EFFECT OF PARTIAL REPLACEMENT OF COARSE AGGREGATE AND FINE AGGREGATE BY SCRAP TYRE RUBBER: A REVIEW

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Abstract - *The disposal of tyres in landfills has proven to have negative effects on the environment. they take up a great deal of space within a landfill and their process of decomposing has created a wide variety of issues that have made their disposal in landfills unfeasible and in many regions, banned. The waste tyres can be used for many purposes that are beneficial in helping reduce the amount of waste tires in stockpiles. In this review paper we studied different physical and mechanical properties of concrete containing tyre rubber waste.*

Keywords: Rubberized concrete, chipped rubber, tyre rubber, NaOH solution, Shredded rubber, Split tensile test.

1. Introduction

In the global total of waste tyres India account for about 6-7%. As the local tyre industries growing at 12% per annum, waste volumes of tyres are rising. Every year over 1billion tyres are manufactured worldwide and equal no. of tyres are permanently removed from vehicles which are becoming waste. The largest producer of waste tyres is U.S., about 290 million a year. Due to rapidly increase in new vehicles sales in China and India waste tyre volumes are increasing with higher rate. Since tyres are made to last long, the same things that make them durable can also make them difficult to dispose off thus effecting the environment in long run. India has been recycling and reusing waste tyres for four decades, although it is estimated that more than 60% are disposed of through illegal dumping. Along with this, India is the second larger producer of reclaimed rubber after China. , India produced 90000 metric tonnes of reclaimed rubber from waste tyres in the year 2011. Tyre alone takes thousands of years to decomposed it completely. In most of the cases ends up being burnt, releasing toxins and pollutants into air, water and soil. Stockpiling or illegally dumping or landfilling is the traditional method of disposal waste tyres, but these are short-term solution. The vehicle tyres should be recycled because disposal of waste tyres is not an easy task These tyres are among the largest and most problematic sources of waste, Due to large volume produced and their durability these tyres are among the largest and most problematic sources of waste,.

2. EXPERIMENTAL STUDY

2.1 Workability

Onkar et.al. used Portland cement, course aggregate (size-20mm), uncrushed river sand (size- 5mm) for concrete mixture. They used shredded tyre rubber of size 20mm for replacement of course aggregate by 5%, 10%, and 15% in volume. The w/c ratio for the total experimental study is 0.45. They found that slump value decreases as percentage of rubber increases. To obtain better workability they add superplasticizer. The result of the study is as shown in fig.1 [1]

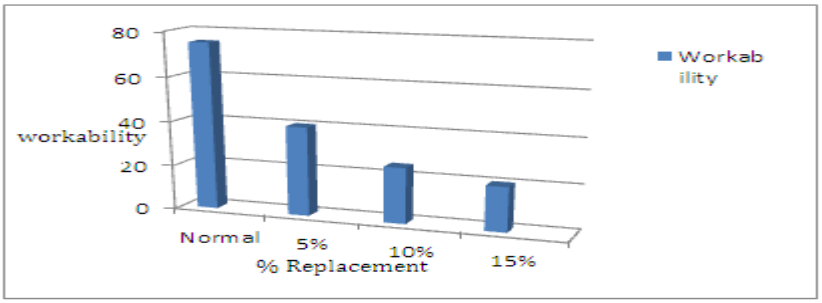

Fig.1- Graph of workability test according to percentage of rubber

In some researches authors used concrete mix which is prepared by M25 grade of concrete. They casted concrete cubes of size 15cm×15cm×15cm [2]. The results of the experiment are as follows,

Table 1-Changes in slump value due to partial replacement of course aggregate by scrap tyre rubber

Quantity of rubber in concrete mix (%)	Slump value (mm)
0	85
10	100
20	125
30	150

The results of the slump test are shows that, there is an increase in slump value and workability with increase in percentage partial replacement of course aggregate by waste tyre rubber. But if we use chipped tyre rubbers in concrete, then these reduces workability of concrete [2]. I. Topçu et.al. Used portland cement with fly ash, rubber, admixture, plasticizer, fine aggregate, course aggregate in concrete mix. They found that the rubber waste with a maximum dimension of4mm in self-compacting concretes instead of sand resulting that increase in concrete workability which is due to the presence of viscosity agents even to a volume of 180kg/m3 [3]. Some other auther used crumb tyre of size 0.075-4.75mm to replace sand in various proportion i.e.20%, 40%, 60%, 100%. They concluded that increasing quantity of rubber content in concrete decreases the concrete slump [4].

Table 2-Results of workability test according to quantity of rubber [4]

Quantity of rubber (in %)	Slump value (mm)
0	75
20	61
40	36
60	18
80	10
100	5

Skripkiunas replace the fine aggregate of 23 kg by crumb rubber but they used 0.6% of policarboxile superplasticizer and they obtained same workability [5]. Bignozzi & Sandrolini used scrap tyre rubber(size is 0.5-2mm) and crumb tyre rubber (0.05-0.7mm) to replace 22.2% and 33.3% of fine aggregate in self-compacting concrete resulting that the addition of rubber particles does not affect on the workability of the concrete if the doses of superplasticizer also increases significantly [6]. Khatib and Bayomy added two types of rubber i.e. crumb and chipped. They made three groups for testing according to type rubber they going to replace.

Group A: - Fine aggregate was replaced by crumb rubber.

Group B: - Course aggregate was replaced by chipped rubber.

Group C: - Both aggregate were replaced in equal volumes.

Again these three rubbers had different content of rubber in the range of 5-100%. They stated that there is constant decrease in slump value as rubber content is increases. Also they found that concrete mixture which made by fine crumb rubber is more workable than the concrete mixture which is made by chipped tyre rubber [7]. K.Charankumar et.al used two concrete grade (M15, M25), rubber aggregate in 10%, 25%, and 50% with coarse aggregate. They found that the addition of scrap rubber tires into concrete mix significantly increased the slump and workability of concrete. They noted that there is constant increase in value of slump as the percentage of rubber content was increased constantly [8].

2.2 Compressive strength

K.C. Panda et.al. Carried out the compression test on concrete block of size 150X150X150 according to IS: 516(1959). They used Portland-pozzolana cement, shredded/chipped rubber (size is 100-230mm), crumb rubber (size is 0.075-0.475mm), fine aggregate, course aggregate. They compression test is carried out after 7days and 28days. The results of the test are as given in Table no.2&3. They found that there is constant decrease in compressive strength of concrete at 7 days and 28 days [9]

Table 3- Result of compression test at 7 days [9]

Concrete Mix	Compressive strength(N/mm2)
MC-00	26.33
MCR-03	24.25
MCR-06	19.53
MCR-09	15.62
MCR-12	12.58
MCR-15	10.86

Table 4- Result of compression test at 28days [9]

Concrete Mix	Compressive strength(N/mm2)
MC-00	39.43
MCR-03	39.85
MCR-06	34.13
MCR-09	25.29
MCR-12	26.13
MCR-15	21.82

According to Chou et al. pretreatment of crumb rubber with the organic sulphur can improve rubber surface properties and increase the bonding between wastes and cement paste [10]. Snelson et al. replaces course aggregate by shredded tyre chips partially in several percentages i.e. 2.5%, 5%, 15%. The rubber mixture containing pulverized fuel ash is used for partial replacement of cement which results in reduction of compressive strength. They stated that the loss in strength occure due to the low adhesion between cement paste and tyre rubber waste. To improve the strength they add some admixtures with low pozzolanic activity [11]. M.Gesoglu et al. noticed that strength of concrete mix which containing silica fume, crumb tyre rubber, tyre chips drecreases with increase in % of rubber content in mix. They suggested that it is possible to achieve compressive strength upto 40MPa by replacing 15% volume of aggregate by rubber waste [12]. Raghavan et al. stated that immersion of rubber pieces in aqueous NaOH solution could improve the bonding property between cement paste and rubber waste and leading to better performance of concrete. The NaOH removes the zinc stearate from the rubber surface (which is responsible for poor bonding characteristics of concrete mix) and improves the surface homogeneity [13]. Some authers used the pretreated rubber waste to increase bonding property between rubbers and cement paste i.e. they used NaOH solution to wash the rubber surface and keep it for drying for 20min [14]. Investigations regarding compressive strength of rubberized concrete show that compressive strength of concrete decreases as % of rubber increased concrete, but it can improve also by giving some pretreatment to tyre chipps.

2.3 Split tensile strength

Nagesh Kumar et al.have shown the strength pattern for various mixes. They replaced cement with silica fume by 15% & fine aggregate with rubber powder by 10%, a reduction in tensile strength upto 25% was observed [15]. Also they replaced sand with tyre rubber powder by 40%, the tensile strength is reduced by 22%. Also observed that when both coarse aggregate and fine aggregate were replaced with chipped rubber by 2.5% & powder by 20% respectively then there was a reduction in split tensile strength by 21% [15]. Ganjian et al. tested the specimen for the tensile strength where coarse aggregate and cement is partially replaced with chipped rubber and ground rubber respectively. They have compared the reduction in tensile strength in both the mixtures with the control mixture [16]. Neela Deshpande et al. observed the result for split tensile strength for various mixes. According to observations the split tensile strength is reduced upto 76.59% when aggregate content is replaced with 10% of shredded rubber. Also, total aggregate content is replaced by 1% of shredded rubber treated with NaOH shows a small reduction in tensile strength upto 5.24%. [17].

These authors stated that the tensile strength decreases when percentage of replacement of rubber increases. A high % of reduction is due to poor bond between cement paste and tyre rubber powder. It was assumed that the tensile strength in concrete containing rubber should be higher than the control mixture. It can reduce the crack growth in concrete as it is soft material. However practically it is not possible. This is due to the weak interface zone which accelerates concrete breakdown. The stress exerted during crack expansion causes a surface segregation between rubber & cement paste [16].

Kumaran S.G et.al. used cement of grade 53 with combination of fine sand and coarse aggregate with 10mm and 20mm. They used waste tyre rubber in the form of chips and fibres. The replacement of coarse aggregate is 0%, 5%, 10%, 20% and 25%. The W/C ratio is 0.4. The waste tyre rubber chips are of 6mm diameter and fibre rubber having dimension 75mmX7mmX7mm. They observed that there is 50% reduction in tensile strength but also they noticed that there is energy absorption during tensile loading [18]. Moayyad Al-Nasra et.al used Portland cement, sand aggregate, rubber aggregate. 0%, 10%, 20% is the quantity of replacement in percentage. They conclude that as the quantity of rubber aggregates increases there is constant decrease in tensile strength. Also they suggested that several properties of concrete are improved due to addition of rubber [19].

2.4 Flexure Test:

G. Nagesh Kumar et.al. studied changes in flexural strength for various mixtures. They observed a reduction of 34% in flexural strength when sand is replaced with tyre rubber powder by 40%. When course aggregate and fine aggregate were partially replaced with chipped tyre rubber, flexural strength is reduced by 16%. In addition to this when cement and fine aggregate were partially replaced by silica fume tyre rubber powder, they observed 34% reduction of flexural strength [15]. Kotresh K.M. et. al. suggested that rubberized concrete can be used where M10 and M15 grade of concrete is required [2]. E. Ganjian et.al. prepared prism of size 100mmX100mmX150mm with W/C ratio 0.5.They replaced 5%, 7.5% and 10% weight of course aggregate by rubber chipped tyre and 5%,7.5% and 10% weight of course aggregate by ground tyre rubber also the replaced cement with superplastisizer by 0.4% of weight of cement. They noticed that there is reduction in flexural strength about 37% for replacement of course aggregate and 29% for replacement of cement [16]. Sulagno Banerjee et al. prepared a specimen of size 100mmX100mmX500mm using ordinary Portland cement of grade 43, natural sand, truck tyre rubber. They found decrease in flexural strength with increase in rubber content [20]. Neela Deshpande et.al. treated shredded rubber with NaOH solution to increase the flexural strength. As the result of that flexural strength is increased by 12% when shredded rubber was coated with NaOH solution [17]. This is due to the weak bonding between concrete and tyre rubber [15].

Conclusion

As tyre rubber is non-degradable material it causes hazardous effect on environment and creates many issues of disposal. As the use of tyre rubber reduces its compressive, tensile and flexural strength it also affects the workability in fresh concrete, investigations are carried out to minimize these negative factors. This can be done by limiting the percentage of tyre rubber used. It can be used in concrete structures which are located in earthquake zone and also used in structures which are subjected to dynamic actions like railway sleepers, road pavement, etc. The use of tyre rubber as partial replacement for aggregates is ecological as well as economical solution.

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