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Study on Behaviour of Flexural Members by Elastic Approach

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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 tyres waste is being 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 modified concrete is prepared by replacing coarse aggregates in concrete with rubber aggregates by varying the replacement proportion from 0% to 20% with increment of 5%. The elastic properties are determined from concrete cubes. 3 cubes for each percentage of replacement are casted and tested after 28th days of curing. Method of initial functions is used for the analysis of beams. The Method of initial functions (MIF) is an analytical method of elasticity theory from which stresses and displacement can be determined. This attempt of replacing the coarse aggregates with rubber aggregates will save the natural aggregates, reduces weight of structure and also helps achieve sustainability**.

Key words: Rubber scrap, elasticity, Method of initial functions, beams.

1.0 INTRODUCTION

The scarcity and availability of sand and aggregate at reasonable rates are now giving anxiety to the construction industry. Over years, deforestation and extraction of natural aggregates from river beds, lakes and other water bodies have resulted in huge environmental problems. Erosion of the existing topography usually results in flooding and landslides. Moreover, the filtration of rain water achieved by deposits of natural sand is being lost, thereby causing contamination of water reserves used for human consumption. Hence, to prevent pollution authorities are imposing more and more stringent restrictions on the extraction of natural aggregates and its crushing. The best way to overcome this problem is to find alternate aggregates for construction in place of conventional natural aggregates. In this research rubber aggregates from discarded tyre rubber in sizes 20-10 mm, is partially replaced with natural aggregates in cement concrete.

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.

2.0 LITERATURE REVIEW

Recycled tire rubber is used to develop deliberately low elastic modulus and highly ductile ECC repair material so as to alleviate repair failure induced by restrained drying shrinkage [1].Tyre aggregate replaced with coarse aggregate with various percentages and compared with regular concrete. Fresh and hardened concrete strength were identified [2].Rubber waste additives reduced both static and dynamic modulus of elasticity [3].Higher content of waste tyre crumb rubber particle used in concrete increases workability of concrete and produce the light weight concrete [4].Compressive strength of concrete with 100% replacement of chipped rubber showed 90% reduction. However reduction in strength was 80% when crumb rubber was used as 100% replacement to sand in concrete [5].The replacement of coarse aggregate by junk rubber in concrete has resulted in reduced compressive strength and densities [6].Rubber tyre aggregate were added to M35 mix with different percentages. Gradual reduction in the compressive and tensile strength was observed. Upto 8% of rubber aggregate can be added in the concrete without considerable reduction in strength [7].Replacement of rubber increased water permeability depth in the concrete and increases the water absorption in case of coarse aggregate replacement but reduces the water absorption in case of cement replacement. [8].Slump value is decreased as the percentage of replacement of scrap tyre rubber increase so decrease in workability. Also decrease in compressive, split tensile and flexural strength. In the rubberized concrete the loss of strength was 45% with 15% replacement of coarse aggregate with rubber particle [9]. Replacing conventional fine aggregate with crumb rubber at 10–30%, the unit-weight of concrete can be reduced from 14%up to 28% depending on the type and the content of the crumb rubber. The CR concrete exhibits superior thermal and

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sound properties than plain concrete as measured by the decrease in thermal conductivity coefficient, increase in sound absorption coefficient and noise reduction coefficient [10].Method of initial functions is used for two dimensional elasto dynamic problems for plain stress and plain strain conditions [11]. Method of initial function is used for the study of composite beams having two layers of orthotropic material and developed governing equation [13].Result obtained with MIF are compared with result obtained by FEM based software ANSYS and it is observed that they are comparable [14].MIF is successfully applied for the analysis of reinforced concrete brick layer [15]The method of initial function is used to see the effect of elastic properties on the behaviour of the beam [16].The deflection obtained by MIF is equal to the deflection obtained by other theories. The normal stress equal to the intensity of loading and shear stress equal to zero at the top of beam are obtain, this shows that MIF is successfully applied for the analysis of beam [17].MIF gives correct result for both shallow and deep beams. Also in this method it is not necessary to assume the position of neutral axis; it incorporates the position of neutral axis by itself. Hence it is conclude that analysis done by MIF provides more realistic behaviour of beam sections of any depth [18].

3.0 MATERIAL AND METHODS

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. The percentage of replacement is done by volume. Cubes size is taken as 150 x1 50 x 150 mm. The properties of material used are discussed below.

Table 1: Physical properties of materials used

Material	Specific gravity	Bulk Density (kg/m^3)
Rubber aggregates	1.10	650
Fine aggregates	2.6	1650
Coarse aggregates	2.8	1720


Fig 1. Rubber Aggregates (20mm)


Fig 2. Concrete Cubes

Table 2. Mix proportion (kg/m^3)

Designation	Cement (kg)	Water (litres)	Fine aggregates (kg)	Coarse aggregates (kg)	Rubber aggregates (kg)
NC - 0%	364.81	225.17	610.43	1239.64	-
RC -5%	437.77	224.2	590.03	1177.65	23.30
RC -10%	437.77	224.2	590.03	1115.67	46.73
RC- 15%	437.77	224.2	590.03	1053.69	70.101
RC-20%	437.77	224.2	590.03	991.71	93.46

3.1 Compressive test on concrete cubes

The coarse aggregates in the concrete was replaced successively by different percentage of rubber aggregates with varying proportion from 0%, 5%, 10%, 15%, 20%.The concrete cubes of size 150mm^3 were casted and tested after 28 days of curing.


Fig 3. Testing of concrete cubes

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Table 3. Compressive strength of cubes for various percentage of replacement

% of replacement	coarse aggregates replaced concrete (N/mm^2)
0%	31.7
5%	29.23
10%	25.61
15%	21.34
20%	16.61

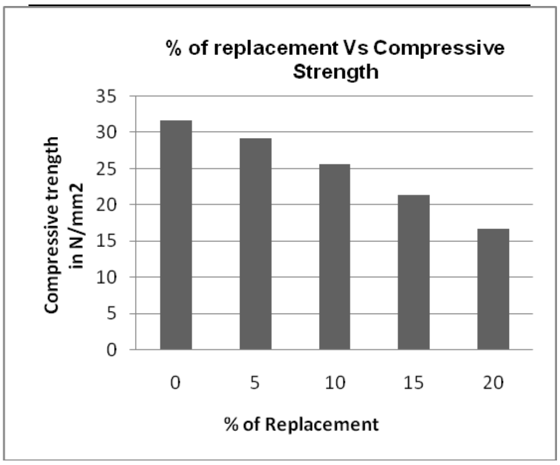

Fig 4. Variation of compressive strength for different percentage of replacement

4. ANALYSIS OF COMPOSITE BEAM BY MIF

The following values of beam dimensions are chosen for the particular problem.
H=250mm, l=2000mm.
The boundary condition of simply supported edges is given by
X=Y=v=0, at x=0 and x=l
A uniformly distributed load is assumed, on top surface of the beam. The expression for point load in sine series is given by

$$P = \frac{4P_o}{l}\{\sin(\frac{\pi x}{l})\}$$

Taking P_o=100 N/m and x=l/2.
The design loads P_o are calculated by using IS 456-2000. The elastic properties are determined by using expression from ACI-318. μ is constant for all cases, and G is determined by using the expression $E=2G(1+\mu)$.

Table 4. Elastic Properties

Material	% of Replacement of Coarse Aggregates	Load (N/mm)	E (N/mm^2)	G (N/mm^2)	μ
Coarse Aggregates Replaced with Rubber aggregates Concrete	0	100	28729.13	1197.47	0.20
	5	98.80	24658.06	10274.19	0.20
	10	97.50	21589.82	8995.75	0.20
	15	93.20	16827.65	7011.52	0.20
	20	85.20	14284.55	5951.89	0.20

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4.1 Results and Discussion

The analytical results of stresses and displacement by using method of initial functions are shown in the following table.

Table 5. Beam loaded with UDL100N/mm.

Depth Of Beam	V (mm)	X (N/mm^2)	Bending Stress (N/mm^2)
400	0.513	0	7.31
350	0.513	0.53	5.43
300	0.513	0.78	3.661
250	0.513	0.93	1.957
200	0.512	0.968	0.30
150	0.511	0.92	-1.331
100	0.511	0.79	-2.966
50	0.509	0.54	-4.628
0	0.507	0	-6.352

Table 6. Beam loaded with point load 98.80 KN

Depth of Beam	v (mm)	X (N/mm^2)	Bending stress (N/mm^2)
400	0.581	0	7.220
350	0.581	0.38	5.380
300	0.581	0.67	3.650
250	0.580	0.85	1.928
200	0.580	0.93	0.28
150	0.579	0.88	-1.245
100	0.578	0.73	-2.863
50	0.576	0.43	-4.515
0	0.576	0	-6.233

Table 7. Beam loaded with point load 97.50 KN

Depth of Beam	v (mm)	X (N/mm^2)	Bending stress (N/mm^2)
400	0.641	6.84	7.130
350	0.641	5.13	5.290
300	0.641	3.5	3.580
250	0.641	1.94	1.510
200	0.640	0.15	0.710
150	0.639	-1.06	-1.127
100	0.638	-2.56	-2.743
50	0.636	-4.08	-4.308
0	0.634	0	-5.964

Table 8. Beam loaded with point load 93.20 KN

Depth of Beam	v (mm)	X (N/mm^2)	Bending stress (N/mm^2)
400	0.734	0	6.990
350	0.7.33	0.35	5.242
300	0.733	0.62	3.495
250	0.732	0.78	1.380
200	0.732	0.85	0.120
150	0.730	0.81	-1.033
100	0.728	0.66	-2.262
50	0.728	0.39	-3.850
0	0.725	0	-5.321

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Table 8. Beam loaded with point load 85.50 KN

Depth of Beam	v (mm)	X (N/mm^2)	Bending stress (N/mm^2)
400	0.811	0	6.046
350	0.811	0.34	4.533
300	0.810	0.6	3.098
250	0.810	0.76	1.15
200	0.810	0.83	0.095
150	0.810	0.79	-0.939
100	0.807	0.64	-2.153
50	0.807	0.38	-3.607
0	0.805	0	-4.903

The following figure shows the profile of stresses and displacement across the depth of beam.

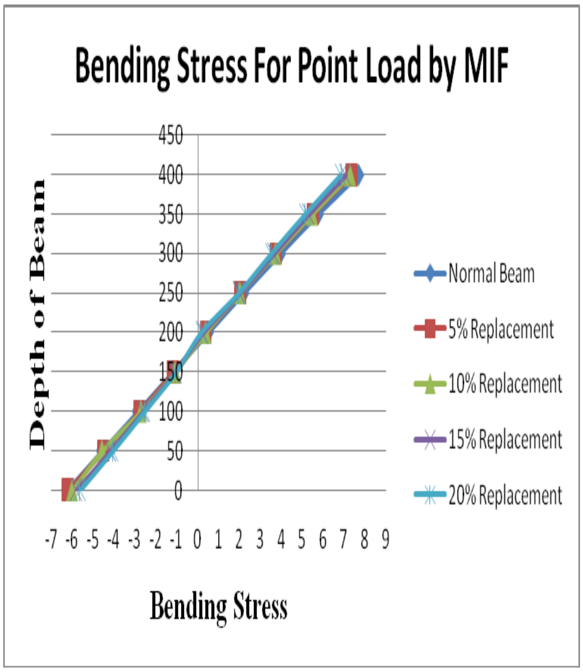

Fig 5. Variation of bending stress for different percentage of replacement. The bending Stress decreases as the percentage replacement of coarse aggregates by rubber aggregates in concrete increases. Reduction of bending stress is less upto 15% but suddenly decreases by 12% for 20% replacement of coarse aggregates.

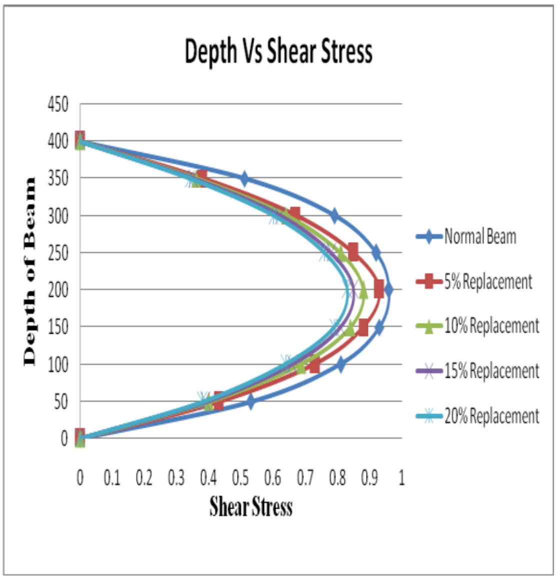

Fig 6. Variation of shear stress for different percentage of replacement across the depth. The shear Stress is zero at top end of the beams and maximum at centre. As percentage replacement of coarse aggregates by rubber aggregates in concrete increases the shear stress decreases.

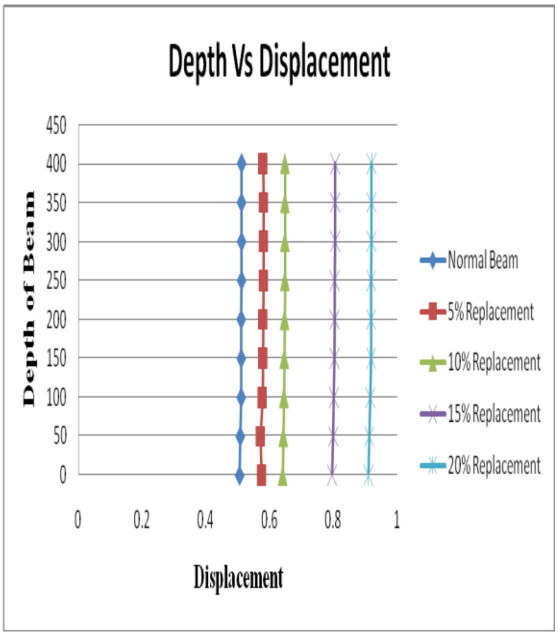

Fig 7. Variation of displacement across depth of beam for different percentage of replacement.

The variation of displacement (v) is almost linear across the depth. It increases with increase in percentage replacement of coarse aggregates by rubber aggregates in concrete. Less variation is observed 5% and 10% but displacement is more for 15 % and 20% replacement

5. CONCLUSIONS

- The following conclusions are made based on the above experimental work and analysis by MIF.
- Experimentally it is seen that the compressive strength of the concrete decreases when coarse aggregates are replaced by rubber aggregates. The rubber aggregates can be effectively replaced up to 15%.
- The results of shear stress and bending stresses are analysed by using MIF satisfies the physical behaviour of beam.
- The analytical results shows that the bending Stress decreases as the percentage replacement of coarse aggregates by rubber aggregates in concrete increases.
- The results indicate that displacements are more for rubber aggregates replacement.
- This study suggest that use of scrap material will help to recycle the material and can be effectively used in concrete. This will save the natural aggregates and also helps to achieves sustainability

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