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Comparative Study on M_{30} And M_{35} Grade of Concrete by Partial Replacement of Cement with Metakaolin and Fine Aggregate with Spent Fire Bricks

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ABSTRACT

Concrete is the most common materials used in the construction industries. In the past few years, many and modification has been done to produce concrete which has the desired characteristics. Cement, sand and aggregate are basic needs for any construction industry. In this research we analyze the strength of concrete made with using some alternate materials. One is Metakaolin and other is Spent Fire Bricks (SFB). The Metakaolin is used up to 20 % partial replacement by weight of cement and Spent Fire Bricks as the partial replacement of fine aggregate from 0%, 10% and 20%. In this project, a comparative study was done on M30 and M35 grade of concrete by conducting various tests such as slump test was carried out for the fresh concrete whereas split tensile and compressive strength tests were carried for the hardened concrete.

Keywords: Metakaolin, Fine aggregate, Fire Bricks and Cement.

1. INTRODUCTION

It is relatively economical, easy to provide continuity with solidity, and it does indeed set out the role of development and improvement or modern life. It is a composite material formed by sand, cement, aggregate and water. The fresh concrete will mould into any form of choice. When operation rises for various regions and services, the natural resources available are frightened. Also, the use of conventional material becomes costly day by day. Hence conservation of the naturally available material is great challenge for the civil engineers. By using alternative materials which have been partially reduced, there is only a way to search for materials which can be completely or partially replaced by naturally available materials in the field of construction. Here we use the two waste materials that are readily available.The Crushed Spent Fire Bricks produced by crushing brick bats which are available locally. It is used here as partially replacement for fine aggregates. Metakaolin, which can be used as a partial substitute for cement, is developed by controlled thermal treatment of kaolin.

1.1 Objectives

Following are the main objectives of this project:

- To investigate the properties of Metakaolin and Crushed Spent Fire Bricks (CSFB).
- To study the performance of fresh and hardened concrete when cement and fine aggregates are partially replaced with Metakaolin and Crushed Spent Fire Bricks respectively in concrete.
- To find out the optimum percentage of replacement material used to prepare concrete mix.
- To compare the test results of M30 and M35 grade of concrete for normal and replaced concrete.

2. METHODOLOGY

Figure 1 shows the methodology of the study.

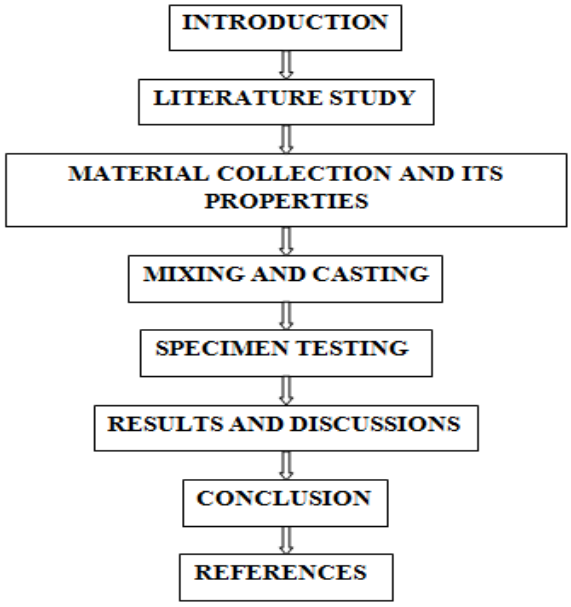

Figure 1 Methodology

3. MATERIAL COLLECTION AND ITS PROPERTIES

3.1 Cement

Ordinary Portland Cement (OPC) is the most common type of binder used for the production of concrete and was therefore used as a binder for OPC 53 grades conforming to Indian Standard IS 12269:1987.

4.2 Aggregates

In general, aggregates represent 70 to 80 % of the concrete volume and can therefore be assumed to have a major impact on their properties. They are granular materials, mainly derived from natural rock and sand.

4.2.1 Fine Aggregate

The local river sand was used as a fine aggregate in the current analysis. The sand consists of clay, salts and organic impurities. The sands have been tested for different properties such as basic gravitational characteristics, fine module, bulk density, etc, in accordance with IS 2386-1963.

4.2.2 Coarse Aggregate

The material whose particles are of size are held on IS strainer of size 4.75 mm is named as coarse total and containing just so a lot better material as is allowed for the different kinds depicted in IS: 383-1970 is considered as coarse total. Totals ought to be of uniform quality as for shape and reviewing. The size of coarse collected relies on the idea of the work. The coarse aggregate utilized in this test examination is 20 mm size.

4.3 Metakaolin

Metakaolin is a dehydroxylated form of the kaolinite clay minerals. Rocks rich in kaolinite are known as china clay are kaolin, which is traditionally used in porcelain production. Metakaolin particle size is smaller than cement particles but not as fine as silica fume. Metakaolin (MK) is a pozzolanic compound. It is obtained when kaolinite clay is calcinated at temperature ra. Table 1 shows the coarse metakaolin.

Table 1: Properties of coarse Metakaolin

S. No	Properties	Value
1	Specific gravity	2.60
2	Colour	Off white
3	Physical form	Powder
4	Bulk density (kg/m^3)	710
5	Particle size (µm)	1.6

Figure 2 shows the metakaolin.

Figure 2 Metakaolin

4.4 Crushed Spent Fire Bricks (CSFB)

The crushed brick bats in coarse powder were used to render concrete as a fine aggregate. The shattered bricks expended on the fire are available locally. The crushed spent fire brick that is passed through 4.75 IS sieve and kept on 75micron (0.075 mm) sieve to get fine aggregate grading. The crushed bricks spent on fire satisfy the gradation of Zone II. Table 2 shows the Properties of Crushed Spent Fire Bricks (CSFB).

Table 2: Properties of Crushed Spent Fire Bricks (CSFB)

S. No	Properties	Value
1	Fineness modulus	2.34
2	Specific gravity	2.65
3	Water absorption (%)	0.9

Figure 3 shows the Crushed Spent Fire Bricks (CSFB)

Figure 3 Crushed Spent Fire Bricks (CSFB)

4.5 Water

Water is an important concrete ingredient, as it actively participates with cement in the chemical reaction. Since it helps shape the strength that gives cement gel, it is important to take the quantity and consistency of the water very carefully. Used water should be free of any impurities. Water at sea is not to be used.

5. MIXING AND CASTING

5.1 Mixing.

Based on the properties of the available materials, the mix proportions of the concrete were approximated using absolute volume method as per IS 10262:2009. Selected mix proportions of Metakaolin and Crushed Spent Fire Bricks (CSFB) based concrete are presented in Table 3.

Table 3: Mix proportions of proposed concrete

Mix	% of replacement
CC	Control mix
1	10% M + 10% CSFB
2	20% M + 20% CSFB

Note: M – Metakaolin; CSFB - Crushed Spent Fire Bricks

5.2 Casting

Cube and cylinder specimens were prepared for the various mixtures of concrete. a) Standard cubes 150 x 150 x 150 mm for compressive strength. b) standard cylinders with a diameter of 150 mm and a height of 300 mm for cylindrical disconnected tensile strength. Cubes and cylinders are made of standard cube and cylinder moulds.The slumps were measured at the time of casting cubes. The cube and cylinder specimens are demoulded after 24 hrs and were cured for 7, 14 and 28 days.

6. TESTING OF SPECIMENS

6.1 Slump Cone Test

The Concrete Slump Test or Slump Cone Test shall be used to determine the workability or consistency of a concrete mixture prepared at the laboratory or construction site during the progress of the work. Concrete slump test is carried out from batch to batch to verify the uniform consistency of concrete during construction.The slump test is the simplest test of practicality, involves low costs and delivers immediate results. Generally, concrete slump value is used to determine the workability, which indicates the water-cement ratio, but there are various factors, including material properties, mixing methods, dosing, mixing, etc., which also affect the concrete slump value. Figure 4 shows the types of concrete slump test results.

6.2 Compression Strength Test

The compressive strength is the ability of the material or structure to bear the loads without any crack or deflection on its surface. The material under compression tends to reduce the size while the size is elongated in tension. The test shall be carried out using 150 mm concrete cubes on a universal test machine or a compressive test machine. Figure 6 shows the compression strength test.

6.3 Split Tensile Strength Test

One of the concrete's essential properties is "tensile strength," because structural loads make concrete susceptible to tensile cracking. Concrete tensile strength is much weaker than its compressive strength (that's why it uses steel to bear the stress forces). It has been estimated that the tensile strength of the concrete is approximately 10% of the compressive strength.The tensile strength is calculated by the complexity of the direct approach by individual methods. Noting that the values obtained from these methods are higher than the values obtained from the uniaxial tensile test. Figure 10 shows the split tensile strength test.

7. TEST RESULTS AND DISCUSSIONS

7.1 Compression Strength Test

Table 4 shows the compression strength test results of conventional and Agro waste-based concrete. Mix – 2 shows higher strength than the other mixes.

Table 4: Compression strength test results

S.No	Mix	Compressive strength (N/mm²)					
		M30 grade			M35 grade		
		Days			Days		
		7	14	28	7	14	28
1	CC	20.1	28.2	30.5	23.2	32.1	35.8
		20.5	28.0	30.1	23.5	32.4	35.3
		20.4	28.4	30.5	23.1	32.5	35.5
	Average	**20.3**	**28.2**	**30.3**	**23.2**	**32.3**	**35.5**
2	Mix – 1	21.2	29.0	31.4	24.1	33.4	36.3
		21.5	29.5	31.8	24.3	33.1	36.4
		21.4	29.6	31.5	24.5	33.8	36.1
	Average	**21.3**	**29.3**	**31.5**	**24.3**	**33.4**	**36.2**
3	Mix – 2	22.3	29.5	32.0	25.2	34.8	37.1
		23.8	29.8	33.5	25.1	35.1	37.9
		22.5	30.1	32.8	25.5	35.3	37.5
	Average	**22.8**	**29.8**	**32.7**	**25.2**	**35.1**	**37.5**

Figure 4 shows the compression strength test for M_{30} Grade concrete.

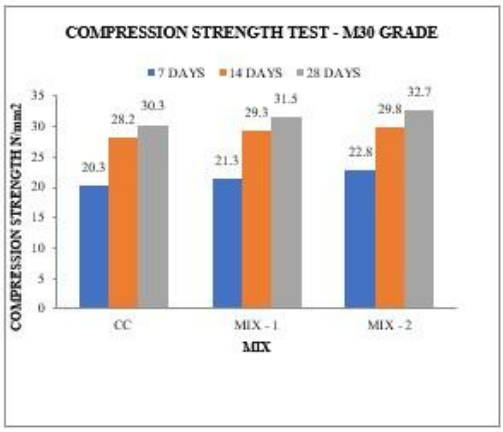

Figure 4 Compression strength test – M30 grade

Figure 5 shows the compression strength test for M_{35} grade.

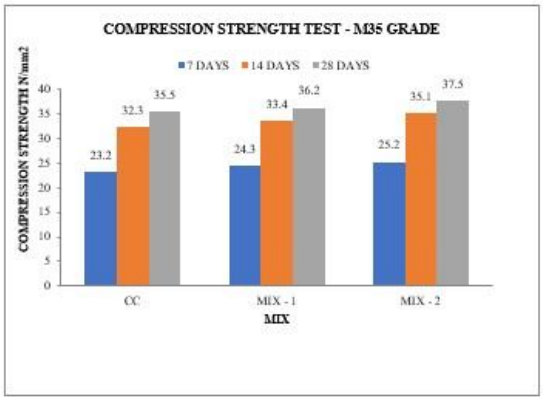

Figure 5 Compression strength test – M35 grade

7.2 Split Tensile Strength Test

Table 5 shows the split tensile strength test results of conventional and proposed concrete. Mix – 2 shows higher strength than the conventional and mix – 1 concrete.

Table 5: Split tensile strength test results

S.No	Mix	Compressive strength (N/mm²)					
		M30 grade			M35 grade		
		Days			Days		
		7	14	28	7	14	28
1	CC	2.01	2.85	3.08	2.35	3.25	3.60
		2.05	2.80	3.03	2.32	3.20	3.55
		2.08	2.83	3.05	2.37	3.22	3.58
	Average	**2.04**	**2.82**	**3.05**	**2.34**	**3.22**	**3.57**
2	Mix – 1	2.15	2.89	3.15	2.45	3.33	3.61
		2.13	2.93	3.21	2.48	3.31	3.62
		2.14	2.98	3.19	2.46	3.35	3.60
	Average	**2.14**	**2.93**	**3.18**	**2.46**	**3.33**	**3.61**
3	Mix – 2	2.35	2.94	3.21	2.50	3.49	3.75
		2.37	3.00	3.31	2.55	3.52	3.79
		2.31	3.10	3.28	2.53	3.50	3.72
	Average	**2.34**	**3.01**	**3.26**	**2.52**	**3.50**	**3.75**

Figure 6 shows the graph of split tensile strength test for M_{30} Grade concrete

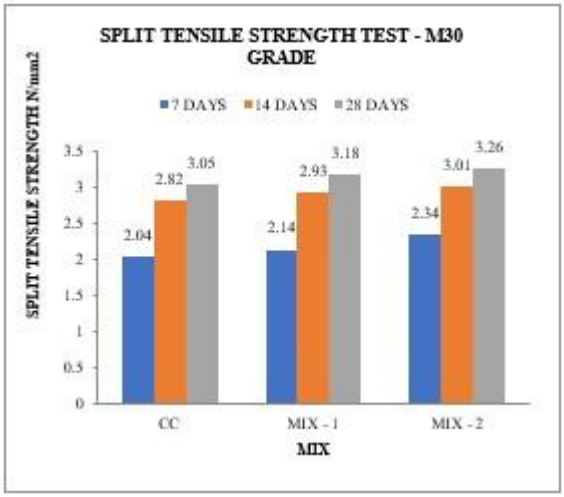

Figure 6 Split tensile strength test – M30 grade

Figure shows the split tensile strength test for M_{35} grade.

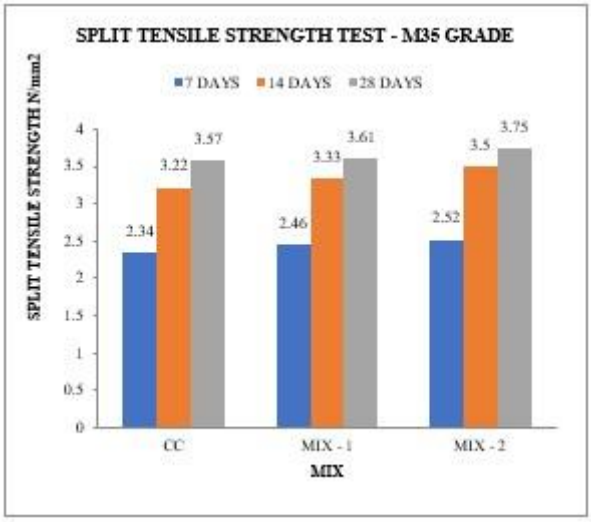

Figure 7 Split tensile strength test – M35 grade

7.3 Slump Cone Test

Table 9 shows the slump test results.

Table 6: Slump test results

S. No	MIX	SLUMP VALUE (mm)	
		M30 grade	M35 grade
1	CC	90	85
2	Mix – 1	105	115
3	Mix - 2	120	130

Figure 8 shows the graph of slump test.

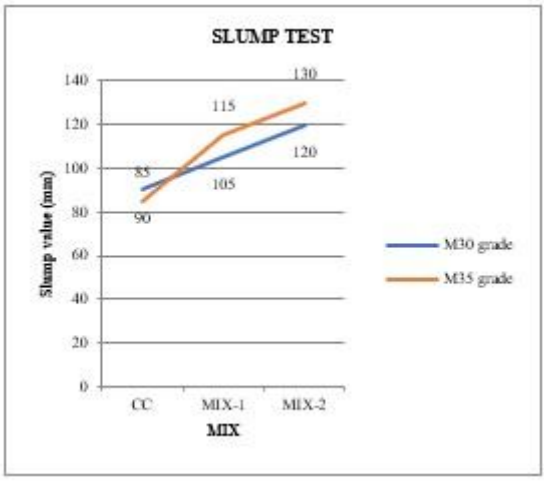

Figure 8 Slump test

8. CONCLUSION

Based on the observations and discussion made in study, following conclusion can be derived upon:

- From the result presented above it is obvious that split tensile strength and compressive strength of concrete increases with increase of grade. Similarly, the strength of concrete decreases with decrease of grade.
- The findings of the test indicate that Metakaolin and Crushed Spent Fire Bricks have partly replaced the cement and fine aggregates, gives maximum strength at 28 days period when compared to control mix.
- Workability of M30 and M35 grade of concrete for various mixes also affects considerably.
- Metakaolin and Crushed Spent Fire Bricks based concrete gives higher workability than the conventional mix.

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