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Study on Geological and Structural Characteristics of different types of Stones and Stone Masonry

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Abstract: An attempt has been made in the present investigation to know the geological characteristics of stones and also structural characteristics of different types of stone and masonry. For a clear understanding of the behaviour of stone masonry under various loading conditions the properties i.e. the strength of masonry are essential. The structural performance of masonry is indeed influenced greatly by the bonding between masonry units and mortar. The two materials fail to act together in the event of a separation between the two. The failure of masonry in compression is often accompanied by a loss of bond between the masonry unit and the mortar. Since the masonry unit mortar interfere is under shearing stress, the failure in shear bond is likely to occur at the interface. Hence the strength of masonry unit stone mortar joints under shear has been examined.

Keywords: Masonry, Stones, Geological characteristics, Compressive strength and Shear bond strength.

I. INTRODUCTION

Stone masonry construction is known since ancient times and has been used for the construction of bridges, dams, forts, palaces and temples in several parts of the world. Stones are now widely used for the construction of walls foundations arches and dooms in buildings depending on local availability. Recently stone masonry arches have been used in foundation of walls as an alternative to the conventional spread footings. In the present study a three stone assembly in 1:6 cement mortar was used to obtain the shear bond strength of the stone mortar joints. The shear bond strength was determined for all the cases for which the compression strength of masonry was determined. Geological characteristics of stones were determined by megascopic studies. The geological characteristics include classification, colour, structure/texture, grain size and mineral composition

II. TEST PROGRAM

The test program consists of determining the characteristics of stone (i.e. compressive strength and geological characteristics), compressive strength and shear bond strength of masonry in 1:6 cement mortar. Stone samples from 6 different locations have been considered in this study. The geological characteristics and compressive strength of stone have been determined for each of the stone samples. Compressive strength of stones was determined as per the guidelines on Indian Standard code IS: 1121-1976[22]. Stone cubes of size 80mm were used for the compressive strength. Compressive strength tests were conducted by applying the load both parallel and perpendicular to the foliation, if the samples had foliation. The test specimens were immersed in water for 72 hour before testing. Geological characteristics were determined by megascopic studies. The geological characteristics include classification, colour, structure/texture, grain size and mineral composition. The compressive strength of stone masonry was determined by testing four stone high stack bonded prisms as per procedures given in IS: 1905-1987[23]. The masonry prism had a height to thickness ratio of 4.20 to 4.30. Cement mortar of 1:6 and joint thickness of 10mm used for all cases. The prisms were cured for 28days by keeping in moist condition under wet burlap. Six prisms were prepared in each case. All prisms were tested in wet state. The prisms were soaked in water for 48 hours prior to testing to achieve a saturated state and

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compressive strength tests were concluded by applying the load both parallel and perpendicular to the foliation.

In the present study a three stone assembly in 1:6 cement mortar was used to obtain the shear bond strength of the stone mortar joints. The shear bond strength was determined for all the cases for which the compression strength of masonry was determined. 43 grade cement conforming to IS: 8112 and sand conforming to Zone II was used in present investigation. The compressive strength of the 1:6 cement mortars was 3.00 MPa. A mortar joint thickness of 10mm was maintained for all the cases. Capping (1:1 cement mortar) of 10mm thick was provided for the top face of the middle stone and bottom faces of the outer stones. The type and duration of curing were same as that of masonry compressive strength specimens. Six specimens were tested to obtain an average value of shear bond strength of stone mortar joints. The outer stone rest against the lower platen of the compressive testing machine, so that the movement in the vertical direction is restrained. The middle stone is not restrained against any movement. The triplet (in the wet state) was placed in between the platens of compression testing machine and the load was applied on the top face of the middle stone till the specimen failed. The shear bond strength was calculated using the formula given below.

$$SBS = \frac{F}{2bd}$$

Where SBS= Shear bond strength of stone mortar joint
F= Load at failure.
b= Width of the prism of the plane of failure
d=Length of the prism at the plane of failure

III. RESULTS AND DISCUSSION

The results of the various tests are summarised in table 1. The stones GN1 to GN3 belong to metamorphic group and are of the type gneiss. The remaining stones GR1to GR3 belongs to Plutonic and rock type being granite group. All the stones tested have the same mineral composition i.e Quartz, orthoclase, and feldspar and biotite mica.

TABLE I. GEOLOGICAL CHARACTERISTICS OF STONES

Designation	Rock type	Geological classification	Color	Structure / Texture / Grain size
GN1	Gniess	Metamorphic	Grey	Gniessose-Banded
GN2	Gniess	Metamorphic	Pink	Gniessose-Banded
GN3	Gniess	Metamorphic	Pink	Gniessose-Banded
GR1	Grey Granite	Plutonic Igneous Rock	Grey	Equigranular Medium Grained
GR2	Grey Granite	Plutonic Igneous Rock	Grey	Equigranular Fine Grained
GR3	Grey Granite	Plutonic Igneous Rock	Pink	Equigranular Coarse Grained

From table 2, the compressive strength of different stones shows that T.M Hossur stones shows very high strength of 70MPa and Kanakapura stones gives strength of 82MPa. This may be attributed to the low biochemical content of this variety of gneiss. The gneiss specimen showed distinct foliation, hence the test were conducted both parallel and perpendicular to the foliation. The strength perpendicular to the foliation was generally somewhat lower than the strength parallel to foliation.

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TABLE II. COMPRESSIVE STRENGTH OF DIFFERENT STONES

Source	Designation	Stone Compressive Strength (MPa)	
		Parallel to Foliation	Perpendicular to Foliation
Chinkurli	GN1	28	22
T.M.Hosur	GN2	70	32
Nagamangala	GN3	38	29
Doddabalapura	GR1	42	-
Kanakapura	GR2	82	-
Magadi	GR3	38	-

In the table 3, the masonry prism compressive strength of gneiss stones varies from 21.86 MPa to 37.56 MPa whereas the shear bond strength varies from 1.34 to 1.81 MPa. It is very interesting to note that the masonry prism compressive strength and shear bond strength of T.M Hossur stones shows very high strength of 37.56 MPa to 1.81 MPa respectively In case of igneous rocks, the nature of the grain structure has an important bearing on the strength of stone masonry.

TABLE 3. COMPRESSIVE STRENGTH AND SHEAR BOND STRENGTH OF STONE MASONRY PRISMS.

Designation	Masonry Prism Compressive Strength (MPa) 1:6		Shear bond strength of masonry prism (MPa)
	Parallel to Foliation	Perpendicular to Foliation	
GN1	21.86	19.93	1.49
GN2	37.56	26.315	1.81
GN3	25.96	24.335	1.34
GR1	24.00	-	1.57
GR2	30.63	-	3.07
GR3	23.22	-	1.60

In all the stone masonry prisms subjected to compression the failure was by vertical splitting cracks on all the four faces of the prism. In case of shear bond strength specimen the failure was at the interface of stone and mortar (Pure bond failure).

IV. CONCLUSION

From the results it can be observed that the masonry compressive strength with a particular cement mortar increases as the compressive strength of the stone increases. This study clearly shows that it is necessary to consider igneous granites where high masonry strength are needed for Civil Engineering applications. The role of fine-grained structures in imparting strength to the stone masonry is also fairly clear. The stone masonry strength is very large compared to the conventional brick masonry.

1. The masonry prism compressive strength and shear bond strength of the stones considered in this study varies from 19.93 MPa to 37.56 MPa and 1.34 to 3.07Mpa respectively. Gneiss masonry specimens showed greater strength when tested by applying the load parallel to the foliation than when tested by applying the load perpendicular to the foliation.
2. The compressive strength of stones has a definite relation with the geological characteristics which varies between 22MPa to 82MPa.
3. The compressive strength of stone masonry increases as the strength of the stone increases.

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4. Masonry Compressive strength of Equi-granular fine-grained stones possess higher compressive strength.
5. Stones can be conveniently used as a masonry unit for walls, domes, arches and vaults.

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