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An experimental investigation on fiber reinforced concrete by using recycled aggregates

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Abstract—*Use of reused materials in the building business is fundamental for all time practical advancement of every nation. The utilization of essential sources and materials is getting to be noticeably insufferable both financially and biologically, and thusly it is important to look for the likelihood of reuse of those materials once their toughness lapsed. Reusing them is the best technique for managing the expanding volume of waste for protection of nature. There is entire scope of uses of reused materials in both building and structural designing.*

This paper is centered around the trial program went for confirming chose material properties of fiber strengthened cement in which the greater part of the common stone totals is supplanted by reused totals – brick work and cement.

The blend of reused development and pulverization squander, manufactured filaments and cover makes an abnormal fiber strengthened cement; new composite, which offers a wide field of conceivable use in development industry.

The paper presents exploratory program and shows come about on this composite - mechanical and physical attributes – thickness, compressive quality, part rigidity and flexural rigidity and modulus of versatility of fiber fortified cement. In light of a substantial arrangement of obtained trial comes about on various qualities of the tried material, it can be judged on the conduct of this composite, Which is sufficiently adequate to be utilized as a part of ground structures as planned.

The use of this composite material is guaranteed by the engineered strands, which alongside alternate segments constitutes the extreme structure of the composite positive particularly under elastic stacking because of its high pliability.

Keywords—Fibre reinforced concrete, recycled aggregate, synthetic fibres, mechanical properties, construction & demolition waste, masonry rubble, concrete rubble.

I.INTRODUCTION

Concrete is the most commonly used material in the construction industry and has contributed to the advancement of civilizations throughout last century. However, construction activities demand a significant amount of natural materials in order to produce cement and aggregates. Procurement of these natural materials significantly modifies the natural sources and creates major environmental problems. Further more, sustainable waste management is another major issue faced by countries all over the world. In order to minimize the environmental impact and energy consistency of concrete used for construction facilities, reuse of construction and demolition wastes can be a beneficial way which leads to sustainable engineering approaches to concrete mix design. As many developing countries all over the world are recycling and reuse area alternatives to minimize the impact of energy and raw material consumption on the environment, another waste that can be potentially used for concrete production is recycled concrete aggregate obtained via construction & demolition waste.

Sustainable development of the cement and concrete industry requires the utilization of industrial waste components. At present, for a variety of reasons, the concrete construction industry is not sustainable. Firstly, it consumes huge quantities of virgin materials which can remain for next generations. Secondly, the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Thirdly, many concrete structures suffer from lack of durability which may waste the natural resources. So, finding a solution to substitute a practical recycled product for part of the cement seems to be desirable for sustainable development. The utilization as mineral admixture to partially replace cement could preserve the non-renewable resources required for the production of cement, and could somehow contribute to like the natural aggregates but the strength is less than the natural aggregates. We can Binding other materials together. Its initial and final setting time is 30 minutes and 600 minutes respectively. The cement contribute to sustainable constructions the recycled concrete aggregate have some properties use the industrial by product to some extent, which do not affect the fresh and hardened properties of the concrete and gives the similar result as normal concrete.

A large number of researches have been directed towards the utilization of waste materials. To increase the durability of the concrete made with recycled concrete aggregates, admixture & fibre can be used, the admixture increase the workability of the concrete at same water cement ratio, whereas the fibre increase compressive, tensile & flexural strength of the concrete. The required durability characteristics are more difficult to define than the strength characteristics, specification often use a combination of performance & prescriptive requirements, such as workability, compressive strength, Split tensile strength, flexural strength and water-cement material ratio to achieve a durable concrete. End result may be a high strength concrete, but this only comes as a construction & demolition waste of requiring a durable concrete.

II. CEMENT

Cement is used as binder in concrete, it is very fine and grey in colour. It has tendency of setting independently and it can be easily affected by violent chemicals after setting.

A. Types of Cement

a) Non-hydraulic cement: This cement sets under dry conditions and reacts with CO_2 in the atmosphere

b) Hydraulic cement: Cement which is obtained using replacement of cement in a mix with Aluminum silicates and pozzolanas, such as fly ash, rice husk etc.

is called hydraulic cement. The chemical reaction makes hydrates which are insoluble in water, durable and safe from chemical attack.

III. AGGREGATES

Aggregates are the inert materials such as fine aggregates, coarse aggregates can be mixed with water and Portland cement are necessary ingredients of concrete. Aggregates can be of three types

Natural
Manufactured
Recycled aggregate

Natural aggregates are obtained from rocks through an open quarry. Extracted rock particles are then grinded to usable sizes by mechanical crushing. Manufactured aggregates are the byproduct of natural aggregates and are manufactured in industries. Recycled aggregate is obtained from demolition of old structural concrete.

IV. FINE AGGREGATES

Fine aggregate is ordinary sand which has been washed and sieved to remove the larger particles more than 4.75mm size. The fine and coarse aggregate are kept separately because mixture of fine aggregates is more expensive than coarse aggregates. The cause for using a mixture of fine and coarse aggregate is that by correct proportions to make the concrete free form voids or very few voids are obtained, and it also reduces the quantity of comparatively expensive fine material like cement.

V. COARSE AGGREGATE

Coarse aggregates are bigger in size i.e. above 4.75 mm. In concrete, 10 mm and 20 mm size of aggregates are commonly used. Coarse aggregates also termed as mineral materials such as gravel and crushed stone aggregates which are used with a bitumen or Portland cement to form compound materials such as asphalt concrete and Portland cement concrete respectively. In road construction 20mm and 40mm aggregate are used as base and sub base in both rigid and flexible pavements. Concrete admixtures are primarily used to increase the setting time of concrete and also to ensure the quality of concreteduring mixing, transporting, placing, and curing. But use of natural aggregates also leads to high cost of construction. In this research work recycled aggregate was used. As the use of recycled aggregate in concrete mix makes it economical.

VI. RECYCLED CONCRETE AGGREGATES

With the demolition of the old structure, the environmental waste increases. To reduce the environmental waste we can process the old concrete by crushing it to the size required for the mix design, the recycled concrete aggregate have same properties like the natural aggregates but the strength is less and water absorption is more than the natural aggregates. As the sources of natural aggregates are reducing and the

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cost of aggregates is increasing, we can use the recycled concrete aggregates to make the concrete mix economical. Many researches have been directed towards the utilization of waste materials, which show that the concrete having partial replacement of natural aggregates with recycled aggregates is having less durability than nominal concrete. To increase the durability of concrete made with partial replacement of natural aggregates with recycled aggregates, fibres can be used, as the workability of concrete containing recycled aggregates is less, so to increase the workability admixture can be used.

VII. STEEL FIBRES

For increasing the strength of the recycled concrete I have used corrugated steel fibres which I purchased from STEWOLS INDIA (P) LTD.5-8B, Nagpur. As the workability of concrete decreases with addition of long length fibre, I have used 25 mm length corrugated steel fibre and having 1mm diameter in section.

VIII.Results & Discussion

a) Workability:

The workability test results of RAC with and without fibre are presented in Table 1.0. From the results it is observed that as Recycle Aggregate (RA) content is increases the workability decreases. The decrease in slump may be due to higher water absorption capacity of RA than the Natural Aggregate (NA) The surface texture and angularity of RA may influence the workability performance. This type of observation was made by Buye-Buddin and Zaharieva (2002).

The slump test is also conducted for RAC with fibres. The design slump during mix designed process was taken as 50mm, where as when it comes to reality it showed the slump in the range of 24 to 17mm. From this it is observed that as the % of fibre increases the workability decreases. The similar trend of decrease in slump is reported by the Frigione (2010), Ismail and Al-Hashmi (2008) and Kou et.al. (2009).

Table 1.0.Workability

S.No.	Nomenclature	Slump (mm)
1	RAC-0	49
2	RAC-20	48
3	RAC-40	46
4	RAC-60	46
5	RAC-80	40
6	RAC-100	39
	1% Fiber	
1	RAC-0	47
2	RAC-20	31
3	RAC-40	31
4	RAC-60	30
5	RAC-80	28

6	RAC-100	27
2% Fiber		
1	RAC-0	32
2	RAC-20	24
3	RAC-40	23
4	RAC-60	22
5	RAC-80	19
6	RAC-100	17

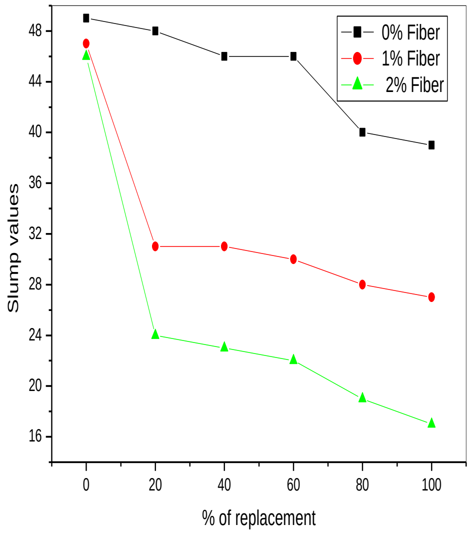

Fig 1.0

Ultimate stage (US):

The bearing strength at ultimate state for all mixes is presented in Table 2.0 and Figure 2.0.From those it is observed that as the % of recycle aggregate is increases the bearing strength was decreased. The behavior at in the ultimate stage is similar to first crack stage trend. For 0% of fibers, the bearing strength is decreased from 15 to 61% for 20 to 100% replacement of recycle aggregate when compared with natural aggregate concrete.

For 1% of fibre concrete mix, the bearing strength decreases as the % of recycle aggregate increases when compared with natural concrete with and without fibres. But the addition of 1%fibres for concrete mix, the bearing strength significantly enhances when compared with corresponding replacements with 0% fibre concrete. The mix with 20% of recycle aggregate along with 1% of fibre exhibits more strength (81.8N/mm^2) when compared with natural aggregate concrete without fibres i.e. 0% fibre (76.30N/mm^2). But for mix with 40% of recycle aggregate along with 1% of fibre showed marginally lesser strength (60.30N/mm^2) of natural aggregate concrete without fibres i.e. 0% fibre (76.30N/mm^2).

For 2% of fibre concrete the bearing strength is decreasing as the replacement recycle aggregate content is increasing. The% of decrease is about 2 to 28, when compared with natural aggregate concrete containing 2% of fibre. The mix with 40% of recycle aggregate along with 2% of fibre exhibits higher strength (77.4Mpa) of natural aggregate concrete without fibres i.e. 0% fibre(76.3Mpa). From this it concluded that, as the fibre content increases the bearing strength may enhances for recycle aggregate concrete. In this mix the fibres placing major role to enhance the strength. These types of results were noticed by S.A.Al-Taan and J.A.Al-Hamdony (2005) for steel fiber concrete.

As stated in the first crack stage the same behavior may be expressed as, the presence of steel fibres in concrete mix show good performance up to 40% replacement. So the designer can be take the concrete mix with recycle aggregate up to 40% replacement with 1 and 2% of fibers while estimating the ultimate load also. The loss of strength in recycle aggregate can be gained by incorporation of steel fibres. This may be due to a law of mixture.

Table 2.0-Bearing strength at Ultimate stage

S.No	Nomenclature	Bearing Strength 0% fibre	Bearing strength 1% fibre	Bearing strength 2% fibre
1.	NC	76.3	90.1	92.2
2.	RC 20	64.5	81.8	90.02
3.	RC 40	47.7	60.3	77.4
4.	RC 60	41.2	66.8	71
5.	RC 80	29.2	59.6	65.5
6	RC 100	27.3	57.4	61.4

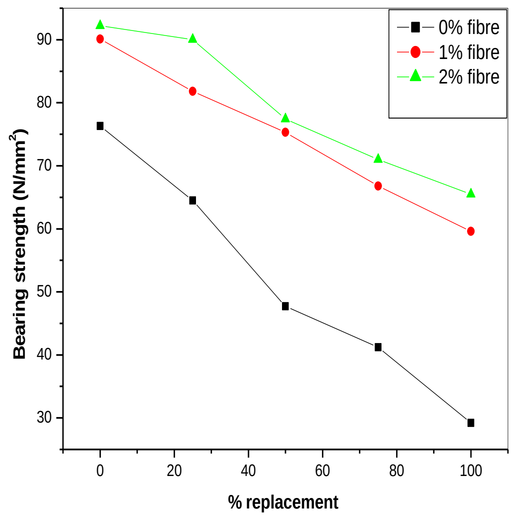

Figure 2.0-Bearing Strength vs. % replacement

Effect of bearing ratio on bearing strength (Effect of plate size)

The size effect of the bearing plate is presented in Table 1.0 to 2.0 & figure 1.0 to 2.0. At first crack stage as the size of the plate is decreasing the bearing strength is increasing. For 0% fibre concrete the increase in bearing strength for 47.4 mm and 38.7mm plate is about 44 to 116 and 79 to 222% when compared with 67.1 mm plate with variation of 20 to 100% recycle aggregate in the concrete. The bearing strength at first crack stage for 38.7mm plate is increases about 80 to 222% when compared with 47.4 mm plate for 20 to 100% of recycled aggregate concrete. For 1% fibre concrete the increase in bearing strength for 47.4 mm and 38.7mm plate is about 40 to 20 and 64% when compared with 67.1 mm plate with variation of 20 to 100% recycle aggregate in the concrete. The bearing strength at first crack stage for 38.7mm plate is increases about 8 to 36% when compared with 47.4 mm plate for 20 to 100% of recycled aggregate concrete. For 2% fibre concrete the increase in bearing strength for 47.4 mm and 38.7mm plate is about 63 to 24 and 77 to 64% when compared with 67.1 mm plate with variation of 20 to 100% recycle aggregate in the concrete. The bearing strength at first crack stage for 38.7mm plate is increases about 8 to 31% when compared with 47.4 mm plate for 20 to 100% of recycle aggregate concrete

At ultimate stage also as the size of the plate is decreasing the bearing strength is increasing. For 0% fibre concrete the increase in bearing strength for 47.4 mm and 38.7mm plate is about 45 to 115 and 80 to 222% when compared with 67.1 mm plate with variation of 20 to 100% recycle aggregate in the concrete. The bearing strength at first crack stage for 38.7mm plate is increases about 80 to 222% when compared with 47.4 mm plate for 20 to 100% of recycle aggregate concrete. For 1% fibre

Concrete the increase in bearing strength for 47.4 mm and 38.7mm plate is about 51 to 20 and 64% when compared with 67.1 mm plate with variation of 20 to 100% recycle aggregate in the concrete. The bearing strength at first crack stage for 38.7mm plate is increases about 8 to 36% when compared with 47.4 mm plate for 20 to 100% of recycle aggregate concrete. For 2%fibre concrete the increase in bearing strength for 47.4 mm and 38.7mm plate is about 64 to 20 and 77 to 64% when compared with 67.1 mm plate with variation of 20 to 100% recycle aggregate in the concrete. The bearing strength at first crack stage for 38.7mm plate is increases about 8 to 31% when compared with 47.4 mm plate for 20 to 100% of recycle aggregate concrete

From the above results it is observed that as the percentage of fibre increases and the plate size decreases the bearing strength is increasing. This may be due to confinement effect of concrete. The lesser size of the plate posses the better confinement than the other two plates. The variation of slopes in the figures for different plates and %of fibre is varying; this indicates the material behavior and fibre effect.

Failure Mode Analysis

For all cubes compression test was conducted. The 0% fibres concrete cubes were shown lower load when compared with cubes containing with 1 and 2%. Among the 1 and 2% fibre cubes the cubes with 2% showed higher load carrying capacity. In 0% fibre cubes the concrete was peel off at edges this can be viewed in the figure5.9 to 5.11, where as the cubes containing fibres showed integrity and as percentage of fibre increases the crack with and less damage was observed during experimentation.

For each mix three cubes were tested for bearing strength with bearing ratio of 5, 10 and 15.In all the cubes during experimentation radial cracks were observed. This can be viewed from figure 5.15 to figure 5.17.Thistype of cracks were also observed by S.A.Al-Taan and J.A.Al-

Hamdony (2005) for steel fiber concrete. The dimensional stability is more for higher percentage concrete cubes when compared with other percentage fibres and also the crack width is decreased as the % of fibre content increases.

Figure 3: Cubes testing for Compressive strength (0%fibre)

Figure 4: Cubes testing for Compressive strength (1%fibre)

Figure 5: Cubes testing for Compressive strength (2%fibre)

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Plate 6: Cubes testing for bearing strength using 38.7mm square plate

Plate 7: Cubes testing for bearing strength using 47.4mm square plate

Plate 8: Cubes testing for bearing strength using 67.1mm square plate

Plate 9: Failure mode of cube using 38.7mm square plate

Plate 10: Failure mode of cube using 47.4mm square plate

IX.Conclusion

The following conclusions are drawn from the experimental work.

1. The slump values decreased as the % of recycle aggregate increases.

2. The compressive and bearing strengths are decreases as the RA content increase in the conventional concrete mix.

3. The compressive and bearing strengths decreased about 2 to 14%and 3 to 12%

with RA content of 20 to 100% respectively
4. The fibre volume with 1% can be used effectively without change in design mix.
6. The Maximum permissible limit for recycle aggregate content with 2% fibre volume is 40%.
7. For RAC with 1% fibre volume the compressive and bearing strengths decreased about 13 to 23% and 8 to 19% with RA content of 0 to 100% respectively when compared with conventional concrete.
8. For RAC with 2% fibre volume the compressive and bearing strengths decreased about 2 to 14% and 19to 27% with RA content of 0 to 100% respectively when compared with conventional concrete.
9. With incorporation of steel fibres (i.e. 1 and 2%) the compressive and bearing strengths were increased when compared with respective replacement of recycled aggregate.
10. From the results it concluded that the presence of steel fibres in concrete mix showed good performance up to 40% replacement i.e. it is as good as natural aggregate concrete. So the designer can be take the concrete mix with recycle aggregate up to 40% replacement with 1 and 2% of fibers.

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