

BEHAVIOUR OF ANISOTROPIC GRANULAR MEDIA UNDER GENERAL STRESS SYSTEM

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BY

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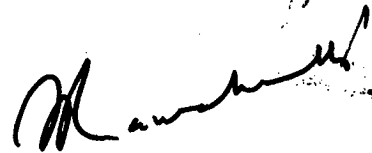
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C E R T I F I C A T E

This is to certify that the thesis entitled, "BEHAVIOUR OF ANISOTROPIC GRANULAR MEDIA UNDER GENERAL STRESS SYSTEM", being submitted by Mr. B.Shankariah to the Indian Institute of Technology, Delhi for the award of the degree of DOCTOR OF PHILOSOPHY is a record of the bonafide research work carried out by him. Mr. B.Shankariah has worked under my guidance for the submission of this thesis which to my knowledge has reached the requisite standard.

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ABSTRACT

The structure of the most of the granular media is anisotropic. An attempt is made to investigate the influence of inherent structural anisotropy on strength and deformation properties of granular media by conducting tests in universal triaxial apparatus.

The investigation was carried out on two uniformly graded sands, namely, Ottawa sand consisting of nearly spherical and rounded grains and crushed stone which consists of flaky and angular particles. Specimens were prepared by freely depositing saturated sand under water and vibrating in a specimen mould at different inclinations. Specimens were prepared at three different porosities. All the specimens were consolidated isotropically. Drained shear tests were conducted in Universal Triaxial Apparatus under monotonically varying mean normal stress conditions. Tests were conducted under the stress conditions of axisymmetric compression, general compression, plane strain compression, general extension and axisymmetric extension. Tests under different stress paths were conducted at identical values of mean normal stress at failure.

It was observed that the strength and deformation properties of granular media are influenced by structural anisotropy. In compression the angle of shearing resistance is constant in the region $0^\circ < \theta < 30^\circ$, decreases in the region $30^\circ < \theta < 60^\circ$ and then again remains constant in the region $60^\circ < \theta < 90^\circ$, in which θ is the angle made by the direction of deposition with the vertical axis of the specimen. In extension the angle of shearing resistance is constant in the region $0^\circ < \theta < 30^\circ$, increases in the

region $30^\circ < \theta < 60^\circ$ and then again remains constant in the region $60^\circ < \theta < 90^\circ$. The variation of strength due to anisotropy is maximum under axisymmetric conditions. As the deviation from axisymmetric conditions increases, the strength anisotropy decreases continuously practically vanishing under plane strain conditions. The intermediate principal stress seems to suppress the structural anisotropy of the material.

With increase in deposition angle, the axial strain at any major principal stress ratio increases in compression but decreases in extension. The lateral strain in the direction of plane of preferred orientation is higher than the other lateral strain. In compression dilation increases with increase in the value of deposition angle.

With increase in the value of intermediate principal stress, the angle of shearing resistance increases upto plane strain condition. With further increase in the value of intermediate principal stress, the angle of shearing resistance decreases continuously upto axisymmetric extension. The value of angle of shearing resistance may be lower or higher than or equal to that in axisymmetric compression depending upon the anisotropy of the material.

C O N T E N T S

ACKNOWLEDGEMENTS	...	iii
ABSTRACT	...	iv
CONTENTS	...	vi
NOTATION	...	xix
<u>CHAPTER 1</u>	<u>INTRODUCTION</u>	...
1.1	Introduction	... 1
1.2	Importance of Stress Path	... 3
1.3	Testing of Cuboidal Samples under General System.	... 3
1.3.1	Introduction	... 3
1.3.2	Rigid Platens	... 5
1.3.3	Flexible bags	... 5
1.3.4	Mixed boundaries	... 8
1.3.4.1	Axial platens, cell pressure and flexible bags	... 9
1.3.4.2	Two pairs of rigid platens and cells pressure	... 11
1.3.4.3	Miscellaneous Apparatuses	... 13
1.4	Scope of the Present Investigation	... 15
<u>CHAPTER 2</u>	<u>ANISOTROPY IN GRANULAR MEDIA</u>	...
2.1	Introduction	... 17
2.2	Soil Structure	... 18
2.3	Granular models	... 25
2.4	Analytical and Grapho-Analytical Studies.	... 31
2.4.1	Elastic solutions-Generalised Hooke's law.	... 31

2.4.1.1	One plane of elastic symmetry	... 31
2.4.1.2	Three planes of elastic symmetry	... 32
2.4.1.3	An axis of elastic symmetry	... 33
2.4.1.4	Relevance of cross-anisotropy in soils.	... 34
2.4.1.5	Complete symmetry	... 35
2.4.2	Grapho-analytical solutions - Modifications to Mohr's theory	... 35
2.5	Strength and Deformation Studies	... 37
2.5.1	Compression at Constant Stress Ratios	... 38
2.5.2	Axisymmetric Compression	... 40
2.5.3	Plane Strain Compression	... 43
2.5.4	Axisymmetric Extension	... 44
2.5.5	Tests with Complex Stress Paths	... 46
2.5.6	Induced Anisotropy	... 49
2.6	Classification of Anisotropy	... 52
2.7	Degree of Anisotropy	... 53
2.8	Factors Contributing to Anisotropy	... 54
2.8.1	Characteristics of Constituent Grains.	... 54
2.8.2	Method of sample Preparation	... 54
2.8.3	Initial Porosity	... 55
2.8.4	Degree of Saturation	... 55
2.8.5	Nature and Amount of Pre-shear Consolidation	... 55
2.8.6	Stress Path Followed during Shearing	... 55

<u>CHAPTER 3</u>	<u>EXPERIMENTAL WORK</u>	...	
3.1	Equipment	...	57
3.1.1	Basic Features of Universal Triaxial Apparatus	...	57
3.1.2	Base with Enlarged Pedestal	...	62
3.1.3	Top Loading Platen	...	64
3.1.4	Sample Former	...	64
3.1.5	Vibration Table	...	65
3.1.6	Sample Sheath	...	65
3.1.7	Membrane Sandwiches	...	67
3.1.8	Porous Stone	...	67
3.1.9	Rubber Bags	...	68
3.1.10	Guides	...	70
3.1.11	Loading Frame	...	72
3.1.12	Self Compensating Mercury Control	...	72
3.2	Materials Tested	...	72
3.2.1	Ottawa Sand	...	72
3.2.2	Crushed Stone	...	73
3.2.3	Preparation of the Material	...	74
3.3	Test Programme	...	74
3.3.1	Introduction	...	74
3.3.2	Angles of Deposition	...	76
3.3.3	Consolidation Pressures	...	76
3.3.4	Deformation Rate	...	78
3.3.5	Stress Paths followed	...	78
	3.3.5.1 Introduction	...	78
	3.3.5.2 Axisymmetric Compression ($\sigma'_z > \sigma'_x = \sigma'_y$)	...	81

3.3.5.3	General compression ($\sigma'_z > \sigma'_x > \sigma'_y$)	...	81
3.3.5.4	Plane strain compression ($\sigma'_z > \sigma'_x > \sigma'_y$ and $\epsilon_x = 0$)	...	82
3.3.5.5	General extension ($\sigma'_x > \sigma'_y > \sigma'_z$)	...	83
3.3.5.6	Axisymmetric extension ($\sigma'_x = \sigma'_y > \sigma'_z$)	...	83
3.4	Specimen Preparation and Test Procedure	84
3.4.1	Specimen Preparation	...	84
3.4.2	Setting up of the Specimen	...	90
3.4.3	Consolidation of the Specimen	...	93
3.4.4	Shearing of the Specimen	...	94
3.4.4.1	Axisymmetric compression	...	94
3.4.4.2	Axisymmetric extension	...	96
3.4.4.3	General compression	...	96
3.4.4.4	Plane strain compression	...	96
3.4.4.5	General extension	...	96
3.4.5	Dismantling	...	97
3.5	Calculation of test Results	...	98
3.5.1	Notation	...	98
3.5.2	Calculations	...	98
3.5.3	Volumetric Strains during Shearing	...	99
3.5.4	Porosity used as a Basis for Comparison	...	100
3.6	A Comment on the Samples	...	101
3.6.1	The Initial Structure	...	101
3.6.2	The Initial Porosities	...	101
3.6.3	Post Consolidated Porosities	...	102
3.6.4	Puncturing of the Sample Sheath	...	104

<u>HAPTER 4</u>	<u>AXISYMMETRIC COMPRESSION - TEST RESULTS</u>	...
	<u>AND DISCUSSION</u>	
4.1	Introduction	... 105
	PART A - OTTAWA SAND	
4.2	Stress-Strain Characteristics	... 108
4.2.1	Axial Strains	... 108
4.2.2	Lateral Strains	... 114
4.2.3	Volumetric Strains	... 114
4.3	Variation of Angle of Shearing Resistance with Porosity	... 115
4.4	Variation of Angle of Shearing Resistance with Deposition Angle.	... 120
4.4.1	Variation with Porosity	... 122
4.4.2	Variation with Axial Strain	... 123
4.5	Secant Modulus	... 124
4.6	Stress-Dilatancy Behaviour	... 124
	PART B - CRUSHED STONE	
4.7	Stress-Strain Characteristics	... 129
4.7.1	Axial Strains	... 135
4.7.2	Lateral Strains	... 135
4.7.3	Volumetric Strains	... 135
4.8	Variation of Angle of Shearing Resistance with Porosity	... 136
4.9	Variation of Angle of Shearing Resistance with Deposition Angle.	... 144
4.9.1	Variation with Porosity	... 147
4.9.2	Variation with Axial Strain	... 147
4.10	Secant Modulus	... 147
4.11	Stress-Dilatancy Behaviour	... 149

PART C - COMPARISON OF THE BEHAVIOUR OF
TWO MATERIALS

4.12	Stress-Strain Characteristics	... 151
4.12.1	Axial Strains	... 151
4.12.2	Lateral Strains	... 153
4.12.3	Volumetric Strains	... 153
4.13	Variation of Angle of Shearing Resistance with Porosity	... 153
4.14	Variation of Angle of Shearing Resistance with Deposition Angle.	... 154
4.14.1	Variation with Porosity	... 155
4.14.2	Variation with Axial Strain	... 155
4.15	Secant Modulus	... 155

CHAPTER 5 GENERAL COMPRESSION - TEST RESULTS AND
DISCUSSION

5.1	Introduction	... 156
	PART A - OTTAWA SAND	
5.2	Variation of b and R with Axial Strain	... 157
5.3	Stress-Strain Characteristics	... 160
5.3.1	Axial Strains	... 164
5.3.2	Lateral Strains	... 164
5.3.3	Volumetric Strains	... 164
5.4	Variation of Angle of Shearing Resistance with Porosity	... 165
5.5	Variation of Angle of Shearing Resistance with Deposition Angle.	... 165
5.6	Stress-Dilatancy Behaviour	... 167

PART B - CRUSHED STONE

5.7	Variation of b and R with Axial Strain	... 169
5.8	Stress-Strain Characteristics	... 172
5.8.1	Axial Strains	... 172
5.8.2	Lateral Strains	... 172
5.8.3	Volumetric Strains	... 177
5.9	Variation of Angle of Shearing Resistance with Porosity	... 177
5.10	Variation of Angle of Shearing Resistance with Deposition Angle.	... 183
5.10.1	Variation with Porosity	... 186
5.10.2	Variation with Axial Strain	... 186
5.11	Stress-Dilatancy Behaviour	... 187

PART C - COMPARISON OF THE BEHAVIOUR OF TWO MATERIALS

5.12	Stress-Strain Characteristics	... 189
5.13	Angle of Shearing Resistance	... 189

CHAPTER 6 PLANE STRAIN COMPRESSION - TEST RESULTS AND DISCUSSION

6.1	Introduction	... 190
PART A - OTTAWA SAND		
6.2	Variation of b and R with Axial Strain	... 192
6.3	Stress-Strain Characteristics	... 192
6.4	Variation of Angle of Shearing Resistance with Porosity	... 200
6.5	Variation of Angle of Shearing Resistance with Deposition Angle	... 200
6.6	Stress-Dilatancy Behaviour	... 206

PART B - CRUSHED STONE

6.7	Variation of b and R with Axial Strain	...	210
6.8	Stress-Strain Characteristics	...	210
6.9	Variation of Angle of Shearing Resistance with Porosity	...	216
6.10	Variation of Angle of Shearing Resistance with Deposition Angle	...	220
6.10.1	Variation with Porosity	...	223
6.10.2	Variation with Axial Strain	...	223
6.11	Stress-Dilatancy Behaviour	...	223

PART C - COMPARISON OF THE BEHAVIOUR OF TWO MATERIALS

6.12	Stress-Strain Characteristics	...	225
6.13	Angle of Shearing Resistance	...	225

CHAPTER 7 GENERAL EXTENSION - TEST RESULTS AND DISCUSSION

7.1	Introduction	...	227
-----	--------------	-----	-----

PART A - OTTAWA SAND

7.2	Variation of b and R with Axial Strain	...	228
7.3	Stress-Strain Characteristics	...	234
7.3.1	Axial Strains	...	234
7.3.2	Lateral Strains	...	234
7.3.3	Volumetric Strains	...	234
7.4	Variation of Angle of shearing Resistance with Porosity	...	238
7.5	Variation of Angle of Shearing Resistance with Deposition Angle	...	243
7.6	Stress-Dilatancy Behaviour	...	243

PART B - CRUSHED STONE

7.7	Variation of b and R with Axial Strain	... 247
7.8	Stress-Strain Characteristics	... 247
7.8.1	Axial Strains	... 254
7.8.2	Lateral Strains	... 254
7.8.3	Volumetric Strains	... 254
7.9	Variation of Angle of Shearing Resistance with Porosity	... 255
7.10	Variation of Angle of Shearing Resistance with Deposition Angle	... 259
7.10.1	Variation with Porosity	... 261
7.10.2	Variation with Axial Strain	... 261
7.11	Stress-Dilatancy Behaviour	... 261

PART C - COMPARISON OF THE BEHAVIOUR OF TWO MATERIALS

7.12	Stress-Strain Characteristics	... 263
7.13	Angle of Shearing Resistance	... 263

CHAPTER 8 AXISYMMETRIC EXTENSION - TEST RESULTS AND DISCUSSION

8.1	Introduction	... 265
PART A - OTTAWA SAND		
8.2	Stress-Strain Characteristics	... 267
8.2.1	Axial Strains	... 267
8.2.2	Lateral Strains	... 273
8.2.3	Volumetric Strains	... 274
8.3	Variation of Angle of Shearing Resistance with Porosity	... 274
8.4	Variation of Angle of Shearing Resistance with Deposition Angle.	... 274

8.4.1	Variation with Porosity	...	280
8.4.2	Variation with Axial Strain	...	280
8.5	Secant Modulus	...	280
8.6	Stress-Dilatancy Behaviour	...	282
PART B - CRUSHED STONE			
8.7	Stress-Strain Characteristics	...	286
8.7.1	Axial Strains	...	286
8.7.2	Lateral Strains	...	286
8.7.3	Volumetric Strains	...	290
8.8	Variation of angle of Shearing Resistance with Porosity	...	290
8.9	Variation of angle of Shearing Resistance with Deposition Angle	...	294
8.9.1	Variation with Porosity	...	296
8.9.2	Variation with Axial Strain	...	296
8.10	Secant Modulus	...	296
8.11	Stress-Dilatancy Behaviour	...	298
PART C - COMPARISON OF THE BEHAVIOUR OF TWO MATERIALS			
8.12	Stress-Strain Characteristics	...	298
8.13	Angle of Shearing Resistance	...	300
8.14	Secant Modulus	...	300
<u>CHAPTER 9</u>	<u>VARIATION OF STRENGTH AND DEFORMATION WITH b</u>		
9.1	Angle of shearing Resistance	...	302
9.1.1	Factors Affecting ϕ' vs b Relationship	...	302
9.1.1.1	Material properties	...	303
9.1.1.2	Shape of the specimen	...	304

9.1.1.3	Type of Deposition and Compaction	...	304
9.1.1.4	Consolidation pressure	...	305
9.1.1.5	Stress path followed during shearing	...	305
9.1.1.6	Mean normal stress at failure	...	306
9.1.1.7	Equipment defects	...	306
9.1.1.8	Porosity used as a basis of comparison	...	307
9.1.2	Angle of Shearing resistance in Ottawa sand	...	307
9.1.3	Angle of Shearing Resistance in Crushed Stone	...	313
9.1.4	Comparison of Angle of Shearing resistance of two materials	...	314
9.2	Lateral Strain ϵ_x	...	315
9.3	Lateral Strain ϵ_y	...	315
9.4	Axial Strain ϵ_z	...	320
9.5	Volumetric Strain	...	322
9.6	Grain Crushing in Crushed Stone	...	322
<u>CHAPTER 10</u> <u>CONCLUSIONS</u>			
10.1	Axisymmetric Compression	...	327
10.2	General Compression	...	328
10.3	Plane Strain Compression	...	329
10.4	General Extension	...	330
10.5	Axisymmetric Extension	...	330
10.6	Variation of Strength and deformation with b.	...	331
10.7	Suggestion for Future Work	...	332

REFERENCES	...	333
LIST OF FIGURES	...	345
LIST OF TABLES	...	353
<u>APPENDIX 1</u>	Upward Thrust of Rubber bags in top Loading Platens.	
A.1.1	Factors affecting	... 355
A.1.1.1	Cross-sectional area of the specimen.	... 355
A.1.1.2	Position of the top platen	... 356
A.1.1.3	Fluid pressure in the rubber bags	... 357
A.1.2	Calibration procedure	... 357
A.1.2.1	Setting up	... 357
A.1.2.2	Calibration for consolidation and axisymmetric compression and extension	... 358
A.1.2.3	Calibration when $\sigma'_x > \sigma'_y$ during shearing.	... 359
<u>APPENDIX 2</u>	Compressibility of Membrane Sandwiches	...
A.2.1	Introduction	... 361
A.2.2	Setting up	... 361
A.2.3	Consolidation	... 362
A.2.4	Compression	... 362
A.2.5	Extension	... 363
<u>APPENDIX 3</u>	Graphical Presentation of Axisymmetric Compression Test Results	... 365
<u>APPENDIX 4</u>	Graphical Presentation of General Compression Test Results	... 418
<u>APPENDIX 5</u>	Graphical Presentation of Plane Strain Compression Test Results.	... 438

<u>APPENDIX 6</u>	Graphical Presentation of General Extension Test Results	...	484
<u>APPENDIX 7</u>	Graphical Presentation of Axisymmetric Extension Test Results	...	541
<u>APPENDIX 8</u>	Comparison of Volumetric Strains	...	587
<u>BIODATA</u>	589

NOTATION

- A = Cross sectional area of the specimen.
- a = Elastic coefficient; subscript refers to an axial parameter.
- b = $(\sigma_2^i - \sigma_3^i) / (\sigma_1^i - \sigma_3^i)$
- c = Cohesion intercept of the soil; subscript refers to a post consolidation parameter
- D = Dilatancy factor; Diameter of cylindrical specimen.
- D_r = $\frac{\text{Relative density of sand.}}{\text{Relative density of sand.}}$
- E = Modulus of elasticity
- e = Void ratio
- f = Subscript refers to failure parameter
- G = Specific gravity of soil particles; shear modulus
- H = Height of the specimen
- h = Subscript refers to a horizontal component.
- i = Subscript refers to an initial parameter
- kN = Kilo Newtons
- L = Length
- m = Meter; subscript refers to a mean parameter
- n = Porosity of soil; degree of anisotropy
- oct = Subscript refers to an octahedral parameter.
- R = Stress ratio = $\sigma_2^i / (\sigma_1^i + \sigma_3^i)$
- R_f = Failure ratio = $(\sigma_1^i - \sigma_3^i)_f / (\sigma_1^i - \sigma_3^i)_c$
- r = Radius; subscript refers to a radial parameter
- u = Subscript refers to an ultimate value
- V = Volume of the specimen
- v = Subscript refers to a vertical parameter
- x,y,z= Subscript refers to a parameter along a coordinate direction.

- α = Angle of rupture or angle of lines of zero extension.
- γ = Unit weight; shear strain
- δ = Small increment.
- ϵ = Linear strain
- ϵ_v = Volumetric strain.
- θ = Angle of deposition; subscript refers to tangential parameter
- μ = Lode's parameter of stress = $(2\sigma_2^1 - \sigma_1^1 - \sigma_3^1) / (\sigma_1^1 - \sigma_3^1)$
- ν = Poisson's ratio; Lode's parameters of strain = $(2\epsilon_2 - \epsilon_1 - \epsilon_3) / (\epsilon_1 - \epsilon_3)$; angle of dilation
- σ = Normal stress
- σ^1 = Effective normal stress
- τ = Shear stress
- ϕ^1 = Effective angle of shearing stress
- ϕ_u = Effective angle of interparticle friction
- 1,2,3 = Subscript refers to major, intermediate and minor principal stress or strain.