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Comparison of Mechanical Properties of Concrete Using Different Fibers

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Abstract:

Solid waste management has become one of the major challenges in metropolitan areas. Alternative methods for the management of solid waste can also be followed. In the light of these circumstances, an attempt has been made to explore the capacity for the re-use of rubber tyre, plastic and rice husk waste materials as fibre composites in concrete. The aim of the analysis is therefore to recognize the mechanical and structural properties of local and waste materials as composites in terms of compressive strength, tensile strength and flexure strength to improve seismic resistance. Since the materials used in this research work are locally accessible, a thorough study using various test and analytical techniques is required. The impact of the percentage of rural fibres, including rubber tyre fibres, plastic fibres and rice husk fibres, on the mechanical properties of concrete was studied in this study and has been found to be highly useful.

Keywords — **Concrete, Fibres, Compressive strength, Split tensile strength**

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I. INTRODUCTION

The structural composite material is developed as a homogeneous composite material and its properties depend not only on the constituent materials, but also on the geometry of the structural components [1]. Two of the most popular structural composites occur. The layered compounds, which have a chosen route of high strength (as in wood) and the sandwich sheets, which have their own durable exterior surfaces, divided by a sheet of far less thick fabric or core [2].

Fiber reinforcement is usually not a substitute for conventional steel reinforcement [3]. In the production of concrete fibres and steel reinforcement have their own function [4]. Thus there are many applications where steel bars can be fibre and rigidly reinforced jointly [5]. However, in contrast with conventional steel reinforcement, fibre does not achieve tensile stress. Fibers, however, are tighter than replacements for steel and are better tailored for crush and shrinkage safety [6]. This increases the load-bearing capacity of a concrete part by means of standard steel reinforcements; the fibres are more effective in crack protection [7].

The loss of tolerance to corrosion of regular steel fibres can be a downside of exposed concrete environments. It is also important to test the fire resistance of synthetic fibres [8]. The inclusion of fibre would result in a rise in building costs. For example, 1 m3 of concrete will have cost Rs. 5,000/-. If 1% of the steel fibre is put to 1m3 of concrete, the expense of the steel fibres will be about Rs. 5,000/-. Synthetic materials are more expensive and outside the reach of middle- and low-income groups [9]. The viability of utilizing locally manufactured modern building materials for medium to low-cost construction also needs to be explored [10].

Analysts around the world have endeavoured to cope with the aforementioned problem with a number of innovative solutions, such as pozzolanic reactions of calcium hydroxide using cementitious materials to produce extra calcium silicate hydrate materials or through empty filling of cementitious materials [9, 11]. Additional cementitious materials have been commonly considered in the cement matrix as pozzolanic materials for the use of the calcium hydroxide formed by the extra calcium silicate hydrate. Partial substitution of cement with additional cement products in the cement matrix would not only improve the mechanical properties of cement, but will also aid in its workability, modification in the setting times and solidity [12, 13]. At this crossroads, nanotechnology is acquiring knowledge in order to develop another period of cement material that defeats certain drawbacks and aims to achieve realistic solid structures. Developing materials is required on a day-to-day basis for improved or better implementation for excellent design applications and for modifying the mass state of materials to the degree that the creation or microstructure or nanostructure has been engineered for the mixing of new materials [14]. More up-to - date products may also be produced by intermingling established products at part stage. Many studies have substituted cement with individual pozzolanic materials, but there is no proof of study on the synthesis of two pozzolanic materials [15].

In addition to the creation of regulations and building codes, attention must also be given to the possibility of utilizing local materials in the design of new technology in the context of the earthquake protection phase. To date, composite analysis is confined to the assessment of mechanical properties and the application to aircraft and industrial industries with relatively few studies being conducted in civil infrastructure operations [16].

At the other hand, solid waste management has become one of the major challenges in metropolitan areas. There are currently two main waste management methods in operation. One is covering the soil and the other is burning. The first needs more fertile land, while the second pollutes the atmosphere. Alternative strategies for the disposal of solid waste should also be sought [17].

In the light of these circumstances, an attempt has been made to explore the capacity for the re-use of rubber tyre, plastic and rice husk waste materials as fibre composites in concrete. The aim of the analysis is therefore to recognize the mechanical and structural properties of local and waste materials as composites in terms of compressive strength, tensile strength and flexure strength to improve seismic resistance. Since the materials used in this research work are locally accessible, a thorough study using various test and analytical techniques is required.

II. MATERIALS

It is all-important to use cement of adapted grade and type for specific applications and ambiance conditions. OPC was used for this work conforming to IS 269-1976. Potable water was used to prepare mixes. Crushed stone with maximum 12.5mm graded aggregates (nominal size) were used. Physical properties are given in Tables 1.

TABLE 1. PHYSICAL CHARACTERISTICS OF FINE AGGREGATES

Property	Value
Bulk Density (Loose)	1670 kg/m^3
Bulk Density (Compacted)	1910 kg/m^3
Specific Gravity	2.59
Water Absorption	1.45%
Moisture content	0.16%
Material finer than 75µ	0.4%

TABLE 2. TYPICAL PROPERTIES OF FIBRES

	Types of fibres		
Properties of Fibres	Tyre	Plastic	Rice Husk
Diameter (mm)	1.50	1.51	1.60
Aspect Ratio	33.1	33.1	12.5
Specific gravity	1.08	1.25	0.4
Water Absorption (%)	72.21	44.76	123.7

Density in kg/m^3	530	763	564

Locally available waste materials were collected from different streams and properly shaped in the form of fibres. Uniform length of fibres was obtained by using a cutting machine. Bi-cycle rubber tyres were collected from local automobile workshops. The natural fibres such as rice husk fibre, were collected from local rice mills. Plastic fibres were collected from recycled waste materials. The waste plastic was collected & then treated & finally made into fibre form. Table 2 shows their typical properties.

III. METHODOLOGY

The present investigation is based upon IS: 10262 (1982) and SP23 (1983) for selecting the concrete mix M40, with some incorporation from IS 456 (2000) [18]. Three different water cement ratio were taken as 0.32, 0.34 and 0.35 to have desired results. Six cubes for each mix were cast to test for compressive strength after 7 days and 28 days. Different ingredients were adjusted. Compressive strength of 28.37 N/mm^2 at 7 days and 43.47 N/mm^2 at 28 days was achieved by 0.34 w/c ratio which is close to the desired strength. So w/c ratio of 0.34 was adopted which is less than 0.45 as given by IS 456-2000 for very severe conditions. The mixing of concrete is done to have a homogeneous mixture of all ingredients in concrete. The hand mixing was done for the ingredients. Batching of concrete was done by weight. Then required quantity of super plasticizer was added to required quantity of water with dip Fibres in it. The solution was added and mixed thoroughly until a uniform coloured mixture was obtained.

Standard cubical moulds (150 x 150 x 150 mm) made up of cast iron were cleaned and oil was applied on the inner faces well before concreting operation of casting of specimen so that oil may not affect concrete ingredients. As per IS 516: 1959 (reaffirmed 1999), the complete procedure was adopted in the making and casting operations. The quantities of cement, coarse aggregate (20 mm and 10 mm size), fine aggregate, and water for each batch was weighed to an accuracy of 0.1kg separately. Fine aggregate and coarse aggregate was mixed thoroughly followed by addition of cement and was again mixed thoroughly. Then water was added carefully and the entire mixture was mixed by mechanical mixer. Then concrete was filled into the previously prepared moulds in three layers. Electric vibrator was used to compaction of concrete. The finished specimens after hardening in air for 24 hours were placed in the water tank.

The moulds had a compactable underlay with an enticing rod and a bullet nose to ensure that the angles and base were properly shaped. Then layers 2 and 3 were positioned and tempted. The moulds were then put on the compaction vibrator table. When the cement slurry arrives on the surface, proper compaction is achieved. It stopped the vibrator and was loaded with a certain quantity of concrete. The mould was vibrated again and a trowel was finished on top of the surface. For every test of cement concrete and rural fibre concrete, casting was performed for the specimens. For desired cure ages, all specimens were immersed in the water tank.

The workability of fresh concrete is a blended property which includes the assorted requirements of stability, mobility, compactability, placeability and finishability. There are altered methods for determination of the workability. Each of them measures alone a accurate aspect of it and there is absolutely no different analysis which measures workability of concrete in its totality. The fresh properties were studied by slump test to measure workability. For the compression strnegth as in line with Indian standard BIS specs: 516-1959 cube specimens with a length with 150 mm were employed. All test samples were finished with metallic trowels after casting. The specimens were coated with sheets immediately after completion to mitigate their moisture loss. After 24 hours, samples were removed and cured with approximately room temperature in water before the experiments were carried out. Compressive force tests for cubes were conducted for 7 , 28 and 90 days. The splitting tensile strength is widely recognized indirect test used for determining the tensile strength of concrete. The splitting tensile strength was determined at the age of 7, 28, and 90 days on cylinders of dimensions 150 mm x 300 mm as in keeping with Indian preferred specs BIS: 516-1959. The flexure strength of concrete is the capacity of a concrete beam or plate to withstand bending failure. The current research coiled and tested bending concrete beams of size 100 x 100 x 500 mm as per IS:516-1995.

IV. RESULTS & DISCUSSIONS

The percentage of Rubber tyre Fibres, plastic fibres and rice husk fibres by 0.5%, 1.0% and 1.5% by weight of cement. The concrete mix was prepared at different %ages of these rural fibres. For each percentage variation of rural fibres, three samples were tested and average value was taken [19].

4.1 Workability

By incorporating various types of rural fibres, the workability of the concrete reduces. Tests for slump cone control mix calculated by workability of 95 mm while by adding fibres it progressively reduces to 78 mm at 1.5% rubber tyre fibres. This decline in operability is attributable to a greater coherence between concrete and rubber tyre fibres. Workability decreases further by adding plastic fibres, and by adding 1.5 per cent plastic fibre it declines to 65 mm. This reduction in workability was because the Fiber serves as a filler and reinforcing medium for improved packaging & intermolecular forces and ultimately decreases workability [16].

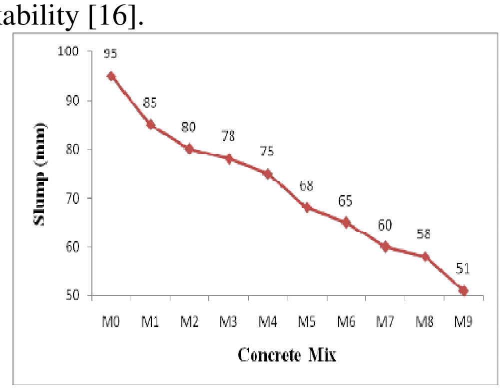

Figure 1. Slump cone test plots

The workability further reduces with addition of rice husk fibres to 51mm at 1.5% of fibre due to the lesser size more compactness & better interlocking.

4.2 Compressive strength

A compression test system in a 150 mm cube was used to calculate the compressive strength of the concrete mix for 7 days, 28 days & 90 days. In contrast to control mixes without any additive, the compressive force was shown to increase in all mixes every day. The increase in compressive strength by 0%, 1.0% and 1.5%, was 3%, 10%, 14%, at 7 days, 2%, 7% and 12% at 28 days and 5%, 8%, 15%, at 90 days of curing. The increase in compressive strength was caused by increased packaging fraction and lower fibre vacuums in concrete [20].

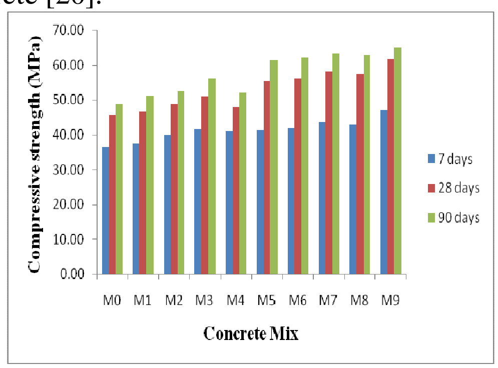

Figure 2. Compressive Strength Plots

The increase in compressive strength was primarily attributable to an improvement in the microstructure and the adhesive relation. Increased bond between sand, aggregation in mix and moistened cement matrix resulted in a higher compression strength by adding the rubber fibres to a concrete mix. This enhanced bonding is due to a CH (calcium hydroxide) conversion to CSH (calcium silicate hydrate) with fibre. Added plastic fibres also showed an improvement in compressive power. The compressive strength by incorporation of 0.5%, 1.0%, and 1.5% plastic fibres rises by 14%, 16% and by 20% for seven days, 22%, 23%, 27% for seven days and 26%, 27% and 30% for ninety days of treating ages. As the fibres act as a reinforcement medium and thus increase compactness and compressive strength the increase in compressive strength due to the increase in plastic fibres was caused by the reduction of micro-cracks in cement. Compressive strength improved sharply by incorporating rice husk fibres to 0.5 %, 1.0% and 1.5% in concrete to 20%, 18% and 30% at 7 days, 27%, 26% & 36% at 28 days, and 30%, 29% and 33% at 90 days. The increase shows that the stronger interlocking effects of rice husk and the crack restriction effects of fibre will add even more to the compressive force of concrete [21].

4.3 Split Tensile Strength

The split strength of the concrete mix was measured at 7 days, 28 days & 90 days by using compression testing machine on 150 x 300mm cylinders. The split tensile strength was found to increase for all mixes at all days in comparison to control mix without any additive. The percentage increase in split tensile strength with addition of with addition of 0.5%, 1.0% and 1.5% rubber tyre fibres was found to be 5%, 7% & 13% at 7 days, 8%, 14% &14% at 28 days and 2%, 4% & 7% at 90 days of curing ages. Studies clearly showed that very high percentages of rubber tyre fibres did not significantly increase the splitting tensile strength. The increase in split tensile strength was also observed with addition of plastic fibres [22].

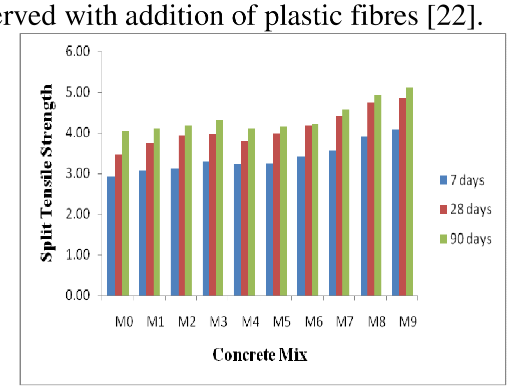

Figure 3. Split Tensile Strength Plots

The percentage increase in split tensile strength with addition of of 0.5%, 1.0% and 1.5% plastic fibres was found to be 10%, 11% & 17% at 7 days, 9%, 15% & 20% at 28 days and 2%, 3% & 4% at 90 days of curing ages. This was as a result of better filler effect due to better distribution of particles by the addition of plastic fibres. The plastic Fibres make the concrete denser & with their filler effect along with reinforcing characteristics enhance the split tensile strength. The split tensile strength increases many fold with the addition of rice husk fibres of 0.5%, 1.0%, and 1.5% in concrete as21%, 33% & 39% at 7 days, 27%, 36% & 40% at 28 days, & 13%, 22% & 27% at 90 days.. This may be attributed to the fact that adding rice husk fibres improves dispersion in the concrete specimens and thereby increase the split tensile strength [23].

4.4 Flexural strength

The flexural strength of the concrete mix was measured at 7 days, 28 days & 90 days by using universal testing machine on standard beams of size (100mmx100mmx500mm). The flexural strength was found to increase for all mixes at all days in comparison to control mix without any additive. The percentage increase in flexural strength with addition of 0.5%, 1.0% and 1.5% rubber tyre fibres was found to be 5%, 10% & 19% at 7 days, 6%, 16% & 20% at 28 days and 7%, 12% & 20% at 90 days of curing ages.

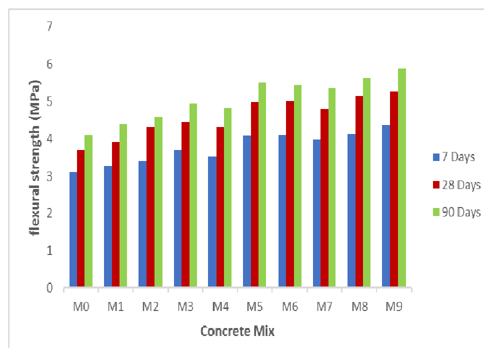

Figure 4. Flexural strength plots

The trends seen in flexural strength was in the same line as split tensile strength. This increase was due to the ductile behavior of fibres which acts as a reinforcing material for concrete. The increase in flexural strength was also observed with addition of plastic fibres. The percentage increase in flexural strength with addition of of 0.5%, 1.0% and 1.5% plastic fibres was found to be 14%, 32% & 33% at 7 days, 17%, 35% & 36% at 28 days and 17%, 34% & 33% at 90 days of curing ages. This was as a esult of better ductility & more filler effect due to better distribution of particles by the addition of plastic fibres [24]. The reinforcing characteristics of the fibres enhance the flexural strength. The flexural strength increases slightly with the addition of rice husk fibres of 0.5%, 1.0%, and 1.5% in concrete as29%, 33% & 41% at 7 days, 30%, 39% & 43% at 28 days, & 30%, 37% & 43% at 90 days with respect to concrete with no fibres. This may be attributed to the fact that adding rice husk fibres improves the reinforcing character in the concrete specimens by better dispersion and thereby increasing the flexural strength [9].

V. CONCLUSIONS

On the basis of this analysis, the following conclusions may be drawn:

1. The workability of concrete is diminished by the inclusion of various forms of rural fibres. This decline in workability was attributed to improved packing and improved intermolecular forces when the Fibres serve as a filler and reinforcement medium and eventually decreases workability.
2. The compressive intensity was observed to improve for all mixtures at all stages relative to the control mix without any additive. The improvement in compressive strength was attributed to improved packaging of fractions and lower valves in fiber-containing concrete. The improvement in compressive strength was primarily attributed to strengthened microstructure and increased aggregate bonding.
3. The improvement in compressive strength was also found with the inclusion of plastic fibres. The improvement in compressive strength due to a rise of plastic fibres was due to a decrease in the micro cracking of concrete when fibres serve as a reinforcement medium and thus improvement compactness and compressive strength. The addition of rubber fibres to the concrete mix resulted in a change in the connection between the sand, the aggregate in the mixture and the hydrated cement matrix, resulting in a rise in the compressive power.
4. The split tensile strength was observed to improve for all mixtures at all stages relative to the control mix without any additive. The plastic fibres render the concrete denser and their filler effect, along with the reinforcement properties, improves the tensile strength.
5. The patterns shown in flexural strength is in the same line as the split tensile strength. This rise was attributed to the ductile conduct of the fibres serving as concrete reinforcement content.

Strengthening properties of the fibres improve flexural strength. This can be due to the fact that the inclusion of rice husk fibres increases the strengthening character of the concrete specimens by increasing the dispersion and hence the flexural intensity. However, the present research ought to cover the following issues in the future: the research must be done for 180 and 365 days of healing duration. Chemical durability and comparison of the concrete mixtures with and without additives.

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