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Waste Rubber as Construction Material

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Abstract—*This paper deals with effective replacement of waste rubber as construction component. The basic source for waste rubber is tyres which are one of the main component of solid waste. This replacement of rubber as construction material without effecting much of the properties of conventional helps in solid waste management.*

1. INTRODUCTION

According to Indian Rubber statistics 2012-2013 disposal of rubber in form of tyre in India is about 110 to 112millions per year. This waste tyres are disposed by land filling in deserted areas and used as a fuel in many of the industries such as thermal power plant, cement kilns, paper industries etc. Unfortunately, this kind of usage is not environment friendly. [1.]

According to statistics of 2003 out of 290 million scrap tyres produced 130 million are used as fuel and about 100 million are dumped and landfilled. Tyre stock piling causes problems like heat retention as they are black in color and act as heat absorbents and due to their shape rain the prone to accumulate water and form an idea habitat for mosquitoes and rodents. These dumped tyres might catch fire and produce in toxic like chromium lead and arsenic.

These chemicals causes problems like

- Respiratory problems due to carbon monoxide.
- Dioxins cause infertility, birth defects, cancer.
- Furans causes nervous breakdown, disorders, damage of immune.
- The burnt black sooth contaminates ground water. [2]

Hence this scrap tyre must be used effectively in civil works so as to reduce environmental treats like air pollution, water pollution and solid waste.

Thus use of this rubber

- As fine aggregate in concrete.
- As binding component in bricks and pavers.
- As railway ballast

Without altering their properties will help in efficient disposal of waste tyre rubber.

2. OBJECTIVE

Use of tyre rubber in civil works without altering their properties and uses is the main objective. Therefore replacing sand as fine aggregate partially with rubber up to which there is no change in conventional properties of concrete, bricks and tiles and use of rubber as coarse aggregate in ballast of railway helps in solid waste treatment.

India, a fast developing country faces sand shortage, sand consumption as fine aggregate is about 650million kg per year which is dug from rivers which is not ecofriendly process so use of rubber will help to overcome this problem. If we replace 15% of sand with rubber 97.5 million kg of rubber can be used up and same amount of sand can be saved. Bricks and tiles use sand so that clay can bind with lime so partially replacing sand with rubber say 15%.

India has widely spread railway transportation about 108000 km. According to Indian standards amount of ballast stones filled between tracks is about 20kg/m. Say we replace 10% of these stones with coarse rubber we can use 2 kg/m that is 216 million kg of rubber.

3. EXPERIMENTAL PROGRAMS

The experiments conducted are to show that replacement of rubber up to which their properties are not altered.

Experiments conducted as per **Indian standard tests** on rubber as

3.1 As fine aggregate in concrete.

3.1.1 Compression test

Compression test is conducted on 150*150*150 mm cubes in UTM. 6 specimen are casted and 3 are tested on 7th day and 3 on 28th day. The strength is computed using F_c =p/a where p- maximum load and A- cross sectional area.

3.1.2 Flexural test

Flexural test is conducted on 100*100*500 mm specimen cured for 28 days. The flexural strength is tested on 3 specimen determined by two point loading. Computed by expression F_b=PL/BD^2.

where p-maximum load, l-length, B-width, D-depth

3.1.3 Split tensile test

Split tensile test is conducted on cylinder of 300mm length and 150mm diameter in universal testing machine. Tested after 7 and 28 days and computed by F_s=2p/3.14ld

3.1.4 Water absorption

Blocks of 150*150*150 shall be completely immersed in clean water at room temperature for 24 hours. The blocks shall then be removed from the water and allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth, the saturated and surface dry blocks immediately weighed. After weighing all blocks shall be dried in a ventilated oven at 100 to 1150C for not less than 24 hours and until two successive weighing at intervals of 2 hours show an increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen. The water absorption calculates as given below:

Absorption, percent = (A-B)/B * 100

Where,

A = wet mass of unit in kg.

B = dry mass of unit in kg.

3.2 As binding component in bricks and pavers.

3.2.1 Water absorption

Dry the specimen in oven at 105-115^{0}c until it attains a constant weight. Cool it to room temperature and note its weight A. Then immerse the dried specimen in water at 27c for 24 hours. Remove the specimen and clean the surface with cloth and weight the specimen B. Calculated by

Absorption, percent = (A-B)/B * 100

3.2.2 Compression test

Prepare specimens of rubber composition say 10% in conventional way either by machine or manmade process. Immerse the specimen in water for 24 hours. Drain out the surplus moisture and place them in compression machine and apply load axially at 140kg/cm^2. Note the max loading before failure and specify the class.

3.3 As railway ballast.

3.3.1 Aggregate abrasion value

Take 10kgs of sample to be tested and choose the required abrasive charge depending on grading. Place the aggregate and charge in Los Angeles testing machine. Rotate the machine at 30 to 33 rpm for 1000 revolutions. Pass them through sieve and determine the grading.

3.3.2 Aggregate impact value

Sieve the sample through 12.5 and 10.0 mm. Weight empty measuring cylinder and fill it with sample by giving blows with tamper rod. Weight note it. Place it in impact test apparatus and hammer it with 15 blows. Pass the sample through 2.36 mm sieve and calculate fraction retained.

4. EXPERIMENTAL OBSERVATIONS

4.1 Rubber replaced concrete

Materials used

OPC grade 43 and as specified by IS codes, sand and fine rubber sieved thought 2.36mm and retained on 150micron, and coarse aggregate sieved through 4.75mm and retained on 2.36mm were used.

Rubber replacement as fine aggregate up to 12% does retains the required properties of the concrete. [3] Therefore concrete blocks with 10% rubber as fine aggregate of M20 grade (1:1.5:3) and w/c ratio 0.60 prepared and tested after 28 days.

	Compressive strength (N/mm2)	Flexural strength (N/mm2)	Split tensile strength (N/mm2)	Water absorption (%)
Conventional concrete	36.3	4.5	3.4	2.74
Rubberized concrete (10%)	27.9	3.4	3.1	2.16

4.2 Rubber replaced bricks and pavers

Cement made bricks were prepared of size 30cm X 20cm X 15cm with 1:2:3 ratio of cement, fine aggregate and gravel.

Conventional block with no rubber and 10% rubber replaced as fine aggregate blocks were made and tested.

	Compressive strength (Mpa)	Water absorption (%)
Conventional block	28.4	4.2
Rubberized block	25.2	4.9

4.3 Rubber as railway ballast.

4.3.1 Aggregate impact value

Sample material is mixed with coarse rubber and sieved through 12.5mm and retained on 10mm is collected and placed in vessel after dried and net weighted i.e 366g. It is tested and sieved through 2.36mm and passing weight is 62g.

Therefore aggregate impact value is 16.93%.

4.3.2 Aggregate abrasion value

4.5kg sample sieved through 50mm and retained on 40 mm and 4.5kg sieved through 40mm and retained on 25mm are mixed with coarse rubber(<25mm) 1kg. This 10kg sample is placed in Los Angeles apparatus with charge i.e 12nos of cast iron balls. After 1000 revolutions the sample is sieved through 1.70mm.

Weight retained on 1.70mm sieve is 7.934 kg

Therefore aggregate abrasion value is 20.66%

5. RESULTS AND DISCUSSIONS

i. Rubberized concrete has 23.14% less compressive strength, 24.22% flexural strength, 8.8% split tensile strength when compared to conventional concrete which is with the acceptable limit but not suitable for heavy load constructions like bridges.
ii. Rubberized concrete has less water absorption i.e. 21.18% less than conventional concrete, so this can be used for tetrapod and many other water based constructions.
iii. Replacement of sand by rubber in cement blocks reduced strength by 11.27% and increased water absorption by 16.67% which is within permissible limits.
iv. Coarse rubber as railway ballast has aggregate abrasion value is 20.66% and aggregate impact value is 16.93% these values indicate that replacement of stone ballast by10% coarse rubber can be used as railway ballast.
v. Rubber as tyres.
   - 250 million–Stockpile.
   - 110 million–Disposed per year.
   - On an average tyre weights 10 kgs.
   - So there’s about 1350 million kg of rubber.
vi. India is second largest bricks producer after china producing 436 million bricks per year. 650 million kg sand as fine aggregate every year. So replacement of rubber by 10 to 15% saves about 195million kg of sand.
vii. As per Indian Railway standards we use about 20kg of ballast stone per meter. India has a wide spread of railway system i.e. 108000km track. So replacement of rubber by 2kg per meter 216 million kg rubber can be used.
viii. Rubber used
   - In concrete. - 95 million
   - In bricks and pavers. - 100 million
   - Railway tracks. - 216 million
   - So we can discard up to 410 million kg of rubber i.e. one third of total rubber as solid waste.

6. CONCLUSION

Thus use of waste rubber as construction material i.e. as cement blocks, pavers, concrete and ballast without effecting their conventional properties reduces efficiently the waste rubber and helps in solid waste management. Also use of rubber in constructions and bricks reduces the use of sand helping in extensive sand mining.

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