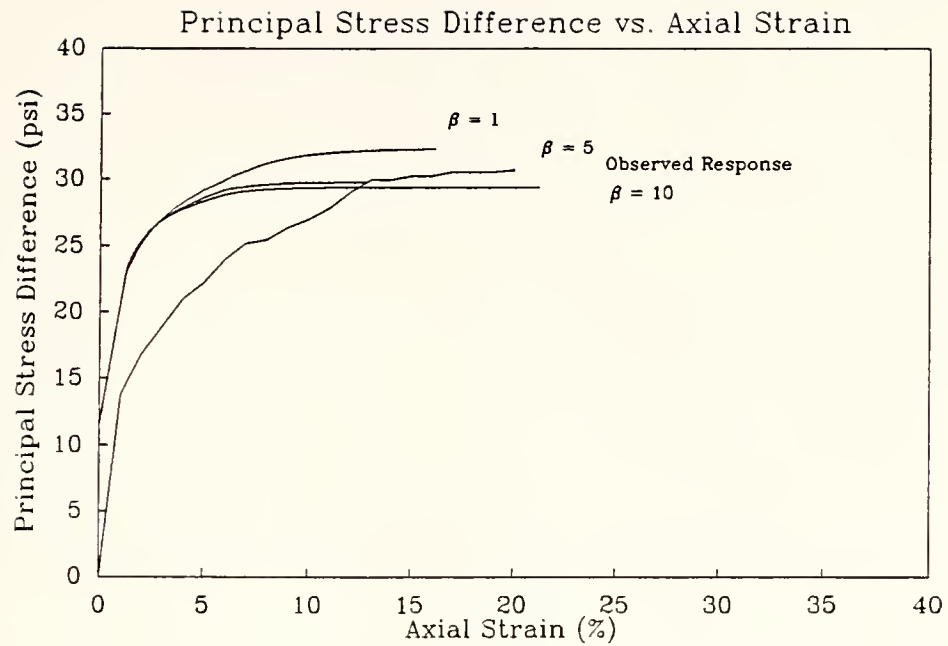


Figure A.4.1 - Effect of the Pore Pressure Response Factor on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

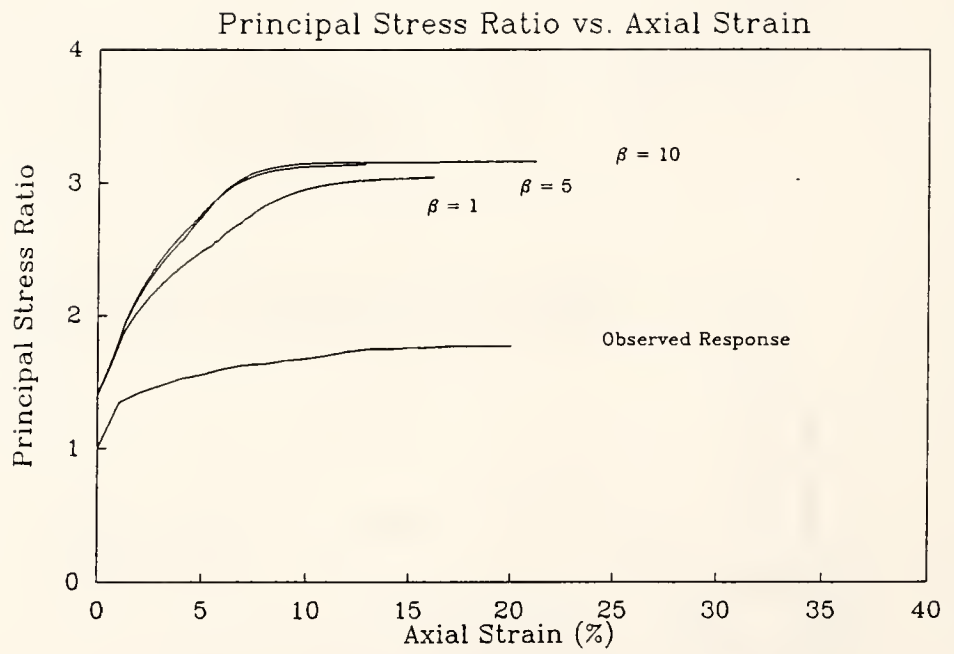


Figure A.4.2 - Effect of the Pore Pressure Response Factor on the Principal Stress Ratio vs. Axial Strain

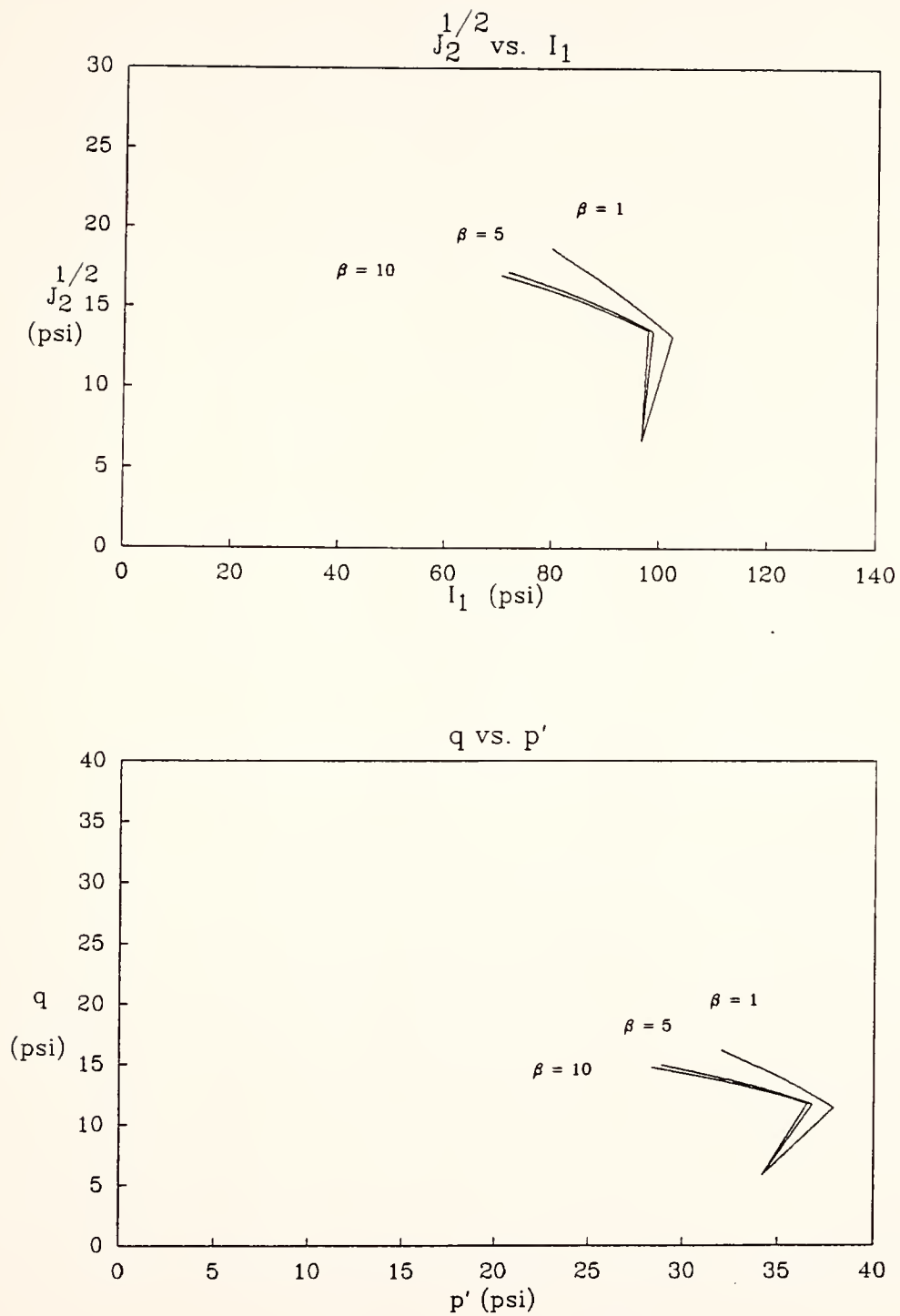


Figure A.4.3 - Effect of the Pore Pressure Response Factor on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

A.5 - Case 5

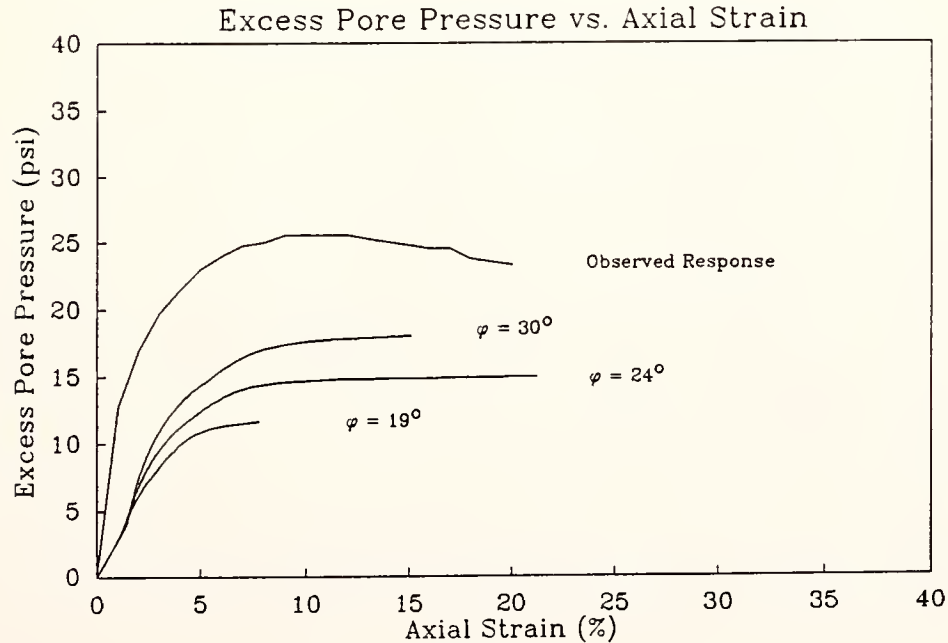
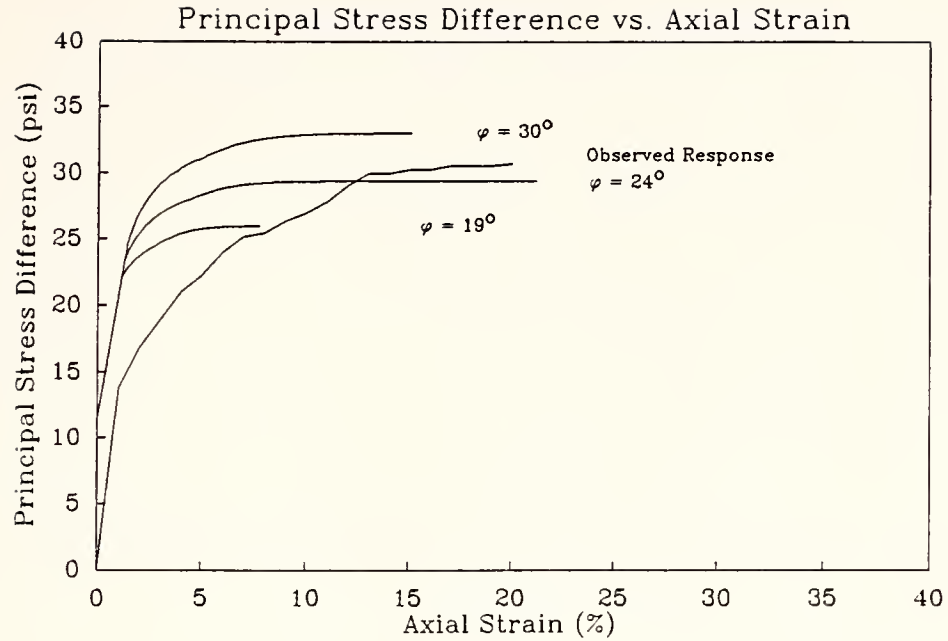


Figure A.5.1 - Effect of the Angle of Internal Friction on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

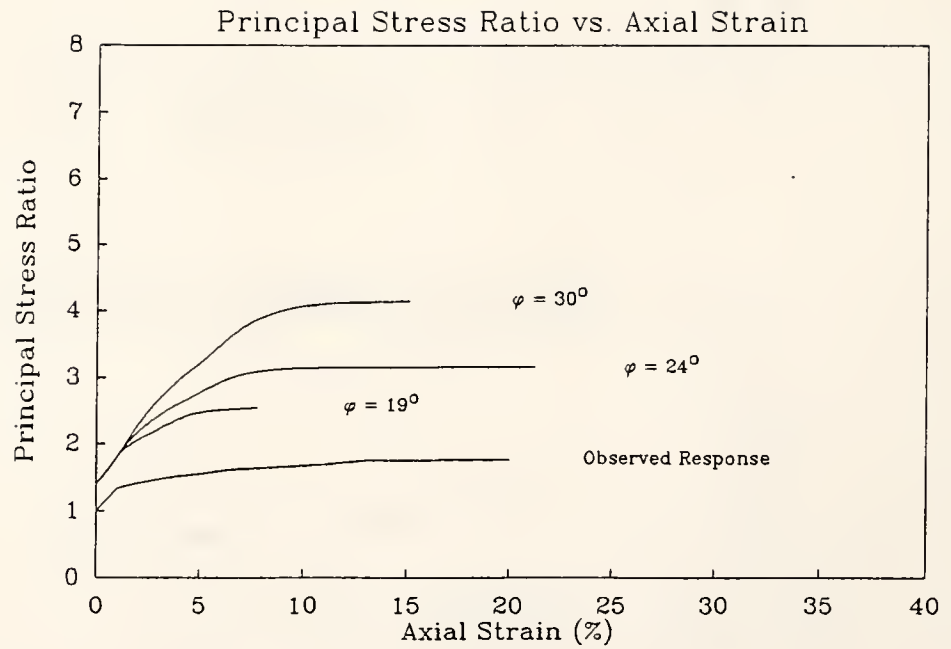


Figure A.5.2 - Effect of the Angle of Internal Friction on the Principal Stress Ratio vs. Axial Strain

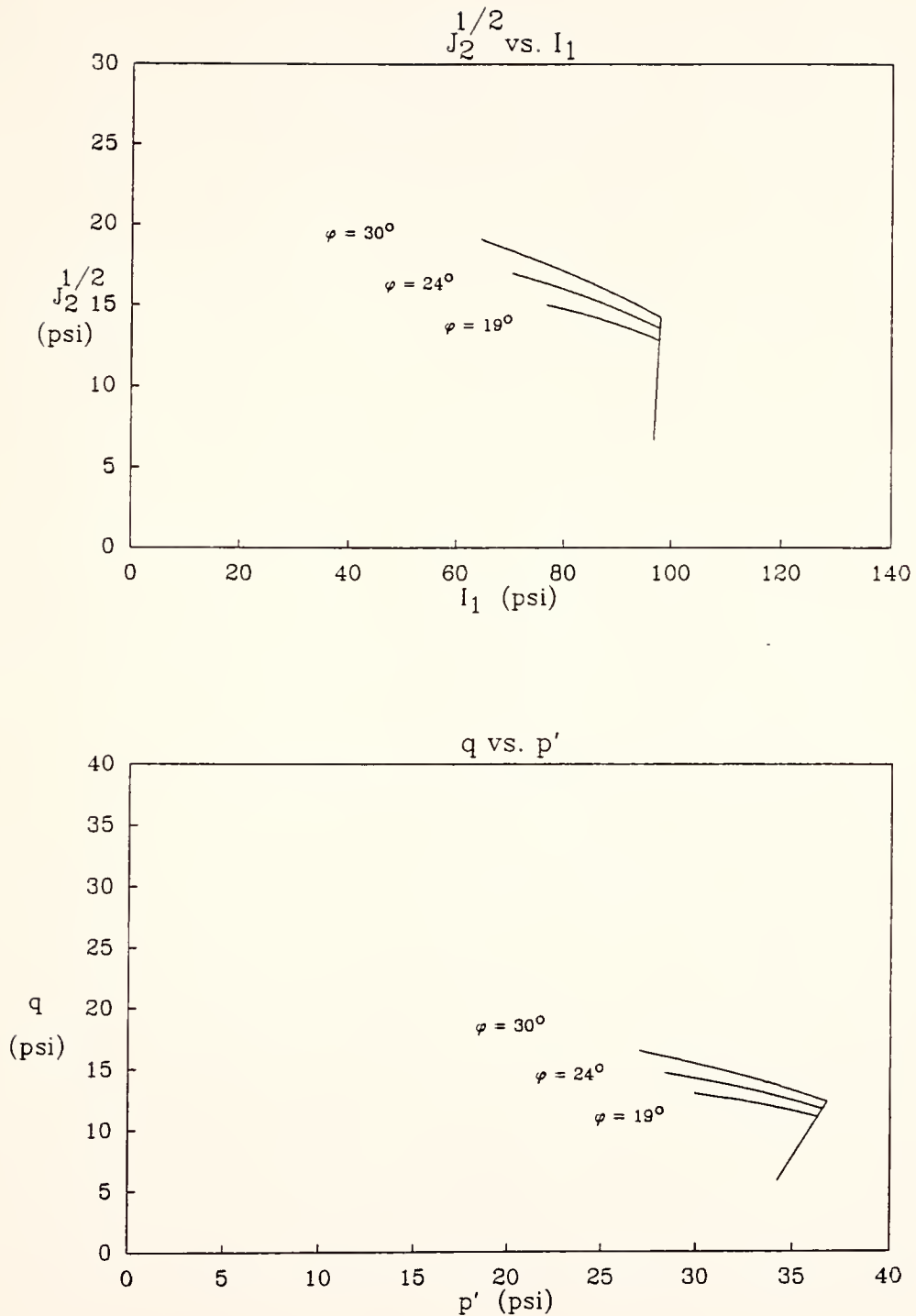


Figure A.5.3 - Effect of the Angle of Internal Friction on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

A.6 - Case 6

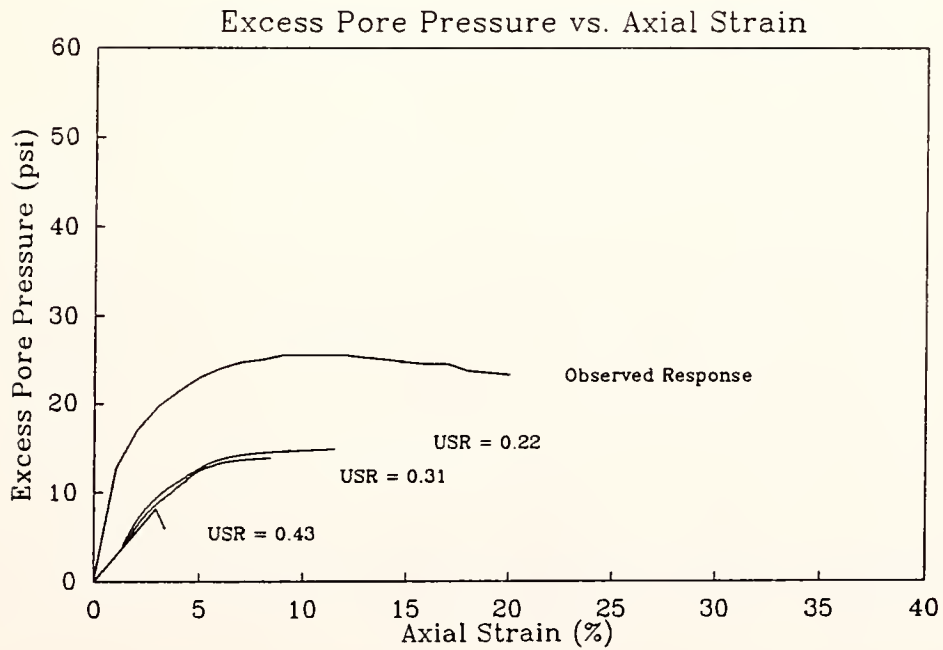
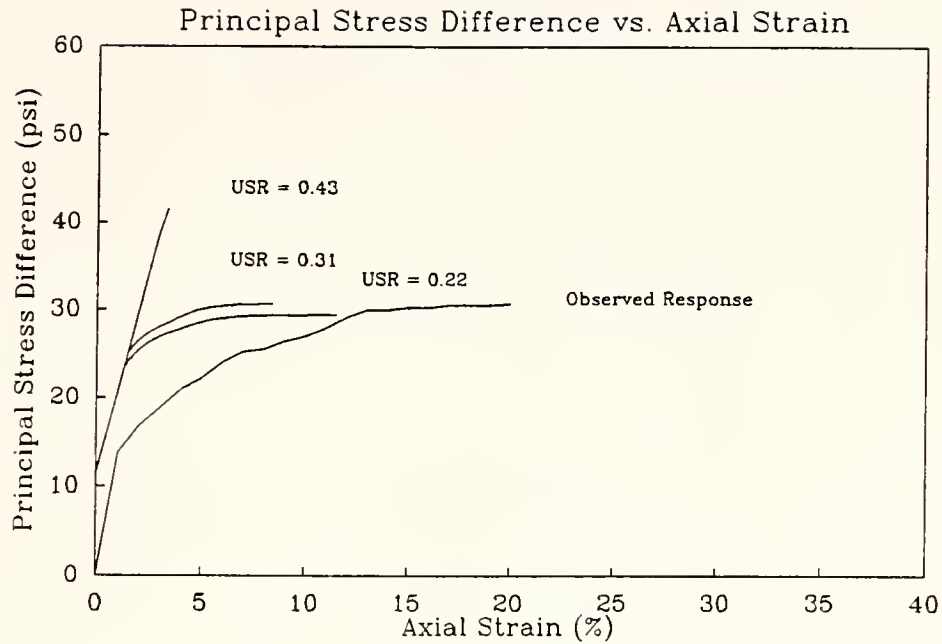


Figure A.6.1 - Effect of the Undrained Shear Strength Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

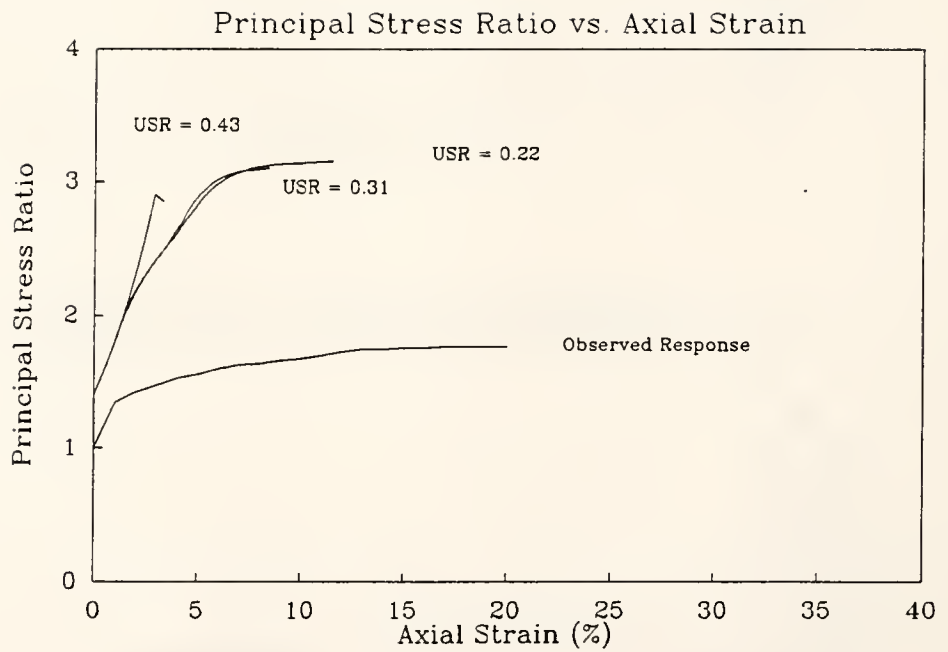


Figure A.6.2 - Effect of the Undrained Shear Strength Ratio on the Principal Stress Ratio vs. Axial Strain

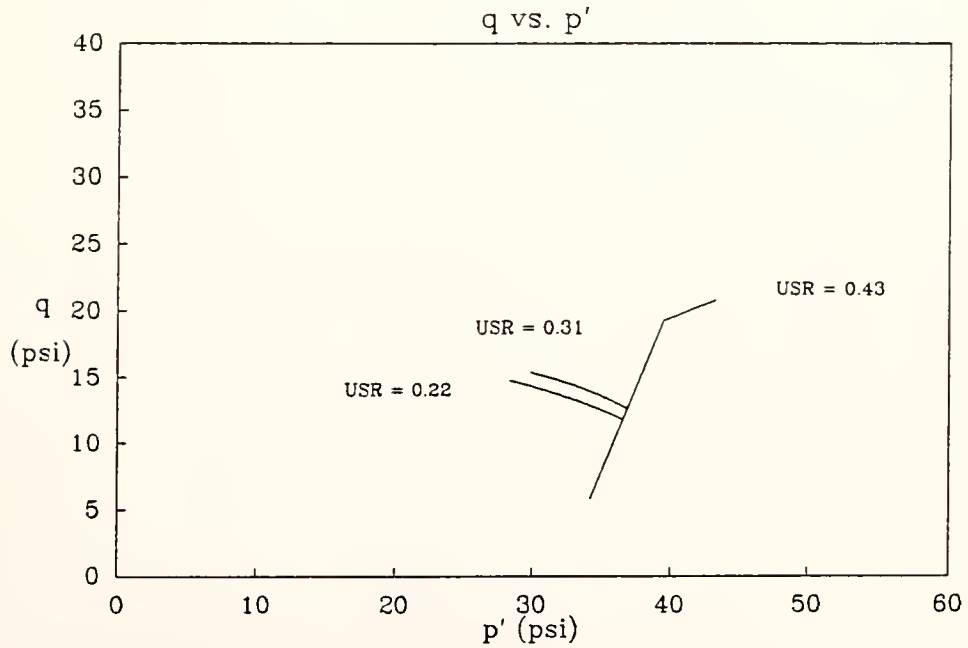
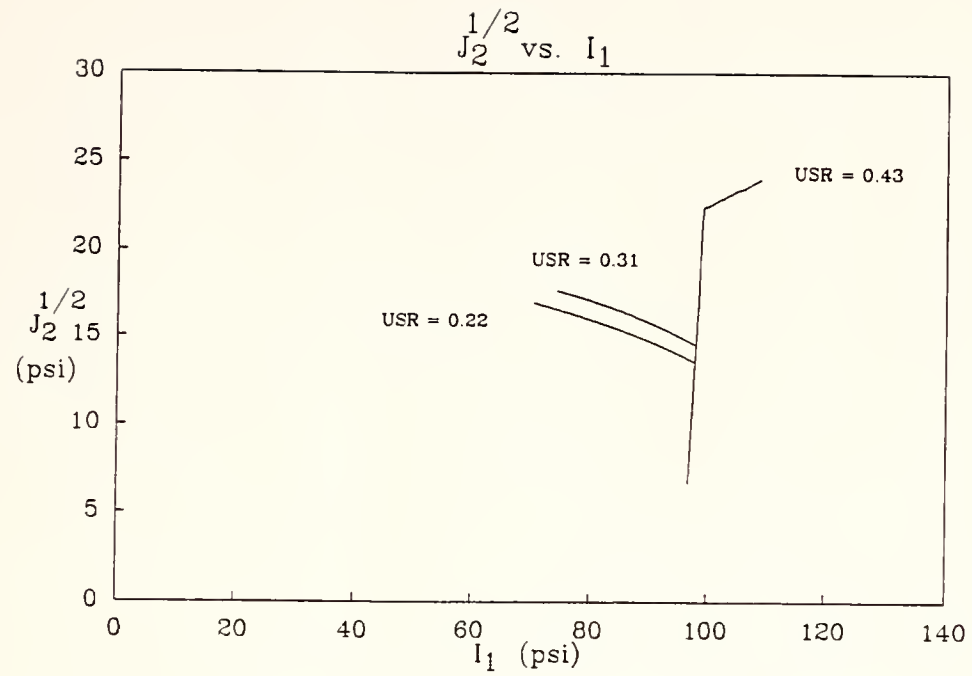


Figure A.6.3 - Effect of the Undrained Shear Strength Ratio on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

A.7 - Case 7

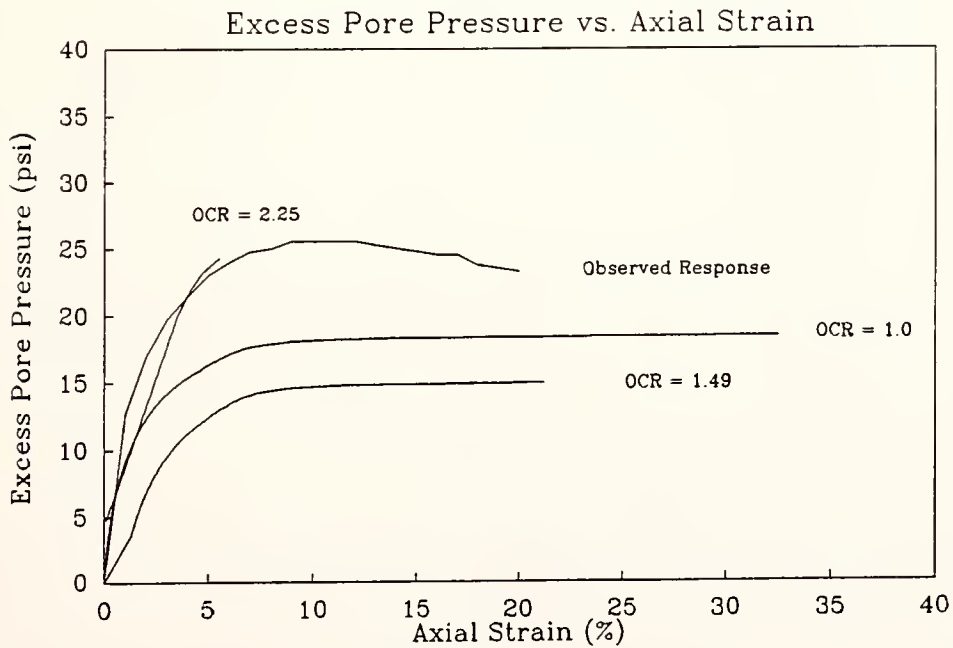
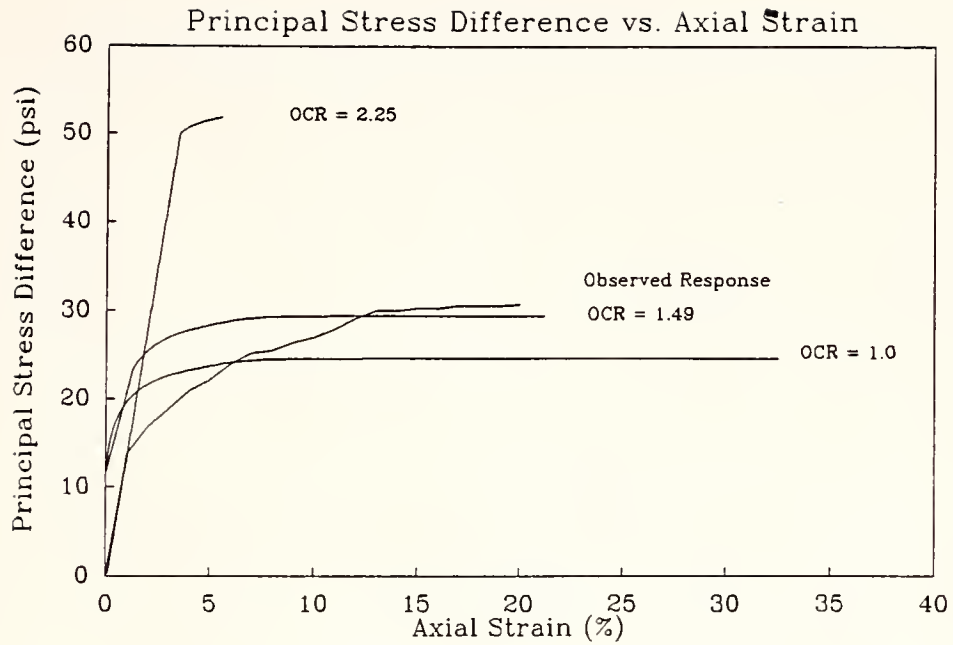


Figure A.7.1 - Effect of the Over-consolidation Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

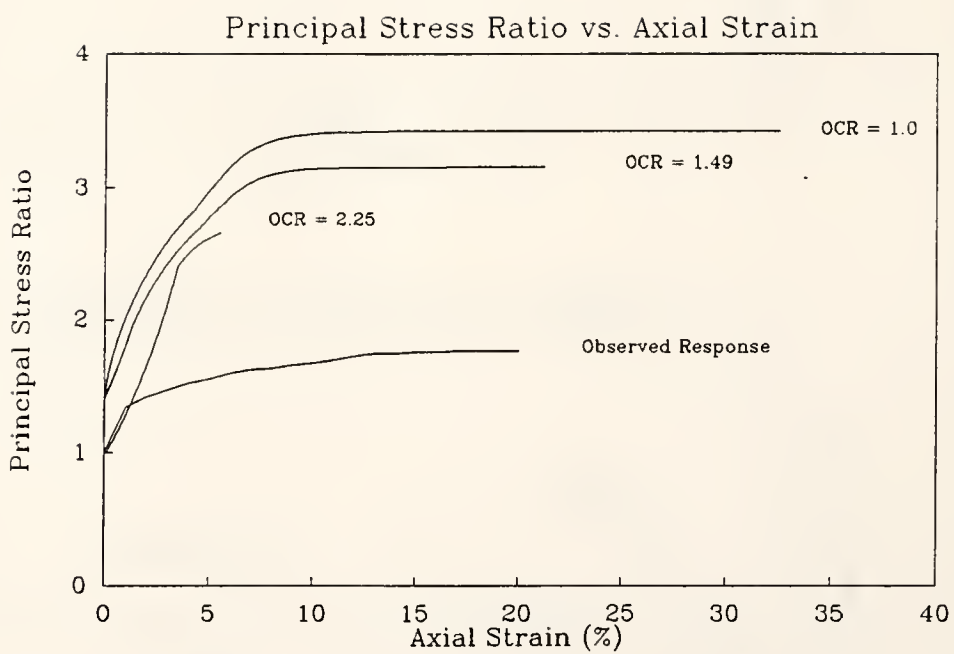


Figure A.7.2 - Effect of the Over-consolidation Ratio on the Principal Stress Ratio vs. Axial Strain

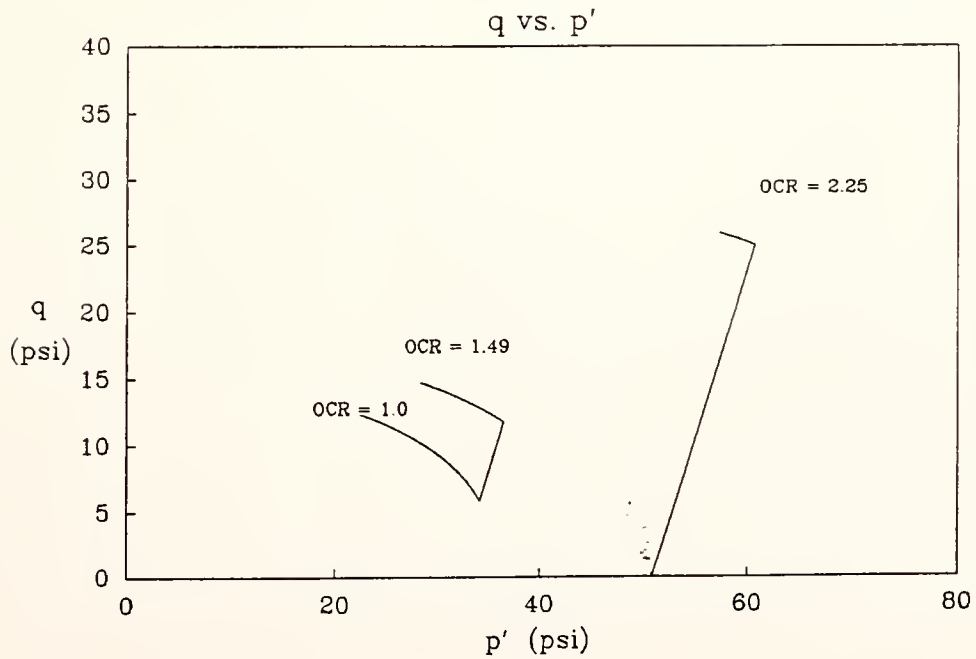
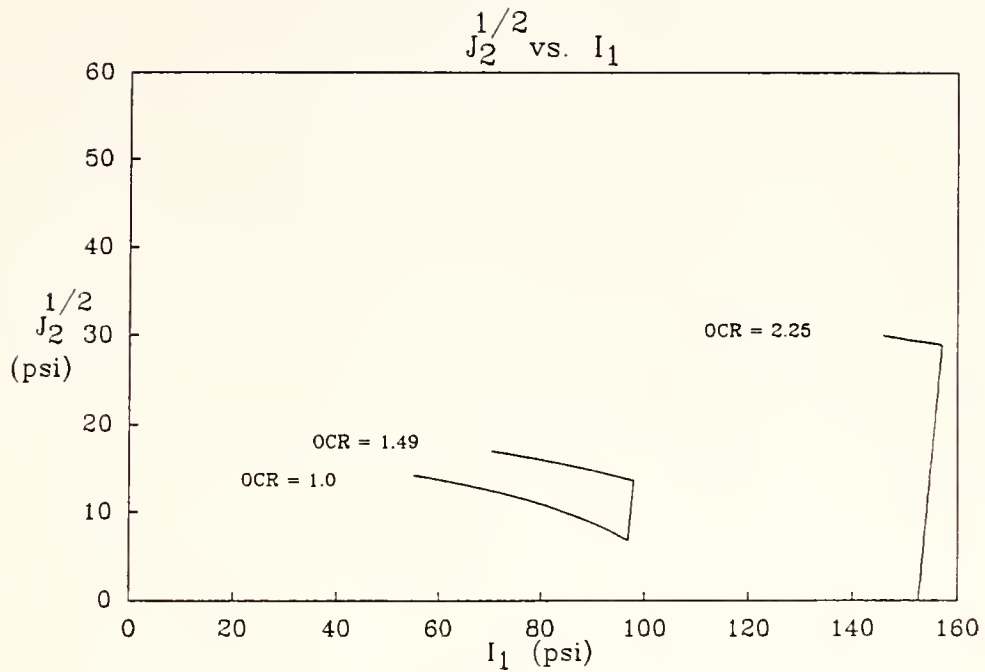


Figure A.7.3 - Effect of the Over-consolidation Ratio on location of the Cap in the $J_2^{1/2}$ - I_1 Space and on the q - p' Diagram

APPENDIX B

Computer disk with input data files

APPENDIX C

List of References

Holtz, R.D., and Kovacs, W.D. (1981), An Introduction to Geotechnical Engineering, Prentice-Hall, Inc., New Jersey, 733 pp.

Huang, T.K., and Chen, W.F. (1990), "Simple Procedure for Determining Cap-Plasticity-Model Parameters," Journal of Geotechnical Engineering, ASCE, Vol. 116, No. 3, pp. 492-513.

Huang, T.K., and Chen, W.F. (1991), "Embankment Widening and Grade Raising on Soft Foundation Soils: Computer Program Implementation," Report No. CE-STR-91-3, School of Civil Engineering, Purdue University, West Lafayette, Indiana, January, 244 pp.

Huang, T.K., Chen, W.F., and Chameau, J.L. (1990), "The Application of Cap-Plasticity-Model to Embankment Problems," Report No. CE-STR-90-21, School of Civil Engineering, Purdue University, West Lafayette, Indiana, 37 pp.

Humphrey, D.N. (1986), "Design of Reinforced Embankments," Report No. JHRP-86-16, Joint Highway Research Project, School of Civil Engineering, Purdue University, West Lafayette, Indiana, October, 423 pp.

Kulhawy, F.H., and Mayne, P.W. (1990), "Manual on Estimating Soil Properties for Foundation Design," Research Project 1493-6, Prepared for Electric Power Research Institute, Prepared by Cornell University, Geotechnical Engineering Group, Ithaca, New York, August.

Ladd, C.C., Foote, R., Ishihara, K., Schlosser, F., and Poulos, H.G., (1977), "Stress-Deformation and Strength Characteristics," State-of-the-Art Report, Proceedings of the Ninth International Conference on Soil Mechanics and Foundation Engineering, Tokyo, Vol. 2, pp. 421-494.

Ludlow, S.J., Personal data base - "Engineering Properties of Soils,".

Ludlow, S.J., Chen, W.F., Bourdeau, P.L., and Lovell, C.W., (1991), "Interim Report: Embankment Widening and Grade Raising on Soft Foundation Soils: Example 1 - Indiana State Route 55 over Turkey Creek in Lake County, Indiana," Report No. JHRP-91-18, Joint Highway Research Project, School of Civil Engineering, Purdue University, West Lafayette, Indiana, December, 56 pp.

Nwabuokei, S.O., (1984), "Compressibility and Shear Strength Characteristics of Impact Compacted Lacustrine Clay," Ph.D. Thesis, Purdue University, West Lafayette, Indiana.

COVER DESIGN BY ALDO GIORGINI