International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.4, pp : 433-436 1April 2014

Study On Waste Tyre Rubber As Concrete Aggregates

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Abstract: At present the disposal of waste tyres is becoming a major waste management problem in the world. It is estimated that 1.2 billions of waste tyre rubber produced globally per year. It is estimated that 11% of post consumer tyres are exported and 27% are sent to landfill, stockpiled or dumped illegally and only 4% is used for civil engineering projects. Hence efforts have been taken to identify the potential application of waste tyres in civil engineering projects. In this context, our present study aims to investigate the optimal use of waste tyre rubber as coarse aggregate in concrete composite.
A total of 24 cubes and 12 prisms are casted of M25 grade by replacing 10, 20 and 30 percent of tyre aggregate with coarse aggregate and compared with regular M20 grade concrete. Fresh and hardened concrete strength were identified.

Keywords: Tyre, Rubber, Rubberized Concrete, Rubcrete, Water proof

Introduction

With the development of modern societies aftermath of industrial revolution, the mobility within automobile sector got momentum. The offshoot of this pragmatic revolution gave rise to new dimensions of problems in the form of rubber garbage. Tyre rubber wastes represent a major environmental problem of increasing significance. An estimated 1000 million tyres reach the end of their useful lives every year. At present enormous quantities of tyres are already stockpiled or landfilled; Tyre landfilling is responsible for a serious ecological threat. Mainly waste tyres disposal areas contribute to the reduction of biodiversity also the tyres hold toxic and soluble components. Secondly although waste tyres are difficult to ignite, this risk is always present. Once tyres start to burn down due to accidental cause's high temperature take place and toxic fumes are generated besides the high temperature causes tyres to melt, thus producing an oil that will contaminate soil and water. Still millions of tyres are just being buried all over the world. Tyre rubber wastes are already used for paving purposes; however, it can only recycle a part of these wastes. Another alternative is an artificial reef formation but some investigation have already questioned the validity of this option. Tyre waste can also be used in cement kilns for energetic purposes and to produce carbon black by tyre pyrolisis, a thermal decomposition of these wastes in the absence of oxygen in order to produce by-products that have low economic viability. Some research has already been conducted on the used of waste tyre as aggregate replacement in concrete showing that a concrete with enhanced toughness and sound insulation properties can be achieved. Rubber aggregates are obtained from waste tyres using two different technologies: mechanical grinding at ambient temperature or cryogenic grinding at a temperature below the glass transition temperature. The first method generates chipped rubber to replace coarse aggregates, whereas the second method usually produces crumb rubber to replace fine aggregates. In this work the most relevant knowledge about the properties and the durability of concrete containing tyre rubber wastes will be reviewed. Furthermore, it discusses the effect of waste treatments, the size of waste particles and the waste replacement volume on the fresh and hardened properties of concrete. Investigations carried out so far reveal that tyre waste concrete is specially recommended for concrete structures located in areas of severe earthquake risk and also for applications submitted to severe dynamic actions like railway sleepers. This material can also be used for non load-bearing purposes such as noise reduction barriers. Investigations about rubber waste concrete show that concrete performance is very dependent on the waste aggregates. Further investigations are needed to clarify for instance which are the characteristics that maximize concrete performance.

Experimental Investigation

Objective

With the increase in urbanization of countries like **INDIA & ETHIOPIA**, the number of vehicles and consequently the amount of used tire is going to increase significantly in the near future. Hence, the no environmental nature of these wastes is going to be a potential threat.

• This study can show an alternative way of recycling tires by incorporating them into concrete construction. Of course, the concept that the problem emerges from urbanization and the solution goes along with it can also be appreciated.

• Therefore, it is the aim of this study to introduce an environmental friendly technology, which can benefit the society and the nation.

• Application of used tires in concrete construction is a new technology.
• Through this study, it is intended to arrive at a suitable mix proportion and percent replacement using locally available materials by partial replacement of the natural coarse aggregates with recycled coarse rubber aggregates.
• Hence the possibility of using waste tires as an alternative construction material will be investigated.
By conducting different laboratory tests on prepared specimens, it is intended to analyze the results.

Materials Used
The basic materials for mixing Concrete are required such as

- Cement,
- Sand,
- Aggregate and
- Tyre rubber.

The cement used for the present investigation was ordinary Portland cement.
Sand is of Zone-II as per IS: 383-1970, Crushed aggregate and rubber aggregate both are 20 mm graded aggregates as per IS: 383-1970.
The physical properties of aggregate were considered according IS: 2386(1963).

Tyre Rubber

Tyre rubber aggregate. About 30 cm long waste tyre rubber pieces are obtained from local market; the pieces were cleaned with soap water and rinse with clean water. After drying under sun at open place, both faces of the tyre pieces were rubbed with hard wire brush to make surfaces as rough as can be done by hand.
The source of the rubber aggregate is recycled tyres which were collected from the local market. For uniformity of the concrete production and convenience, all the tires collected are from medium truck tire. The reason for choosing medium truck tires is that they can give the required shape and size which is similar to the common natural gravel. This study has concentrated on the performance of a single gradation of rubber prepared by manual cutting. The maximum size of the rubber aggregate was 20 mm as shown in **Figure 1**. Specific gravity test was conducted on the rubber aggregate chips and found to be 1.123. The rubber aggregates used in the present investigation are made by manually cutting the tire in to the required sizes. It is very laborious, time consuming and is not easy to handle at the initial stages. However, all this complications can be easily sorted out if a large scale production is devised and proper cutting tools and machineries are made for this particular usage

Figure 1 Rubber aggregates used in the present investigation

Mix Proportion

- In this study four different types of mixes or combination is being considered and designed as per Indian Standard Specification IS: 10262(2009)
- Water cement ratio- The water cement ratio must be optimum according to the grade of concrete chosen and mix design has to be done
- Quality aggregates – The quality of aggregates must be high.
- The other three concrete mixes were made by replacing the coarse aggregates with 10%, 20% and 30% of discarded tyre rubber by weight.

Experimental Program
Workability aspect
The replacement of coarse aggregate by scrap tyre rubber effects on the workability of the concrete. The workability of rubberized concrete shows an increase in slump with increase of waste tyre rubber content of total aggregate volume. The result of the normal concrete mix showed an increase in workability, but it can be summarized that the workability is adversely affected by the incorporation of chipped tyre rubber. The results of the slump test are as shown

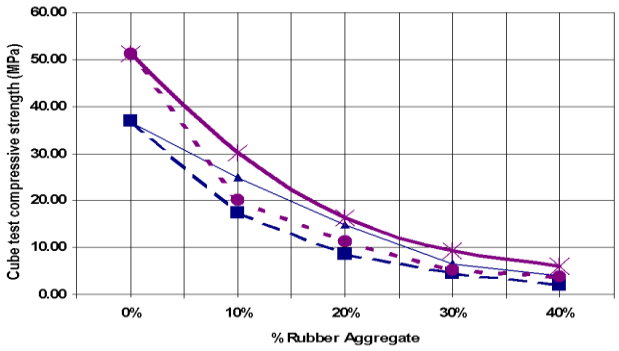
Workability of the Concrete in terms of Slump Value

Sl. No	Test Series	Workability (Slump)
1	Normal Concrete	85 mm
2	Rubberised concrete (10%)	100 mm
3	Rubberised concrete (20%)	125 mm
4	Rubberised concrete (30%)	150 mm

Hardened Concrete Properties

Compressive Strength: Compression test according to IS: 516(1959) is carried out on these cubes. The specimens were loaded at a constant strain rate until failure. The compressive strength is decreased with an increase in the percentage of the tyre rubber chips. The results of compressive strength of cubes for 7 days and 28 days are as follows

COMPRESSIVE STRENGTH OF RUBBERISED CONCRETE		
Type of Mix (w/c = 0.50)	**Compressive Strength (MPa)**	
	7days	**28days**
Normal Concrete	30	35
Rubberised concrete (10% replacement)	27	32
Rubberised concrete (20% replacement)	24	28
Rubberised concrete (30% replacement)	18	22



Flexural Strength

Prismatic specimens 100 × 100 × 500 mm were tested according to IS: 516(1959). The flexural strength is decreased with an increase in the percentage of the tyre rubber chips. The results of flexural strength of cubes for 28 days curing are as follows

FLEXURAL STRENGTH OF RUBBERISED CONCRETE	
Type of Mix (w/c = 0.50)	**Flexural Strength (MPa)**
	28days
Normal Concrete	4.1
Rubberised concrete (10% replacement)	4.0
Rubberised concrete (20% replacement)	3.7
Rubberised concrete (30% replacement)	3.3

Rubberised concrete reduces the concrete strength, however, this may be used where M-10 and M-15 grade concrete is needed. Further researches are needy for its use in RCC Work.

Determination of Unit weight

The unit weight values used for the analysis of this section are measured from the concrete cube samples after 28 days of standard curing. From the results, it was found out that a reduction of unit weight up to 24% was observed when 50% by volume of the coarse aggregate was replaced by rubber aggregate in sample. Whereas 3.39 and 9.48 % reductions were observed for 10 and 25 % rubber aggregate replacement in samples.

UNIT WEIGHT OF RUBBERISED CONCRETE		
Type of Concrete	**Unit Weight (Kg)**	**% reduction**
Normal	8.200	0
Rubberised (5% replacement)	7.620	0.9
Rubberised (10% replacement)	7.370	1.1
Rubberised (15% replacement)	7.200	1.3

Conclusion

1. From the present experimental study, we conclude that despite the reduced compressive strength of rubberized concrete in comparison to conventional concrete, there is a potential large market for concrete products in which inclusion of rubber aggregates would be feasible which will utilize the discarded rubber tyres the disposal of which, is a big problem for environment pollution.
2. Rubberized concrete strength may be improved by improving the bond properties of rubber aggregates. In India, out of 36 tyre manufacturers the tyre recyclers are around 20, the major contribution is only by four or five.. Among these, M/S Gujarat Reclaim has an annual turnover of over Rs.15 Crore from its Haridwar (Uttarakhand, India) tyre recycling plants, with a production of 20 tons of reclaim rubber per day. The tyre recycling factories should supply quality rubber aggregates in 20-10mm, 10-4.75mm and 4.75mm down sizes to be used as cement concrete aggregate.
3. The light unit weight qualities of rubberized concrete may be suitable for architectural application, false facdes, stone baking, interior construction, in building as an earthquake shock wave absorber, where vibration damping is required such as in foundation pads for machinery railway station, where resistance to impact or explosion is required, such as in jersey barrier, railway buffers, bunkers and for trench filling.
4. One of the possible applications of **rubcrete** may be its application in rendering of roof top surfaces for insulation and

waterproofing. With proper Mixed Design a 20 mm thick rendering on roof top surfaces may be done with 4.75 mm down rubber aggregate

Recommendations

1. Even though the use of waste tires for various applications by traditional recyclers has been a common practice in **Ethiopia** so far. With the increase in urbanization and the change in the living conditions of the society, the conventional ways cannot continue with time. Hence, there will be a potential accumulation of waste tires, especially in the larger cities of the country.

The Government so far has made an attempt by declaring the solid waste management proclamation on the *Negarit gazette* prohibiting the import of waste tires. Moreover, the country should also enforce laws regarding the management of waste tires before the problem expands and reaches to an uncontrollable level.

2. Since the use of rubber aggregates in concrete construction is not a common trend in country like India. Many studies and research works need to be carried out in this area and academic institutions should play a major role.

3. Tyre manufacturers and importers should be aware of the environmental consequences of waste tires and they should have research centers that promote an environmental friendly way of tire reprocessing.

4. Most of the time, it is observed that designers and contractors go to a high strength and expensive concrete to get few improved properties such as impact resistance in parking areas and light weight structures for particular applications. Nevertheless, these properties can be achieved through the application of rubberized concrete by first conducting laboratory tests regarding the desired properties. Therefore, the use of rubberized concrete as an alternative concrete making material needs an attention.

5. Since the long-term performance of these mixes was not investigated in the present study, the use of such mixes is recommended in places where high strength of concrete is not as important as the other properties.

6. Future studies should be continued in the following areas as part of the extension of this research work.

i) In this research, a constant dosage of admixture was used for a particular mix category. It will be more helpful if the effects of various dosages of admixtures are investigated.

ii) The effect of using de-airing agents to decrease the entrapped air in rubberized concrete should be studied. Consequently, a considerable increase in compressive strength can be achieved.

iii) The existence of any chemical reactions between the rubber aggregate and other constituents of the rubberized concrete to make sure that there is no undesirable effects that are similar to alkali-silica and alkali-carbonate reactions in natural aggregates needs to be investigated.

iv) This research was done by preparing single graded rubber aggregates of size 20 mm. The effect of different sizes should be studied in the future. Besides to this, the effects in different percentage replacements other than those made in this research needs to be investigated.

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