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EXPERIMENTAL ANALYSIS OF SCRAP TYRE RUBBER AGGREGATES AND STEEL SCRAPS INFILLED BEAMS BY METHOD OF INITIAL FUNCTIONS

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ABSTRACT

Concrete is one the most extensively used construction material all over the world. Many scientists and researchers are in quest for developing alternate construction material that are environment friendly and contribute towards sustainable development. Huge amount of rubber tyre waste is generating day by day which creates the disposal problem and has many environmental issues. As this scrap rubber waste is an elastic material having less specific gravity, energy absorbent material can be used as a replacement material for obtaining light weight concrete. In reinforced concrete beams, concrete is in compression on one side and in tension on another side of neutral axis. In conventional design of RCC structures the concrete on tension side is not considered in the analysis. It is wastage of concrete in tension zone. Hence, concrete in this zone can be replaced by some modified concrete in which the aggregates are replaced by some waste material. Due to this the aggregates can be saved and waste material can be recycle. The aim of this study is to replace the aggregates in less stress concrete zone below the neutral axis by waste material like scrap tyre rubber aggregates (STRA) and steel scrap (SS). Total twenty one beams of size 150 x 250 x 700 mm are casted by replacing 0%, 20%, 40% and 60% of coarse aggregates with scrap tyre rubber aggregates for one set and fine aggregates with steel scraps for another concrete specimens.

The concrete cubes are filled in single layer. The concrete is filled in three layers only for beam specimens, in first layer M25 grade of concrete is filled with thickness h1, second layer is filled by modified concrete with thickness h2, third layer at top is filled again by M25 concrete with thickness h3.The mechanical properties of this modified concrete are studied by testing the cubes and beam specimens. Method of initial functions (MIF) is an analytical method based on elasticity theory is used for finding the bending stress or flexural strength. The experimental and theoretical results by MIF are compared.

INTRODUCTION

Energy cannot be created, it cannot be destroyed, it is the base of all intellectual and spiritual thoughts of human beings. Energy is always subjected to cycles. Thus nothing as such is a waste. Waste generate from one process is in fact a raw material for some other process. Waste is a material that is wrongly placed or lying unutilized. Hence there is a need to decide the suitable place where a particular waste material may be used or recycled. The present work is concerned with the reuse of scrap tyre and steel scrap waste which is as such a solid waste generated in gigantic proportions.

The snappy improvement of the vehicle business and unrivaled standard of living of individuals in India, the amount of vehicles expanded quickly. Presently India is confronting the environmental issues identified with the evacuation of enormous scale waste tires. Close about 1.5 billion waste tires are produced by the world yearly, where 40% in rising markets, for example, China, India, South Africa, South East Asia, South America also, Eastern Europe and so on and in excess of 33 million vehicles added to the Indian Roads over the most recent three years. Presently, as per the measurement information, 80 million piece tires were made in 2002, and with 12% of broadening rate each year, the entire number of surrendered tires arrived at 120 million out of 2005 and 200 million in 2010.

The executives of waste tire elastic is hard for districts to handle in light of the fact that the waste tire elastic isn't effectively biodegradable even after long time of landfill treatment. In any case, reusing of waste tire elastic is an option. Reused waste tire rubbers have been utilized in various application. It has been utilized as a fuel for bond oven, as feedstock for making carbon dark, and as fake reefs in marine condition. It has additionally been utilized as a play area matt, disintegration control, roadway crash hindrances, protect rail posts, commotion boundaries, and in black-top asphalt blends [21]. Elastic materials have been utilized in car, industry application, day by day living types of gear, building water evidence, fixing framework and different employments. There is colossal interest for concrete as a development material everywhere throughout the world. Numerous researchers and scientists are in mission for creating interchange development material that are condition benevolent and contribute towards practical advancement. The measure of elastic expended every year has been developing consistently. Reused waste tire elastic is a promising material in the development business due to its low thickness, long life, light weight, flexibility, vitality assimilation, sound and warmth protecting properties.

Meanwhile reusing can reduce amounts of municipal solid waste going to landfill and also its adverse impact on environment. Rubber recycling has to be taken into consideration in any rubber waste management program. An effective approach is required in an attempt to manage such large quantities of a diverse, contaminated mixture of rubber in an energy efficient and environmentally suitable manner. If not managed properly, the waste tyres in present will increase the environmental problems. Therefore, scrap tyres as sustainable building materials in the construction industry which helps to preserve the natural resources and also helps to maintain the ecological balance.

Fig 1 Scrap tyre rubber

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Fig 2 Waste tyre dumped on fire

PROBLEM FORMULATION AND METHODOLOGY

India has done a major leap on developing the infrastructures such as express highways, power projects, dams and industrial structures etc. For the construction of civil engineering works, concrete play main role and a large quantum of concrete is being utilized. Both coarse aggregates and fine aggregates is a major constituent used for making conventional concrete has become highly expensive and also scarce. Also, the worldwide depletion of natural resources and the simultaneous accumulation of generated industrial wastes are increasing at alarming rates. This situation calls for an upholding of sustainable development in the construction industry with major emphasis on the utilization of innovative and non-conventional industrial by products to replace the natural resources used in concrete along with the recycling and reuse of waste materials.

At present scenario, huge amount of rubber tyre waste is generating day by day which creates the disposal problem and has many environmental issues. As this scrap rubber waste is an elastic material having less specific gravity, energy absorbent material can also be used as a replacement material for obtaining light weight concrete. In reinforced concrete beams, concrete is in compression on one side and in tension on another side of neutral axis. In conventional design of RCC structures the concrete on tension side is not considered in the analysis. It is astage of concrete in tension zone. Hence, concrete in this zone can be replaced by some modified concrete in which the aggregates are replaced by some waste material. Due to this attempt the aggregates can be saved and waste material will be recycle.

METHODOLOGY

In present study concrete of grade M 25 is used. Total twenty one cubes of size 150 x 150 x 150 mm and twenty one beams of size 150 x 250 x 700 mm are casted by using modified concrete which prepared by replacing 0%, 20%, 40% and 60% of coarse aggregates with scrap tyre rubber aggregates for one set and fine aggregates with steel scraps for another concrete specimens. Twenty one beams includes three beams without any replacement of aggregates in concrete, Nine beams casted by replacing coarse aggregates in concrete below neutral axis in tension zone with rubber aggregates and Nine beams casted by replacing fine aggregates in concrete below neutral axis in tension zone with steel scraps. The replacement is done by volume fractions. For each percentage three numbers of specimens are casted. Cubes are casted to determine density and compressive strength of concrete. Beams are casted for flexural strength and to determine modulus of elasticity. Method of initial functions is used for finding bending stress or flexural strength. Experimentally calculated bending stress by using IS 516:1959 and bending stress results by MIF are compared.

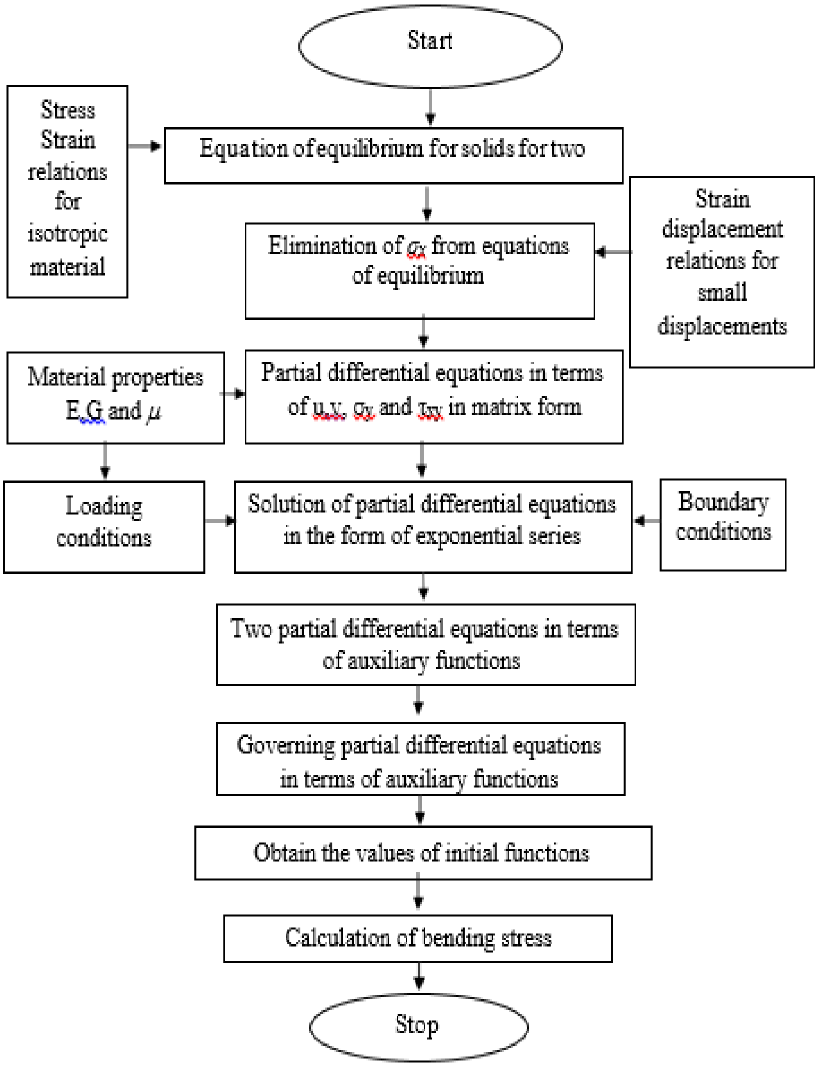

Fig 3 Flow chart for MIF

Table.1 Nomenclature for cube specimens

Sr. No.	Nomenclature	Description
1	C-0	Cubes with zero percent replacement
2	C-RA-20	Cubes with 20% replacement of coarse aggregates with rubber aggregates
3	C-RA-40	Cube with 40% replacement of coarse aggregates with rubber aggregates
4	C-RA-60	Cube with 60% replacement of coarse aggregates with rubber aggregates
5	C-SS-20	Cube with 20% replacement of fine aggregates with steel scraps
6	C-SS-40	Cube with 40% replacement of fine aggregates with steel scraps
7	C-SS-60	Cube with 60% replacement of fine aggregates with steel scraps

Table 2 Nomenclature for beam specimens

Sr. No.	Nomenclature	Sub Specimens	Description
1	CB-0	CB1-0 CB2-0 CB3-0	Controlled Beam Specimens
2	LB-R-20	LB1-R-20 LB2-R-20 LB3-R-20	Layered beam with 20% replacement of coarse aggregates by rubber aggregates
3	LB-R-40	LB1-R-40 LB2-R-40 LB3-R-40	Layered beam with 40% replacement of coarse aggregates by rubber aggregates
4	LB-R-60	LB1-R-60 LB2-R-60 LB3-R-60	Layered beam with 60% replacement of coarse aggregates by rubber aggregates
5	LB-SS-20	LB1-SS-20 LB2-SS-20 LB3-SS-20	Layered beam with 20% replacement of fine aggregates by steel scraps
6	LB-SS-40	LB1-SS-40 LB2-SS-40 LB3-SS-40	Layered beam with 40% replacement of fine aggregates by steel scraps
7	LB-SS-60	LB1-SS-60 LB2-SS-60 LB3-SS-60	Layered beam with 60% replacement of fine aggregates by steel scraps

MATERIALS AND CONCRETE MIX DESIGN

The materials used for experimental programme are discussed in this chapter. The properties of a material are invariably dependant on the properties of its constituents. For finding the final mix proportion the properties of material are determined by conducting tests conforming to the IS codes.

Materials Used

Rubber Aggregates (20mm): The rubber aggregates required for experimental work are prepared by shredding the heavy vehicle tyres into small pieces as shown below.

Steel Scraps: For this research the scrap material produced fom milling machine is sed which is obtained from the Ratna gears industry, Hadapsar pune.

Steel

Thermo Mechanically Treated (TMT) steel bars are used for tension and compression reinforcement confirmed to IS: 432-1982.

Concrete

M25 concrete was prepared by a mixture consist of ordinary Portland cement, fine and coarse aggregates. Birla super cement (OPC grade 53) is used.

CASTING OF SPECIMENS

i) Concrete Cubes

Total twenty one cubes of size 150 x 150 x 150 mm confirming to (IS: 10086-1982) are casted by using modified concrete which is prepared by replacing 0%, 20%, 40% and 60% of coarse aggregates with scrap tyre rubber aggregates for one set and fine aggregates with steel scraps for another concrete specimens. For each percentage of replacement three specimens were casted. Hand mixing of concrete is done. The concrete cubes are filled in moulds throughout of one material. For proper compaction 35 strokes are given for each 50 mm layer.

ii) Design Considerations for Beams

The beams are casted in three layers. In first layer of thickness h1, M 25 grade concrete is used. Second layer of thickness h2 is by aggregates replaced concrete, and remaining height h3 is again filled by M25 concrete. Twenty one RC beams of size 150 x 250 x 700 mm were casted. The selected beam size is a normal beam as effective span to depth ratio is more than 2 (IS 456 - 2000, cl. 29.1, pg 51). For all specimens thermo mechanically treated (TMT) bars of 2-10 Φ were used for compression and tension reinforcement. Shear reinforcement in the form of 2 legged stirrups were provided by 10 Φ @ 125 mm c/c.

iii) Casting of Beams

Total twenty one beams are casted in which three beams are casted without any replacement of aggregates in concrete, nine beams casted by replacing coarse aggregates in concrete below neutral axis in tension zone with rubber aggregates and nine beams casted by replacing fine aggregates in concrete below neutral axis in tension zone with steel scraps. The casting of beam specimens is done according to the methodology as as explained above in design considerations for beams specimens.

CURING OF SPECIMENS

Before keeping the specimens for curing the specimens are marked by paint or permanent marker so that they can be identify after curing period. Specimens are immediately submerged in clean and fresh water. The specimens are not allowed to become dry at any time until they had tested.

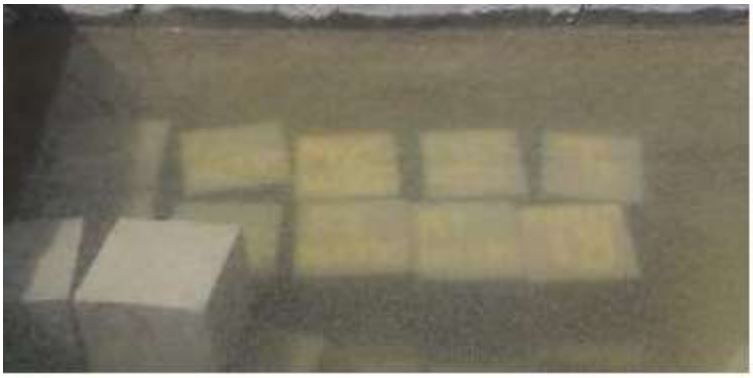

Figure 4 Curing of concrete cubes

Figure 5 Curing of RC beams

RESULT

In this experimental tests results of concrete cubes, three layers filled RC beams and theoretical results by MIF are elaborated. The comparison of increase or decrease in strength of concrete is done with controlled specimens.

Table 3 Results for density of concrete

Sr. No.	Specimen	Weight of Cubes in kg	Average weight in kg	Density of concrete in Kg/m3	Average Density in (Kg/m3)
1	C1-0	8.705	8.705	2579.259	2579.555
2	C2-0	8.708	2580.148		
3	C3-0	8.705	2579.259		
4	C1-R-20	7.902	7.903	2341.331	2341.826
5	C2-R-20	7.905	2342.222		
6	C3-R-20	7.904	2341.925		
7	C1-R1-40	7.425	7.436	2200.296	2203.555
8	C2-R2-40	7.442	2205.037		
9	C3-R3-40	7.443	2205.333		
10	C1-R1-60	7.030	7.032	2082.966	2083.655
11	C2-R2-60	7.035	2084.444		
12	C3-R-60	7.032	2083.555		
13	C1-SS-20	8.709	8.710	2580.443	2580.839
14	C2-SS-20	8.710	2580.741		
15	C3-SS-20	8.712	2581.337		
16	C1-SS-40	8.806	8.805	2609.185	2608.978
17	C2-SS-40	8.805	2608.892		
18	C3-SS-40	8.805	2608.889		
19	C1-SS-60	8.301	8.301	2459.555	2459.653
20	C2-SS-60	8.301	2459.555		
21	C2-SS-60	8.302	2459.851		

The values in the above table shows that as percentage replacement of course aggregates with scrap tyre rubber aggregates increases the density of concrete decreases. The maximum decrease in density is 19.22% for 60% replacement. When fine aggregates in concrete are replaced with steel scraps upto 40% less variation is observed in density of concrete and suddenly decreases to 60%

Compressive Strength of Concrete

Table 4 Results for compressive strength of concrete

Sr. No.	Specimen	Load in KN	Average load in KN	Compressive strength in N/mm2	Average Compressive strength in N/mm2
1	C1-0	804.2	806.9	35.7	35.8
2	C2-0	809.7	35.9		
3	C3-0	807.0	35.8		
4	C1-R-20	670.2	664.8	29.7	29.5
5	C2-R-20	662.3	29.4		
6	C3-R-20	660.8	29.3		
7	C1-R1-40	390.0	398.3	17.3	17.7
8	C2-R2-40	395.0	17.5		
9	C3-R3-40	410.0	18.2		
10	C1-R1-60	303.7	303.7	13.4	13.5
11	C2-R2-60	305.5	13.5		
12	C3-R-60	302.3	13.4		
13	C1-SS-20	835.2	836.0	37.1	37.1
14	C2-SS-20	840.6	37.3		
15	C3-SS-20	832.4	37.0		
16	C1-SS-40	895.4	895.9	39.7	39.7
17	C2-SS-40	900	40.0		

18	C3-SS-40	892.3	39.6		
19	C1-SS-60	740.6	736.8	32.9	32.7
20	C2-SS-60	732.1	32.5		
21	C2-SS-60	737.9	32.7		

CONCLUSIONS

The following conclusions are made based on the experimental work, theoretical results by MIF are discussed below.

1. When percentage of using rubber aggregates in concrete increases the density of concrete decreases, due to this light weight concrete is obtained which will helps to reduce the weight of structural members. Hence the design can become economical.
2. The use of rubber aggregates in concrete as a replacement material affects the mechanical properties of concrete. Upto 40% the flexural strength reduces without any significant loss, on the other hand the flexural strength increases i.e. mechanical properties of concrete improves when fine aggregates are replaced with steel scraps as compared to Controlled beam.
3. The impact of using scrap tyre rubber aggregates in concrete is more on modulus of elasticity. The modulus of elasticity decreases as percentage replacement of rubber aggregates in concrete increases. On the other hand there is increase in value of E in case of fine aggregates are replaced with steel scraps.
4. The test result of this study indicates that there is a great potential for the utilisation of scrap tyre rubber aggregates in concrete mixes up to 40% and steel scraps upto 60% in less stress zone below neutral axis. Hence, can be conclude that not to use this rubberized modified concrete above 40% replacement in structural element where high strength is required, it can be used in other construction elements like partition walls, road barriers, pavements, sidewalks, etc. which has high demand in construction industries.
5. The solution of bending stress obtain from method of initial functions are nearly equal to the experimental results having difference from 0 to 10%.
6. Thus from this study an environmental friendly technology is introduced which can benefit the society and nation, through which the impact of solid waste on environment is reduced and material can recycle in proper manner

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