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Effect of Steam Curing on the Strength of Concrete by Using Mineral Admixtures

Seema G N[1], Sneha S R[2], Suneel Kagi[3], Tilak B[4], Swapna Channagoudar[5]

[1234] UG Students, Dept of Civil Engineering, S T J Institute of Technology Ranebennur, Karnatak, India
[5] Asst Professor, Dept of Civil Engineering, S T J Institute of Technology Ranebennur, Karnatak, India

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Abstract - *In view of sustainable development, it is imperative that mineral admixtures be used to replace cement in the concrete industry. This paper presents a laboratory study on the performance of steam cured concrete by adding mineral admixtures. Mineral admixtures are replaced by cement with varying percentages i.e. FA (20%), GGBS (30%), MK (9%), SF (10%) and RHA (7%). Cubes, beams and cylinders are tested for its compressive, flexural and split tensile strength after the completion of steam curing cycle of 11:30 hours. As compared to the pure cement concrete (R1) strength will be increased for concrete with mineral admixtures (R2, R3, R4, & R5), among these R4 will gives more strength. R6 will not give the strength as compared to the R1. Steam curing also aids in faster and safer construction as sufficient strength attained in short period and maintained without any other form of curing.*

Key Words: **Cement, Rice Husk Ash, Metakaolin, GGBS, Silica Fume, Fly Ash, Steam curing etc.**

1. INTRODUCTION

Concrete plays an important role in the construction industry. In the last few decades, many researchers have been carried on the properties of concrete by using waste materials and by products. It is well known heterogeneous mix of cement, water, coarse aggregate and water. Portland cement production is one of the major reasons for CO_2 emissions into atmosphere. It is due to the use of fossil fuels, including the fuels required to generate electricity during cement manufacturing process. The use of supplementary cementitious materials for making concrete is considered efficient, as it allows the reduction of cement consumption while improving the strength and durability of the concrete. Supplementary cementitious materials, which in itself possesses little or no cementitious properties. But in the presence of moisture, it chemically reacts with calcium hydroxide to form compounds possessing cementitious properties. Mineral admixtures include fly ash (FA), ground granulated blast furnace slag (GGBS), silica fume (SF), metakaolin (MK) and rice husk ash (RHA) which possess certain characteristics through which they influence the properties of concrete differently. Adding of these mineral admixtures reduces cost of concrete work when compared with pure cement using in concrete work.

1.1 Steam Curing

The technique of steam curing is most frequently employed technique among various production processes of prefabricated members. It is the process of gaining high early strength under high atmospheric pressure and temperature. Steam curing is one of the curing method it consist of few stages in its regime, namely pre-streaming stage, heating stage, thermostatic stage and cooling stage. Many researchers have reported that under steam curing condition the quality of concrete with mineral admixtures is better than that of the pure cement concrete. Steam temperature in the en-closer should be kept about 60˚C until the desired concrete strength has developed. Strength will not increase significantly if the maximum steam temperature is raised from 60 to 70˚C. Steam curing temperature above 70˚C should be avoided. Concrete temperatures are commonly monitored at the exposed ends of the concrete element. Monitoring air temperatures alone is not sufficient because the heat of hydration may cause the internal temperature of the concrete to exceed 70˚C. The benefits of steam curing are as follows: simple process, convenient operation, production with high early strength, short production cycle and superior economic benefits.

Fig – 1 Steam Chamber

1.2 Objectives

The main objective of this project to know the effect steam curing on strength properties of M-30 grade concrete and also know about the effect of mineral admixtures on the concrete.

To compare the strength properties like compressive, flexural and split tensile for the conventional concrete and concrete with mineral admixtures subjected to steam curing.

2. LITERATURE REVIEW

A.Kaur and V.P.S.Sran (2016) [1] deliberated the partial replacement of cement with the metakaolin in concrete which cause great improvement in the strength. The cement replacement upto 9% is increase the strength after this the strength will be decrease. Workability of concrete decreases with increase in the metakaolin percentage.

Lakhbir Singh et. al. (2016) [2] discussed the partial replacement of cement by silica fume the strength parameters of concrete have been studied .Silica fume were used to replace 0% to 15% of cement , by weight at increment of 5% for both cube and cylinder. The strength of concrete increases rapidly as we increase the silica fume content and the optimum value of compressive strength and split tensile strength is obtained at 10% replacement. After10% its start decreasing under uniform load conditions.

Rishabh Kashyap et. al. (2015) [3] concluded rice husk ash has economical and technical advantages to be used in concrete. Using RHA as replacement of OPC in concrete, the emission of greenhouse gases can be reduced up to a greater extent. OPC replacement by RHA results in reduction of cost of production of concrete in the range of 7 to 10%.

He Zhimin et. al. (2012) [4] investigated that the steam cured concrete with mineral admixtures has better capacity of resistance to penetration of Chloride ions and less dry shrinkage compared with blank concrete. Under the steam curing condition, the high temperature will greatly enhance the reactivity of FA and GGBS in concrete, and thus the hydration action of mineral admixtures.

Ali Papzan et. al. (2012) [5] concluded the steam curing is an important technique for obtaining high early strength in precast concrete production. After steam curing, the concrete will have 50% of the 8- day desired compressive strength. It can increase early strength development; on the other hand, it significantly reduces the ultimate strength of concrete and also it was found to deteriorate the properties of OPC concrete for all ages.

3. MATERIALS

3.1 Cement: Ordinary Portland cement of grade 43 is adopted for this work.

3.2 Fine aggregate: Locally available M-sand is used as a fine aggregate and its having 2.60 specific gravity.

3.3 Coarse aggregate: Locally available crushed stones having the maximum size of 20mm with 2.49 specific gravity.

3.4 Water: The water that is used for this work was obtained locally. The water was suitable for drinking and free from suspended solids.

3.5 Fly ash: Fly ash is the ash that is obtained from coal combustion in the thermal power station. It includes aluminium dioxide, silicon dioxide and calcium oxides as the main mineral compounds in the stratum of coal.

Fig–2: Fly Ash

3.6 GGBS: Ground granulates blast furnace slag is a by-product in the manufacture of iron.

Fig–3: GGBS

3.7 Silica fume: Silica fume is obtained after reducing high purity quartz wit coal in electric arc furnace by heating upto 2000^{0}C. It contains more than 90%of silicon dioxide (SiO_2).

Fig–4: Silica Fume

3.8 Metakaolin: Metakaolin is the by-product of kaolin and this obtained by heating the kaolin upto to temperature 60 to 850^{0}C.

Fig-5: Metakaolin

3.9 Rice husk ash: Rice husk is the ash that is obtained by burning the rice husk at temperature 500 to 700^{0}C.

Fig–6: Rice Husk Ash

4. EXPERIMENTAL PROCEDURE

- Preparation of design mix of M30 grade using relevant IS code book 10262:2009.
- The mix proportion arrived is 1:1.6:2.7 (C: FA: CA) with a water cement ratio of 0.44.
- Preparation of different concrete mix using fly as, GGBS, metakaolin, silica fume and rice husk ash as a partial replacement of 20%, 30%, 9%, 10% & 7% by weight of cement with a mix designations R1, R2, R3, R4, R5 and R6 respectively.
- The specimens are cast for compressive, flexural and split tensile test.
- The specimens are cured in steam chamber for 11:30 hours as per the steam cycle.
  - 2hrs pre-streaming stage at temperature of 40^{0}C.
  - 2:30hrs heating stage at rising temperature of 40^0 to 70^{0}C.
  - 4hrs thermostatic stage at constant temperature of 70^{0}C.
  - 3hrs cooling stage at temperature of 70^{0}C to 40^{0}C.

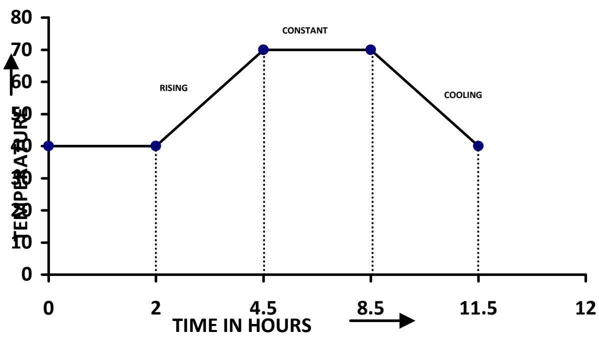

Fig-7: Steam Curing Cycle

- The specimens are removed from steam chamber and then they are tested for their respective strengths.

5. EXPERIMENTAL RESULTS

5.1 Slump Cone, Compaction Factor and Vee - Bee Consistometer Test:

Table 1 shows the results of slump and compaction factor of concrete with partial replacement of cement by mineral admixtures with proper mix designations.

Table 1: Workability of concrete results

Mix Designation	Slump (mm)	Compaction Factor
R1	50	0.83
R2	32	0.90
R3	28	0.90
R4	25	0.90
R5	30	0.91
R6	80	0.90

- Where the R1, R2, R3, R4, R5 and R6 mix designations represents R1 – 100% cement, R2- 80% cement and 20% fly ash, R3 – 70% cement and 30% GGBS, R4 – 91% cement and 9% metakaolin, R5 – 90% cement and 10% silica fume and R6 – 93% cement and 7% rice husk ash.

5.2 Compressive strength

Cube strength of M30 grade concrete with varying percentages of different mineral admixtures as substituted for cement. For every mix designation, three cubes of size 150 × 150 × 150 mm were cast, average compressive strength was determined. Table-2 and Fig-11 explain the variations in compressive strength.

Fig-8: Compression Strength Testing

5.3 Flexural strength

Flexural concrete strength is also known as modulus of rupture and it is the property of material. Flexural test gives the value of highest stress just before the materials yields. For each mix designation, three beams of size 100 × 100 × 500 mm were cast and cured .Average of three specimen readings was determined. Universal Testing Machine (UTM) has been used for testing of specimens. Table-2 and Fig-12 explain the variations in flexural strength.

Fig-9: Flexural Strength Testing

5.4 Split Tensile Strength

Split tensile defines the strength of concrete in tension. Due to the brittle nature of concrete, it is very weak in tension. Whenever the tensile force is applied it develops cracks and leading to failure. To calculate the tensile strength, cylinder of size 150mm diameter and 300mm in length were cast and tested. Table-2 and Fig-12 explain the variation in split tensile strength.

Fig-10: Split tensile Strength Testing

5.4 Test Results

Table 2: Strength results

Mix Designation	Compressive Strength (MPa)	Flexural Strength (MPa)	Split Tensile Strength (MPa)
R1	24.888	3.566	1.488
R2	27.288	3.828	1.825
R3	29.511	4.304	2.256
R4	31.066	4.530	2.552
R5	29.022	3.880	2.163
R6	18.373	2.684	1.404

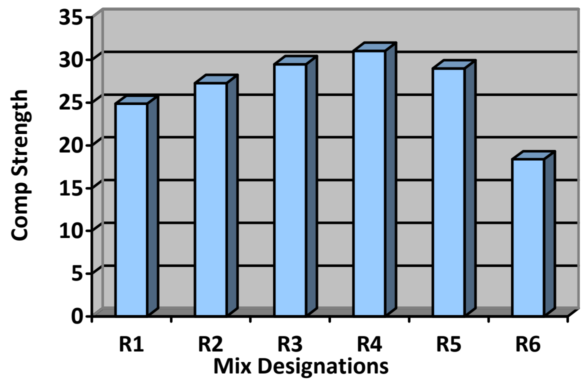

Fig-11: Compressive Strength of Concrete

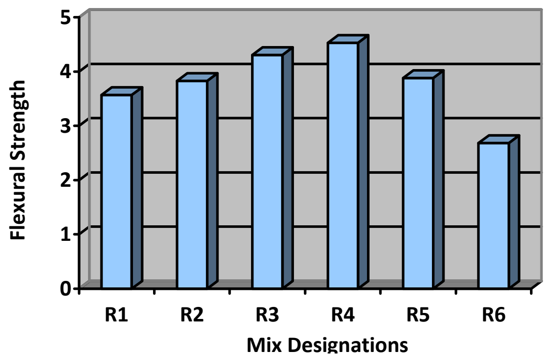

Fig-12: Flexural Strength of Concrete

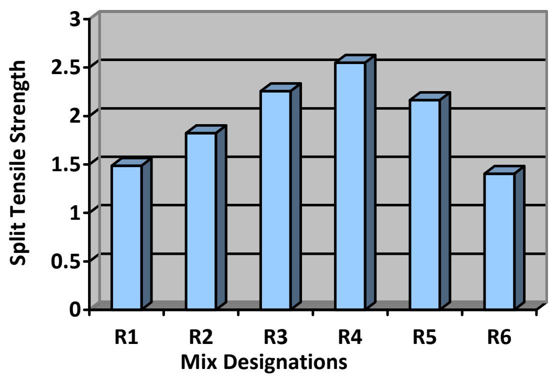

Fig-13: Split Tensile Strength

6. CONCLUSIONS

Based on experimental observations, following conclusions can be drawn:

1. Steam curing also aids in faster and safer construction as sufficient strength attained in short period.
2. As compared to pure cement concrete mix, the material strength will be increases for concrete mix with mineral admixtures like fly ash, GGBS, metakaolin, silica fume.
3. Among them concrete with metakaolin gives more strength.
4. The concrete with a rice husk ash having less strength as compared to pure cement concrete.
5. As far as cost is concerned, the cost of mineral admixtures in the market is less than the OPC.

REFERENCES

[1] A. Kaur and V .P. S. Sran, (2016), "Use of Metakaolin as Pozzolanic Materials and Partial Replacement with Cement in Concrete (M30)," Asian Review of Mechanical Engineering (ARME) Vol 5, ISSN: 2249-6289, pp: 9-13.

[2] Lakhbir Singh et al (2016), "Study of Partial Replacement of Cement by Silica Fume," International Journal of Advanced Research (IJAR) Vol 4, Issue 7, ISSN: 2320-5407, pp: 104-120.

[3] Rishabh Kashyap et al (2015), "Effect of Partial Replacement of Cement by Rice Husk Ash in Concrete," International Journal of Science and Research (IJSR) Vol 4, Issue 5, ISSN: 2319-7064, pp: 1572-1574.

[4] He Zhimin et al (2012), "Influence of Mineral Admixtures on the Short and Long-term Performance of Steam cured Concrete," International Materials Science Society (IMSS) Vol 16, ISSN: 1876-6102, pp: 836-841.

[5] Ali Papzan et al (2012), "The Effect of Steam Curing on Porosity of Concrete Containing Metakaolin," Journal of American Science (JAS) Vol 8, ISSN: 1545-1003, pp: 518-522.

[6] M.S Shetty and S Chand (1982), "Concrete Technology," 7 Edition, 1982.

CODE BOOKS:

- IS 456-2000 (Code of practice for plain and reinforced concrete)
- IS 10262-2009 (Concrete mix proportioning guide lines)
- IS 383-1970 (Specifications for fine and coarse aggregates from natural sources for concrete)