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A Review on Optimizing M70 Grade Concrete Mix Design with Fly-Ash (IS: 10262 – 2019)

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***Abstract*: The main object of this paper is to design a mix for High-strength concrete (HSC) of M70 grade concrete for various water-to-cement ratios using proper proportion, admixtures, and manufactured sand with the required workability of concrete to adopt any shape and develop strength on hardening had made one of the most versatile materials on the earth. Concrete comprises various ingredients that help create a good matrix of it. Concrete ingredients affect its various characteristics like strength, durability, etc. High-strength concrete has a compressive strength of up to 100 MPa compared to conventional concrete, which has a compressive strength of less than 40 MPa. The low water-cement ratio is a crucial aspect that can be achieved using chemical admixtures such as superplasticizers. The study follows the IS Method of Concrete Mix Design as per IS Code 10262:2019. Also, in the design mix of HSC, the fly ash was used at various percentage replacement levels, i.e., 15%, 17.5%, and 20%, respectively.**

***Keywords*: HSC, Mix design, W/C, Fly ash replacement, Chemical admixtures.**

1. Introduction

The topic of this project is "Optimizing M70 Grade Concrete Mix Design with Fly Ash by IS: 10262 – 2019". This involves developing a concrete mix that meets the specific requirements of M70 grade concrete, characterized by its high compressive strength of 70 MPa. The inclusion of fly ash, a byproduct of coal combustion, is explored to enhance the properties of the concrete mix while promoting sustainability. The basic concept of sustainable construction and development for civil engineers is employing high-performance materials at a reasonable cost that imparts a lesser environmental impact. The environmental impact can be minimized by decreasing the production of waste and emission of harmful greenhouse gases, making efficient use of minerals, and increasing the use of recycled materials like aggregates, etc. A well-known material is Portland cement which is used as a binder material in most construction practices around the globe. But, magnifies - Turing the same factories results in the discharging of huge volumes of carbon dioxide gas into the atmosphere, which results in the greenhouse effect and induces global warming.

2. Relevance

High-strength concrete (HSC) is essential in modern construction due to its superior Quality and Strength. It is ideal for high-rise buildings, bridges, and other infrastructure projects that require robust structural integrity. Utilizing fly ash in concrete improves its mechanical properties and durability and addresses environmental concerns by reducing the reliance on Portland cement, whose production is a significant source of carbon dioxide emissions. This study is particularly relevant as it aligns with sustainable construction practices & contributes to advancing high-performance materials in the construction industry.

3. Literature Review

Karade et al. (2019) [3] - Superplasticizers made of ether are used in the HSC to increase workability without using more water. Superplasticizers based on ether are frequently used in India since they are efficient and inexpensive. The impact of several ether-based superplasticizer kinds and dosages on the workability and compressive strength of HSC was examined in a study by Karade et al. (2019) [3]. The study discovered that 2% by weight of cement was the ideal superplasticizer dosage and that the type of superplasticizer had no discernible impact on the compressive strength of HSC.

Jadhav et al. (2017) [1] - A byproduct of burning coal, fly ash is readily accessible in India. Its use in concrete has been demonstrated to enhance workability, lower the need for water, and boost strength. The impact of fly ash on the compressive strength of HSC was examined in a study by Jadhav et al. (2017) [1]. According to the study, a 30% weight replacement level of fly ash in cement produced a 28-day compressive strength of 80 MPa.

J. Chena et. al. [1] (2017). The author studied the production of high-performance concrete by adding fly ash. Concerning the packing model of concrete materials, adding fly ash microspheres (FAM) to fill the voids between cement grains would further reduce the water content and achieve the desired flowability. This could allow the adoption of a lower water/cementitious materials (W/CM) ratio to produce High-Performance Concrete (HPC). This study aimed to evaluate the

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effects of FAM and CSF on cementitious material's packing density and the cement paste's flowability and strength. The results showed that adding FAM and CSF can significantly increase the packing density, thereby enhancing flowability and strength performance concurrently.

Basha et al. (2017) [4]. Scholars have extensively researched the mixed design of HSC employing fly ash and ether-based superplasticizers. A mixed design for HSC was suggested in a study by Basha et al. (2017) [4] with a goal compressive strength of 90 MPa. The mix design consisted of 180 kg/m3 of fly ash, 70 kg/m3 of silica fume, and 0.75% by weight of cement-based superplasticizer. According to the investigation, the mix design produced 92 MPa of compressive strength after 28 days.

B. Krishna Kumari Bai and M. Kanta Rao (2015) - did a detailed study on the effect of fly ash, SF, and its combinations on the strength and durability properties of HPC. Fly ash was replaced with cement by various percentages, i.e., 5%, 10%, 15%, 20%, 25%, and SF as an addition of 10% by weight of cement for a w/b ratio of 0.32.

Swati Choudhary et al. [3] (2014) - The author studied High-Performance concrete (HPC) has immensely increased due to the utilization of large quantities of concrete, thereby leading to the development of infrastructure Viz., Buildings, Industrial Structures, Hydraulic Structures, Bridges and Highways, etc. This paper includes a detailed study of the recent developments in high-performance concrete, stressing more about earthquake-prone areas.

Shriram H. Mahure. - The fresh and hardened properties of self-compacting concrete using Fly ash 2014. The author studied the fresh and hardened properties of self-compacting concrete using Fly ash as a partial cement replacement in different percentages in addition of filler.

Viatceslav Konkov et. al. [4] (2013). The author studied Principle Approaches to High-Performance Concrete Application in Construction. The design of high-performance concrete compositions and the optimal application of this material in the field of erecting unique buildings and constructions, such as in large-scale construction, are discussed in the article. Requirements for high-performance concrete are set; the present practice of its application in modern construction is described. Constantly growing standards for physical and mechanical properties of buildings and structures erected so for their maintenance, including issues of safety and ecological matters, determine increasing requirements for functional characteristics of construction materials.

Yves F. Houst et.al. [5] (2008) - The author studied on design and function of novel superplasticizers for most durable high-performance concrete. In this article, we shall describe our quest and ultimate success in furthering our understanding of the action of superplasticizers on the theology of cement and concrete.

M. Mazloom et al. (2004) have done experimental work on the short and long-term mechanical properties of HSC at different levels of silica fume. The mixes were made with a fixed water-to-binder ratio of 0.35. The cement is replaced by silica fume at 0%, 6%, 10%, and 15% percentage levels. From the results, it was concluded that higher replacement of silica fume requires a dose of superplasticizer.

4. Proposed Work

Preparing M70 grade concrete using IS: 10262-2019.

5. Methodology

The methodology of the present work are,

1. We have taken mix design of m70 grade concrete through IS code 10262:2019. We have studied it thoroughly and deeply the design of m70 grade with the help of IS code.
2. Literature survey is carried out for designing concrete mix.
3. We did test of the materials i.e. specific gravity of cement, Crushed Sand, Aggregate, Fly Ash, Water & Chemical admixture (Cera Plast 300 PS):

a. *Cement:* The specific gravity of cement is 3.14.

Fig. 1. S.G. of cement

b. *Crushed Sand:* The specific gravity of Crushed Sand is 2.66.

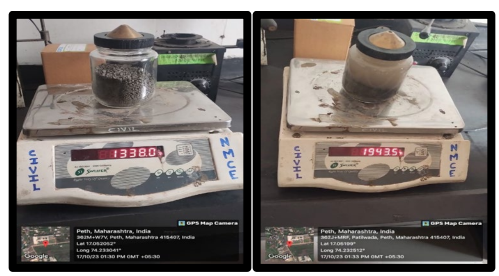

Fig. 2. S.G. of crushed sand

c. *Aggregate:* The specific gravity of Aggregate is 2.97.

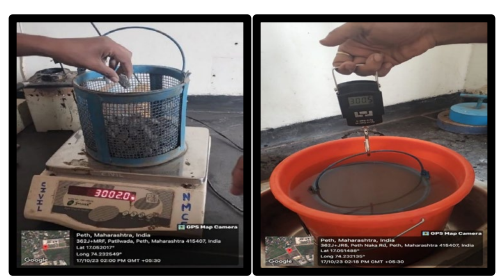

Fig. 3. S.G. of aggregate

d. *Fly Ash:* The specific gravity of Fly Ash is 2.34.


Fig. 4. S.G. of fly ash

e. *Chemical admixture* (Taken through Company)**:** The specific gravity of Cera Plast 300 PS is 1.20.

Fig. 5. Cera plast 300 PS

4. The cement was substituted with fly ash at 15%, 17.5% and 20%
5. Collect the locally available materials to prepare the High Strength concrete.
6. Trials are made for achieving the proposed strength by casting Cubes.
7. The Strength test may be made at the age of 28, 56 and 90 days.
8. Once the proportioning of concrete ingredients is decided for the strength, the cubes are cast to assess the compressive and tensile strength of concrete.
9. The results obtained may be compared with the results in the literature.

6. Materials for Experimentation Work

A. *Material Selection*

The main ingredients of HPC are almost the same as that of conventional concrete. These are:

1) Cement
2) Crushed Sand
3) Coarse aggregate
4) Fly – Ash
5) Chemical admixtures: Super Plasticizer Cera plast 300PS (Polycarboxylate ether based).
6) Water.

1) Cement

- Ordinary Portland cement of 53 grade (Trade name 'Penna Cement') conforming to IS: 269-1976 has been used throughout the experimentation.
- In this research work, Penna Cement OPC 53 grade cement is used. The most widely used cement is Portland cement. The specific gravity of cement is 3.14. Ordinary Portland cement of 53 grade conforming to IS: 12269-1987 has been used throughout the experimentation.

2) Crushed Sands:

- The passing through the 4.75 mm and retaining 150 µm is called Crushed Sand. The maximum size used is 4.75 mm to 150 µm, called Crushed Sand.
- Crushed Sands are crushed sand particles from the land through the mining process.
- The sand used for this work should be clean, fresh, dust-free, and organic matter-free.

3) Coarse aggregate

- Aggregate bigger than 4.75 mm or retrained on a 4.75 mm IS Sieve is known as Coarse aggregate.
- It combines cement and Crushed Sand to create a strong, durable concrete mixture that can withstand various environmental and physical stresses.

4) Fly - Ash

- Fly ash is a heterogeneous byproduct of coal combustion in power stations. It is a fine gray-colored powder with spherical glassy particles that rise with the flue gases. Fly ash contains pozzolanic components that react with lime to form cementitious materials. It is used in concrete, mines, landfills, and dams.
- The use of fly ash in Ordinary Portland Cement (OPC) has many benefits and advances concrete performance in both fresh and hardened states. Fly ash use in concrete improves plastic concrete's workability and hardened concrete's strength and durability. Fly ash use is also cost-effective.

5) Chemical Admixtures

- Cera Plast 300PS is a high-grade superplasticizer based on naphthalene. It is highly recommended for increased workability and high early and ultimate strengths of concrete.

7. Mix Proportion & Mix Details

Concrete mix proportion is designed as per IS 10262:2019 Concrete mix proportioning guidelines. The amount of fly ash replaced is 15%, 17.5%, and 20% of cementitious material, and the superplasticizer used is 1%, 1.2%, and 1.4% of cementitious material at a W/C ratio of 0.29. First trials are made for each w/c ratio.

Table 1

Cement	434 kg/m^3
F.A.	699 kg/m^3
C.A.	1217 kg/m^3
Fly-Ash	77 kg/m^3
Chemical	2.60 kg/m^3
Water	153 kg/m^3
W/CM Ratio	0.29

8. Results

The properties of material are as follows:
We did test of the materials i.e. specific gravity of cement,

Crushed Sand, Aggregate, Fly Ash, Water & Chemical admixture (Cera Plast 300PS):

a) Cement: The specific gravity of cement is 3.14.

Fig. 6. S.G. of cement

b) Crushed Sand: The specific gravity of Crushed Sand is 2.66.

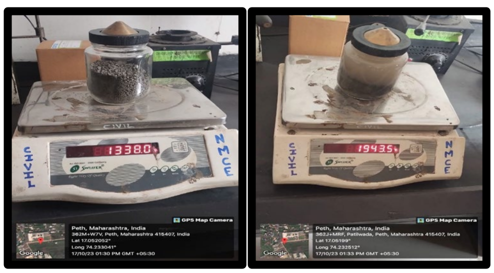

Fig. 7. S.G. of crushed sand

c) Aggregate: The specific gravity of Aggregate is 2.97.

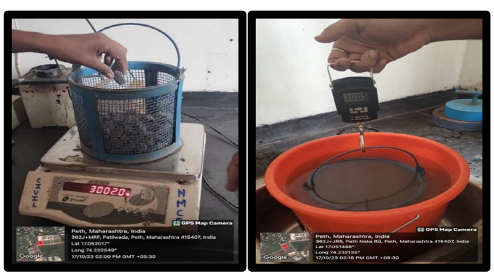

Fig. 8. S.G. of aggregate

d) Fly Ash: The specific gravity of Fly Ash is 2.34.

Fig. 9. S.G. of fly ash

e) Chemical admixture (Taken through Company):
The specific gravity of Cera Plast 300 PS is 1.20.

Fig. 10. Cera Plast 300 PS

9. Conclusion

The reviewed studies highlight the advancements and optimization techniques for High-Strength Concrete (HSC) and High-Performance Concrete (HPC) using various admixtures and mix designs.

- Karade et al. (2019) determined that ether-based superplasticizers at 2% by weight of cement significantly enhance workability without compromising compressive strength.
- Jadhav et al. (2017) found that incorporating 30% fly ash by weight in cement resulted in a 28-day compressive strength of 80 MPa, enhancing workability and strength.
- J. Chena et al. (2017) demonstrated that adding fly ash microspheres (FAM) improves packing density, enhancing flowability and strength.
- Basha et al. (2017) developed a mix design achieving 92 MPa compressive strength using 180 kg/m³ fly ash, 70 kg/m³ silica fume, and 0.75% superplasticizer by cement weight.
- Bai and Rao (2015) highlighted optimal fly ash and silica fume combinations for strength and durability, noting a w/b ratio of 0.32.
- Choudhary (2014) emphasized HPC's role in infrastructure development, particularly in earthquake-prone areas.
- Mahure (2014) studied the properties of self-compacting concrete with varying fly ash percentages.
- Konkov et al. (2013) discussed HPC applications in unique and large-scale constructions, focusing on improved functional characteristics.
- Houst et al. (2008) explored the design of novel superplasticizers for durable HPC.
- Mazloom et al. (2004) found that higher silica fume replacements enhance mechanical properties but require increased superplasticizer dosages.

Overall, these studies underscore the significant impact of admixtures like fly ash, silica fume, and superplasticizers in optimizing the performance of HSC and HPC.

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