C H A P T E R - IV

SCOPE OBJECTIVES AND SCHEME

4.1.0. GENERAL

The focus of the various theoretical developments and experimental investigations conducted is on finding out a phenomenological parameter which accounts for the energy absorption beyond the minimum energy absorption in basic friction so as to achieve total energy balance involved in shearing behaviour of a jointed rock mass. While the phenomenon may be complex to evaluate from microscopic considerations involving sliding, rolling and fracturing of individual asperities, it should be convenient to work through macroscopic considerations based on actual observations of the gross geometry of the sliding between the two intact rock blocks. To workout the energy balance equation for shearing of jointed rock, it is hypothesised that the ratio of energy input to the energy out put must be minimum for the energy absorbed in frictional heat and the balance energy is towards the dilation process which is the consequence of sliding deviating from the plastic plane of sliding.

4.2.0. SCOPE

The scope of the present work is to understand the dilatancy aspect on shearing behaviour of jointed rock mass through experimental investigations on a cylindrical specimens with precut at diffenent orientations and filled with gouge materials possessing different strength characteristics under the conventional triaxial test conditions $\sigma_1 > \sigma_2 = \sigma_3$ with an aim to modify the failure criteria for jointed rocks to include the dilatancy effect and review the efficacy of various joint elements incorporating dilatancy.

4.3.0. OBJECTIVES

The present work has following objectives:

(i) To investigate the effect of different joint orientations on the shearing behaviour of jointed rock.

(ii) To investigate the influence of gouge material possessing different strength characteristics on shearing behaviour of jointed rock.

(iii) To investigate the size effect on the shearing behaviour of jointed rock.

(iv) To develop a failure criterion for jointed rock.

(v) To identify the phenomenological parameter for dilatancy.

(vi) To conduct experiments on jointed rock specimens under different stress fields.

(vii) To study the constitutive properties for jointed rock.

(viii) To delineate the failure mechanism for jointed rock.

4.4.0. SCHEME

It is proposed to develop a theoretical model from basic equilibrium conditions for sliding bodies so as to generate a failure criterion interms of stress invariants for its utilization in mathematical framework of plasticity. To verify the theoretical model extensive experimental investigations are proposed to be conducted employing strain controlled conventional triaxial set up for various factors. Also it is envisaged to perform few loading events on Servo controlled sophisticated MTS setup.

4.4.1. Materials

4.4.1.1 Basalt rock cores

The basalt rock core specimens of A_x and N_x sizes from Narmada Dam site are proposed to be utilized for the present investigation. The physical properties of the basalt rock are described below:

(i)	Rock type	: Basalt
(ii)	Megascopic characteristics	: Fresh black coloured fine grained massive and homegeneous in nature.
(iii)	Microscopic characterstics :	
	Texture	: Porphyritic
	Mineral composition	: Phenocrysts of plagioclase feldspar.

4.4.1.2 Gouge materials

The gouge materials consisting of various proportions of cement : bentonite, 50:50, 40:60, 30:70 and cement : sand 1:2, 1:3 and 1:4 are proposed to be used. The physical properties of constituents of above gouge materials are presented below:

(a) Bentonite:

High grade bentonite from Bhavnagar district possessing following composition.

(i) Grain size analysis (in %):

Gravel	Sand	Silt	Clay
-	1	29	70

(ii) Consistency (Atterberg) limits:

Liquid limit	Plastic limit	Plasticity index
528	39	489

(iii) Freeswell : 1117 %

(iv) pH Value : 9.8

(b) Cement:

Ordinary portland cement having following charasticstics. Tests performed as per I.S.

Initial setting time : 110 minutes

Final setting time : 215 minutes

compressive strength on 3rd day : 248 kg/cm^2

compressive strength on 7thdday : 305 kg/cm^2

(c) Sand:

Goma river sand with following properties.

Sieve analysis : The sand used is passing from 212 micron IS sieve and retained on 75 micron sieve.

(d) Strength of gouge materials.

The strength characteristics of all gouge materials are given in table 4.1.

TABLE 4.1

Strength of gouge materials.

Sr. No.	Gouge	Compressive strength after 28 days kg/cm^2
1	*C:B, 50:50	63.25
2	C:B, 40:60	26.91
3	C:B, 30:70	12.59
4	**C:S, 1:2	95.28
5	C:S, 1:3	71.34
6	C:S, 1:4	45.15

*C:B - Cement : Bentonite

**C:S - Cement : Sand

4.4.2 Equipments

4.4.2.1 Conventional triaxial setup

A conventional strain controlled experimental set-up consisting of a motorized 30 speed strain controlled loading frame, proving ring, triaxial cell, dial gauge and Bishop's constant pressure mercury system is proposed to be used for experimental investigations. Figure 4.1 represent schemetic diagram of the experimental setup.

4.4.2.2 Servo controlled testing system

The MTS servo controlled testing system proposed to be used has a static load capacity of 10 tonne. The load frame is equipped with cross head mounted actuator for ease of installation of triaxial cell and hydraulic power is supplied to the actuator consistant with the specimen size.

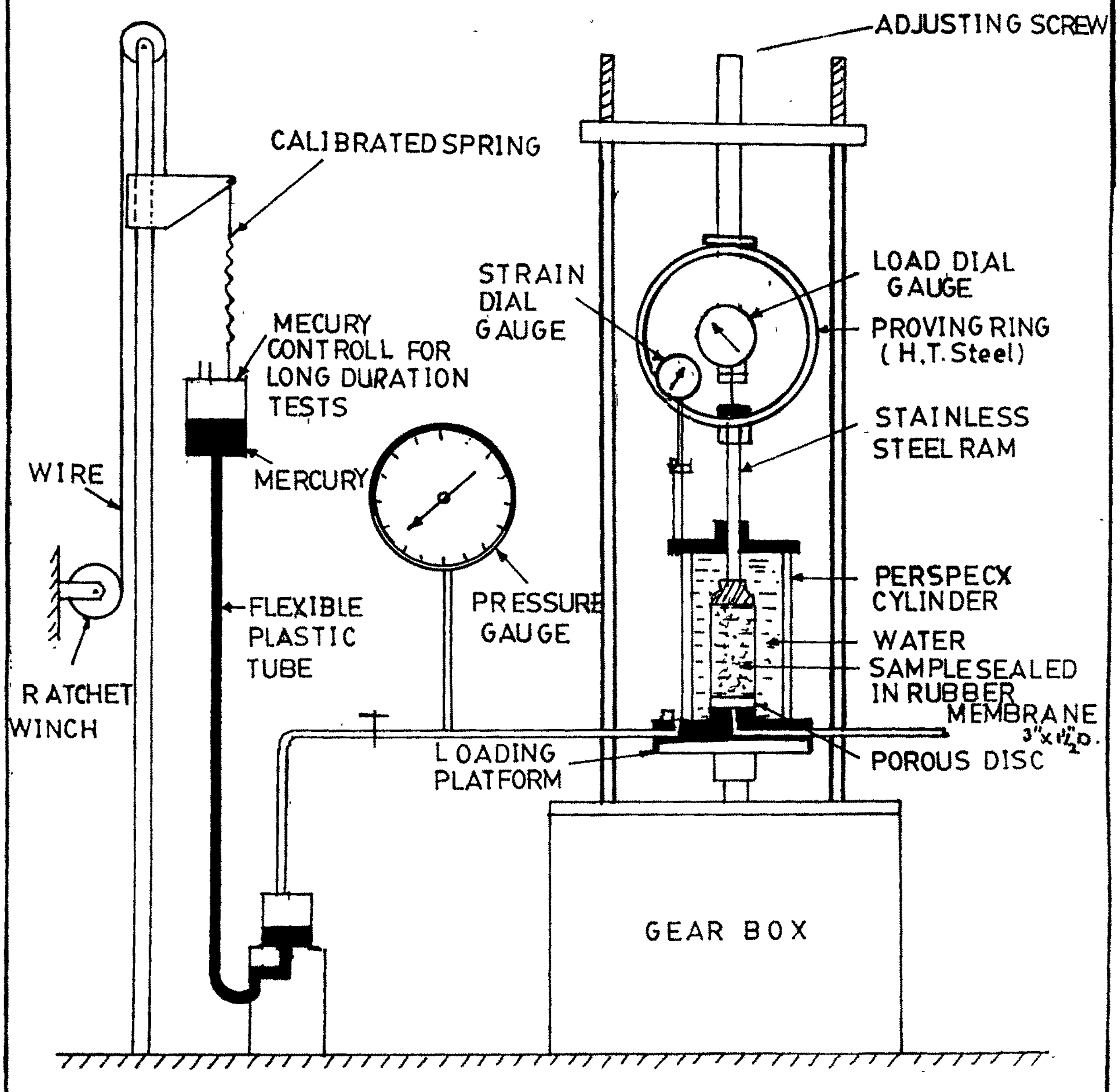

FIG. 4·1 SCHEMETIC DIAGRAM OF CONVENTIONAL TRIAXIAL TEST SYSTEM

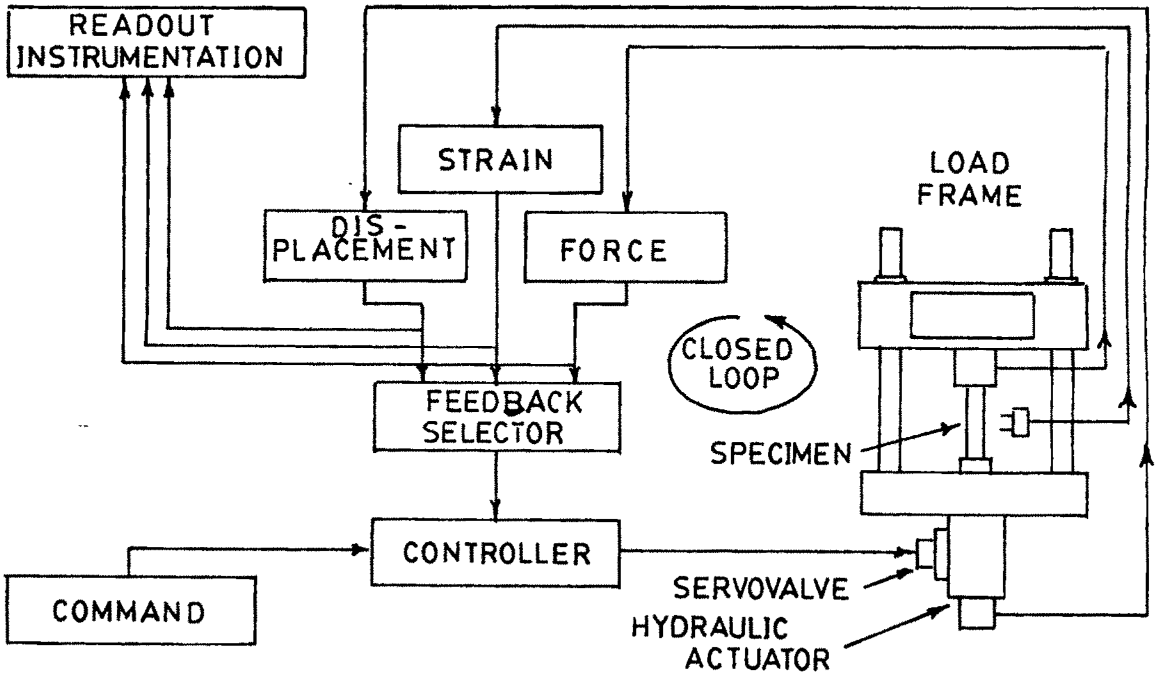

FIG. 4·2 SCHEMETIC DIAGRAM FOR MTS CLOSED LOOP SYSTEM

It consists of control package for precise control of test programmes and read out of test data. The basic modules are controller, function genetator, counter panel, x-y plotter, strip chart recorder, printer etc. Figure 4.2 represents schmetic diagram of the experimental set up.

4.4.3 <u>Special jobs</u>

(a) To develop grips for cutting core specimens at different orientations to prepare jointed rock specimens.

(b) To develop techniques to achive joint filled with gouge materials.

(c) To adopt a method for checking dimensions of the jointed rock specimens.

4.4.4 <u>Test Series</u>

The test series that are planned for the present investigation are given in Tables 4.2 a, 4.2 b and 4.2 c. Thickness of joint for all C:S specimens is 2 mm and for all C:B specimens is 3 mm.

4.5.0. CONCLUDING REMARKS

The present research project has been planned on the basis of the appraisal of various investigations described in the preceeding chapters. The succeeding chapters present the theoretical and experimental developments to understand the behaviour of jointed rocks. Recommendations for further studies based on analysis of results from the present investigations are also included.

TABLE 4.1 a

Designation	Gouge material Cement: sand	Angle of inclination degrees	Cell pressure kg/cm^2	Size of the specimen Height cms.	Diameter cms.
1	2	3	4	5	6
$1/A_2^{54.8}$	1:2	54.8	2	16.7	N_x=5.47
$2/A_4^{54.8}$	1:2	54.8	4	16.4	N_x=5.47
$3/A_6^{54.8}$	1:2	54.8	6	16.4	N_x=5.47
$4/A_2^{45}$	1:2	45	2	16.4	N_x=5.47
$5/A_4^{45}$	1:2	45	4	16.2	N_x=5.47
$6/A_6^{45}$	1:2	45	6	16.4	N_x=5.47
$7/A_2^{30}$	1:2	30	2	16.2	N_x=5.47
$8/A_4^{30}$	1:2	30	4	16.4	N_x=5.47
$9/A_6^{30}$	1:2	30	6	16.4	N_x=5.47
$10/B_2^{54.8}$	1:3	54.8	2	16.7	N_x=5.47
$11/B_4^{54.8}$	1:3	54.8	4	16.7	N_x=5.47
$12/B_6^{54.8}$	1:3	54.8	6	16.4	N_x=5.47
$13/B_2^{45}$	1:3	45	2	16.00	N_x=5.47
$14/B_4^{45}$	1:3	45	4	16.70	N_x=5.47
$15/B_6^{45}$	1:3	45	6	16.40	N_x=5.47

1	2	3	4	5	6
$16/B_2^{30}$	1:3	30	2	16.6	N_x=5.47
$17/B_4^{30}$	1:3	30	4	16.7	N_x=5.47
$18/B_6^{30}$	1:3	30	6	16.4	N_x=5.47
$19/C_2^{54.8}$	1:4	54.8	2	16.4	N_x=5.47
$20/C_4^{54.8}$	1:4	54.8	4	16.7	N_x=5.47
$21/C_6^{54.8}$	1:4	54.8	6	17.2	N_x=5.47
$22/C_2^{45}$	1:4	45	2	16.9	N_x=5.47
$23/C_4^{45}$	1:4	45	4	16.9	N_x=5.47
$24/C_6^{45}$	1:4	45	6	16.7	N_x=5.47
$25/C_2^{30}$	1:4	30	2	16.7	N_x=5.47
$26/C_4^{30}$	1:4	30	4	16.2	N_x=5.47
$27/C_6^{30}$	1:4	30	6	16.4	N_x=5.47

TABLE 4.1 b

Designation	Gouge material Cement : Bentonite	Angle of inclination degrees	Cell pressure kg/cm^2	Size of the specimen Height cms.	Size of the specimen Diameter cms.
1	2	3	4	5	6
$28/X_2^{54.8}$	50:50	54.8	2	13.3	N_x=5.40
$29/X_4^{54.8}$	50:50	54.8	4	16.2	N_x=5.40
$30/X_6^{54.8}$	50:50	54.8	6	16.7	N_x=5.40
$31/X_8^{54.8}$	50:50	54.8	8	15.2	N_x=5.40
$32/Y_2^{54.8}$	40:60	54.8	2	12.7	N_x=5.40
$33/Y_4^{54.8}$	40:60	54.8	4	15.4	N_x=5.40
$34/Y_6^{54.8}$	40:60	54.8	6	15.0	N_x=5.40
$35/Y_8^{54.8}$	40:60	54.8	8	15.6	N_x=5.40
$36/Z_2^{54.8}$	30:70	54.8	2	15.4	N_x=5.40
$37/Z_4^{54.8}$	30:70	54.8	4	18.2	N_x=5.40
$38/Z_6^{54.8}$	30:70	54.8	6	14.8	N_x=5.40
$39/Z_8^{54.8}$	30:70	54.8	8	15.1	N_x=5.40
$40/XX_2^{54.8}$	50:50	54.8	2	13.4	A_x=2.86
$41/XX_4^{54.8}$	50:50	54.8	4	13.6	A_x=2.86

1	2	3	4	5	6
$42/XX_{6}^{54.8}$	50:50	54.8	6	14.3	A_x=2.86
$43/XX_{8}^{54.8}$	50:50	54.8	8	13.6	A_x=2.86
$44/YY_{2}^{54.8}$	40:60	54.8	2	13.1	A_x=2.86
$45/YY_{4}^{54.8}$	40:60	54.8	4	13.4	A_x=2.86
$46/YY_{6}^{54.8}$	40:60	54.8	6	14.3	A_x=2.86
$47/YY_{8}^{54.8}$	40:60	54.8	8	13.4	A_x=2.86
$48/ZZ_{2}^{54.8}$	30:70	54.8	2	13.0	A_x=2.86
$49/ZZ_{4}^{54.8}$	30:70	54.8	4	13.2	A_x=2.86
$50/ZZ_{6}^{54.8}$	30:70	54.8	6	13.4	A_x=2.86
$51/ZZ_{8}^{54.8}$	30:70	54.8	8	13.4	A_x=2.86

TABLE 4.1 c

Designation 1	Gouge material Cement: Sand 2	Angle of inclination degrees 3	Cell pressure kg/cm^2 4	Size of the specimen Height cms. 5	Diameter cms. 6
$52/B_4^{54.8}$	1:3	54.8	4	16.00	N_x=5.47 *
$53/B_4^{54.8}$	1:3	54.8	4	16.40	N_x=5.47 **
$54/B_4^{54.8}$	1:3	54.8	4	16.00	N_x=5.47 ***
$55/B_2^{45}$	1:3	45	2	16.2	N_x=5.47 *
$56/B_4^{45}$	1:3	45	4	16.7	N_x=5.47 *
$57/B_6^{45}$	1:3	45	6	16.10	N_x=5.47 *
$58/B_4^{30}$	1:3	30	4	16.2	N_x=5.47 *

* Monotonic load application till failure.

** Triangular load application, after every two cycles the load is increased and repeated till failure.

*** Sinusoidal load application, after every two cycles the load is increased and repeated till failure.

Note: The above tests are performed by employing closed loop servo controlled MTS setup.