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Effect of Partial Replacement of Course Aggregates in Concrete by Waste Tyre Rubber Aggregates in Rigid Pavements

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Abstract: Our present study intends to explore the 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. These enhanced properties can be helpful in using this concrete in flexible slabs and as light weight concretes. Appreciable compressive strength, more 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
Keywords: Rubber aggregates, rubberized concrete, sodium hydroxide (NaOH), cement paste, tread.

I. INTRODUCTION

A. General

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. In the last five fiscal years i.e. 2010 to 2015, the tyre industry in India has shown a growth of about 12% due to increased automobile production.

This growth is considered to be very good for the nation's economy and from industrialization point of view but taking into consideration the environmental aspect; it has been seen as a challenge and an emerging threat grade from the point of view of traffic safety.

Uninterrupted flow is possible for the crossing traffic. There is increased safety for turning traffic. There is overall increase in comfort & convenience. It is possible to adopt grade separation for all likely angles and layout of intersecting roads.

II. METHODOLOGY

Experimentation is done on the concrete samples with coarse aggregates partially replaced by waste rubber pieces for the construction of rigid pavements.The waste rubber material replaced, tests conducted with various quantities of waste rubber material at the rate of 5%, 10% and 15% by weight duely replaced for coarse aggregate. Even without replacing the coarse aggregate by waste rubber, tests were conducted to know about the effect.The rubber pieces of coarse aggregate guage are dipped (treated/coated) in two different types of solutions such as Sodium Hydroxide (NaOH) and cement paste separately to get the effect of both solutions respectively.

A. Treatment (Coating/Dipping) Of Waste Rubber Material

The treatment to the rubber aggregate particles before being used into the casting of samples are the surface treatment with one molar sodium hydroxide and cement paste. One molar of NaOH solution is prepared and the rubber particles are dipped in the solution for almost 20 minutes before being used in the concrete. Same procedure is adopted in case of the treatment with cement paste in which cement and water is mixed to form a thick paste and then rubber particles are kept soaked in it for almost 20 minutes before being used in the concrete. These treatments are done in order to improve the surface characteristics of the rubber particles so that its bonding with cement in the concrete gets enhanced to impart better strength to the hardened concrete.

Fig. 3.2 NaOH-treated and Cement paste-treated Rubber

B. Material Testing

The material used in the work is cement, fine aggregates, coarse aggregates,tyre rubber and sodium hydroxide. Out of these materials waste tyre rubber available is in limited quantity as well as at limited places.. For this work the tyre rubber collected from a local garage and the sodium hydroxide was obtained from the market. Cement is a dispersed solid whose particle size is ranging from 0.1 to 250 micron-meter. The rubber thus obtained was brought down to a size comparable to the size of coarse aggregate. For this purpose the rubber obtained cut down manually/mechanically to get the desired size of materials.

C. Compressive Strength

This test is performed in compression testing machine.The cubical moulds of size 15cm x15cm x 15cm are used to perform this test. In this test the concrete is poured into the mould and tempered properly so as to avoid any voids. After 24 hours these moulds are removed and test specimens are put in water for curing.The top surface should be even and smooth.These specimens are tested by compression testing machine after 7 days curing or 28 days curing by applying load gradually at the rate 140kg/cm per minute till the specimen fails. Load at the failure divided by area of specimen gives the compressive strength of the rubberized concrete.The procedure is for plain concrete and same procedure is repeated same for sodium hydroxide(NaOH) treated mixture and cement paste treated mixture as well as for untreated mixture Fig.3.11shows the cube under compression and table 3.8 shows compressive strength of different samples.

Fig. 3.11 Cube under compression

Table 3.8 Compressive strength of different samples

SAMPLE	7-DAY COMPRESSIVE STRENGTH-CUBE (N/mm^2)	28-DAY COMPRESSIVE STRENGTH-CUBE (N/mm^2)
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

III. DATA COLLECTION, ANALYSIS AND DISCUSSION

The 7 days compressive strength of NTR-10 is found to be highest among all the replaced mixes but lower than plain concrete. However 92.62% compressive strength of plain concrete is regained in this case which is quite satisfactory considering the material used. Similarly, 28 days compressive strength is found to be highest for NTR-10 but again lower than plain concrete. It accounts for 92.57% compressive strength of the conventional normal concrete which is quite considered satisfactory. The compressive strengths of untreated and cement treated rubberized concrete as compared to NTR-10 and plain concrete is found to be very less. Huge difference of elastic modules, lack of decent bonding and low adhesion between concrete constituents and untreated rubber particles may be attributed for less compressive strength. It is also due to low strength of rubber particles than concrete matrix around them and thus when force is applied; cracks first of all appear in contact zone of rubber and concrete matrix.

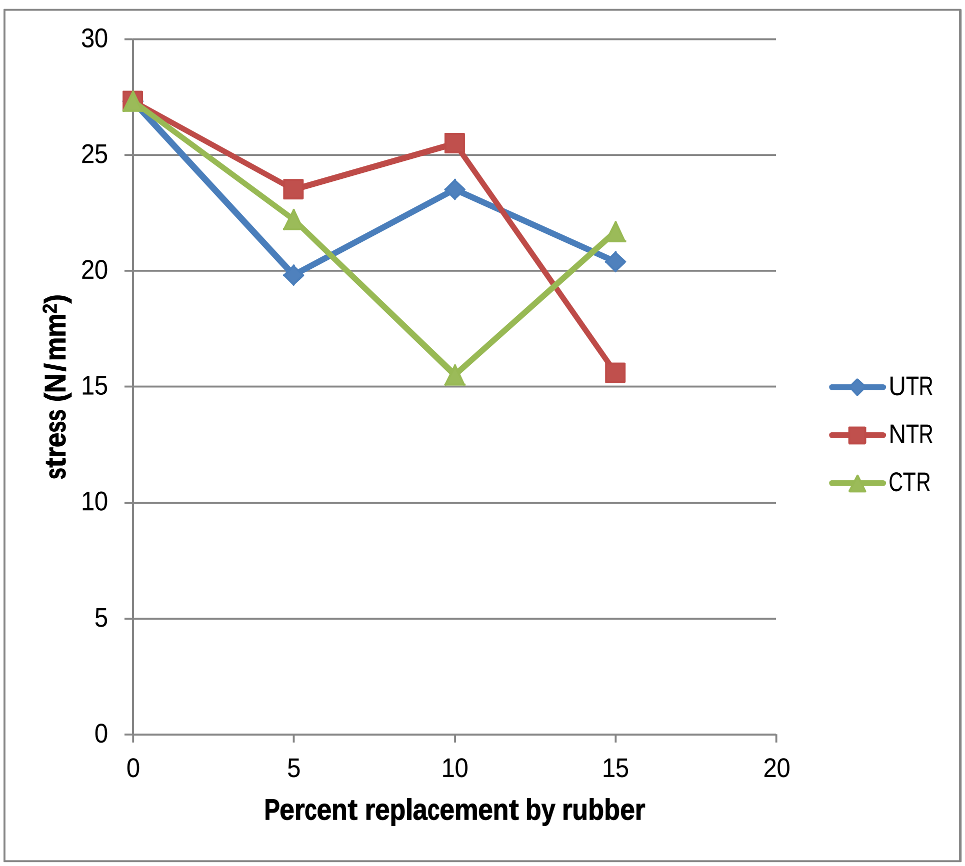

Fig.4.2 Variation of 28 day compressive strength vs percent replacement by rubber

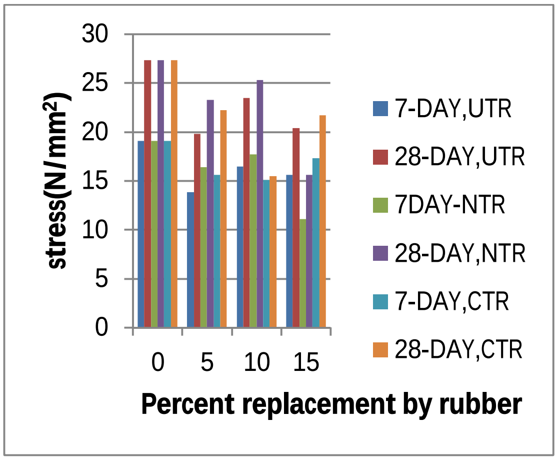

Fig. 4.3 Comparison between 7 and 28 day compressive strength on varying percentages of rubber

A. Future Scope

Easy availability of waste tyre rubber and never ending output of waste tyres from the tyre industry means that this waste product will always need to be recycled. And based on the present research and other work done on this topic, there is great potential of tyre rubber to be used in the construction industry. The use of waste tyre rubber results in more economical and eco friendly concrete. Also if some treatments are provided to rubber, the strength properties surely increase. If some new and better techniques of its use are found to overcome the present flaws which previous researches have shown, there will be greater opportunity for waste tyre rubber to be used in the construction industry.

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