

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

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PURDUE UNIVERSITY



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

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Joint Highway Research Project  
HPR 2031

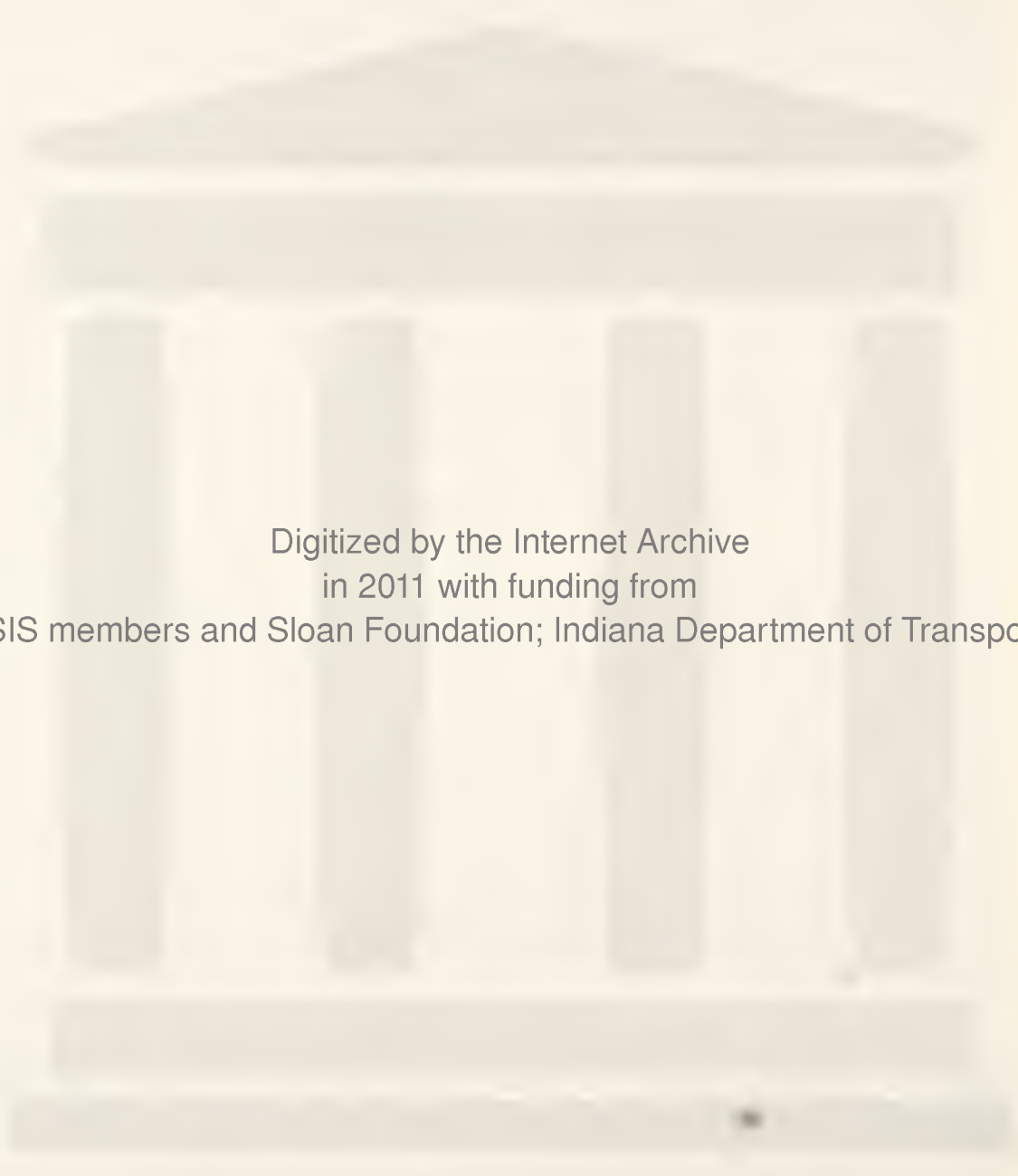
Project No.: C-36-36U  
File No.: 6-14-21

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.

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Date: January 23, 1991



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APPENDIX A

A.1 - Case 1

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

PARAMETER ----- CASE	$\nu$	$C_c$	$C_r$	$\beta$	$\phi$	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

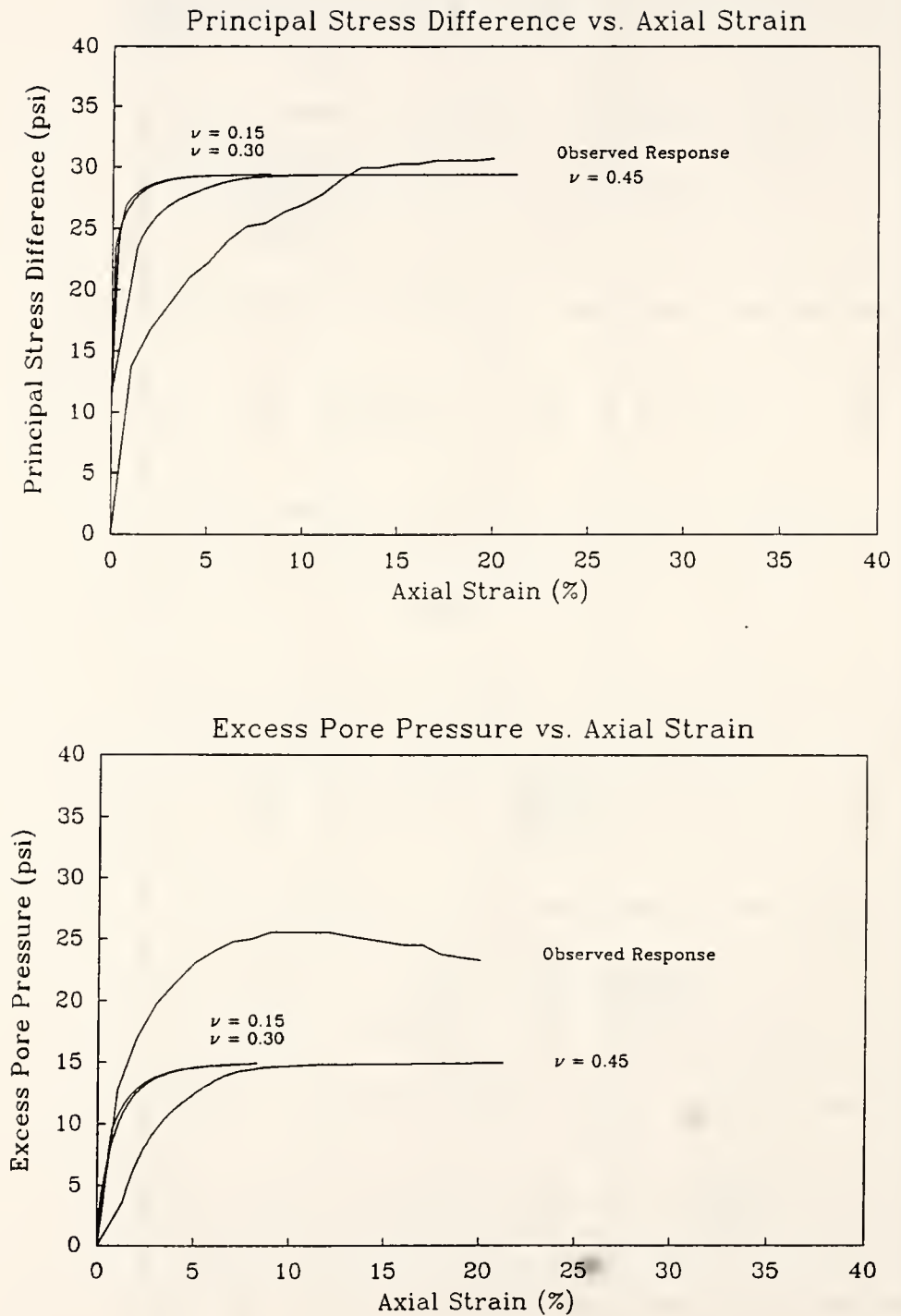


Figure A.1.1 - Effect of Poisson's Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

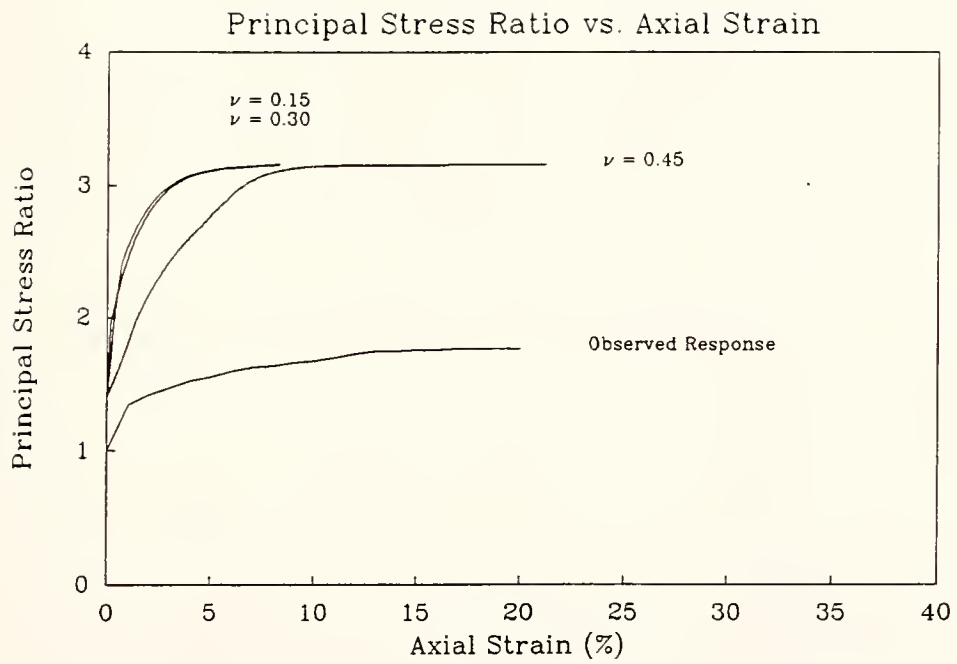


Figure A.1.2 - Effect of Poisson's Ratio on the Principal Stress Ratio vs. Axial Strain

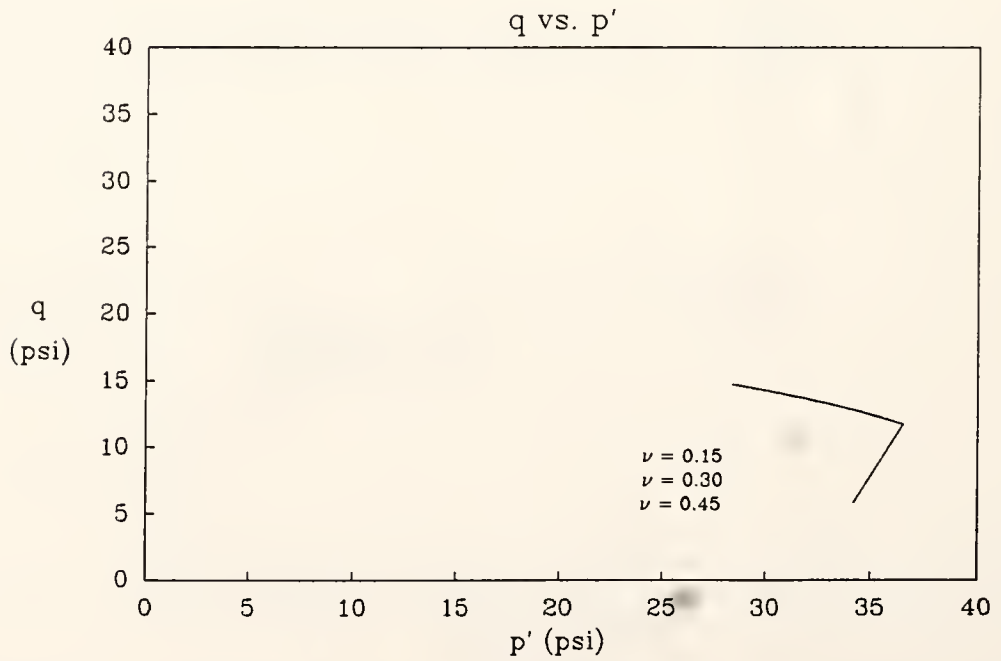
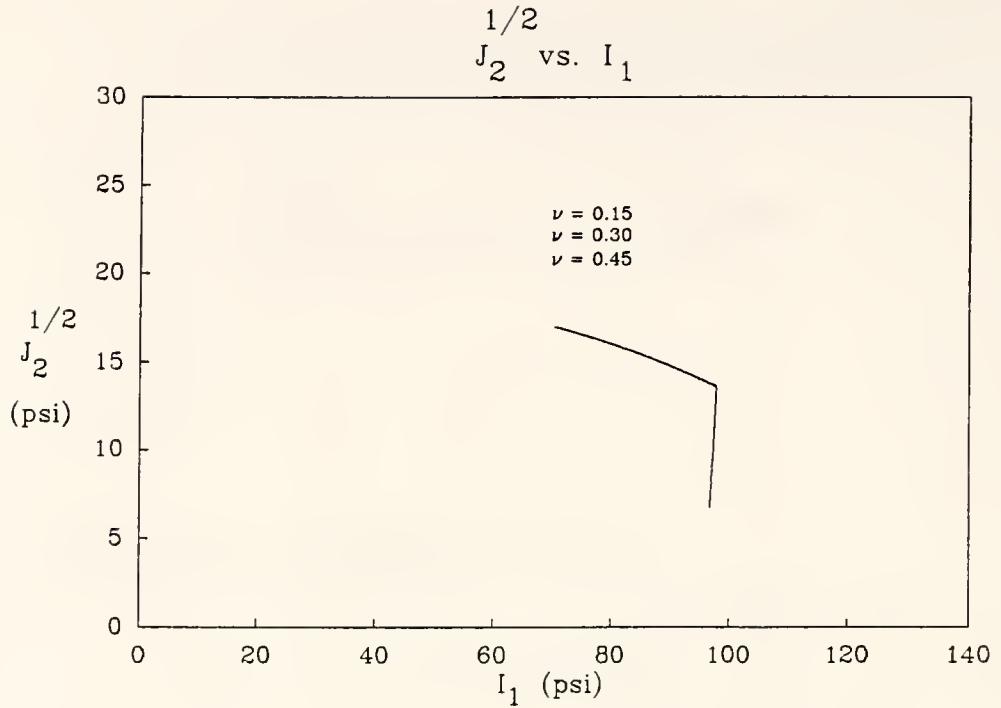


Figure A.1.3 - Effect of Poisson's Ratio on the location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the q- $p'$  Diagram

A.2 - Case 2

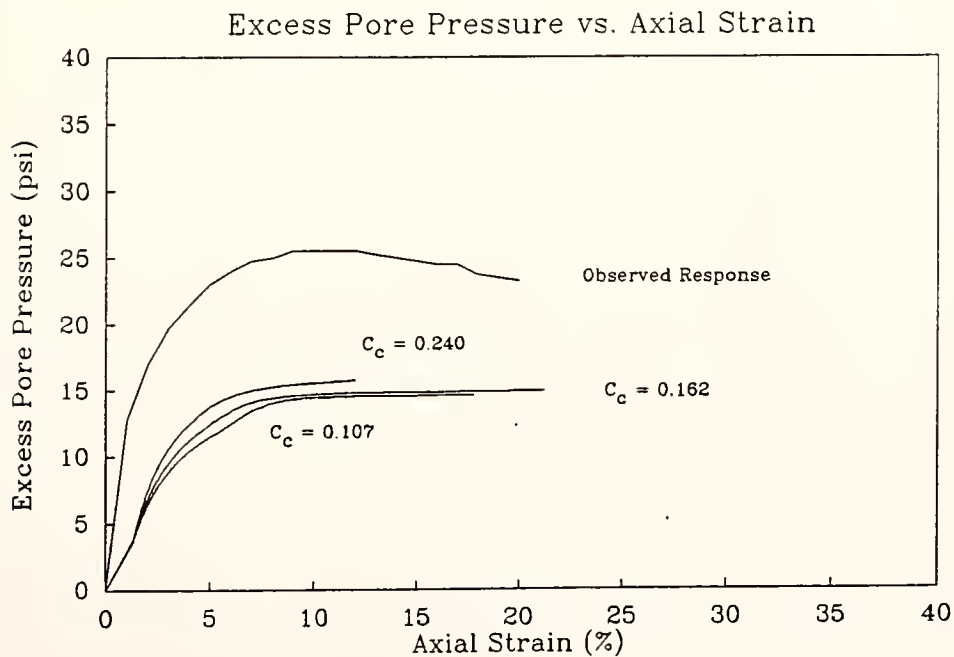
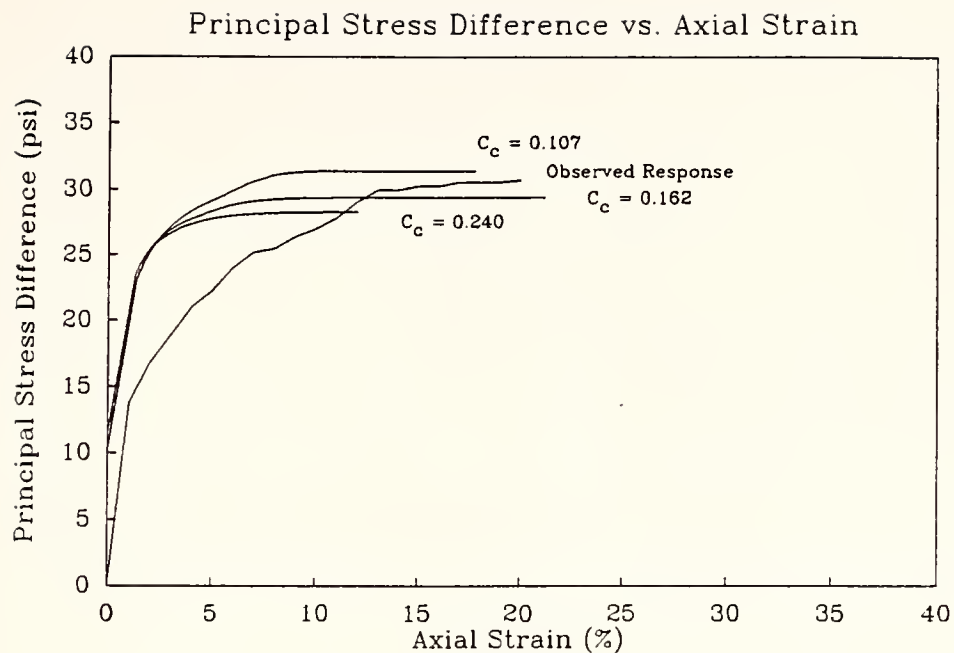


Figure A.2.1 - Effect of the Compression Index on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain



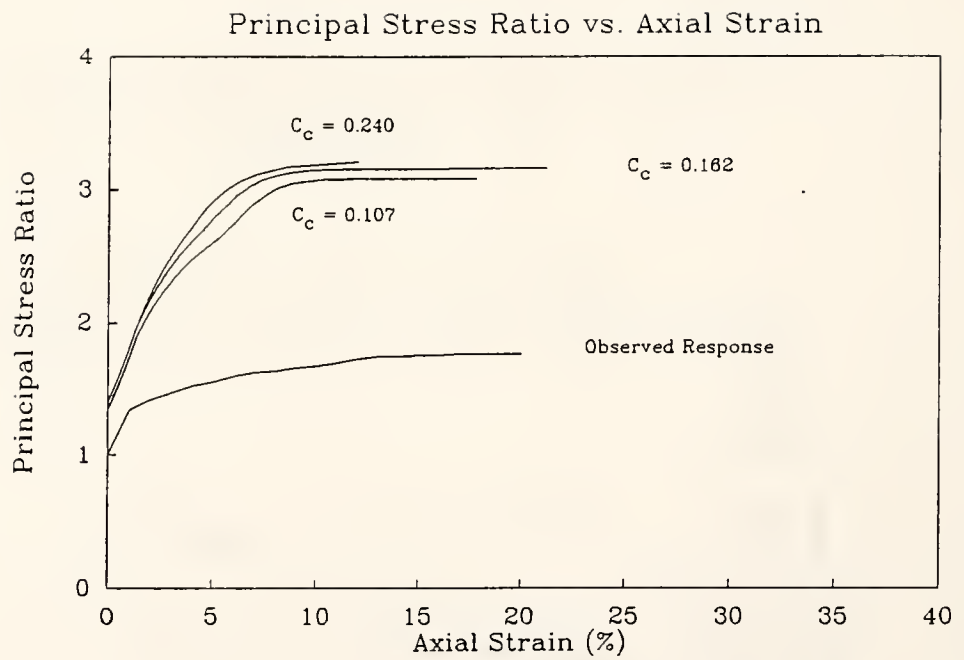


Figure A.2.2 - Effect of the Compression Index on the Principal Stress Ratio vs. Axial Strain

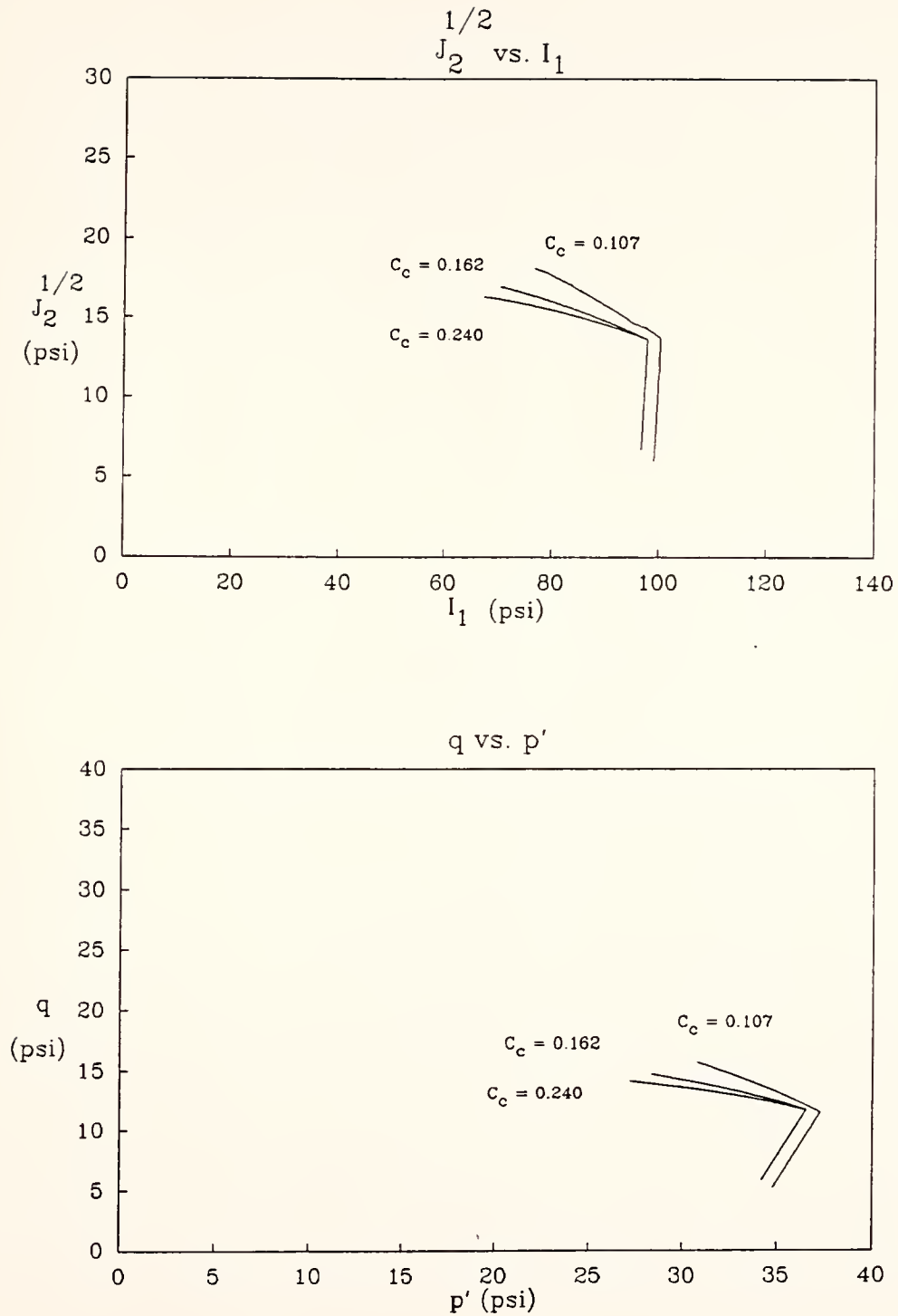


Figure A.2.3 - Effect of the Compression Index on location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the  $q$ - $p'$  Diagram

A.3 - Case 3

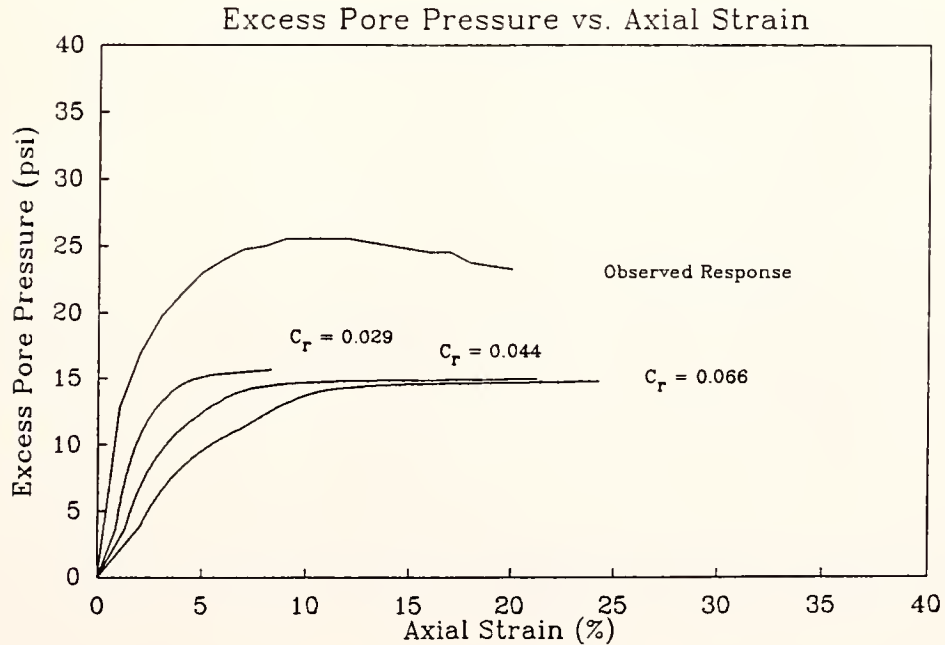
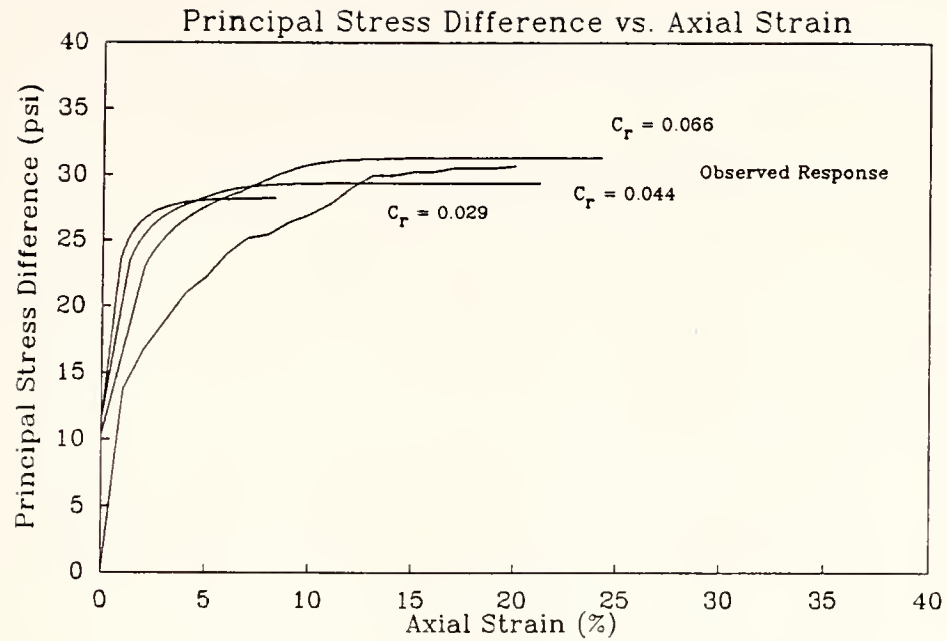


Figure A.3.1 - Effect of the Recompression Index on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

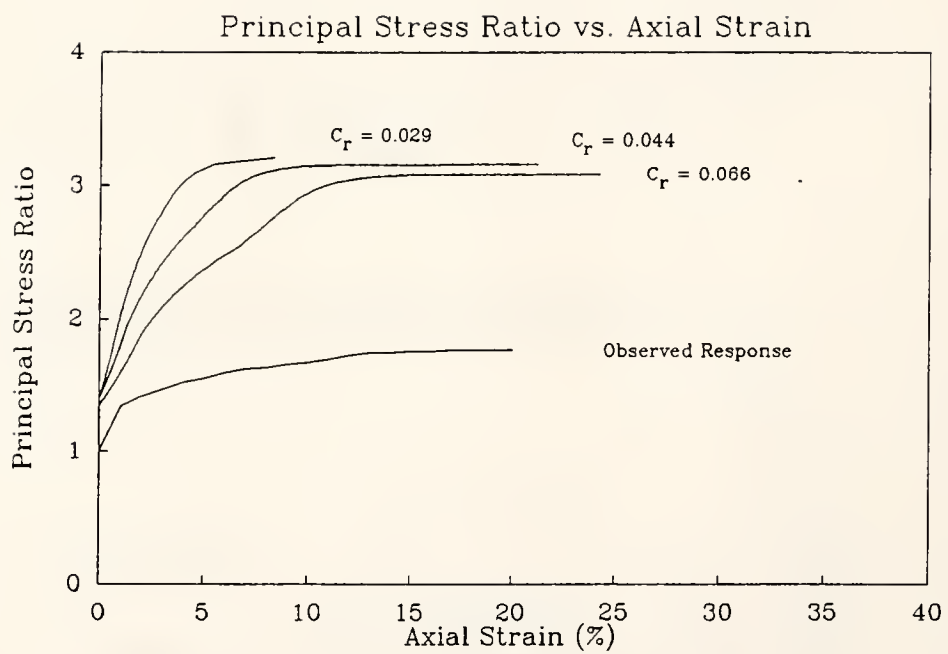


Figure A.3.2 - Effect of the Recompression Index on the Principal Stress Ratio vs. Axial Strain

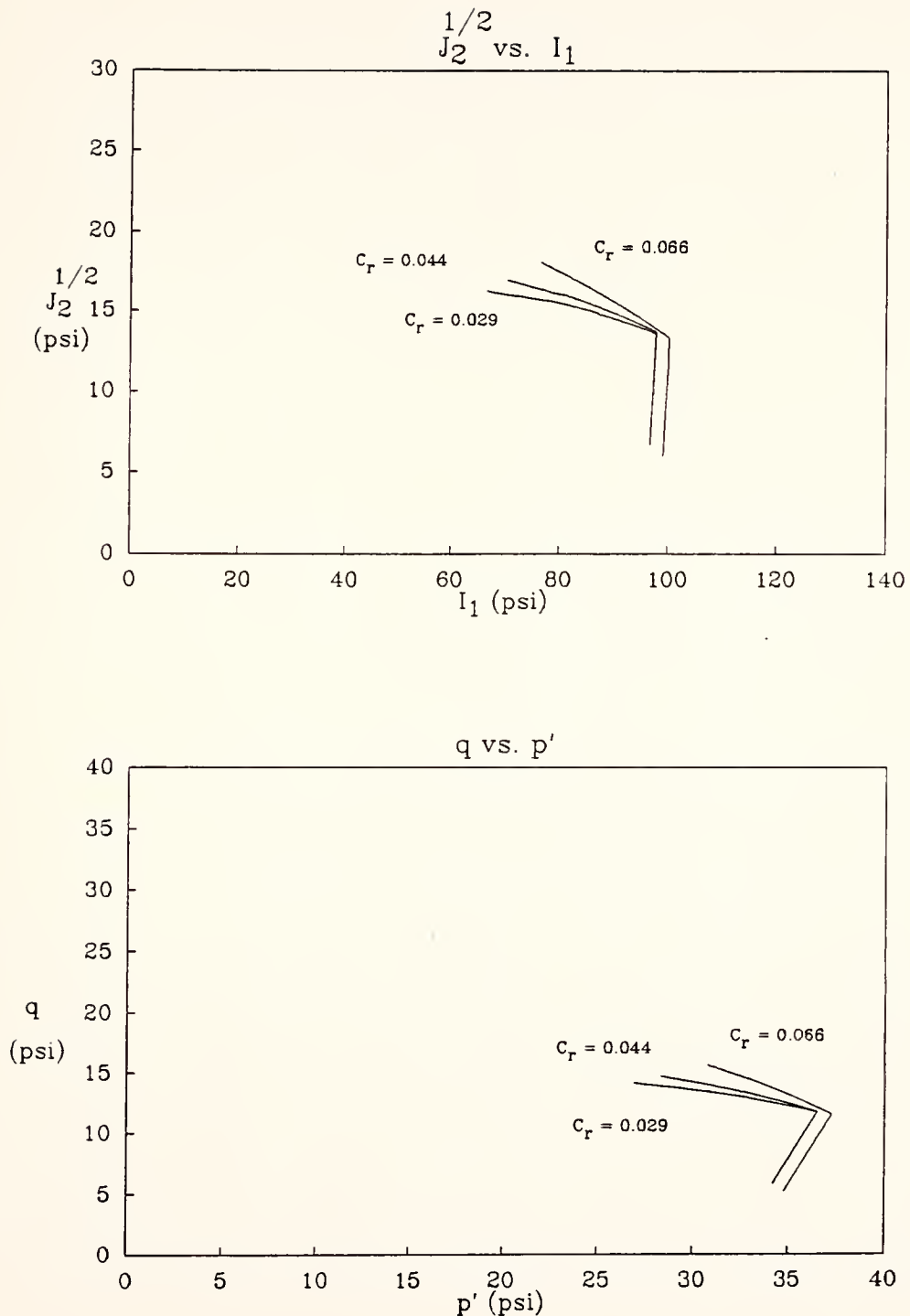


Figure A.3.3 - Effect of the Recompression Index on location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the  $q$ - $p'$  Diagram

A.4 - Case 4

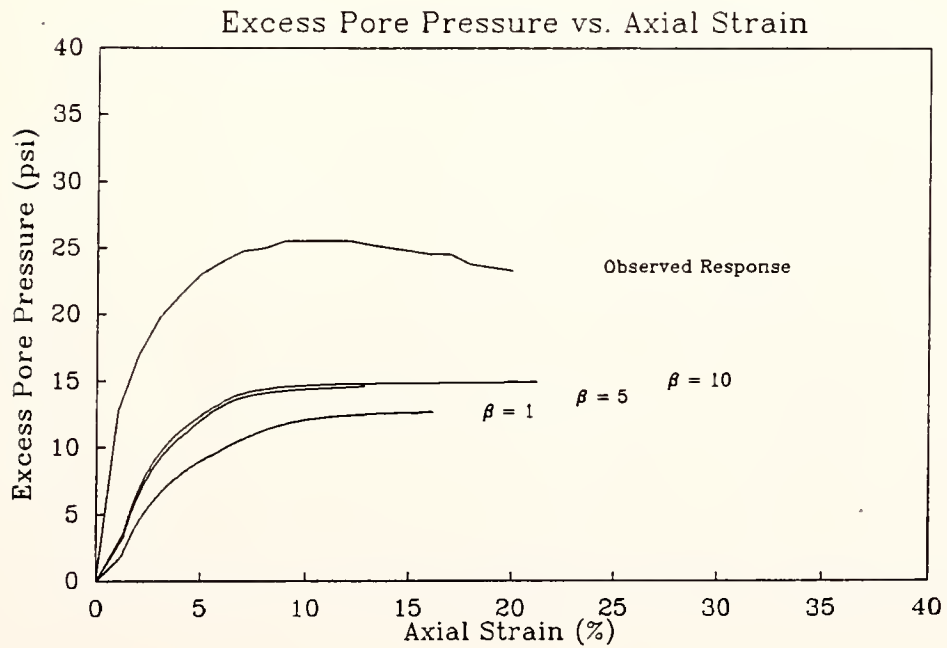
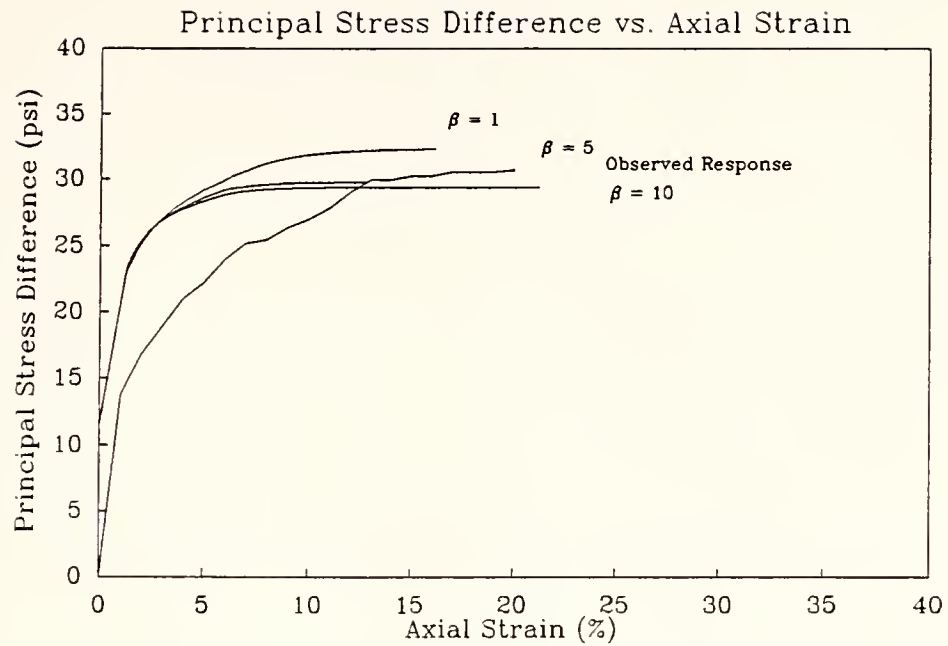


Figure A.4.1 - Effect of the Pore Pressure Response Factor on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain



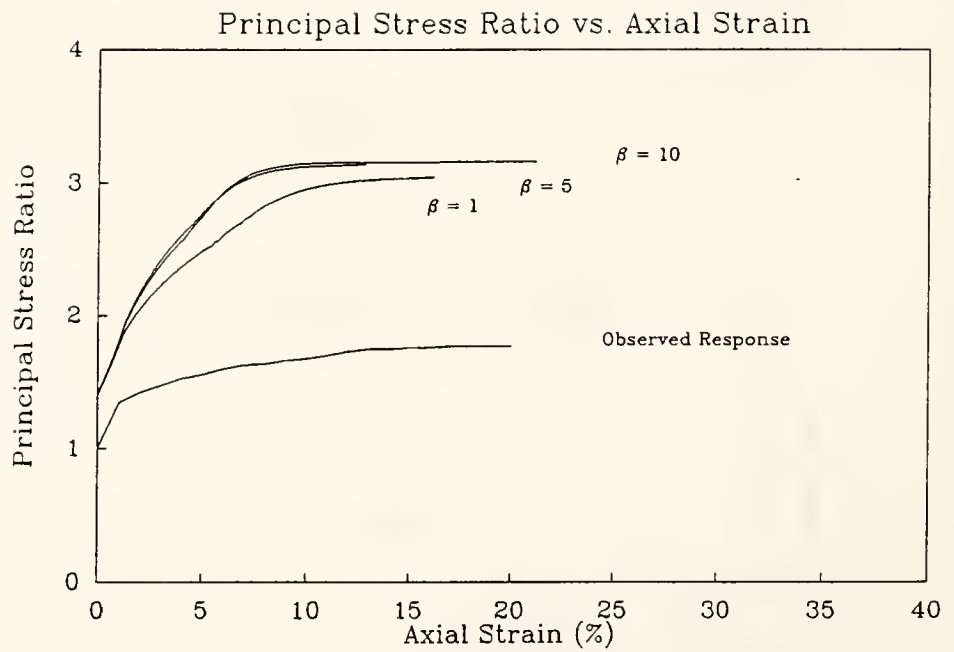


Figure A.4.2 - Effect of the Pore Pressure Response Factor on the Principal Stress Ratio vs. Axial Strain

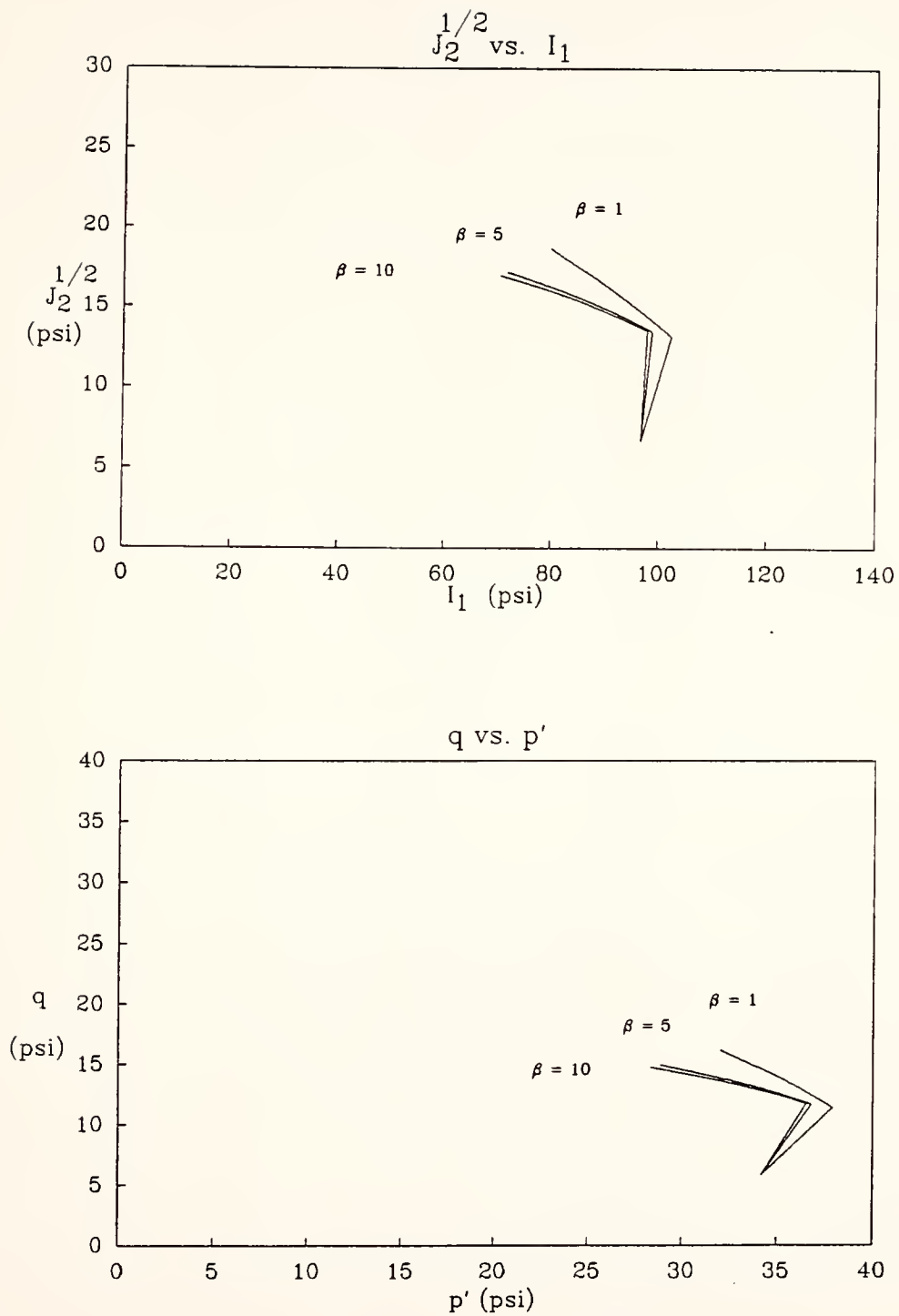


Figure A.4.3 - Effect of the Pore Pressure Response Factor on location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the  $q$ - $p'$  Diagram

A.5 - Case 5

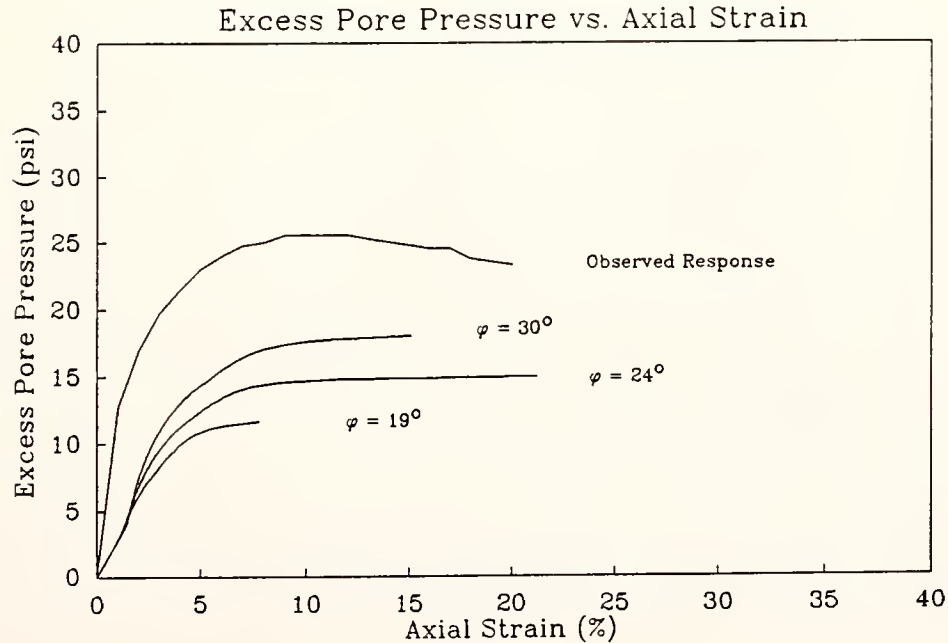
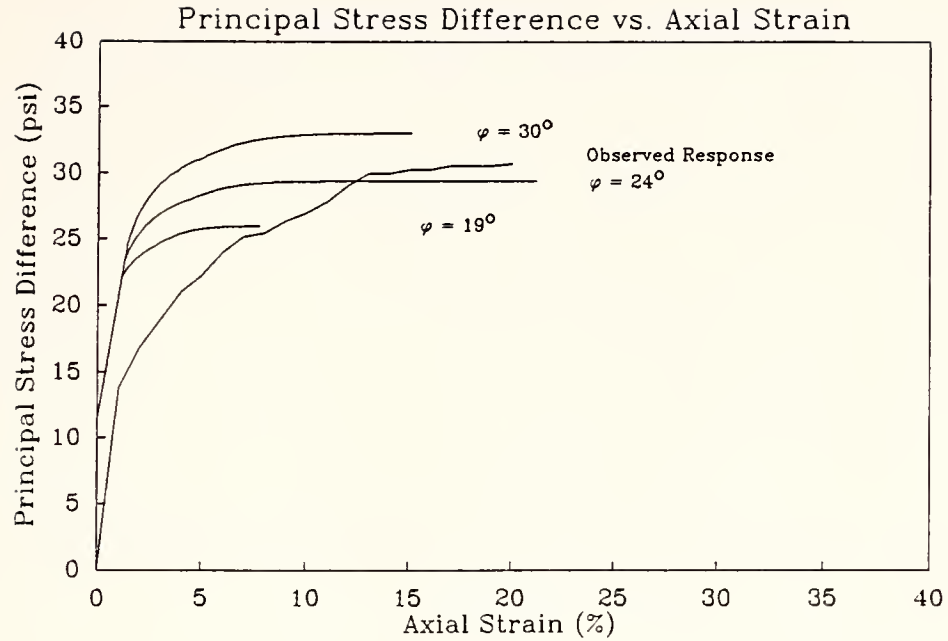


Figure A.5.1 - Effect of the Angle of Internal Friction on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

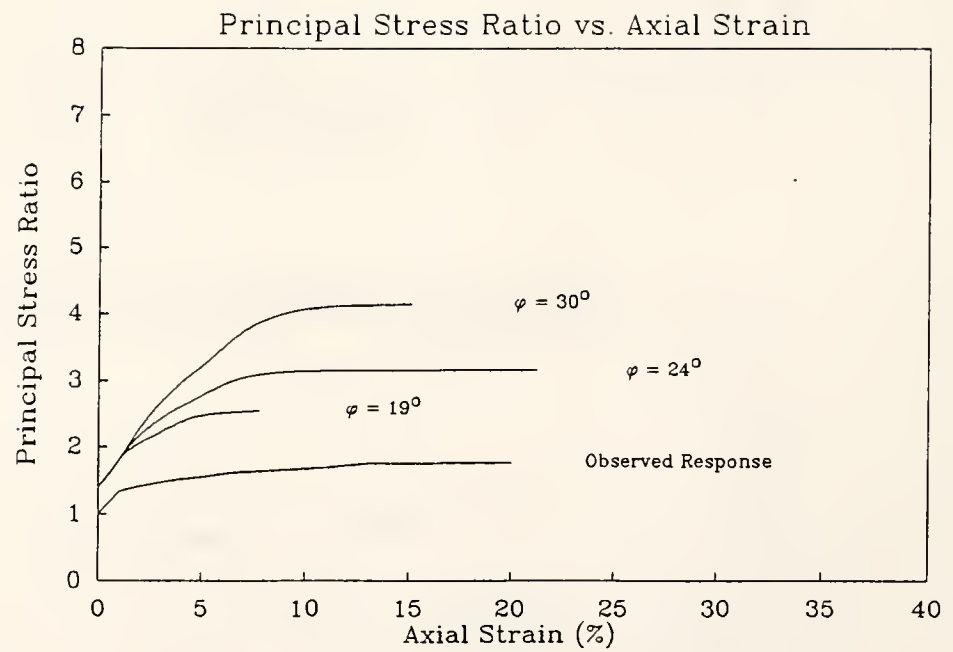


Figure A.5.2 - Effect of the Angle of Internal Friction on the Principal Stress Ratio vs. Axial Strain

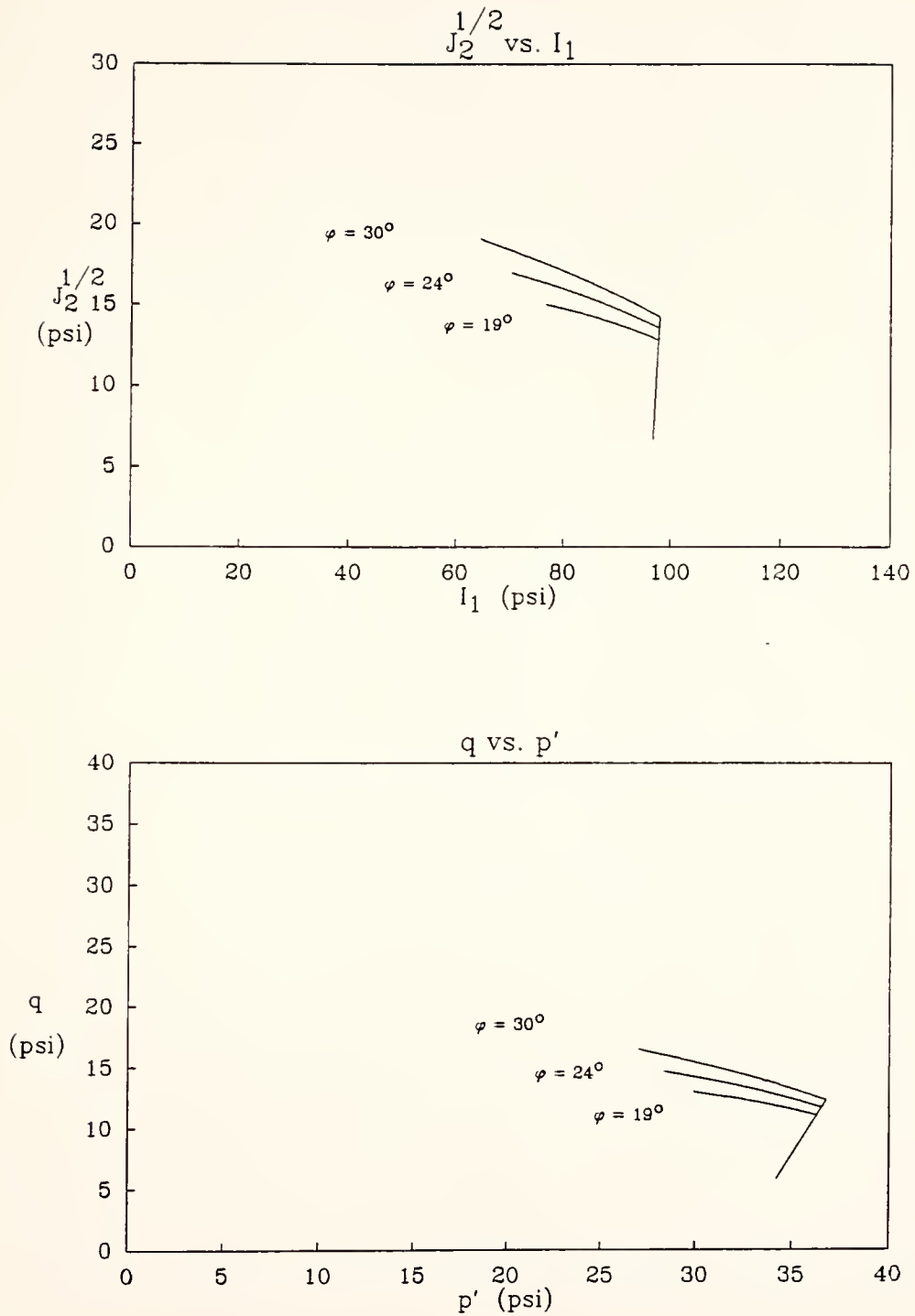


Figure A.5.3 - Effect of the Angle of Internal Friction on location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the  $q$ - $p'$  Diagram

A.6 - Case 6

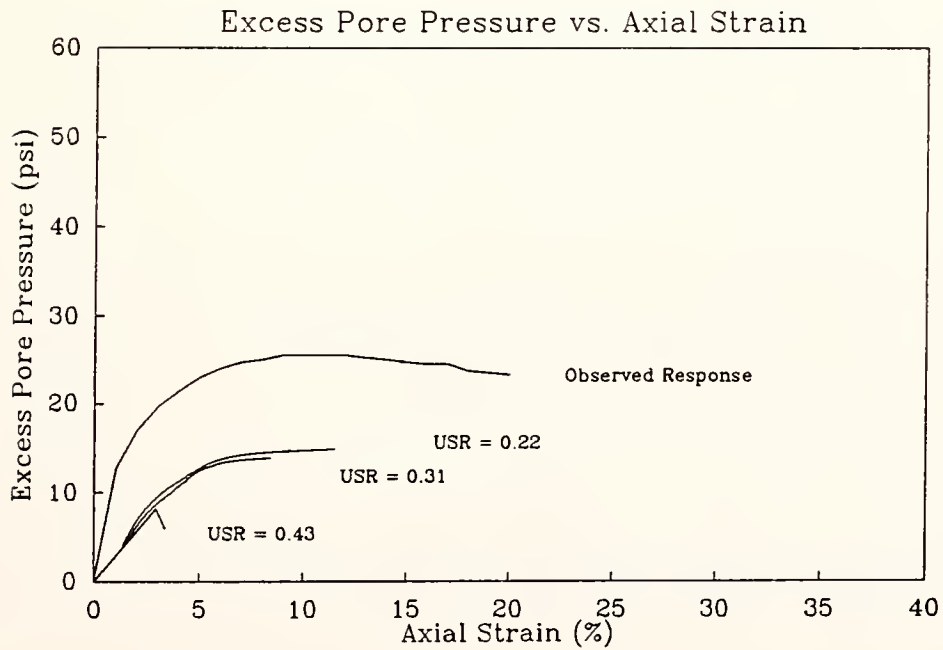
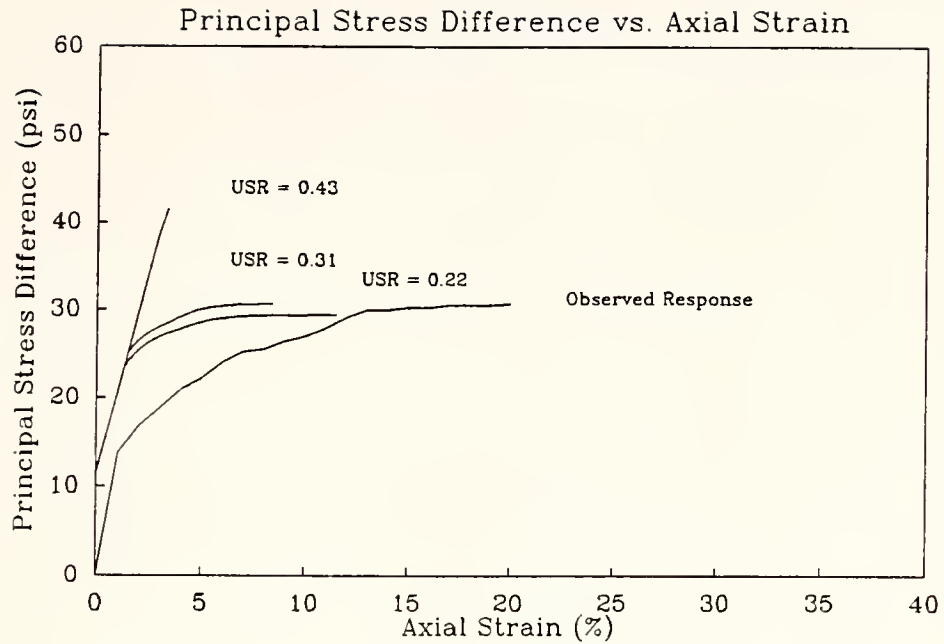


Figure A.6.1 - Effect of the Undrained Shear Strength Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain



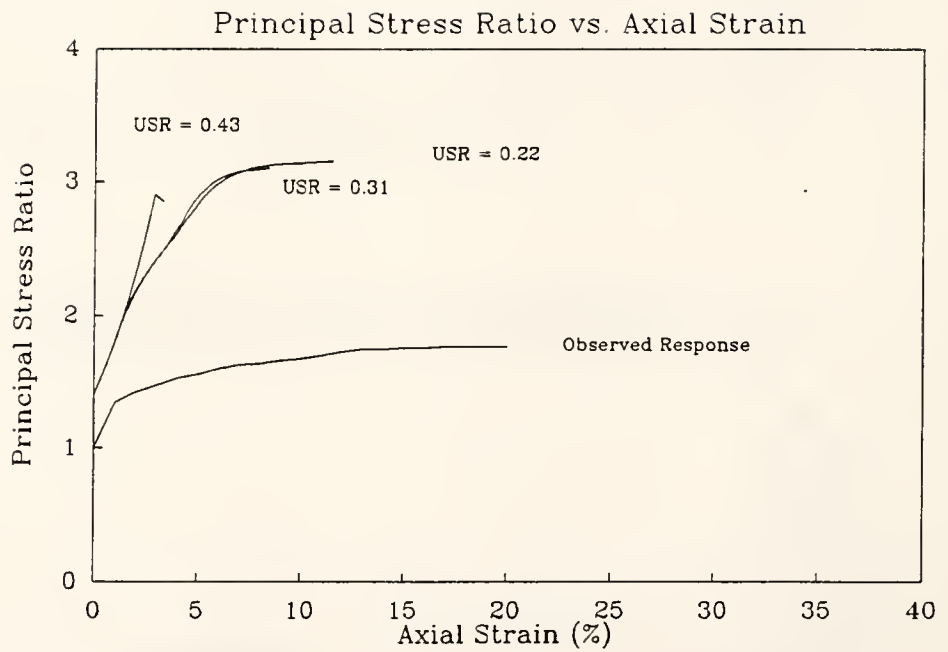


Figure A.6.2 - Effect of the Undrained Shear Strength Ratio on the Principal Stress Ratio vs. Axial Strain

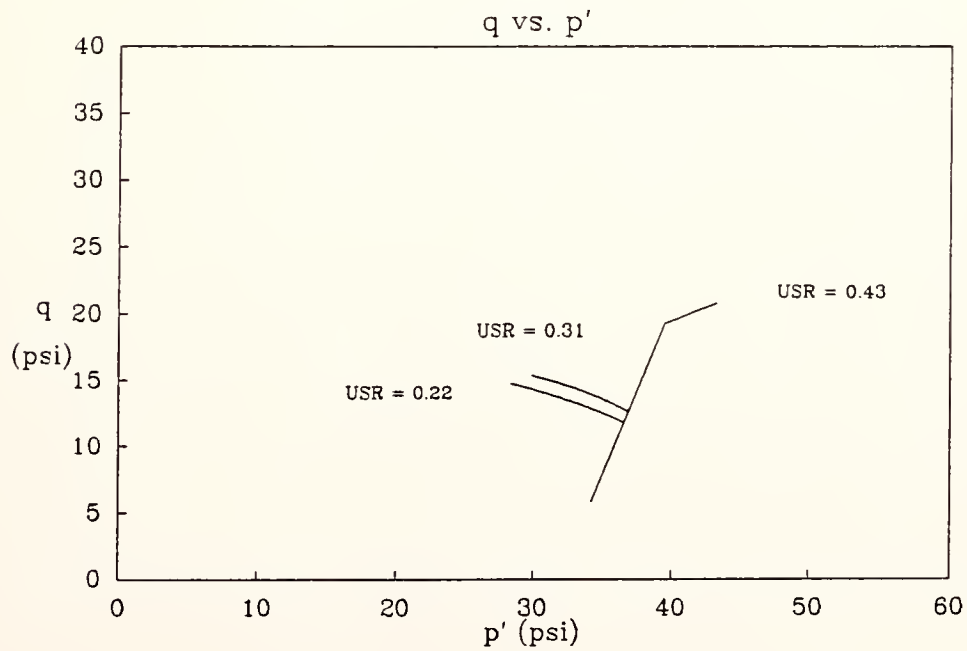
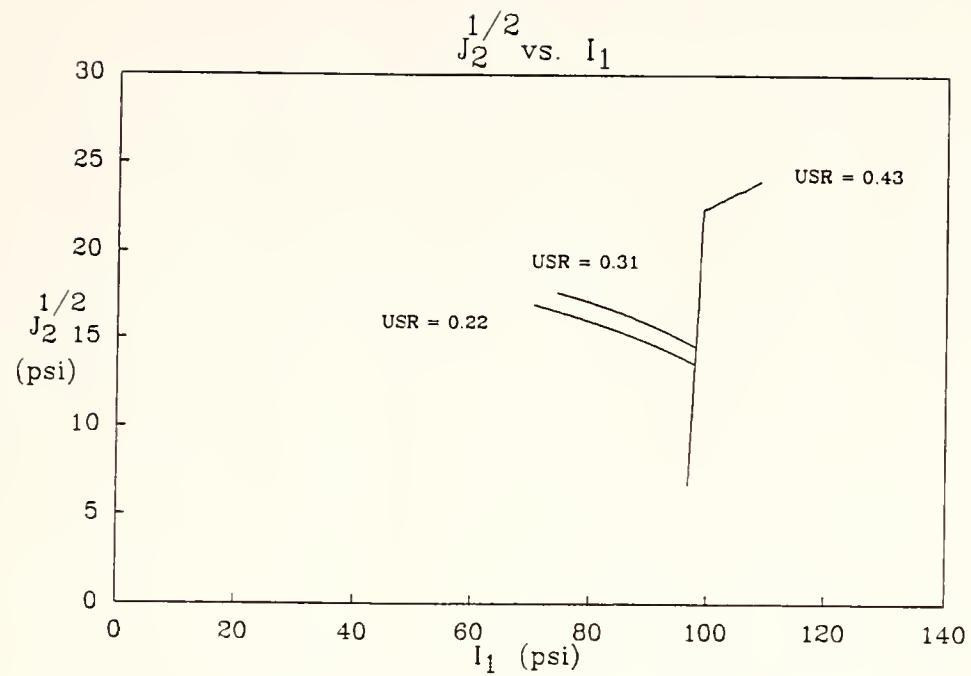


Figure A.6.3 - Effect of the Undrained Shear Strength Ratio on location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the  $q$ - $p'$  Diagram

A.7 - Case 7

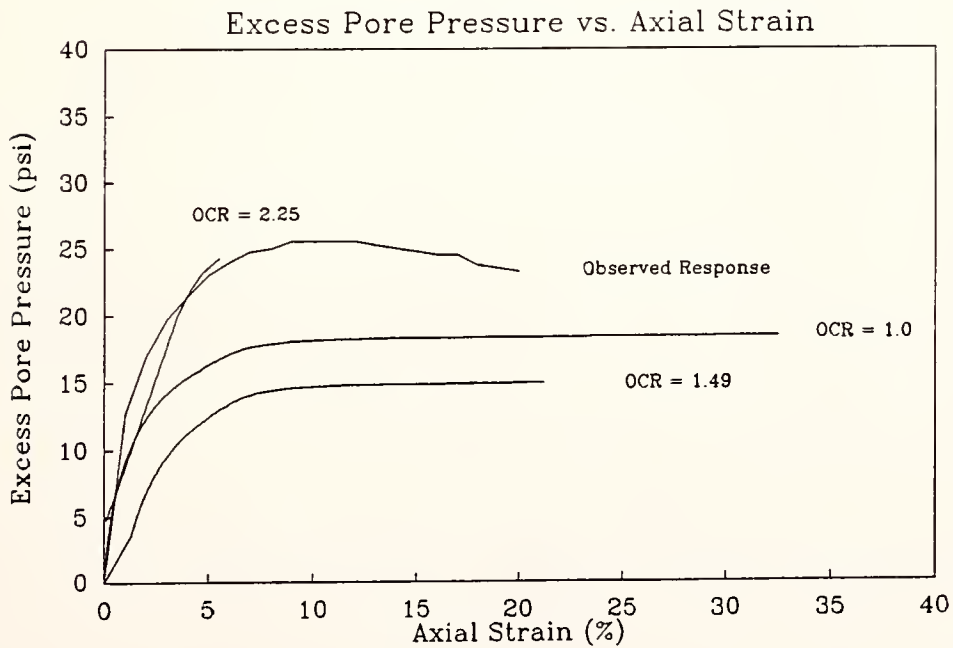
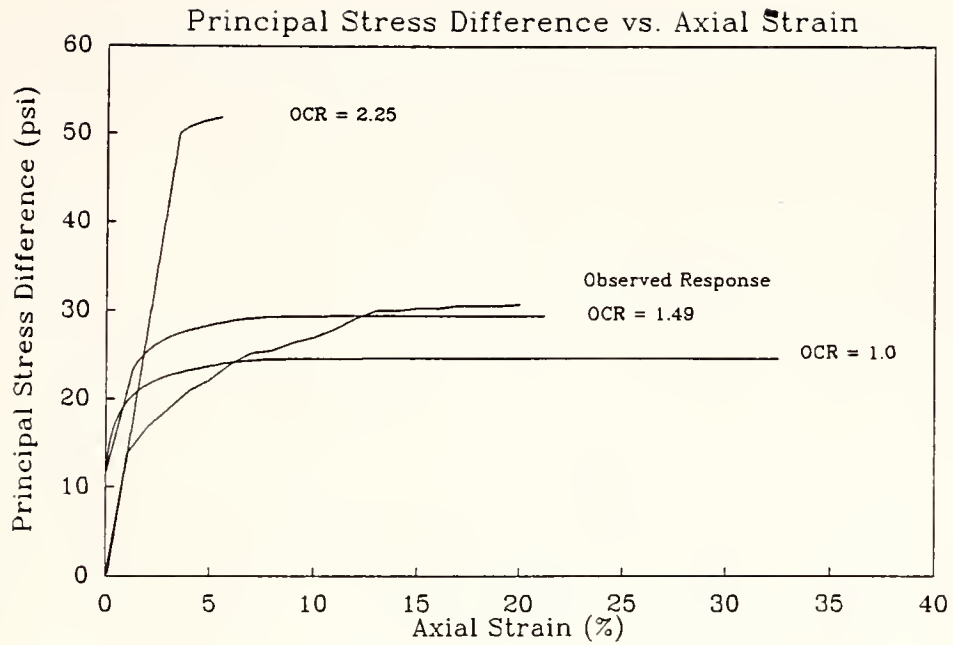


Figure A.7.1 - Effect of the Over-consolidation Ratio on the Principal Stress Difference and Excess Pore Pressure vs. Axial Strain

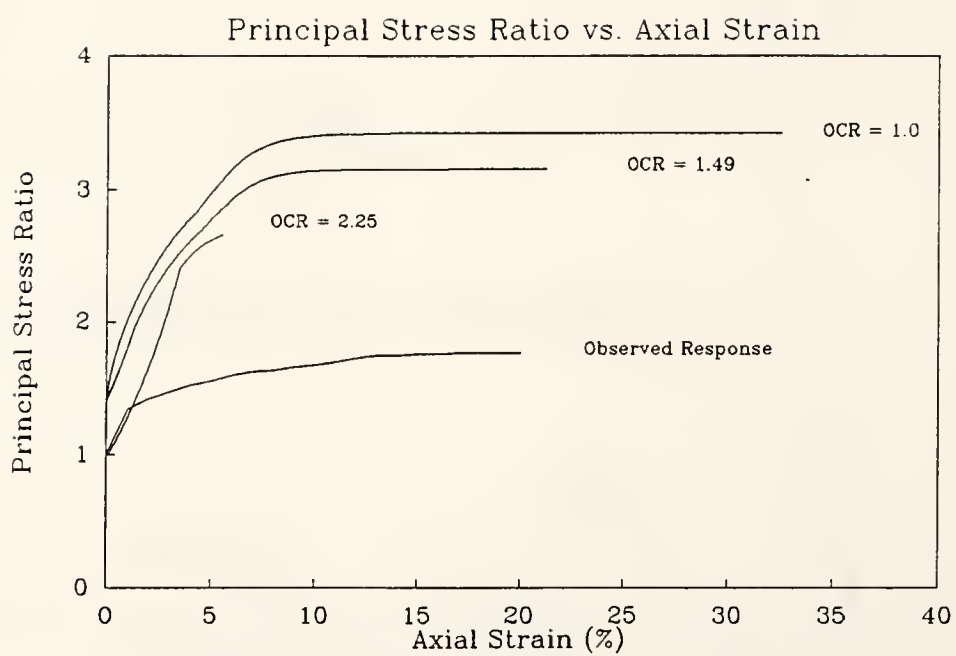


Figure A.7.2 - Effect of the Over-consolidation Ratio on the Principal Stress Ratio vs. Axial Strain

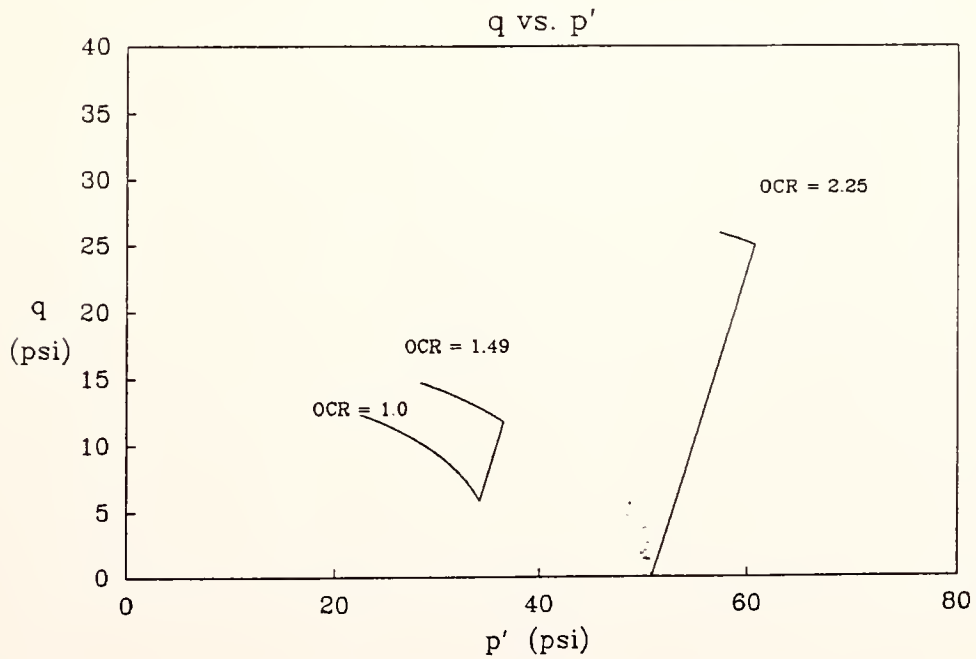
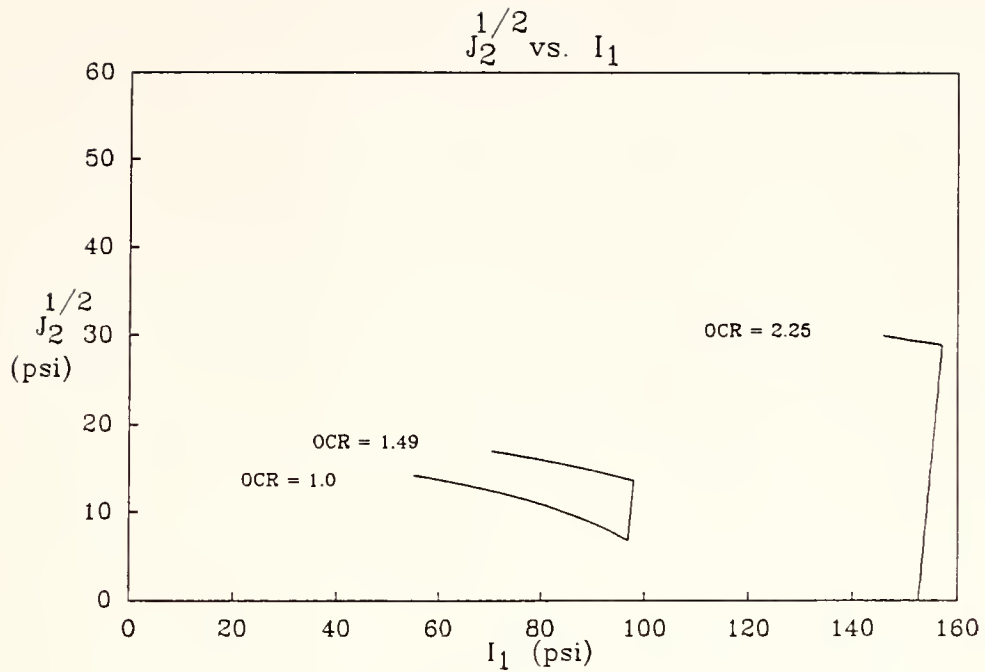


Figure A.7.3 - Effect of the Over-consolidation Ratio on location of the Cap in the  $J_2^{1/2}$ - $I_1$  Space and on the  $q$ - $p'$  Diagram

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.



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