CHAPTER IV

SCOPE OBJECTIVES AND SCHEME OF INVESTIGATION

4.1 GENERAL

The expositions from the various investigations on jointed rock reveal clearly that the delineation of the mechanical behaviour of jointed rock calls for an approach from first principles. It may necessiate to reapprise the classical laws of friction and may involve a modification to include a parameter for 'dilatancy' to incorporate the behaviour of jointed rocks. It can be conceptualized that in the sliding process in a jointed rock surface structural changes continually occur and it can be visualized to be analogous to sliding taking place simultaneously on number of planes. Based on the mechanistic picture of the sliding behaviour of jointed rock it should be possible to evolve a constitutive relationship in terms of a realistic joint element, for its utilization in solution of engineering problems.

4.2 SCOPE

The scope of the present work is to delineate the factors affecting the mechanical behaviour of jointed rock and to identify a dilation parameter to be included in a constitutive relationship for a dilatant joint element for application in Finite Element Method of analysis. It is proposed to verify the theoretical development against the observations not only obtained in laboratory but also obtained from field tests. The efficacy and efficiency can be ascertained by applying to exemplary cases employing Finite Element Method.

4.3 OBJECTIVES

The objectives of the present investigation are :

(i) To understand the basic phenomenon of friction in jointed rock

(ii) To delineate the factors affecting the mechanical behaviour of jointed rock

(iii) To develop investigative technique for delineation of the factors

(iv) To identify a dilation parameter for the joint element

(v) To formulate a constitutive relationship for the joint element

(vi) To verify the relationship with the experimental data

(vii) To implement the developed joint element in Finite Element Method for analysis

(viii) To compare the modifications of joint behaviour owing to the direct incorporation of dilatancy parameter.

4.4 SCHEME

4.4.1 Principal Aspects

Following are the principal aspects of the scheme :

(i) To conduct the typical tests for the establishment of the concept of friction for jointed rocks. For this purpose, conventional direct shear experiments on following types of surfaces are planned :

(a) Unlubricated plane surfaces without any apparent asperities

(b) Lubricated plane surfaces without any apparent asperities (lubricated with silicon grease)

(c) Regularly aspirated surfaces with asperity angle of 25°

(d) Plane surfaces with irregular asperities created with fine sand (quartz) particles

(e) Gouged plane surfaces with gouge of grease and fine sand.

All these surfaces are schematically shown in Fig. 4.1. Samples of plane and regularly aspirated surfaces prepared are shown in Fig. 4.2 and Fig. 4.3 respectively.

(ii) To analyse the laboratory and the field test observations to understand the phenomenon of dilation. For this purpose following investigations are planned to be considered in addition to data of typical tests listed hereinabove.

(a) Conventional direct shear tests conducted by Dave (1987) on saw cut joints in Basalt with and without gouge of cement-sand mortar of different proportions.

(b) Cyclic direct shear tests conducted by Shah (1987) on saw cut joints in Basalt with gouge of cement mortar of different proportions.

(c) In situ shear tests conducted by Datir (1981) on concrete rock interface.

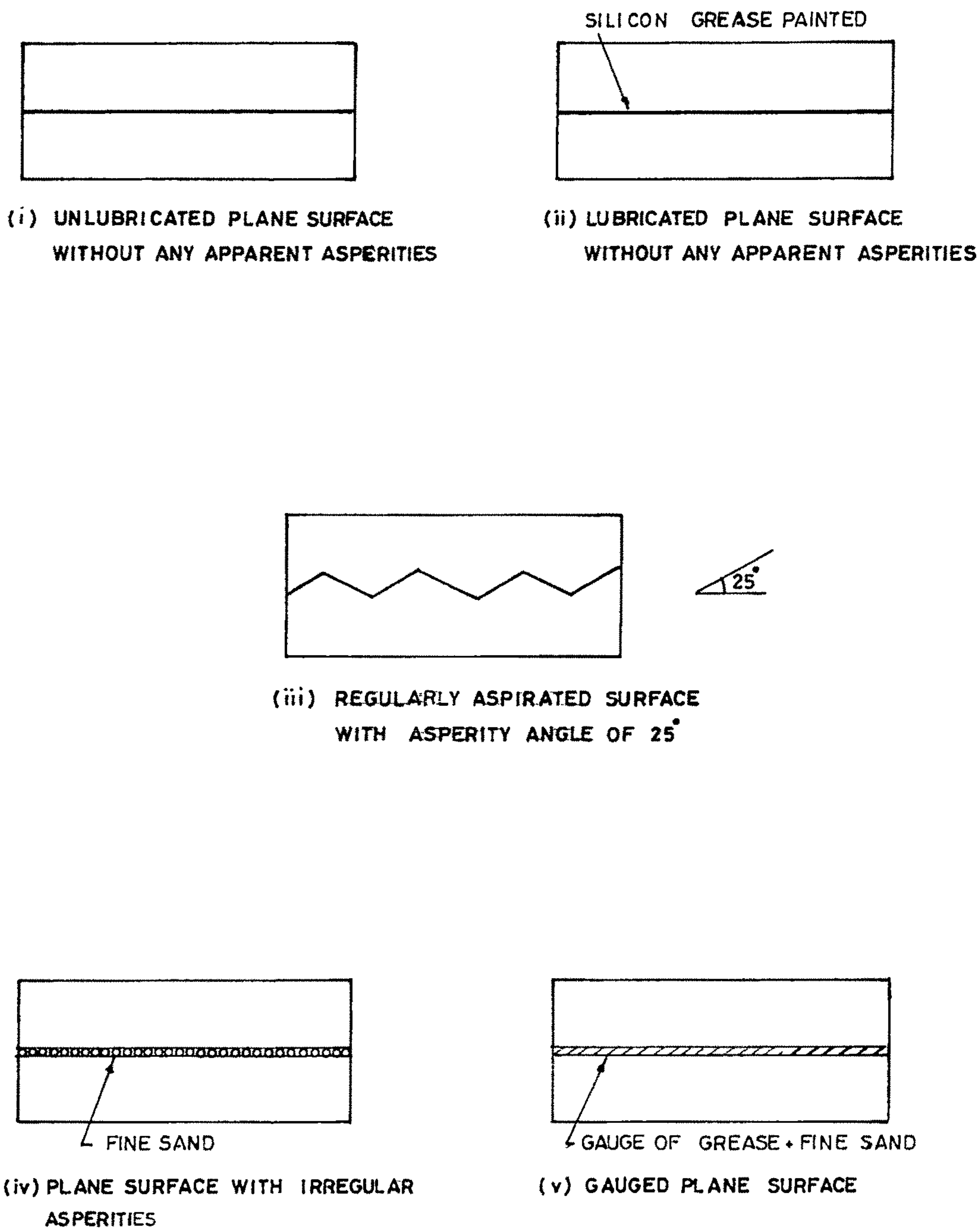

FIG: 4·1 VARIOUS TYPES OF SURFACES PROPOSED TO BE TESTED

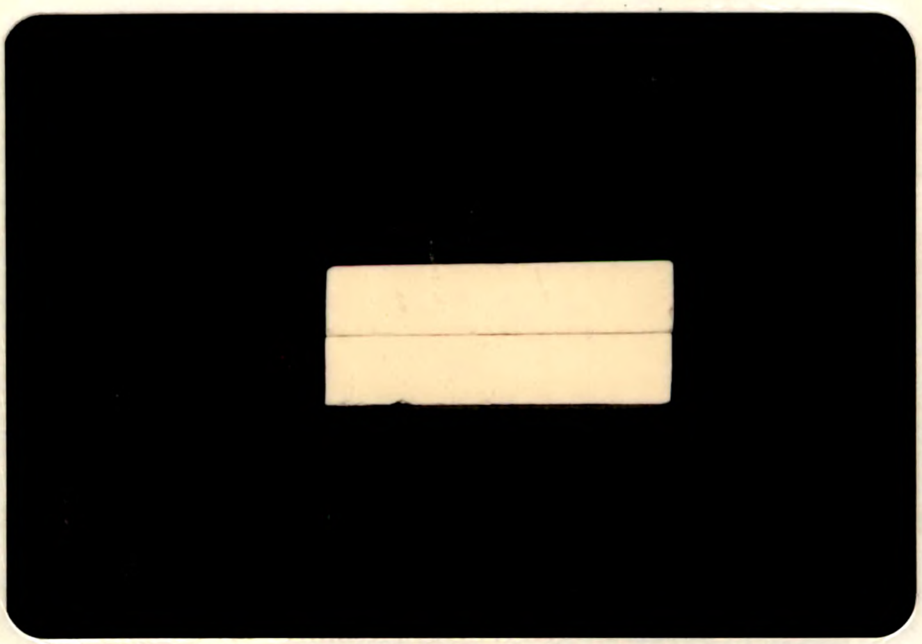

FIG: 4·2 SAMPLE OF PLANE SURFACE

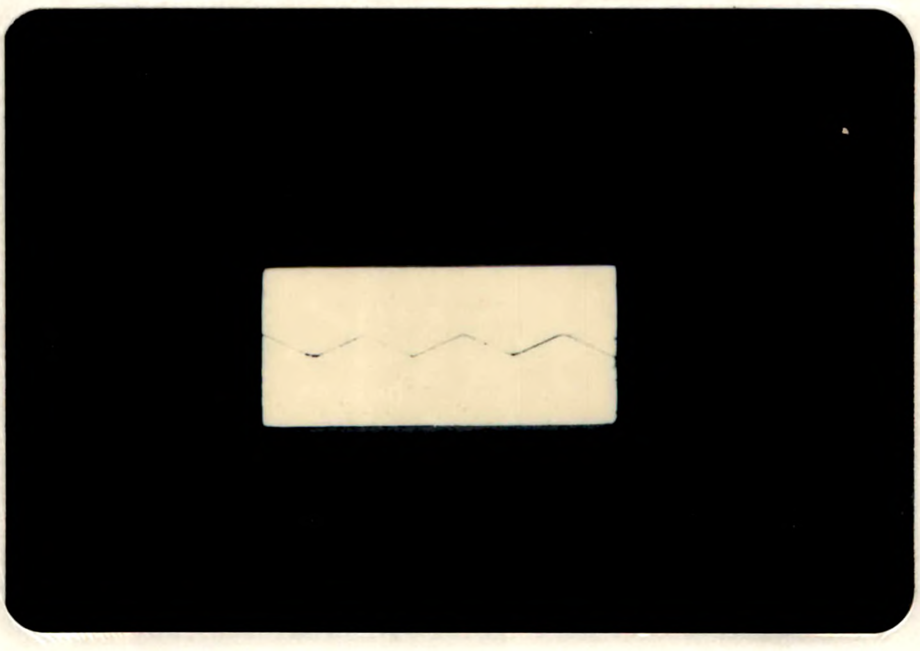

FIG: 4·3 SAMPLE OF REGULARLY ASPIRATED SURFACE

(iii) To translate the mechanistic picture of sliding of a jointed rock in mathematical formulation under the frame work of mechanics. Following aspects are proposed to be studied.

(a) Study of variation in ε_{xy} with respect to σ_{xy}.

(b) Study of variation in ε_{yy} with respect to σ_{yy} and σ_{xy}.

(c) Study of variation in ν with respect to σ_{xy}.

(iv) To verify the constitutive model by comparision of observed and predicted values. For this purpose observed values of following experiments are proposed to be considered.

(a) Conventional direct shear tests conducted on regularly aspirated surfaces having asperity angle of 25°.

(b) Conventional direct shear tests conducted by Dave (1987).

(c) Cyclic direct shear tests conducted by Shah (1987).

(d) In situ shear tests conducted by Datir (1981).

(v) To apply the constitutive model through Finite Element Method analysis to following typical cases.

(a) Single joint element discussed by Desai and Zaman (1984).

(b) Two dimensional case discussed by Desai and Zaman (1984).

(c) Case of a thick circular cylinder, typical of a tunnel in jointed rock, discussed by Hinton and Owen (1977).

4.4.2 Materials

It is proposed to use snowwhite, quick setting, fine textured, nonhydrated calcium sulphate - plaster of paris - as the modelling material. This material is particularly found suitable for accurately reproducing asperities on the sliding surfaces. The general physical properties of the material utilized during the investigation are,

$$\gamma_d = 1.10 \text{ g/cc}$$

$$\sigma_c = 12.0 \text{ kg/cm}^2$$

$$\sigma_t = 5.5 \text{ kg/cm}^2$$

$$E_t = 1500 \text{ kg/cm}^2$$

4.4.3 Preparation of Samples

For preparing a specimen, a standard brass mould of 60 x 60 x 22.5 mm size open from both ends is proposed to be used. A mild steel plate machined to have desired shape, size and number of asperities and having an overall size of 60 x 60 x 10 mm is proposed to be inserted in the mould. The following stepwise procedure is then proposed to be followed.

(i) Pour a mixture of plaster of paris and water taken in desired proportion in the space left in the mould.

(ii) Remove the specimen from the mould after it has set.

(iii) Prepare two such specimen to form one test piece.

(iv) After allowing the specimen to become air dry for 4 hours, keep them in oven for drying at 105° C for a period of 24 hours.

The specimen are thus ready for testing. The machined mild steel plate with regular asperities proposed to be used in the moulding of samples is shown in Fig. 4.4 alongwith samples repared.

4.4.4 Equipment

A conventional small size (6 cm x 6 cm) direct shear test apparatus shall be employed for experimental investigation. The apparatus has a normal loading capacity of 300 kg. Capacity of proving ring for shear loading is 250 kg. Normal load is applied through dead weights and is held constant during the test. The shear load is applied through motorised system and is measured on a proving ring. The apparatus has facilities to apply shear load at different strain rates from 1.25 mm/min to 0.0005 mm/min. It is proposed to conduct tests at a rate of 0.05 mm/min. The normal displacement is measured with a mechanical dial gauge having an accuracy of 0.01 mm. Similarly shear displacement is measured through another dial gauge having the accuracy of 0.01 mm.

4.4.5 Procedure

Following procedure is proposed to be followed in conducting a conventional direct shear test;

(i) Place the specimen in the position in the two halves of the shear box such that the joint plane is free to shear.

(ii) Apply the normal load in increments till pre-determined load is reached.

(iii) During application of normal load record normal and shear (if any) displacements, for each increment of normal load.

(iv) Apply shear load gradually and continuously

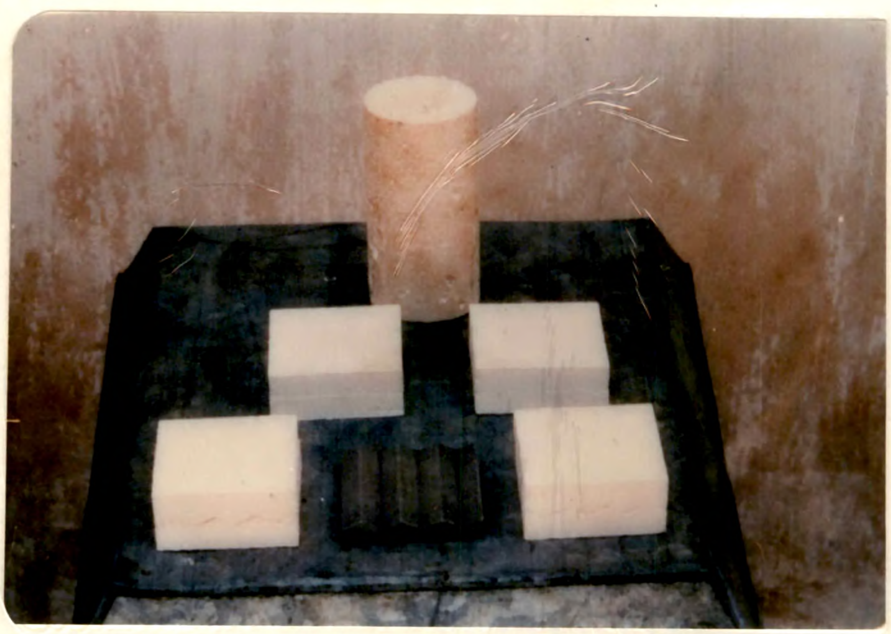

FIG: 4·4 MACHINED PLATE AND SAMPLES

at a strain rate of 0.05 mm/min.

(v) Record normal and shear displacements at regular intervals of shear load.

(vi) Continue the process sufficiently beyond the peak shear stress.

4.4.6 Test Series

The test series that is planned for the present investigation is given in Table 4.1.

4.5 CONCLUDING REMARKS

The present research work has been planned on the basis of the appraisal of various investigations described in the preceding chapters. The succeeding chapters present the theoretical and experimental developments to understand the mechanical behaviour of jointed rocks.

TABLE 4.1 : DETAILS OF TEST SERIES PLANNED

Designation	Type of surface	Size of specimen length x breadth x height in cm	Normal stress intensity kg/cm^2
T_1B_1	Unlubricated plane surfaces without any apparent asperities	6 x 6 x 2.5	1.0
T_2B_2	- do -	6 x 6 x 2.5	1.5
T_3B_3	- do -	6 x 6 x 2.5	2.0
T_4B_4	Lubricated plane surfaces without any apparent asperities	6 x 6 x 2.5	1.0
T_5B_5	- do -	6 x 6 x 2.5	1.5
T_6B_6	- do -	6 x 6 x 2.5	2.0
T_7B_7	Regularly aspirated surfaces with asperity angle of 25°	6 x 6 x 2.5	1.0
T_8B_8	- do -	6 x 6 x 2.5	1.5
T_9B_9	- do -	6 x 6 x 2.5	2.0
$T_{10}B_{10}$	Plane surfaces with irregular asperities created with fine sand particles	6 x 6 x 2.5	1.0
$T_{11}B_{11}$	- do -	6 x 6 x 2.5	1.5
$T_{12}B_{12}$	- do -	6 x 6 x 2.5	2.0
$T_{13}B_{13}$	Gouged plane surfaces with gouge of grease & fine sand	6 x 6 x 2.5	1.0
$T_{14}B_{14}$	- do -	6 x 6 x 2.5	1.5
$T_{15}B_{15}$	- do -	6 x 6 x 2.5	2.0