EXPERIMENTAL STUDY ON PERFORMANCE OF COMPOSITE BEAMS

Priyanka Asutkar[1] Pankaj Punase [2],
Assistant Professor [1][2]
G.H. Raisoni Institute of Engineering and Managemant, Jalgaon[1]
SSBT Collage of Engineering and Technology Bambhori Jalgaon, MH, India[2]

Abstract

India has done a major leap on developing the infrastructures such as express highways, power projects and industrial structures, dams etc. to meet the requirements of globalization. For the construction of civil engineering works, concrete play main role and a large quantum of concrete is being utilized. Both coarse aggregate and fine aggregate is a major constituent used for making conventional concrete, has become highly expensive and also scarce. 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 present study the aggregates in less stress concrete zone below the neutral axis are replaced by the scrap material like scrap tyre rubber aggregates (STRA) for one set and for other set fine aggregates in concrete are replaced byand steel scrap (SS). Replacement is done with varying proportion from 0% to 60% with increment of 20 %. Method of initial functions is used for finding bending stress of beams. The Method of initial functions (MIF) is an analytical method of elasticity theory.

Key word: Rubber scrap, steel scrap, Method of initial functions, beams.

1. 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. The waste generate from one process is in fact a raw material for some other process. Waste is a material that is wrongly placed or laying 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.

One of the most crucial environmental issues all around the world is the disposal of the waste materials. Accumulations of discarded waste tyres have been a major concern because the waste rubber is not easily biodegradable even after a long period landfill treatment. Thus it gets accumulated and creates variety of problems. It creates unsightly appearance. If burnt under conventional uncontrolled fashion it creates harmful vapours. If dumped in land fill sites, in rainy seasons it accumulates water and harbours mosquitoes and fly bleedings. If buried in land fill sites, it slowly decomposes under anaerobic environment and generates methane. Methane is generated by other sources also in land fill sites [1]. Adding industrial steel solid wastes obtained from lathes in concrete enhances its compressive strength [2].When rubber aggregates are increase there is decrease in mechanical properties of concrete depends on type and content of rubber used [3]. The Slump and workability was significantly increased with the introduction of recycled rubber tires into concrete [4]. Partial replacement of crumb rubber in foamed concrete leads to reduced density of concrete found that rubberized concrete is the best solution for non-structural purpose [5]. Rubberized concrete mixtures with and without silica fume appeared to be workable to certain degree and reduction in weight by 77% by replacing 50% total aggregate volume enhances the mechanical properties [6]. Self compacting rubberized concrete required slightly higher amount of super plasticizer than self compacting concrete to reach self-compacting properties [7].

Method of initial functions is used for two dimensional elasto dynamic problems for plain stress and plain strain conditions [8]. And used for the analysis of thick circular plates. The governing equations are derived from the three dimensional elasticity equatio-ns in cylindrical polar coordinates using Maclaurin's series [9]. A 3d problem of loading a linearly elastic layer using a method of initial functions is solved. MIF has been applied for deriving higher order theories for laminated composite thick rectangular plates [10]. Mathematical founda-tions, the theory and application of the Method of Initial Functions (MIF) to rectangular anisotropic plates subjected to both statical and dynamical loads are discussed [11]. It is used for the analysis of composite laminated beams and the governing equations of two dimensional elasticity are derived [12]. MIF is used for analysis of flexure member for finding stresses and displacement [13].

1.1 Method of initial functions (MIF)

MIF was first proposed by Malieev in 1951 and further developed by Vlasov in 1955. Beams that are built of more than one material are called comp-osite beams. It is difficult to analyze the laminated beams by the bending theory used for ordinary beams. In MIF, equations governing the flexure of composite laminated beams are derived without making any assumption regarding the physical behaviour of beams. The method of initial functions (MIF) has been used for deriving the equations. It is an analytical method of elasticity theory allows us to obtain the exact solutions for certain types of problems without use of hypotheses about the charac-ter of the stress-strain state of the structural element. In recent years the MIF has been used intensively for the analysis of various problems. For example, three-dimensional elasticity equations for circular cylind-rical shells are solved by assuming Taylor series expansions for finding stresses and displacements

2. DETAILS OF EXPERIMENTAL WORK

The rubber aggregates are obtained by shredding the scrap tire rubber in 20mm size. Heavy vehicles tire scraps were used for preparing the rubber aggregates. On the other hand the steel scraps were obtained from the lathe machines, it is the waste produced from milling, polishing etc. The percentage of replacement is done by volume. The properties of material used are discussed below.

Table 1: Physical properties of materials used

Sr no	Material	Specific gravity	Bulk Density (kg/m^3)
1	Rubber aggregates	1.12	645
2	Steel scraps	3.24	1350
3	Fine aggregates	2.6	1750
4	Coarse aggregates	2.8	1710

2.0 Materials used

2.1 Concrete

M25 concrete is used by preparing a mixture consist of ordinary Portland cement, fine and coarse aggregates confirming to respective IS code were used for concrete. The mix design is done by using IS: 10262:2009.

2.2 Steel

Thermo Mechanically Treated (TMT) steel bars is used for reinforcement confirmed to IS: 432-1982.

2.3 Rubber aggregates (20mm)

These were obtained by shredding the heavy vehicle tyres into small pieces as shown below.

Fig 1. Rubber Aggregates (20mm)

2.3 Steel scraps

Is a waste produced from milling process. For this research the material is obtained from the Ratna gears industry, Hadapsar pune.

Fig 2. Steel Scraps

Table no 2: Mix proportion (kg/m^3)

Designation	Cement	Water	Fine aggregates	Coarse aggregates	Rubber aggregates	Steel scraps

CB-0%	354.78	191.58	741.94	1182.65	---	---
LB-R-20%	354.78	191.58	741.94	946.12	89.21	---
LB-R-40%	354.78	191.58	741.94	709.59	178.43	---
LB-R-60%	354.78	191.58	741.94	473.06	267.65	---
LB-SS-20%	354.78	191.58	593.55	1182.65	---	111.07
LB-SS-40%	354.78	191.58	445.16	1182.65	---	222.15
LB-SS-60%	354.78	191.58	296.776	1182.65	---	333.23

2.3 Specimen Preparation:

The beams are casted by concreting it in three layers. In first layer of thickness h_1, M 25 concrete is used. Second layer of thickness h_2 is by aggregates replaced concrete, and remaining height h_3 is again filled by M25 concrete.21 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).Thermo Mechanically Treated (TMT) bars of 10mm φ were used for the longitudinal reinforcement also for stirrups. The arrangements of reinforcements used on compression and tension face are 2-10 Φ for all specimens. Shear reinforcement in the form of 2 legged stirrups were provided by 10 Φ @ 125 mm c/c.

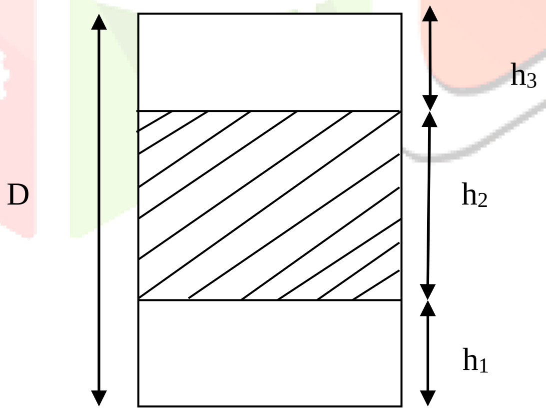

Figure 3 concrete filled in layers

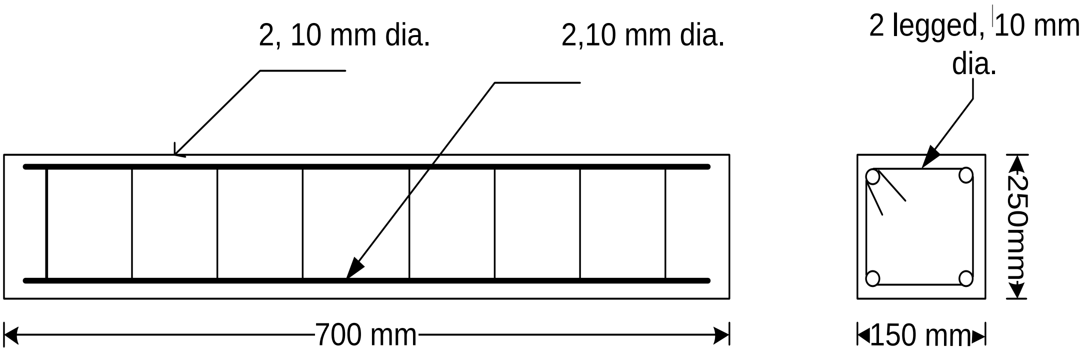

Figure 4 Typical reinforcement detailing of beam

2.4 Selection of replacement zone

To replace the material below neutral axis the formula for depth of neutral axis according to IS 456:2000 is as follows

$$X_u = (0.87\, f_y.Ast)/\,(0.36 f_{ck}.b)$$

Where,

f_y = Characteristic strength of reinforcement in N/mm^2

Ast = area of tension reinforcement

f_{ck} = characteristics compressive strength of concrete in N/mm^2

b = breadth of beam

$$x_u = \frac{0.87 \times 500 \times 157.07}{0.36 \times 25 \times 150}$$

$$x_u \;=\; 50.61 \approx 50\text{mm}$$

To fill the beam in layers the bottom thickness h_1 is assumed to be 2 x cover + diameter of bar [14]. where, h_1 is the thickness of concrete layer available to maintain bond between steel and concrete. It is assumed the provision of thickness of concrete not less than the cover provided on each side of the tension reinforcement will satisfy the bond requirement.

Therefore,

h_1 = 2 x 20+10

h_1 = 50mm.

As depth of beam D = 250, assume h_1= h_3= x_u= 50mm,

Therefore, Replacement zone (h_2) = depth of beam - (h_1+h_3)

= 250 - (50+50)

Replacement zone (h_2) = 150mm.

3. TESTING OF BEAMS

All specimens are tested under flexural loading on universal testing machine (UTM). The deflection at center of beams are recorded for each specimen. The observed deflections are used for finding modulus of elasticity of each specimens. It is observed that all the spec-imens are fail in shear.

IJCRT Publish Paper record is available at DOI: http://doi.one/10.1727/IJCRT.17205

Figure 5 Shows failure of beam with flexural crack at centre

Figure 6 Shows shear crack at supports and flexural cracks at center

4. ANALYSIS OF FLEXURE MEMBER BY MIF

4.1 Procedure for Analysis of Flexural Member

Following steps are followed for analysis

a. Select size of beam D and l.

b. Define material properties (E, G, μ)

c. Apply boundary conditions for simply supported beam as $X = Y = v = 0$ at $x = 0$ and $x = l$.

d. Select the auxiliary function to satisfy the the boundary conditions.

e. Apply the loading conditions at top of the beam. For beam subjected to two point loading the equation in sine series is given by

$$P(x) = \sum_{n=1}^{\infty} \frac{2}{l} \left[p_1 \sin\left(\frac{n\pi x_1}{l}\right) + p_2 \sin\left(\frac{n\pi x_2}{l}\right) \right] \sin\left(\frac{n\pi x}{l}\right) \quad \text{.......... (4.31)}$$

f. Apply load P in Newton.

4.2 Beam dimensions

The following values of beam dimensions are chosen for the particular problem,

Effective length (l) = 600mm.

Effective depth (d) = 225 mm

The boundary condition of simply supported edges is $X=Y=v=0$, at $x=0$ and $x=l$.

Table 4.Elastic properties for analysis

Material	% of replacement	E (N/mm^2)	G (N/mm^2)	μ
Rubber aggregates	0	26191.01	$11.38x10^3$	0.15
	20	21483.05	$9.345x10^3$	0.15
	40	17050	$7.41x10^3$	0.15
	60	13620.39	$5.921x10^3$	0.15
Steel scraps	20	26090.94	$11.34x10^3$	0.15
	40	26672.87	$11.594x10^3$	0.15
	60	27487.13	$11.96x10^3$	0.15

5. RESULTS AND DISCUSSION

5.1 Results

Following are the comparative results of bending stress determined experimentally by using (IS 516:1959) and by MIF.

Table 5 Comparative results of bending stress

Sr no	Specimen	Load (KN)	Bending stress Experimentally (N/mm2)	Bending stress MIF (N/mm2)
1	CB	208.68	15.82	14.76
2	R-20	198.4	14.85	14.77
3	R-40	190.76	14.70	14.33
4	R-60	172.36	12.76	12.76
5	SS-20	210.34	15.61	15.61
6	SS-40	213.23	15.98	16.23
7	SS-60	218.03	17.08	16.67

5.2 Discussion

The comparison results from above table shows that the experimentally calculated bending stress by using IS 516-1959 and bending calculated by MIF are having value nearly equal with difference less than 0% to10%. MIF is an analytical method based on elasticity theory is giving the exact solutions of bending stress with considering any assumptions regarding physical behaviour of beam.

From experimental results of bending stress, it is observed that when coarse aggregates in concrete below neutral axis in tension zone are replaced with rubber aggregates the flexural strength decreases. For 20% replacement the strength decreases by 6.3% for 40% decreases by 7.07% and decreases to 16.18% for 60% replacement.

When F.A are replaced by steel scraps the flexural strength increases as the percentage replacement increases. When fine aggregates are replaced with steel scraps in less stress zone concrete there is less variation in flexural strength of concrete for 20% %, 40% but for 60% it increases to 7.37 % . The maximum increase in strength is for 60% for ultimate load 218.03 KN.

6. CONCLUSION

The following conclusions are made based on the above experimental work and analysis by MIF

a. Experimentally it is seen that flexural strength of the concrete decreases when coarse aggregates are replaced by rubber aggregates.

b. The rubber aggregates can be effectively replaced up to 40% below neutral axis in tension zone.

c. It is recommend that, as for 60% replacement of rubber the strength decreases by 19% it cannot be used ,where high strength of concrete is required, but for non structural components it can be used upto 60%. industry these can be can be used upto 60% non structural components

d. As the replacement is in less stress zone the strength is not too increase or decrease. All the experimental results are within 20% increase or decrease in strength.

e. As analytical results are near to the experimental results it shows that the method can be effectively used for the analysis of composite laminated beams.

REFRENCES

1. A.A. Adeyanju, and K. Manohar, "Effects of Steel Fibers and Iron Filings on Thermal and Mechanical Properties of Concrete for Energy Storage Application," Journal of Minerals & Materials Characterization & Engineering,Vol.10, No.15,pp.1429-1448, 2011.
2. Abbas Hadi Abbas, "Management of Steel Solid Waste Genera-ted from Lathes as Fiber Reinforced Concrete," European journal of scientific research, ISSN 1450, Vol.500 No.4 (2011), pp 481-485.
3. A Ahangar-Asr, A Faramarzi and A. A. Javadi, "An evolutionary numerical approach to modelling the numerical poperties of rubber concrete". Preceeding of the international conference on computing in civil and building engineering. Icccbe 2010.
4. Abrham Kebede Seyfu, "The Use of Recycled Rubber Tires as a Partial Replacement for Coarse Aggregate in Concrete Construc-tion," Addis Ababa University, School of graduate studies faculty of technology, dept. of civil engg. June 2010
5. Ameer Abdul rahman Hilal, "Effect of crumb tires rubber on some properties of foamed concrete, "Anbar Journal for Engineer-ing Sciences, AJES-2011, Vol.4, No.2 (2011), pp1-17.
6. El-Gammal, A, A. K. Abdel-Gawad, Y. El-Sherbini and A. Shalaby, "Compressive Strength of Concrete Utilizing Waste Tire Rubber," Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 1 (1): 96-99.
7. M.C. Bignozzi, F. Sandrolini, "Tire rubber waste recycling in self-compacting concrete," Science Direct Elsevier Ltd, Cement and Concrete Research 36,(2006), 735–739.
8. Das, Y.C. and Setlur, A.V."Method of initial functions in Two dimensional Elastic dynamic

problems, "Journal of Applied Mechanics Vol.37 (1), 1970, pp.137-140.

9. Sebastian V.K, Iyengar Raja K.T. and Chandra shekhara K., "Method of initial functions in the analysis of thick circular plates," Nuclear Engineering and Design, Vol. 36(3), 1976, pp. 341-354
10. K. T. S. Iyengar and S. K. Pandya, " Application of the method of initial functions for the analysis of composite laminated plates", Ingenieur-Arehiv 56 (1986) 407-416
11. Sergey M. Galileev, Pavel Y. Tabakov, "Mathematical Foundations of the Method of Initial Functions for the Application to Anisotropic Plates", 2nd International Conference on Mechanical, Nanotechnology and Cryogenics Engineering (ICMNC'2013) Sept. 25-26, 2013 Phnom Penh (Cambodia).
12. Patel Rakesh, Dubey S. K, Pathak K.K. "Analysis of Composite Beams using Method of Initial Functions" International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 01, No. 02, October 2012.
13. Patel Rakesh, Dubey S.K and Pathak K.K."Analysis of Flexural Members using an Alternative approach" Research Journal of Engineering Sciences, ISSN 2278 – 9472, Vol. 2(4), 40-42, April (2013).
14. Patel Rakesh, Dubey S.K, Pathak K.K. "Analysis of RC Brick Filled Composite Beams using MIF" Procedia Engineering 51 (2013) 30–34.
15. Bashar S. Mohammed "Structural behaviour and m–k value of composite slab utilizing concrete containing crumb rubber" Construction and Building Materials 24 (2010) 1214–1221.
16. Eshmaiel Ganjian, Morteza Khorami, Ali Akbar Maghsoudi "Scrap tyre rubber repl-acement for aggregate and filler in concrete" Construction and Building Materials 23 (2009) 1828–1836.
17. Her-Yung Wang, Bo-Tsun Chen, Yu-Wu Wu "A study of the fresh properties of controlled low-strength rubber lightweight aggregate concrete (CLSRLC)"Constr-uction and Building Materials 41 (2013) 526–531.
18. Theory of elasticity by Dr. Sadhu Singh.
19. IS 456 : 2000 – Code of practice for plain and reinforced concrete.
20. IS 516 : 1959 – Methods of tests for strength of concrete.