

Changes in Mix Proportions for the Cement Mortars with the Use of High Grade Ordinary Portland Cement

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Introduction

The latest technological developments in the manufacture of Ordinary Portland Cement have led to the production of high grade cements viz., 43 and 53 grades. The increase in strengths results in economy in consumption of cement in the production of concrete (1, 2). The mix proportions for the cement mortars which are now in use were fixed when only 33 grade OPC was available. Since then no modifications were made in the proportions of cement mortars used as a binder in masonry even after the introduction of high grade cements. Hence, there is a need for an investigation in the direction of fixing the mix proportions of high grade cement mortars.

This paper presents an experimental investigation carried out to know whether any changes can be made in the mix proportions of mortars with the use of high grade cements. In fixing the mix proportions with high grade cements the parameters selected were the flow value and compression strength of mortars.

Experimental investigation

The experimental programme consisted of casting and testing of 342 mortar cubes, prepared as per IS practice. Three nominal mixes with 33 grade cement viz., 1:2, 1:3, 1:4 are considered for study. The reason for selecting the above three mixes for study is owing to the fact that the requirement of cement in making these mixes is considerable and if any reduction in the cement consumption due to the use of high grade cements will be economical. In order to arrive at an equivalent mix proportions for the above three types of mixes, eight different mixes were selected for study. For each of the mixes three different water cement ratios were selected in order to arrive at a constant flow value while fixing the equivalent proportions.

The sand conforming to IS 650 was used as a fine aggregate in all the cement mortar mixes. The details of various mixes adopted in the investigations are given in table 1.

Measurement of flow value

The flow value of the mortar was measured as per IS 5512 using flow table. The flow values obtained are expressed in percentage. Fig. 1 shows the flow value versus percentage of water content used for 33 grade cement mortar. Similarly the flow values of high grade cement mortars were noted for different mix proportions with different percentages of mixing water.

Table 1 - Details of mix proportion adopted in the investigation

Grade of Cement	Mix Proportion	Percentage of water	No. of mortar cubes tested
33 grade	1:2, 1:3, 1:4	11,13,15	54
43 grade	1:2, 1:2.5, 1:3, 1:3.5, 1:4, 1:4.5, 1:5, 1:5.5	11,13,15	144
53 grade	1:2, 1:2.5, 1:3, 1:3.5, 1:4, 1:4.5, 1:5, 1:5.5	11,13,15	144

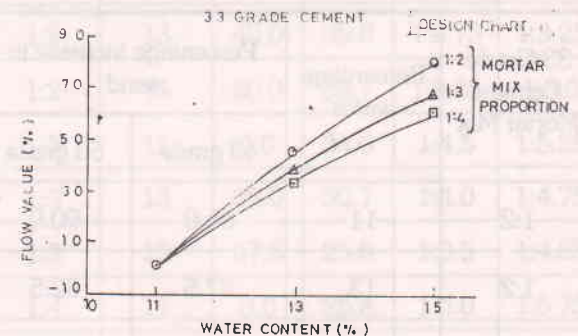


Fig. 1 Flow value vs water content

Testing

All the cured mortar cube specimens were tested on Tinius Olsen Testing Machine of 2000 kN capacity for obtaining 28 day compressive strength. Fig. 2 shows the compressive strength versus percentage of water used for 33 grade

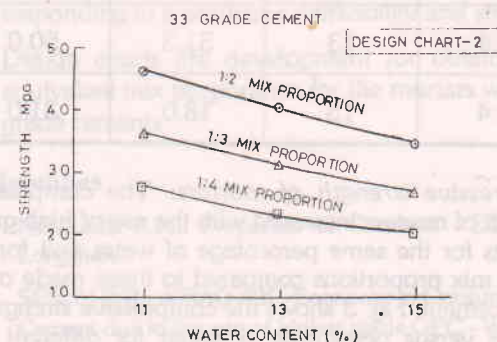


Fig. 2 Compressive strength vs water content

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reference cement mortars. Similarly the compressive strength of high grade mortar mixes for different percentages of water were obtained.

Interpretation of Results

Effect of high grade cement on

Flow value of mortars: The flow values have increased for the same percentage of water and for the similar mix proportions with the use of high grade cements. This indicates that the requirement of water can be reduced in case of mixes with high grade cements without effecting the workability of the mix. This is advantageous from the point of view of permeability. Also the flow value decreases with the increase in sand content for the same percentage of water. This indicates that the sand content in the mortars with high grade cement can be increased without effecting the workability. Table - 2 shows the percentage increase in the sand in mortars with high grade cements.

Table 2 - Percentage increase in sand in mortars with high grade cements

33 Grade Cement Mortar Mix	Percentage water	Percentage increase in sand	
		43 grade	53 grade
1:2	11	55.0	90.0
1:2	13	37.5	62.5
1:2	15	22.5	50.0
1:3	11	50.0	75.0
1:3	13	33.0	58.0
1:3	15	19.7	41.7
1:4	11	50.0	69.0
1:4	13	31.3	50.0
1:4	15	18.0	31.0

Compressive strength of mortars: The compressive strength of mortars increased with the use of high grade cements for the same percentage of water and for the similar mix proportions compared to those made of 33 grade cement. Fig. 3 shows the compressive strength of mortars versus percentage of water for different mix proportions made with different grades of cement. This indicates that the sand content in the mortar mixes with high grade cements can be increased without affecting

the strength. This leads to economy in consumption of cement for a given volume of mortar.

Design chart for use of fixing equivalent

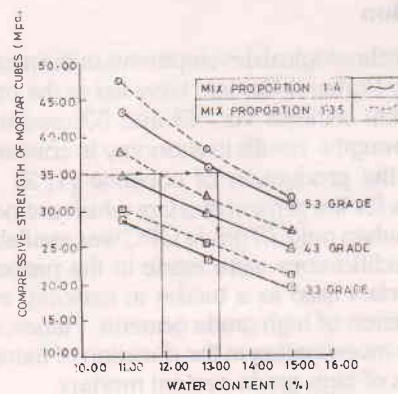


Fig. 3 Compressive strength of mortar cubes vs water content

mix proportions for mortars made with high grade cement

The results obtained from the experimental investigations were made use in preparing a set of design charts which are useful in fixing equivalent mix proportions for mortars made with high grade cements without affecting workability and strength. Such design charts are presented in Fig. 4 to 9. The procedure to be followed in arriving at equivalent mix proportions of high grade cement mortars is explained below with an example.

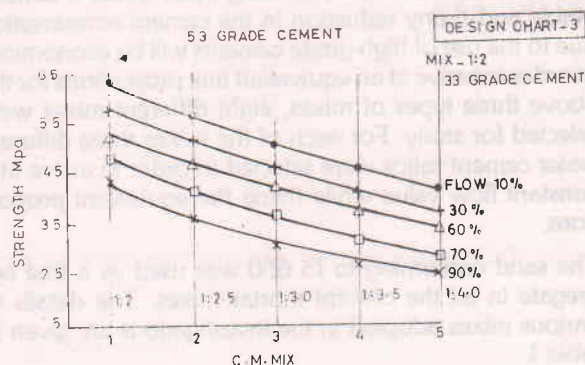


Fig. 4 Compressive strength of mortar cubes vs mix proportion

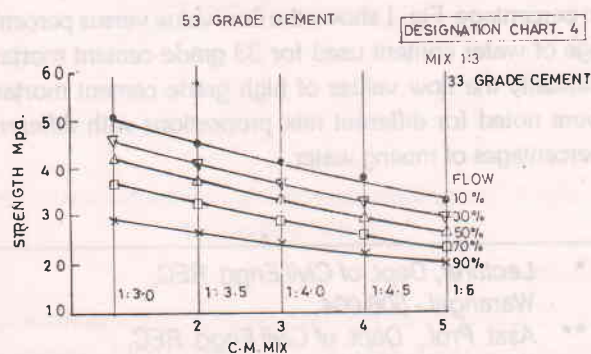


Fig. 5 Compressive strength of mortar cubes vs mix proportion

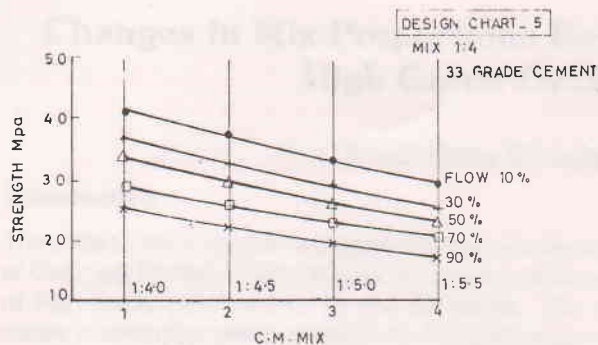


Fig. 6 Compressive strength of mortar cubes vs mix proportion

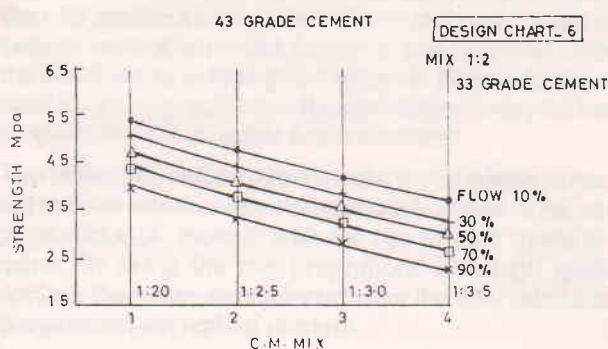


Fig. 7 Compressive strength of mortar cubes vs mix proportion

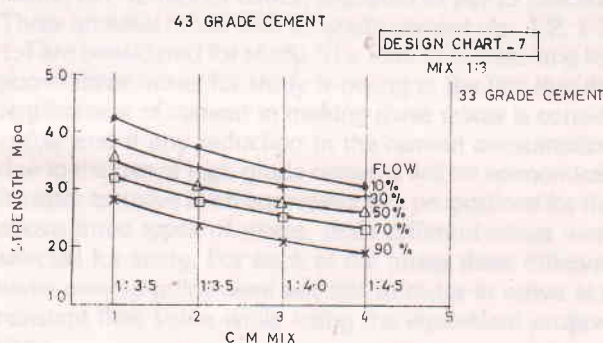


Fig. 8 Compressive strength of cement mortar cubes vs mix proportion

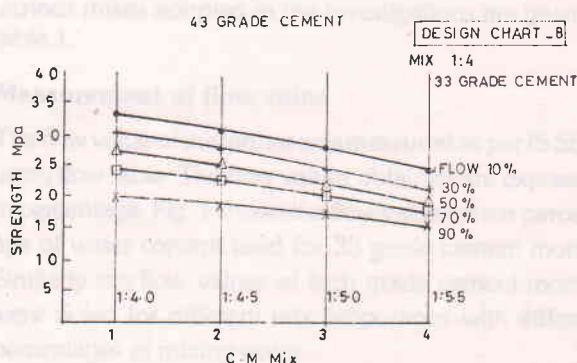


Fig. 9 Compressive strength of cement mortar cubes vs mix proportion

Example

If 1:2 is a nominal mix with 33 grade cement, obtained an equivalent mortar mix made with 53 grade cement for a flow value of 50%.

Procedure

- From the Fig. 1, obtain the percentage of water content for 50% flow value and 1:2 mix proportion. (mix made with 33 grade cement)
- Obtain the compressive strength value for the known percentage of water as obtained in step 1 and for 1:2 mix proportion with 33 grade cement using Fig. 2.
- Read out the equivalent mix proportion for 53 grade cement, for the required strength and flow value from the Fig. 4.

Table 3 shows the equivalent mix proportions with high grade cement for the mixes made with 33 grade cement.

Table 3 - Mix Proportions with high grade cement mortars

Mix proportions with 33 grade cement	Percentage of water	33 Grade Cement		Equivalent Mix Proportion with	
		Flow (%)	Strength (MPa)	43 Grade	53 Grade
1:2	11	0.0	45.2	1:3.1	1:3.8
1:2	13	40.0	39.0	1:2.75	1:3.25
1:2	15	80.0	33.7	1:2.25	1:3.0
1:3	11	0.0	34.0	1:4.5	1:5.25
1:3	13	35.0	30.7	1:4.0	1:4.75
1:3	15	67.5	25.8	1:3.5	1:4.25
1:4	11	0.0	25.8	1:6.0	1:6.75
1:4	13	30.0	22.8	1:5.25	1:6.0
1:4	15	60.0	19.3	1:4.75	1:5.25

Conclusions

- The use of high grade cement results in changes in the mix proportions of the 33 grade cement mortars.
- The quantity of cement in the cement mortar mixes reduces with the use of high grade cements corresponding to a particular workability and strength.
- Design charts are development for obtaining the equivalent mix proportions for the mortars with high grade cements.

References

1. NAVILLIE A.M., Properties of Concrete - ELBS with Longman.
2. SESHU D.R., & RAO A.K., Economy in Consumption of Cement due to the use of higher grade OPC - Workshop on advances in cement and concrete technology, Aug - 1995, IIBE, Secunderabad.