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Assessment of Mix Design for Government Project

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***Abstract*: In this paper a study on mix design of Indian standard method IS 10262-2019, IS 456:2000 has been made for M20, M25 grades and the comparison of water-cement ratio water content, cement content, fine aggregate and coarse aggregate content has been observed and done and been presented. It was concluded that new revised version of Indian Standard code has the lowest value of water/cement ratio and highest quantity of cement as compared to other standards. Concrete mix-design is the method to transform the required engineering properties into the composition of the concrete mixture in terms of kg/m^3 of cement, water, sand and coarse aggregate. There are two types of mix-design depending on the complexity of the required performances: simple or complex mix design. Complex mix design also includes the calculation of the slump loss depending on the time and temperature transportation, as well as the presence of chemical admixtures. The reason of enormous use of concrete from many years is its universal versatility, economy, ease in mould to any shape and good durability. Also, ingredients of concrete are easily available in any part of the country.**

***Keywords*: Cement (OPC 53), sand, aggregate, chem bond.**

1. Introduction

Concrete is one of the most consumable construction materials on the earth. The concrete constitutes cement, sand, gravel, water and/or additives in definite proportions. The proportions of raw materials of concrete are decided by the concrete mix design. The mix design depends on the various factors. For mix design, most of the countries have their own specifications. In the present study, standard guidelines of India, Britain and America for the concrete mix design have been discussed. The concrete grades of M20, M25 and M30 were designed and compared. Indian Standards were also compared. Concrete is made up of cement as binder, aggregates as inert materials, water and admixtures (optional) in a definite proportion. The proportions of ingredients in concrete mixtures are determined by mix design. Concrete mixes are classified as nominal mix and design mix. Nominal mix is adopted for small scale constructions while design mix concrete is adopted for important or large-scale construction work. Concrete mix design is a technical procedure to select the suitable proportions of ingredients to achieve the required strength or performance to satisfy the job requirements i.e., workability, strength and durability etc. This definite proportion of materials in the concrete mixtures has important role in quality of end product. This proportion of ingredients is expressed ratio wise i.e., 1:3:6 represents 1 part of cement, 3 parts of fine aggregate (FA) and 6 parts of coarse aggregate (CA). water-cement ratio (w/c) or any additives are expressed separately. The purpose of mix proportioning is to obtain the most economic and practical combination of readily available materials; which satisfy the performance of concrete. Basic data required for the mix proportioning are concrete grade, type and content of cement, maximum nominal size of aggregates, maximum water-cement ratio (w/c), slump. Mixture proportioning is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete having certain minimum workability, strength and durability as economically as possible. Mixture proportioning is to determine the most economical and practical combination of readily available materials to produce a concrete that will satisfy the performance requirements under particular conditions of use. Concrete mix design is step by step procedure to work out the various proportions of the ingredient.

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance. The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g., quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

2. Laboratory Test

A. Cement Test

1) Consistency test

Consistency test of cement is conducted to determine the

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quantity of water required to produce a cement paste of standard or normal consistency for use in other tests. This test is performed with the help of Vicat's Apparatus, Standard or normal consistency of a cement paste is that consistency which will permit the Vicat plunger (10 mm in diameter & 40-50 mm in length) to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.

2) Initial and Final setting time test

When cement is mixed with water is stiff and sticky paste is formed. This cement paste remains plastic for a short period. As the time lapses, the plasticity gradually disappears and the paste changes into a solid mass. The phenomenon by virtue of which the cement paste changes from a plastic state to a solid-state is known as the setting of cement. The time to reach this stage is known as setting time. The time is reckoned from the instant when water is added to the cement. The setting time is divided into two parts namely initial setting time and final setting time. The time at which the cement paste loses its plasticity is termed the initial setting time. The time is taken to reach the stage when the paste becomes a hard mass is known as the final setting time. The initial and final setting time test on cement is performed with the help of Vicat apparatus. The initial setting time of cement shall be the time from the period elapsing between the time when the water is added to the cement and the time at which the needle (1 mm square or 1.13 mm in dia and 40 to 50 mm in length) penetrate to a point 5 mm from the bottom of the Vicat mould.

3) Soundness test

Soundness test of cement is performed to identify the presence of excess free lime and magnesia in the cement. This test is performed with the help of Le-Chatelier apparatus.

4) Compressive strength test

The cube is tested by placing it under the Jaws of the compressive testing machine. The load is steadily and uniformly applied. The load at which the cube is fractured is noted in each case. The compressive strength is calculated by dividing this load by the cross-sectional area of the cube.

B. Sand Test

1) Sieve analysis

Sieve analysis is an analytical technique used to determine this particle size distribution of granular material with macroscopic granular sizes. This sieve analysis technique involves the layering of sieves with different grades of sieve opening sizes. This finest sized sieve lies on the bottom of the stack with every layered sieve stacked above in order of increasing sieve size.

2) Specific gravity and water absorption test

Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregates.

The main objective of these test is to,

1. To measure the strength or quality of the material.
2. To determine the water absorption of aggregates.

Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. It is the measure of strength or quality of the specific material. Aggregates having low specific gravity are generally weaker than those with higher specific gravity values.

C. Aggregate

1) Sieve analysis

Same as per 2.B(1)

2) Impact Value and crushing value

It is the ability of aggregates that resist sudden impact or shock load on it. Also, it can be defined as the resistance of aggregate to failure by impact load is known as the Impact Value of Aggregate. The characteristic of any material to resist sudden impact is known as toughness. When we use aggregate in roads and pavement on which vehicular movement is done and there is a possibility of impact load on aggregate. This impact load can break aggregate into smaller pieces and which results in the failure of roads and pavements. Therefore, the aggregate used for such a proposal should have sufficient toughness to resist their disintegration due to the impact. This important property of aggregate is determined by the aggregate impact value test. This resistance of aggregate may differ from resistance to gradual load which we measure in the crushing value test.

3) Flakiness and elongation value

Flakiness and Elongation Index Test are very important tests to be performed on aggregate in the laboratory. This test gives the percentage of flaky and elongate aggregate present in the total aggregate sample. Aggregate shape, size, and surface texture majorly affect the properties of freshly mixed concrete more than the properties of hardened concrete. Angular, flaky, rough-textured, and elongated aggregate particles require more water to produce workable concrete than the smooth, rounded compact aggregate. Also, such irregular–shaped aggregate cement content must also be increased to maintain the water-cement ratio. Elongated and flaky aggregate, when used in the construction of pavement may result in failure of the pavement due to their random position under repeated loading and vibration. It is important to keep the amount of flaky and elongated aggregate within permissible levels.

3. Experimental Program

Experimental and examination have been carried out to determine the compressive strength of concrete.

A. Materials Used

Cement (Wonder OPC 53 Grade), Course Aggregate,Fine Aggregate(Natural And Artificial Sand), Admixuture-Chem bond.

B. Mix Design

Since there are various method for concrete mix design procedure, We are using here standard method (I.S. Method).

1) Water content

IS 456 maximum water-cement ratio 0.50 and 0.45 is adopted. Similarly, as per table 2 of IS 10262 water content for the 20 mm aggregate is adopted as 186 kg (for 25 to 50 slump).

2) Cement content

As per we get water cement ratio 0.45 and water content 186

kg, cement content has been got as 416.62 kg i.e. nearly 400 kg. It is checked, as per table 5 of IS 456 clause 8.2.4.2, which says cement content should be less than 450 kg.

3) Proportion volume of aggregate content

Air content in concrete as per IS 10262: 2019 table no.3 for 20mm aggregates: 0.01 cum.IS 10262-2009, volume of coarse aggregate corresponding to 20 mm size of fine aggregate (zone I). Then total volume of aggregate investigates as subtracting difference between volume of cement and volume of water from 1 cubic meter volume of concrete. Which results in 0.69 cubic meter.

4) Mass of coarse and fine aggregates

From the found total volume of aggregate 0.69 m^3, mass of coarse aggregate got by product of total volume of aggregate, volume of coarse aggregate, specific gravity and 1000.

Mass of coarse aggregate=723.83kg/m^3

Mass of fine aggregate=713.18 kg/m^3

4. Results, Discussion and Conclusion

- For the M – 20 and M-25 Grade of concrete, we have a target mean strength of 26.66 N/mm² and we have OPC – 53 grade of cement.
- As per our cement grade OPC -53, we have to follow Curve 3. From the graph, for 26.66 N/mm² concrete strength at 28 days bisect the curve 3 at 0.62 free water-cement ratios.
- Where supplementary cementitious materials are used, that is, mineral admixtures, the water cementitious materials ratio (w/cm) shall be calculated, in accordance with Table 5 of IS 456 and this w/cm shall be as per Table 3 and Table 5 of IS 456 or as specified.

Suggestion:

- Always prefer a higher water-cement ratio for your concrete because IS code tests and studies are done in a controlled manner in laboratories which procedure and care are not possible on construction sites. So, my suggestion is to select a higher water-cement ratio for your concrete grade. (Higher means, for M -20 grade of concrete IS code indicates 0.62, select 0.5 less that is 0.45).
- 150*150*150MM of size of mould to cast specimens for compressive strength testing.
- Combination of 20 and10 mm sizes of C.A. were used.
- The specimens were used, the specimens were cast, tested in compressive testing machine at the age of 3,7 and 28 days after curing.

For determining of the compressive strength at the end of 3 days, 7 days and 28 days, the cube specimens had been tested. The same specimens were tested once surface of the specimen dried. The load was applied on the smooth sides while not shock and redoubled unceasingly till the failure of the cube specimens. The maximum load resistivity by specimens is noted, mean compressive strength is determined by,

Table 1

3 Days cube testing result	26.64N/mm^2
7 Days cube testing result	35.45N/mm^2
28 Days cube testing result	56.67N/mm^2
Average	39.58N/mm^2

It is ascertained that each of the 3 days, 7 days and 28 days compressive strength results for the concrete mixing with chembond give most end in compressive strength compared to conventional concrete.

Table 2

3 Days cube testing result	7.992N/mm^2
7 Days cube testing result	18.66N/mm^2
28 Days cube testing result	56.67N/mm^2
Average	27.774N/mm^2

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