TO STUDY THE SUITABILITY OF MORTAR PROPORTIONS FOR SECOND CLASS BRICK MASONRY WITH RESPECT TO CONSISTENCY AND COMPRESSIVE STRENGTH

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ABSTRACT

Resulting masonry strength is combined strength of bricks and mortar used for construction. Monitoring in bricks preparation is not possible at every site, but in case of mortar it is possible. As well as in our country, there are several problems like non availability of river sand in a rainy season, shortage of cement, disposal of waste from power plants and industrial sectors. Now-a-days there is one more problem of environmental imbalance due to some human activities and over utilization of natural resources for fulfillment of human needs. This paper synthesizes findings from the literature review and experimental investigation carried out as per I.S.standards to evaluate the compressive strength of mortar cubes at 7,14 and 28 days,effect on strength with the application of different curring methods, effect on strength with use of natural and artificial (crushed) sand, effect on strength by using different binding material for replacement to cement like lime, flyash, surkhi with standard proportions of structural grades of mortar mixes with flow value of 112 mm. Experimental investigation in this paper results that membrane curing, use of pozzolana like flyash/surkhi and crushed sand gives more compressive strength and better consistency.

Keywords: Compressive Strength, Consistency, Flow Value, Pozzolana, Membrane Curing, Crushed Sand.

I. INTRODUCTION

As we know that, resulting masonry strength is combined strength of bricks and mortar used. But in our country, there are several problems like non availability of river sand in rainy season, shortage of cement supply, problems of waste treatment from power plant and industrial sectors. Hence for increase brick masonry strength we have to increase strength of brick as well as mortar. Brick strength is depend upon its composition material and these composition material and temperature monitoring is not possible at every brick manufacturing plant; But monitoring in mortar preparation is possible at every site and can be easily achieved by some precautions hence mortar is a key factor to increase masonry strength.

IS code gives us information about different mortar proportions for masonry construction but even though using these proportions there are several problems like cracks and disintegration of masonry. Because generally at site while construction workers use more amount of water for preparing a mortar and due to which
this undesirable practice may leads to form a problems like reducing masonry strength.

Now a days there is main problem of environmental imbalance due to some human activities and over utilization of natural resources for development and fulfillment of human needs. Use of river sand for construction may create problem in river route and flowing process also too much problem due to unwanted flyash from power station and surki from brick kiln. Henceforth to avoid environmental problem as well as to reduce construction cost by using waste product as substitute in construction acivity may leeds us towards a sustainable development.

Hence in this experimental programe we are going to study different type of mortar and their proportions with their performance in plasic as well as in hardened state.

II. LITERATURE REVIEW

Consistency of mortar increased with the increase of w/c ratio and with introduction of lime. However, sands grading only influenced the consistency of mortars without lime. Mortars manufactured with fine sands exhibited lower consistency due to the higher amount of water required to wet the solid particles [1]. Mortars with flow values ranging from 150mm to 200mm are suitable, 175mm recommended for the best consistency. The consistency was more sensitive to the variation of the w/c ratio than compressive and flexural strength. Increasing the w/c ratio does not seem to lower the compressive and flexural strength. Addition of lime in mortar makes the masonry more deformable [2]. Replacement of cement with natural clay pozzolanic significantly increased the strength of mortar [3].

Compressive strength increased with curing age for all fly ash replacements. Irrespective of fly ash percentage the compressive strength decreased at early age when compared to reference mortar. However, at later curing age mortars made with 5%, 10% and 15% showed higher strength than reference mortar. Similar to concrete the maximum efficiency was at 10% for mortars. However, the efficiency factor was higher for fly ash mortars than fly ash concretes up to nearly 20%, further increase in fly ash percentage reduced efficiency factor for fly ash mortars than fly ash concretes in terms of strength. Be assessed with a simple efficiency factor [4]. Mortars made with cement-lime mortars can have excellent workability with low levels of air entrainment. The water-retentive property of lime optimizes cement hydration and is beneficial for use on highly-absorptive masonry units. CL mortars resist penetration of liquid water through the wall. [5].

The high lime mortar is considered to have low bond strength, yet high extent of bond and durability; the high cement mortars are just the reverse [6]. The mining of sand from riverbeds is being regulated by the statutory authorities, as indiscriminate mining is causing damage to the environment. This has resulted in shortage of sand hampering the construction activity. Realizing the severity of the problem, the Governments of various States have allowed the use of Manufactured Sand (not Crusher dust), as an alternative to River Sand after establishing the performance of Concrete and Mortar containing Manufactured Sand as fine aggregates. A case study initiated by Karnataka Government at II Sc reveals that the characteristics of mortars and concrete using

Manufactured Sand as fine aggregate are superior when compared to mortars and concretes using natural river sand as fine aggregate. Manufactured Sand falling within the grading Zone II as specified by IS 383 manufactured from the hard rock is suitable as fine aggregate in concrete and masonry mortars. Also, IS-2116 and IS 383 codes permit the use of crushed stone fine aggregate in masonry mortars and concrete. In view of this, Manufactured Sand is recommended to be used as an alternative to River sand. This would easily take care of handling the scarcity of river sand and lead to lessening the impact of construction activity on the environment [7].

At the early ages, the strength activity index of fly ash due to packing effect is higher than due to pozzolanic reaction. Pozzolan S1 can provide a satisfactory substitute for fly ash and other natural pozzolans as tested against ASTM .It was clearly found to be effective in controlling ASR. It also produces about 15% less heat of hydration than Class F fly ash, whereas Class F fly ash produces about 30% less heat of hydration than Portland cement only [8]. A significant increase of strength of the mortars was achieved on the basis of the lime material basis, without using cement that was never used in buildings older than about 100 years. Perlite, the pozzolanic admixture chosen in this work for the improvement of mechanical properties of lime plaster was found to play a very positive role in this respect. In addition the most physical properties of newly designed lime-pozzolan mortar were found to be either comparable or even better than the respective properties of the classical lime mortars. [9].

The effect of partial replacement of natural sand by manufactured sand on the compressive strength of cement mortar of proportion 1:2, 1:3 and 1:6 with water cement ration as 0.5 and 0.55 are studied. Manufactured sand has a potential to provide alternative to natural sand and helps in maintaining the environment as well as economical balance. Non-availability of natural sand at reasonable cost, forces to search for alternative material. Manufactured sand qualifies itself as suitable substitute for river sand at reasonable cost. The manufactured sand found to have good gradation and nice finish which is lacking in natural sand and this has been resulted in good cohesive cement mortar [10].

The workability of mortar increases with partial replacements upto 80% and reduces upon complete replacement. The strength of M-sand mortar is high when compared to natural sand cement mortar at all replacement levels. Since workability of 100% m-sand cement mortar is less, but strength is more, use of admixtures can be made to achieve workability in par with natural sand cement mortar. The mortar with M-sand can be recommended for masonry work [11]. powder sand can be used for mortar as an alternative of sand. For mortar, mixture of sand and powder sand can be used as well as it showed better performance. Moreover, the economic value of powder sand is almost zero and generally is treated as waste. If it is used in making of mortar and concrete cost will be minimized as well as waste will be reduced [12]. The most commonly used and accepted method of testing pozzolanicity is by measuring the strength that a pozzolan imparts to a mortar. Strength enhancement is derived from the cementing calcium silicate hydrates formed in the reaction between pozzolan and lime. More reactive pozzolans result in higher strength mortars. Because strength is a property that is easily measured, strength testing yields very specific data (compressive strength = maximum load/surface area of test specimen) that can be compared to a non-pozzolanic control and can also differentiate between pozzolans to determine degrees of pozzolanicity. [13].

An improvement in the compressive strength, split tensile strength and flexural strength of concrete by addition of copper slag can be seen. The density of concrete increases with replacement of copper slag in concrete. There is increase in the flexural strength of the beam by 21% to 51% while replacement of copper slag. By partial replacement of sand by copper slag, the strength increase is observed up to 40% replacement. The 100% replacement of sand can be achieved by addition of fly ash along with quarry dust. For mortar, stone powder is well suitable to choose it as an alternative of sand. The availability of the stone powder is depends on the locality and its price is mar vary. If the stone powder is available in the market, it can be used as an alternative to sand and it is observed that concrete made stone chip will have higher compressive strength compared with that of concrete made with brick chips. This may be due to inferior quality brick chip, poor workmanship, and improper proportions of mixing. Since brick chip is inexpensive and normally available, hence used for the low strength structures [14].

Using membrane curing and saturated wet covering, one can achieve 80 to 90% efficiency (in terms of compressive strength) as compared to conventional water immersion method. Membrane curing is a practical and widely used curing method suitable in water scarce areas. Higher strength is the outcome of low water loss obtained using respective compound. As depicted from the test results, lower the water loss, more efficient is the curing and higher is the strength of the compound [15].

There in an increase in compressive strength of all the mortar mixes with 12% replacement of cement with pozzolanic material when compared to control mortar [16].

III. METHODOLOGY

- Step1- Determination of on site consistency.
- Step2- Deciding the mortar mix proportions.
- Step3- Determination of w/c ratios for different proportion w.r.t. the standard consistency (reference flow) .
- Step4- Preparation of mortar cubes for differnt mortar proportions at w/c ratio which give standard consistency.
- Step5- Determination of compressive strength at 7,14 and 28 days.
- Step6- Comparing the results and determining best mortar proportion for standard consistency from each type of mortar.

IV. EXPERIMENTAL INVESTIGATIONS

Experiment were conducted on standard grade mortar mixes like cement mortar, cement+lime mortar, cement+flyash mortar and cement+surkhi mortar of different proportions but of same consistency (flow value detrtmined by using flow table test). The mortar cubes of size 70.70mm X 70.70mm X 70.70mm are prepared and test them at 7,14 and 28 days for compressive strength. Results are compared between different type of curing method used and different type of sand used in preparation of mortar mix.

4.1 Material used

- **Cement-**

Patriculars	Information	Remarks
Grade	43	-
Type	Ordinary Portland Cement	-
fineness	Residue retain on sieve no.9 (90 micron) is 8 %	Ok (residue retain on sieve not exceed 10%by wt.)
Standard Consistency	143 ml	By using vicat's apparatus
Initial Setting Time	122 min	Ok (not less than 30 min)

- **Sand-**

Type I- Natural Sand (F.M.=2.56)

Type II- crushed sand (F.M.=3.89)

- **Flyash-**

Flyash used is collected from deepnagar electricity generation power plant. Flyash tested in laboratory to determine chemical composition of various constituents . The chemical composition of flyash is confirms to IS 3812-1981**(**Specification For Fly Ash For Use As Pozzolana and Admixture).

- **Surkhi (brick powder)-**

The finelly sieved brick powder is used as surkhi .The chemical composition of surkhi is conforms to the specification required for pozzolanas as a admixture or additives.

- **Water-**

Potable tap water is used for mixing. Water is free from dirt and suspended particals with normal pH value near to range 5 to 8.

4.2 Instruments and apparatus used:

- Flow table apparatus
- Moulds
- Oven
- Universal testing machine (UTM)

V. DETAILED PROCEDURE

1. First of all on-site consistency is determined by using flow table apparatus as shown in fig.1 from 10 different number of sites in locality.

Site designation	Flow values			Average Flow	Remark
	Batch I	Batch II	Batch III		
Site 01	111.25	117.50	128.75	119.20	Overall average flow at all the sites is 110.188 mm
Site 02	97.50	98.75	102.91	99.72	
Site 03	108.75	105.00	130.00	114.58	
Site 04	115.62	108.91	113.45	112.66	
Site 05	108.85	106.21	105.66	106.89	
Site 06	105.00	101.50	97.66	101.38	
Site 07	112.00	113.25	115.65	113.63	
Site 08	110.50	111.50	113.56	111.85	
Site 09	108.60	103.50	98.60	103.56	
Site 10	118.75	115.00	121.50	118.41	

Table.1.On Site Consistency At Different Sites

Fig.1. Flow Table Apparatus

As per IS 2250 , specified range of flow for masonary mortar must be between 110 to 115 mm.In this experimental studies the reference flow value is adopted by taking value between the range 110 to 115 mm.Reference flow for the experimental study is calculated as follow-

$$= \frac{110 + 115}{2} = \frac{225}{2} = 112.50 \text{ ...say } 112\text{mm}$$

The flow concluded is 112mm and it is used as a reference for calculating w/c ratio for selected proportion of mortar.

2 . Decide mortar mix proportions from standard mix as per IS code. In this experimental studies six types of mortar proportions were selected from IS 2250:1981 by considering different grades of mortar. The mortar proportions consisted of variety of mixes spanning from combination mortars of a) lime + cement, b) cement + pozzolana c) cement alone. It consisted of some lean,moderately rich and rich mixes. The grade of mortar mixes states the compressive strength at 28 day.

Designation	proportion	C	L	P	F.A.	Type of mortar
Mix 01	1:6	1	-	-	6	C
Mix 02	1:2:9	1	2	-	9	C+L
Mix 03	1:0.25:4	1	0.25	-	4	C+L
Mix 04	1:0.5:4.5	1	0.5	-	4.5	C+L
Mix 05	1:0.2:2	1	-	0.2	2	C+F
Mix 06	1:0.5:6	1	-	0.5	6	C+F
Mix 07	1:0.2:2	1	-	0.2	2	C+S
Mix 08	1:0.5:6	1	-	0.5	6	C+S

Table 2. Mix Proportions Used For Study

(C :Cement, L: Lime, P: Pozzolana, F: Flyash, S: Surkhi F.A.: Fine Aggregate.)

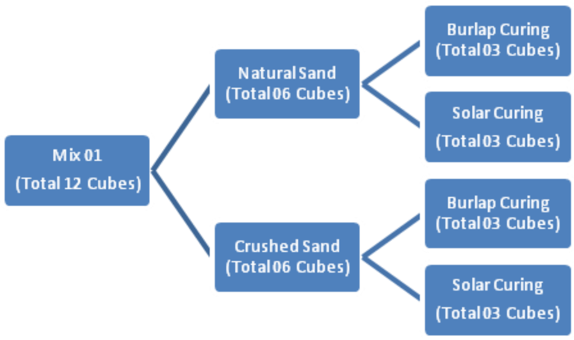
3 . Determination of w/c ratios for different proportion w.r.t. the standard consistency (reference flow) . The consistency was determined by Flow Table Test. For every proportion, w/c ratio required for 112 flow was determined and hence respective variation of w/c ratio required for a specific proportion was determined.

Sr. no.	Mix designation	proportion	Water / cement ratio at 112 mm flow	
			River sand	Crushed sand
1	Mix 01	1:6	1.25	1.07
2	Mix 02	1:2:9	2.89	2.72
3	Mix 03	1:0.25:4	0.99	0.855
4	Mix 04	1:0.5:4.5	1.156	1.07
5	Mix 05	1:0.2:2	0.66	0.50
6	Mix 06	1:0.5:6	1.45	1.13
7	Mix 07	1:0.2:2	0.60	0.51
8	Mix 08	1:0.5:6	1.37	1.025

Table 3. water/cement ratio at 112 mm flow for river and crushed sand for different mix proportions by flow table test

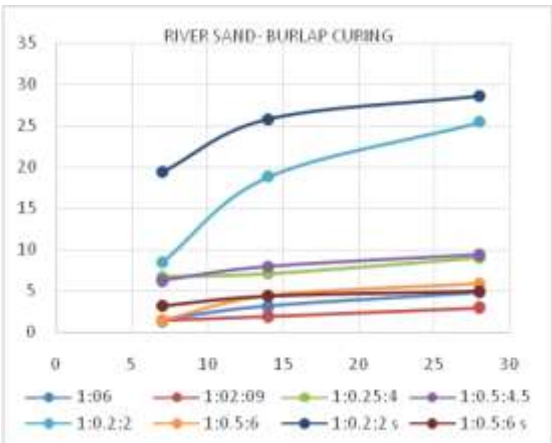
4 . Preparation of mortar cubes for diffrent mortar proportions at w/c ratio which give standard consistency. For each proportion total 12 cubes are casted by using standard cube mould of size 70.70 mm x 70.70 mm x 70.70 mm. out of which 6 cubes are prepared by using natural (river) sand and remaining 6 cubes are prepared by using crushed sand + stone powder.

5 . Determination of compressive strength at 7,14 and 28 days.



Mix designation	proportion	Compressive strength		
		7 th day	14 th day	28 th day
Mix 01	1:6	1.53	3.19	4.86
Mix 02	1:2:9	1.40	1.90	3.00
Mix 03	1:0.25:4	6.72	7.07	9.00
Mix 04	1:0.5:4.5	6.25	7.92	9.37
Mix 05	1:0.2:2	8.48	18.80	25.40
Mix 06	1:0.5:6	1.46	4.45	5.92
Mix 07	1:0.2:2	19.40	25.80	28.60
Mix 08	1:0.5:6	3.21	4.38	4.96

Table.4.compressive strength reading of mortar prepared by using natural sand and cured by burlap curing



Graph 1. River Sand – Burlap Curing (compressive strength on y –axis and number of days on x-axis)

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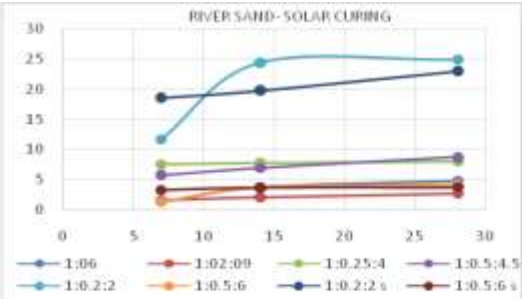
Mix designation	proportion	Compressive strength		
		7 th day	14 th day	28 th day
Mix 01	1:6	1.36	3.74	4.80
Mix 02	1:2:9	1.64	2.11	2.73
Mix 03	1:0.25:4	7.61	7.80	8.01
Mix 04	1:0.5:4.5	5.81	6.97	8.72
Mix 05	1:0.2:2	11.64	24.40	24.90
Mix 06	1:0.5:6	1.33	3.70	4.16
Mix 07	1:0.2:2	18.60	19.80	23.00
Mix 08	1:0.5:6	3.33	3.69	3.71

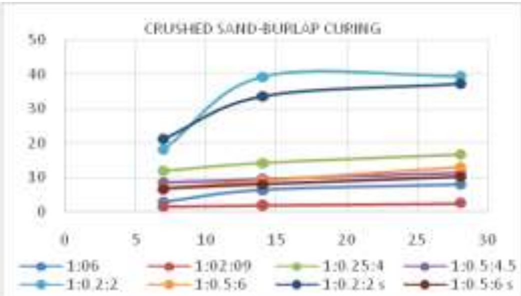
Table.5.compressive strength reading of mortar prepared by using river sand and cured by solar (membrane) curing



Graph 2. River sand – Solar curing (compressive strength on y –axis and number of days on x-axis)

Mix designation	proportion	Compressive strength		
		7 th day	14 th day	28 th day
Mix 01	1:6	2.88	6.47	8.07
Mix 02	1:2:9	1.49	1.91	2.50
Mix 03	1:0.25:4	11.93	14.30	16.83
Mix 04	1:0.5:4.5	8.61	9.54	11.40
Mix 05	1:0.2:2	18.29	39.40	39.60
Mix 06	1:0.5:6	6.78	9.00	13.00
Mix 07	1:0.2:2	21.36	33.60	37.20
Mix 08	1:0.5:6	6.79	8.06	10.29

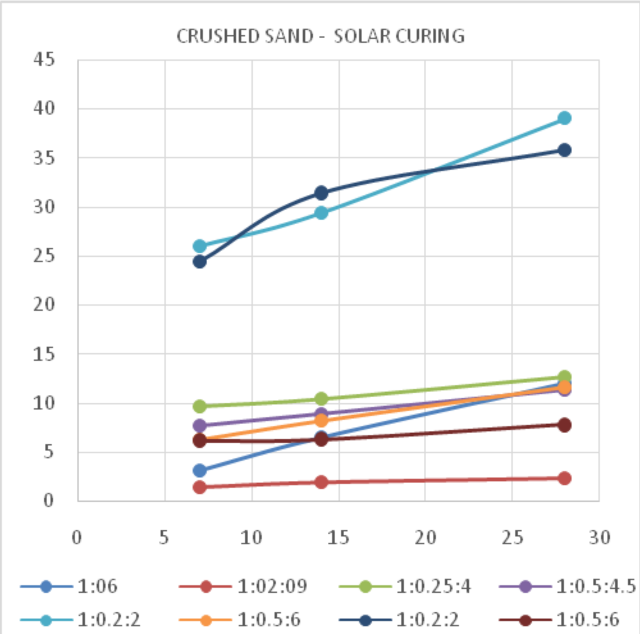
Table.6.compressive strength reading of mortar prepared by Using crushed sand and cured by burlap curing



Graph 3. Crushed Sand – Burlap Curing (compressive strength on y –axis and number of days on x-axis)

Mix designation	proportion	Compressive strength		
		7 th day	14 th day	28 th day
Mix 01	1:6	3.11	6.48	12.00
Mix 02	1:2:9	1.40	1.91	2.35
Mix 03	1:0.25:4	9.63	10.40	12.69
Mix 04	1:0.5:4.5	7.67	8.89	11.34
Mix 05	1:0.2:2	26.00	29.40	39.00
Mix 06	1:0.5:6	6.30	8.20	11.60
Mix 07	1:0.2:2	24.40	31.40	35.80
Mix 08	1:0.5:6	6.18	6.30	7.76

Table.5.compressive strength reading of mortar prepared by using crushed sand and cured by solar (membrane) curing



Graph 4. Crushed Sand – Solar Curing (compressive strength on y –axis and number of days on x-axis)

Fig.2. mortar cubes and solar(membrane) curing of cubes

VI. RESULTS AND DISCUSSIONS

- Irrespective of sand type and number of days allotted for strength gain, when the fly ash proportions were compared, 1:0.5:6 proportion exhibited lower compressive strength than 1:0.2:2.
- When fly ash is added in proportion 50% that of cement to 1:0.6 proportion, for river sand, there is a decrease in compressive strength and the decrement is by a minor amount. Whereas for crushed sand, the value again decreases but decrement is by a considerably large value. (1.5x to 2x)
- When the compressive strength of 1:0.5:6 proportion of fly ash and surkhi were compared, the 7 days strength was low of fly ash whereas it increased at 14 and 28 days readings.
- When the compressive strength of 1:0.2:2 proportion of fly ash and surkhi were compared in terms of curing type, for following sand types, following inferences were observed.
- For River Sand and Burlap Curing: The strength of fly ash is more than that of surkhi irrespective of number of days allotted for strength gain.
- For River Sand and Solar Curing: The strength at 7 days is more that of fly ash than surkhi, while for 14 and 28 days, it is less for fly ash.
- For Crushed Sand and Burlap Curing: The strength at 7 days is more that of fly ash than surkhi, while for 14 and 28 days, it is less for fly ash.
- For Crushed Sand and Solar Curing: The strength of fly ash is less than that of surkhi irrespective of number of days allotted for strength gain.
- On comparing proportion 1:6 (cement:sand) with 1:0.5:6 (c:p:s) we can observe that on addition of pozzolona the initial rate of strength gain is less (7 day strength) ,whereas the rate of strength gain is more for pozzolonic mixture thereafter.(14&28 days).

VII. CONCLUSION

- To attain the same level of consistency, the mortar proportions consisting of river sand requires higher water cement ratio than proportions consisting of crushed sand. (the increment from crushed to river observed is in range of 6.25%-33.66%).
- The mortar proportions consisting of surkhi requires less water cement ratio to attain same consistency than flyash.
- In each of the lime mortar proportions the rate of increase in flow decreases with increase in w/c ratio
- Strength gain in mortar proportions consisting of crushed sand has been observed more than that in river sand.
- In lime mortar proportions consisting of crushed sand, the compressive strength acquired in solar curing is less then burlap curing.
- In all proportion of pozzolona 28 days compressive strength observed for flyash is maximum for mortar proportions consisting crushed sand.
- For all mortar proportion rate of increase in strength gain decreases with time (except for lime mortar proportions).

- In pozzolanic mortar proportions (C:P:S) the initial rate of strength gain (upto 7 days) is higher in surkhi mortar proportions, whereas after 7 days the rate of strength gain is higher in flyash mortar proportions.

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