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Experimental Study on Effect of Partial Replacement of Coarse Aggregates in Concrete by Waste Tyre Rubber Aggregates in Rigid Pavements

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ABSTRACT- Our study intends to explore the flexural and split tensile strength, light weight, higher impact and toughness resistance which means prolonged and better resistance to formation of cracks, upgraded ductility, etc most effective use of the waste tyre rubber as a constituent of concrete mix replacing the coarse aggregate partially. In this research work, emphasis is given on the pre-treating of the rubber particles and then using them as the partial replacement of the conventional rock aggregates. To get the best results, the rubber aggregates used are surface treated by sodium hydroxide and cement paste before using them in the concrete.M20 grade concrete is used. Using untreated rubber aggregates, the compressive strength of the resultant concrete reduced rapidly, but when treated rubber aggregates were introduced, it resulted in the regaining of more than 90% of the 28 day compressive strength of normal concrete which can be considered quite satisfactory considering the easy and cheap availability of the used tyres and the negative impacts it can have on the environment if left unused. This much compressive strength is enough for treated-rubberized concrete for its use in different areas where compressive strength is not much important like in floors and concrete road pavements. Flexural and split tensile strength is found to be higher than that of the normal concrete but only when treatment is given to the rubber aggregates before using them. Workability is decreased. Flexibility gets increased and due to the lower unit weight of the rubber particles, it is also lighter than the normal concrete.

KEYWORDS- M2O, Toughness Resistance, concrete mix, Split Tensile Strength, Light Weight Concrete.

I. INTRODUCTION

Use of waste tyres or used tyres of automobiles have been a long environmental issue in western countries but now due to the modernization and industrialization, this problem has slowly been felt in different Asian countries especially India and China. India has at a very slow pace started to work against this menace, but not effectively when compared to its western counterparts.

As India is on its way from being a developing country to a developed country, rate of vehicles hitting the road per year is increasing very fast and so is the number of tyres. Increasing number of tyres produced or used per year means more number of waste tyres being produced at the end of that year which in turn produces more number of landfills or sea shores that are hazardous to the environment. Burning of these tyres has also not been recommended due to the production of a variety of poisonous gases which is again a big environmental problem.

II. OBJECTIVES

- To study different optimization method for pavement management
- To apply LaGrange an relaxation and sub gradient optimization procedures to obtain lower
- To compare different pavement parameters of proposed and existing approach

III. LITERATURE REVIEW

Lee et al. [1] studied the crumb rubber filled concrete and observed its impact and flexural strength. It was found that the flexural and impact strength of the crumb rubber filled concrete is more as compared to the latex modified concrete as well as portland cement concrete. It was concluded that due to the formation of styrene-butadiene rubber (SBR) latex, the interfacial bond between the crumb rubber particles and cement paste becomes much stronger as compared to the conventional bond when there is no SBR latex.

Taha et al. [2] added various percentages of rubber aggregates having the size range of 5mm to 20 mm. When 100% of aggregates were replaced by the rubber aggregate, a huge reduction of 75% in the compressive strength of resultant concrete was found which is considered to be extremely poor.

Akinwonmi et al. [3] separately replaced the natural aggregates by both shredded rubber as well as by crumb rubber. After testing the specimen which contained different percentages of the crumb rubber and others which contained the different percentage of shredded rubber, it was observed that up to the replacement level of 2.5% by shredded tyre, the compressive strength slightly increased but when the replacement level there is a massive decrease in the strength.

Ishtiaq Alam et al. [12] also replaced the natural aggregates in concrete with rubber aggregates and found that the compressive strength of the resultant concrete gets drastically reduced. To increase it, surface treatment of rubber particles just before use, by silica fume was recommended. This review paper also contains some positive effects on the resultant concrete like development of ductile behavior in concrete before it fails [4].

Guo et al. [16] works on different surface treatments were given to the rubber particles before using them in the mix. they were treated with sodium hydroxide and silane coupling agent were used. The rubber particles were also treated with cement, silica fume and blended cement with sodium silicate. these all treatments were given in order to increase the bonding between the cement paste and the rubber particles. the tests revealed that the best results were shown by the concrete which contained NaOH treated rubber particles[5].

IV. METHODOLOGY

A. Experimental Setup

The moulds used for the preparation of samples were cubes of size (15cm x15cm x 15cm) for compressive strength testing, the beams of size (50cm x 10cm x 10cm) for flexural testing and the cylinders of size (10cm x 20cm) for split tensile strength testing.

Treatment of rubber wastes involves its surface modification to improve the bond between rubber and the concrete components like cement paste and aggregates and it was done by soaking rubber particles in 0.1 molar solution of NaOH and in cemented suspension for about 20 minutes just before using them in concrete. A total of 20 cubes, 10 beams and 10 prisms are casted of M20 grade by replacing 5, 10 and 15 percent of natural coarse aggregate with untreated and treated waste rubbertyre aggregate and compared with regular M20 grade concrete.

1) Consistency test for cement

Consistency of cement is its ability to flow. It depends upon the compound composition and fineness of the cement. Standard consistency of the cement paste is defined as that consistency which permits Vicat's plunger to penetrate through a depth of 33-35 mm from top of the mould. In other words, we can also define it as the consistency at which Vicat's plunger penetrates up to a point which is 5-7 mm from the bottom of the Vicat'smould. The Vicat's plunger has a needle with diameter of 10 mm and length of 50 mm.

2) Initial setting time

Initial setting time is defined as the time period measured from when the water is added to the cement up to the time when it starts to lose its plasticity. For calculating the initial setting time, the needle used has 1 mm square section. This needle is lowered and then quickly released which allows it to penetrate into the mould. In the initial minutes, it will completely get pierced through the 40 mm of the mould. We repeatedly continue to let the needle pierce through the cement paste in the mould until it fails to pierce the test block to a depth of 5-7 mm from the bottom of the mould. The time elapsed between the time when water is added to the cement and the time at which the needle fails to go through the paste in the mould to a depth of 5-7 mm from the bottom. The initial setting time for the ordinary Portland cement (OPC) is generally taken as 30 minutes.

3) Final setting time: The procedure is almost same as that of calculating the initial setting

time with the difference of the type of needle used. For calculating final setting time, the needle used for initial setting time is replaced with a needle having an angular ring at bottom. The needle is released which makes an impression on the cement paste. The same procedure is again repeated up to the time when the needle fails to make an impression on the paste. Final setting time is thus calculated as the time period elapsed between when water is added to the cement at the start up to the time when the needle fails to make an impression on it. It is generally taken as 4 hours.

4) Crushing Tests:- The crushing strength of aggregates is determined by crushing test

which is done in order to find the load under which it fails when compressive stress is applied on it. This test is standardized by IS: 2386 part- IV. This value gives us the relative measure of resistance of the aggregates to crushing when load is applied gradually. In other words, it is the resistance to crushing under severe stress.The test is carried out using the aggregates of size between 10-12.5 mm. The setup contains a mould of 115mm diameter and 180 mm depth. The load which is applied on the aggregates in the mould is 40 tones and the load is applied for 10 minute.

5) Abrasion test

Hardness feature of the aggregates is found out by performing abrasion test on them and then depending upon the test results, decision is taken if the aggregates are suitable for the various construction works. There are three types of abrasion tests:Los Angeles test, Deval abrasion test, Dory abrasion test.

In general, out of the above the types of abrasion tests, Los Angeles test is preferred and most widely used . The wear in the test is caused due to the relative rubbing action between steel balls used as abrasive charge in the steel drum and the aggregates. Aggregates are placed in the rotating steel drum which is attached with a shelf plate attached to its outer wall. The steel drum has a diameter of 700 mm and is 500 mm long. The steel balls used are 48 mm diameter spheres with a weight of 390-455 gm. The rotation of the drum at the time of testing takes place at 30-33 rpm. The number of the steel balls used in the drum varies with the gradation of the aggregates used. The Los Angeles abrasion value of the aggregates is calculated as the material passing through 1.7 mm sieve expressed as the percentage of total aggregate as shown in fig.1.

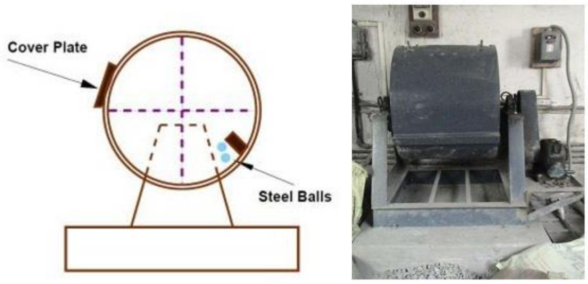

Figure1: Setup for Los Angeles Abrasion Test

6) Impact test

The aggregate impact test is performed in order to find out the resistance of aggregates to impact or sudden load. The size of the aggregates used for the test should be 10-12.5 mm. the mould which is used to carry out this test is 50 mm deep and has a diameter of 102 mm. the hammer which is used to impart the impact load to the aggregates is 13.5-14 kg and has a fall of about 380 mm. A total of 15 blows are given to the aggregates.The impact value of the aggregates is calculated as the material passing through 2.36 mm sieve expressed as the percentage of total aggregate.

7) Soundness test

Freezing and thawing causes some aggregates to disintegrate at a very fast rate. This test is conducted to check the durability of such kind of aggregates. This test is meant to investigate the resistance of aggregates against the weathering action. This is done by repeatedly submerging the aggregate sample to be tested in some chemicals. The loss in weight should be less than 12 % when sodium sulphate is used and is case of magnesium, the limiting value of soundness is 18%.

8) Shape Test

This test is very important for compaction, workability in PCC and binder requirement in bituminous mixes. Cubic angular aggregates which possess rough texture are considered better in terms of strength but the workability is affected. Rounded aggregates are easier to compact but impart less strength .Flakiness index is the percent by weight of the aggregate particles whose least dimension is less than 0.6 times the average size of the aggregate fraction. It is applicable for the sizes larger than 6.3 mm. Flakiness gauge is used as shown in Fig.2. Elongation index is the percent by weight of the aggregate particles having maximum dimension greater than 1.8 times the average dimension. Length gauge is used as shown in Fig.2.

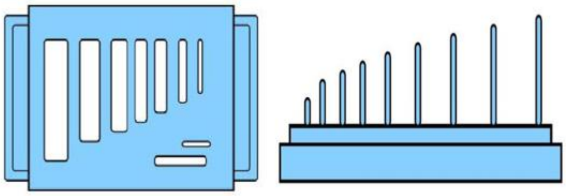

Figure 2: Flakiness and Elongation Index apparatus

9) Specific gravity and water absorption test

Two kilograms of dry aggregates are kept in water for 24 hours. The aggregate sample weight is found in water and thus we get the buoyant weight. Then the same aggregates are placed in oven with a temperature of 100- 110oC for about 24 hours and then weighed. The specific gravity is calculated by dividing dry weight of aggregates by weight of equal volume of water at a specified temperature. Value of specific gravity of aggregates lies between 2.6 and 2.9.Water absorption can be expressed as the percent water absorbed in terms of oven dried weight of aggregates. The value of the water absorption should be less than 0.6 % of the weight of aggregates.

10) Sieve analysis

In order to check the gradation of aggregates, sieve analysis is performed on them. The aggregate sample is sieved through a mesh with a standard size and the cumulative percentage of the aggregates passing is plotted against the sieve sizes. It generally done in logarithmic scale and a curve is plotted. The curve thus formed is called as particle distribution curve.

V. RESULTS

Table 1: Consistency results of different samples

Sample number	Consistency value	Weight of water(gm)
1	28.9	115.6
2	28.5	114
3	29.3	117.2

- The consideration is taken that the average of above three sample result as shown in Table 1, as the consistency value of the cement. Therefore, consistency value (P) is 28.9 %.
- Initial Setting time was observed as 40 minutes
- Final setting time for our sample was observed as 3 hours and 35 minutes.
- Crushing value= 23.01%
- Abrasion Value= 30.90%
- Crushing value= 21%
- Slump test results are shown in Table 2.

Table 2: Slump test results of various samples

SAMPLE	SLUMP VALUE (mm)	PERCENT REDUCTION OF SLUMP
PC	50	0
UTR-5	47	6
UTR-10	45	10
UTR-15	43	14
NTR-5	48	4
NTR-10	44	12
NTR-15	40	20
CTR-5	45	10
CTR-10	42	16
CTR-15	35	30

Strength values are shown in table 3.

Table 3: Stren Gth values of different samples

SAMPLE	7-DAY COMPRESSIVE STRENGTH-CUBE (N/mm2)	28-DAY COMPRESSIVE STRENGTH-CUBE (N/mm2)
PC	19.11	27.33
UTR-5	13.87	19.80
UTR-10	16.44	23.50
UTR-15	15.60	20.40
NTR-5	16.40	23.30
NTR-10	17.70	25.30
NTR-15	11.11	15.60
CTR-5	15.60	22.2
CTR-10	12.11	15.50
CTR-15	17.33	21.70

Ultimate load and displacement values are shown in table 4.

Table 4: Ultimate load and displacement values of various samples

SAMPLE	28-DAY FLEXURAL STRENGTH BEAM (N/mm2)	ULTIMATE LOAD `(KN)	DISPLACEMENT (mm)
PC	8.10	16.20	0.96
UTR-5	7.95	15.90	1.12
UTR-10	6.90	13.80	1.10
UTR-15	6.40	14.80	0.80
NTR-5	9.30	18.60	1.30
NTR-10	8.75	17.50	1.50
NTR-15	7.51	15.02	1.38
CTR-5	9.25	18.50	1.60
CTR-10	8.51	17.02	1.45
CTR-15	8.00	16.00	1.30

28-Days split tensile strength values of various samples are shown in table 5.

Table 5: 28- Days split tensile strength of various samples

SAMPLE	28-DAY SPLIT TENSILE STRENGTH CYLINDER(N/mm2)
PC	2.38
UTR-5	2.10
UTR-10	1.90
UTR-15	1.60
NTR-5	3.82
NTR-10	5.72
NTR-15	6.36
CTR-5	4.76
CTR-10	4.28
CTR-15	4.07

VI. CONCLUSIONS

Following are the conclusions:

- The best results for treated waste tyre rubber material by NaOH replaced by 5% has slight increase of 1mm in slump value than the UTR-5. The compressive strength obtained is 92.57% which is considered to be quite satisfactory value from structural point of view as the waste tyre rubber replacement shows natural resource of course aggregates.
- Flexural and split tensile strength of almost all replacement levels of treated rubberized concrete is found to be more than in the normal conventional concretes. 28 day flexural and split tensile strength is found to be highest at NTR-5 and NTR-15 respectively.
- The purpose of this study was to determine if a waste material like worn out tyresenhance the basic properties of concrete. The data presented in this research shows that there is great potential for the utilization of tyres as aggregates. It is considered that used tyres would provide much greater opportunities for value adding and cost recovery, as it could be used as a replacement for more expensive material such as rock aggregate.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] Lee, Hee Suk, et al., "Development of tire added latex concrete." Materials Journal 95.4 (1998): 356-364.

[2] Taha, MM Reda, A. S. El-Dieb, and MA Abd El-Wahab., "Fracture toughness of concrete incorporating rubber tire particles." International conference on performance of construction materials. 2003.

[3] Akinwonmi, SAdemola et al., "mechanical strength of concrete with crumb and shredded tyre as aggregate replacement.",International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 2, March -April 2013, pp.1098-1101.

[4] Alam, Ishtiaq, UmerAmmarMahmood and NoumanKhattak., "Use of Rubber as Aggregate in Concrete: A Review." International Journal of Advanced Structures and Geotechnical Engineering 4.02 (2015).

[5] Guo, Shuaicheng, et al., "Evaluation of properties and performance of rubber-modified concrete for recycling of waste scrap tire." Journal of Cleaner Production 148 (2017): 681-689.

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