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A Study on Strength Of Concrete Using Rubber Fiber and Granite Waste

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***Abstract*— In the present world of urbanization and industrialization, concrete is an important structural material. It is a heterogeneous mixture of cement or lime as a binding material, fine aggregate, coarse aggregate, water and admixture. For fine aggregates, natural river sand is commonly used and due to the restriction on the extraction and scarcity of natural resources, construction cost comes out to be very high. On one side, excess depletion of natural river sand shows very clear environmental impacts like exploitation of natural water bodies, damage to the vegetations and fisheries, etc., on the other side, various industries face problems in safe disposal and handling of the wastes generated by them due to its excessive accumulation. For example, mining industries of granite stones produce tons of non-biodegradable fine powder waste and various rubber processing units produce rubber wastes, which is quite difficult to handle and involves various tedious disposal procedures that are quite harmful to the environment. If these wastes possess suitable properties, they can be used as an addition or replacement of one or more components of concrete. The utilization of these hazardous wastes in concrete manufacturing not only reduces the cost of construction but also would result in a green environment and viable concrete technology.**

The main aim of this work is to experimentally investigate the possibility of using granite cutting waste (GCW) and rubber fiber as a partial substitution of sand in concrete. Fibers obtained from mechanical grinding of used rubber tire have been incorporated in this research work. The percentage of rubber fiber in all concrete mixes is kept fixed which is 10% by weight of fine aggregates while the remaining fine aggregates have been replaced by granite cutting waste (GCW) with the percentages 0%, 10%, 20%, 30% & 40%. It was observed that the substitution of 20% natural sand with granite cutting waste & 10% sand by rubber fiber appeared to be most effective in increasing the compressive, flexural strength, impact resistance, improved abrasion resistance and resistance to water permeability and water absorption as compared to other ratios.

***Index Terms*— granite cutting w,aste, Rubber Fiber.**

I. Introduction

In recent years, more attention has been given to the use of recycled materials in concrete and sustainable design. Industrial waste products have generally been disposed off in landfills, yet lately, those landfills are starting to load up with materials that are certainly non-biodegradable. Due to significant pile-up waste products, there is an urgent need for other alternatives. Rather than discarding waste products, a whole industry in reused materials has started to flourish with the ultimate goal to minimize the amount of waste sent to landfills every year. In addition to everyday recycling of aluminum cans, plastic bottles and paper, there is also recycling of industrial by-products, glass, wastes from milling industries and even tires. Various attempts have been made to include fly ash, silica fume, glass, etc. into the construction industry. Also, there have been a number of studies completed, looking for the use of recycled tire particles as aggregates in both asphalt and concrete in an effort to dispose off the millions of scrap tires generated each year in the country.

As a result of rapid industrialization and urbanization in the country, the consumption of natural river sand has increased because of the sizeable use of concrete. Recently in India, some states (Rajasthan and Tamil Nadu) have imposed regulations on the removal of sand from the river beds due to its various environmental threatening consequences and have forced the search of feasible alternative material. Out of other states in India, Rajasthan has the largest share in the Indian stone industry. It has significant reserves of various stones like sandstone, marble, granite, Kota stone, and limestone, having almost 20% of granite reserves in the country. The amount of waste produced during the industrial cutting and granite stone processing is 65 percent of the total output and the proper disposal and use of this waste are one of the problems faced by the stone industry.

II. REVIEW OF LITERATURE

Karahan et al. (2012) **[24]** carried out some experiments to check the fresh, durability and mechanical performances of self-compacting rubberized concrete (SCRC). For testing, hey prepared SCRC mixtures iwithiaiwateribinderiratio (w/b) iofi0.32; and crumb rubber content of 0, 10, 20, and 30% by volume of fine aggregate. To deduce the fresh properties of concrete, they used V-funnel, slump flow, L-Box and J-Ring tests and itheitestiresultsishowedithatitheiuseioficrumb rubber diminished the passing and filling ability of SCRC, when used as fine aggregate. They also observed a gradual decrease in mechanical properties, with an increase in crumb rubber content. On the other hand, the reduction rate of the compressive strength was more evident than the tensile strength. They observed a decrease in the initial and secondary water sorptivity of SCRC, however, with the use of crumb rubber, water absorption, chloride ion permeability and water porosity increased slightly. For SCRC having 10%

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crumb rubber, no significant decrease was observed in the corrosion resistance and freezing & thawing, however, beyond that level, durability performance was affected significantly.

Gupta et al. (2015) **[35]** used rubber fibers procured from waste tires, as a partial substitution of fine aggregates, and carried out experimental investigations on compressive as well as flexural strength, abrasion resistance and carbonation depth of the concrete. They made mixes of three water-binder ratios, each having rubber fibers in the percentage 0%, 5%, 10%, 15%, 20% and 25%. The test results revealed that the flexural strength and abrasion resistance was increased with the increase in rubber fiber percentage which might be due to long fibers of rubber. Whereas, it was observed that the trend of carbonation depth and 90-days compressive strength was increasing, with the increase iinireplacementilevels, which could be due to insufficient bond between rubber fiber and cement paste.

Najim et al. (2011) **[17]**examined the dynamic and mechanical properties of self-compacting rubberized concrete (SCRC) which is prepared by partially replacing the fine aggregate, coarse aggregate iandicombinedifineiandicoarseiaggregate by crumb rubber at 5, 10 and 15% weight proportions. They found that the dynamic properties of SCRC were quite superior to plain, NVC or SCC mixes and have sufficient mechanical properties required for its use in various structural applications. Crumb Rubber significantly improved the strain capacity of the concrete, reducing the crack mouth open displacement (CMOD), as compared to the reference SCC mix, on the other hand, the flexural strength was decreased. For all the SCC mixes, young's modulus of elasticity (E) was found to be decreased, which is the sign of improved energy absorption and ductile behaviour. Up to 15% wt. replacement, UPV measurements showed 'good' quality of SCRC mixes. The SCRC mix corresponding to 15% crumb rubber, showed isuperiorivibrationidamping capability when icompared with iSCCiand NVC imixes.

Issa, et al. (2013)**[5]** used recycled crumb rubber iasiaisubstituteiforifineiaggregate, replacing crushed sand in the concrete mixture at i0 itoi100 percent. The result revealed that 25 percent substitution ioficrushedisandigivesigood compressive strength and by using crumb rubber iupitoi25 percent, results in 8 percent reduction in concrete density and ductility of the concrete increases, therefore, it is beneficial in shock-resistant feature, ihighwayibarrier, etc. iandialso improves the idampingiproperties, wherever required.

Gerges et al. (2018)**[22]** studied the effect of recycled rubber powder, when used as fine aggregate in concrete, in 5%, 10%, 15% and 20% of the total fine aggregate quantity and examined the physical properties of concrete such as compressive and flexural strength, density, split tension and impact capacity. The test results revealed that with the increase in substitution percentage of rubber, compressive strength decreases whereas, at all the rubber replacement percentages, the concrete showed a slight increase in tensile strength, but this increase is much less as compared to the compressive strength reduction rate. The addition of rubber also had a negative effect on concrete's modulus of elasticity, but it also means that the capability of the rubberized concrete to show elastic behavior increases, when loaded in tension. The rubberized concrete also did not undergo typical brittle failure, as it exhibits increased energy absorption.

Thomas et al. (2014)**[4]** examined the effect of partially replaced discarded crumb rubber, iusedias fine aggregate in the concrete mixture in the percentages of 0% to 20% at 2.5% intervals. M30 grade of concrete was designed with three water-cement ratios of 0.4, 0.45 and 0.5. iTestsiwereidoneitoidetermineitheicompressive, flexural strengths, water permeability, sorptivity and abrasion resistance of the concrete. The test results showed a decreasing trend for both compressive and flexural strengths, iwithian increase iinitheipercentageiof rubber ireplacement, while an increase in abrasion resistance was observed for the same. On the other hand, it was first discovered that water permeability first decreased up to 5% replacement level and then increased for both w/c ratios of 0.4 and 0.45. It was also found that the value of sorptivity increased with the increase in the percentage of substitution. Eventually, they concluded that crumb rubber can ibeiusediasiaipartial substitution iofifineiaggregate up to 7.5%, without significantly affecting the desired strength.

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III. MIX PROPORTION:

Table 3.15 Material quantities from mix proportion required for control mix

S. No.	Material	Mix proportion for 1m^3 concrete (kg)	Mix proportion for required volume (kg)
1.	Cement	394.32	36.15
2.	River sand	681.15	61.75
3.	C. A. (10 mm)	619.18	56.46
4.	C. A. (20 mm)	619.18	56.46
5.	Water	158	15.53
6.	Admixture	1.738	0.198 (0.5%)

Table 3.16 Material quantities after adding GCW and rubber fiber

S. No.	Material	Material quantity (kg)				
		10R , 0G	10R , 10G	10R , 20G	10R , 30G	10R , 40G
1.	Cement	36.15	36.15	36.15	36.15	36.15
2.	Water	15.53	15.53	15.53	15.53	15.53
3.	F. A.	55.575	49.4	43.225	37.05	30.875
4.	Rubber	3.028	3.028	3.028	3.028	3.028
5.	GCW	0	6.175	12.35	18.525	24.7
6.	CA (10mm)	56.46	56.46	56.46	56.46	56.46
7.	CA (20mm)	56.46	56.46	56.46	56.46	56.46
8.	Admix.	0.275 (0.7%)	0.297 (0.75%)	0.253 (0.65%)	0.220 (0.55%)	0.154 (0.4%)
9.	Comp. factor	0.85	0.85	0.87	0.865	0.86

IV. Results and Discussion

Table 4.1 7 days compressive strength (in MPa)

S. No.	Mix name	Sample 1	Sample 2	Sample 3	Average (MPa)
1.	Control mix	30.44	27.29	26.42	**28.05**
2.	10% R, 0% G	19.14	22.69	24.77	**22.2**
3.	10% R, 10% G	25.44	24.02	22.879	**24.113**
4.	10% R, 20% G	26.95	26.62	27.79	**27.12**
5.	10% R, 30% G	25.2	25.46	25.45	**25.37**
6.	10% R, 40% G	20.05	20.05	21.1	**20.4**

Table 4.2 28 days compressive strength (in MPa)

S. No.	Mix name	Sample 1	Sample 2	Sample 3	Average (MPa)
1.	Control mix	31.64	29.41	32.12	**31.056**
2.	10% R, 0% G	21.272	26.22	28.75	**25.414**
3.	10% R, 10% G	26.74	27.45	27.47	**27.22**
4.	10% R, 20% G	29.5	30.98	29.79	**30.09**
5.	10% R, 30% G	28.95	28.96	27.77	**28.56**
6.	10% R, 40% G	22.68	22.81	23.84	**23.11**

Table 4.3 28 days flexural strength (in MPa)

S. No.	Mix name	Sample 1	Sample 2	Sample 3	Average (MPa)
1.	Control mix	4.84	4.4	4.7	**4.64**
2.	10% R, 0% G	5.14	4.88	5.25	**5.09**
3.	10% R, 10% G	5.21	5.14	5.04	**5.13**
4.	10% R, 20% G	5.27	5.29	5.22	**5.26**
5.	10% R, 30% G	5.3	5.23	5.04	**5.19**
6.	10% R, 40% G	5.1	4.89	5.07	**5.02**

V. CONCLUSION AND DISCUSSION

A. *CONCLUSION*

- The compressive strength of rubberized concrete has decreased with an increasein the level of substitution of fine aggregates by rubber fibers. The strength, however,increased when fine aggregate was partially substituted by granite cutting waste. At 28 days, the maximum compressive strength value of 30.09 MPa was obtained for 10% rubber fiber and 20% GCW mix, which is slightly less than the compressive strength of the control mix, which has a value of 31.056 MPa.
- The flexural strength has also improved with the increase in the percentage substitution of fine aggregate by rubber fiber. At i28 idays, itheimaximumiflexural strength of 5.26 MPa was obtained for 10% rubber fiber and 20% GCW mix.
- The mix having 10% rubber fiber and 20% GCW

showed maximum impact resistance, which is almost double as compared to the impact resistance value of the control mix.

- The iincorporationiof rubber ifibersiiniconcrete has increased iits abrasion resistance compared itoitheicontrolimix. iThe average thickness lost due to abrasion was least for 10% rubber fiber and 20% GCW mix, out of all the mixes.

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