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Compressive Strength of Concrete using Different Mix Design Methods

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ABSTRACT *Concrete mix design is the process of choosing suitable ingredient of concrete and determining their relative quantities with the object of producing as economically as possible concrete of certain minimum properties, notable workability, strength and durability. It should be explained that an exact determination of mix proportions by means of table or computer data is generally not possible. The main objective of the study was to design M25 concrete mix and find the compressive strength using different mix design methods like IS10262-1982, IS 10262-2009, ACI method and DOE method. We conclude that in above four methods minimum cement content used in DOE methods and it gives desire compressive strength of concrete economical way .*

Introduction

The design of concrete mix is not a simple task on account of the widely varying properties of the constituent materials. Mix design is the process of determining the appropriate proportions of cement, fine aggregate, coarse aggregate, water and admixtures if any which will satisfy the requirements of compressive strength, workability and durability. The purpose of designing as can be seen from the above definitions is two-fold. First object is to achieve the stipulated minimum strength and durability. Second object is to make the concrete in the most economical manner. The basic assumption made in mix design is that the compressive strength of workable concrete is, governed by the water cement ratio. Another most convenient relationship applicable to normal concretes is that for a given type, shape, size and grading of aggregates, the amount of water determines its workability. However, there are various other factors which affect the properties of concrete, for example, the quality and quantity of cement, water and aggregates; batching; transportation; placing; compaction; curing; etc.

Therefore, the specific relationships that are used in proportioning concrete mixes should be considered only as a basis for trial, subject to modifications in the light of experience as well as for the particular materials used at the site in each case. The recent development of using chemical and mineral admixtures in concrete has not alerted the applicability of the age-old Abram's water-cement ratio 'law', and the compressive strength of concrete is governed by the water-cement ratio materials ratio used in concrete. The cementations materials include cement (OPC, PPC and PSC) and mineral admixtures, like, fly ash, GGBFS, metakaolin and silica fume.

Concrete has to be of satisfactory quality in both the fresh and hardened states. The task of proportioning concrete mixes is accomplished by the use of certain established relationships which afford reasonably accurate guidance for selecting the best combination of ingredients so as to achieve his desirable properties of the fresh and hardened concrete. Out of all the physical characteristics of concrete, compressive strength is often taken as an index of its quality in terms of durability, impermeability and water tightness and is easily measurable. Therefore, the mix design is generally carried out for a particular compressive strength of concrete, coupled with adequate workability, so that the fresh concrete can be properly placed and compacted. In addition, the mix proportions are also checked against the requirements of adequate durability for the type of exposure condition anticipated in service. This standard lays down the recommended procedure for designing concrete mixes for general types of construction using the concreting materials normally available. The design is carried out for a desired compressive strength and workability of concrete, using continuously graded aggregates. This standard does not include the design of concrete mixes for flexural strength or when gap-graded aggregates or various admixtures and pozzolana are to be used. If the performance of the mix found not satisfactory, then the mix shall be modified with the consultation of contractor Designer/Expert to get the mix of required properties. Then only the mix should be allowed to be used in the construction. This may be noted any change of materials, site conditions and climate again will required modifications in the mix to give concrete of required properties and specifications.

Objective The main objective of the study was to design M25 concrete mix and find the compressive strength using different mix design methods like IS10262-1982(1), IS 10262-2009(2), ACI method (5) and DOE(5) method and deciding the most economical method of design.

Materials and methodology :

- **Cement:**

53 grade ordinary portland cement (OPC), with specific gravity 3.15, initial setting time 120 minutes and final setting time 220 minutes, and 7 day compressive strength of 29N/mm^2 and 28 day compressive strength of 54N/mm^2, complying with IS: 12269 – 1987 was used.

- **Fine aggregates:**

Locally available sand with specific gravity of 2.67, falling under the zone-II, complying with IS: 383 – 1970(4) was used.

- **Coarse aggregates:**

Locally available coarse aggregates of 12mm and down size having a specific gravity of 2.74, complying with IS: 383 – 1970(4) was used.

The mix design was carried out for M25 grade concrete as perIS:10262-1982, IS: 10262-2009 , ACI and DOE method of mix design which yielded the following proportion as given in table 1. The cement, sand and coarse aggregates were weighed according to the proportions of different methods. The required amount of water(5) was added to this dry mix and intimately mixed. Then the mix was placed layer by layer in the moulds to cast the specimens. The specimens were prepared both by hand compaction as well by imparting vibrations through vibrating table. The specimens were fin-

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ished smooth and kept under wet gunny bags for 24 hours after which they were cured for 3 days, 7 days and 28 days. After curing, they were tested for their compressive strength as per IS specifications on standard cube specimens of 150 x 150 x 150 mm .

The mix design was carried out for M25 grade concrete as per IS: 10262-1982, 10262-2009 , ACI and DOE method which yielded a proportions as given as following.

Table 1. Mix proportion

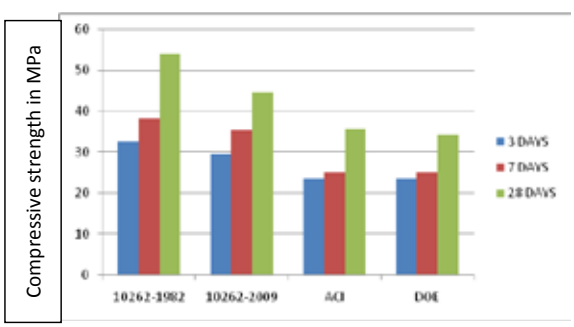
Mix design method	Cement kg/m^3	Fine Aggregate kg/m^3	Coarse Aggregate kg/m^3	Water kg/m^3
IS10262-1982	387.6	649.49	1172.95	193.81
IS 10262-2009	394.3	680	1248	197.2
ACI method	393.62	887.13	992.0	185.0
DOE method	375	553.5	1291.5	180.0

Observation and discussion

Average compressive strength results using different methods of mix design.

Mix Design Method	3 DAYS N/mm^2	7 DAYS N/mm^2	28 DAYS N/mm^2
10262-1982	32.59	38.22	54.07
10262-2009	29.74	35.55	44.73
ACI	23.7	24.99	35.84
DOE	23.7	24.99	34.22

Figure 1 Compressive Strength Graph



Conclusions

Based on the analysis of the above methods of mix design following conclusions can be drawn:

1. The compressive strength in decreasing order are found as follows for the different methods IS10262-1982, IS 10262-2009, ACI method and DOE method.
2. It is seen that the IS 10262-1982 mix design method gives higher strength but also consumes more cement and has much higher factor of safety.
3. DOE methods gives desire compressive strength of concrete in economical way, thus being the most economical method of design.
4. The fine aggregate content in ACI method is higher compared to new BIS method.
5. Coarse aggregate is substantially more with BIS method. Thus, ACI mix will lead to higher workability. Presumably, it would also contribute to increased strength as the voids are filled by fine aggregate.
6. In the case of BIS, fine aggregate content is reduced as the design strength requirement goes up. Therefore voids are likely to be higher for high strength concrete which may lead to decreased strength in such cases.
7. We conclude that in above four methods minimum cement content used in DOE methods and it gives desire compressive strength of concrete economical way for both the tests.

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