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Full Length Article

Study on the behaviour of rubber aggregates concrete beams using analytical approach

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A B S T R A C T

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 generated 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 lightweight concrete. In present study an attempt is made to partially replace the rubber aggregates by coarse aggregates in concrete and to study its impact on properties of concrete. A 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%. 3 cubes for each percentage of replacement are casted and tested after 28th days of curing. The physiomechanical properties like density, compressive strength and elastic properties of modified concrete are determined from concrete cubes experimentally and further stresses and displacement at every 50 mm depth of beams are determined analytically by method of initial functions (MIF). MIF is an analytical method in which elastic properties and theoretical loads are used to analyse the beams without conducting any experimental programme. The analytical results by MIF are compared with bending theory.

1. 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. 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 size ranges from 10 to 20 mm is partially replaced with natural aggregates in cement concrete. This attempt of replacing the coarse aggregates with rubber aggregates will save the natural aggregates, reduces weight of structure and also helps achieve sustainability.

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 composite beams. It is difficult to analyse 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 character 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 cylindrical shells are solved by assuming Taylor series expansions for finding stresses and displacements [18].

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Notations

L	length of beam	G	shear modulus of elasticity
H	depth of beam	μ	Poisson's ratio
b	width of beam	v	vertical displacement
d	density of concrete	X	shear stress
E	Young's modulus of elasticity	σ_x	bending stress
F	characteristics compressive strength of concrete		

2. Literature review

Recycled tyre 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 lightweight 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 concrete exhibits superior thermal and

Fig. 1. Rubber aggregates 10–20 mm.

Fig. 2. Concrete cubes.

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

Table 3
Compressive strength and density of concrete.

% of replacement	Ultimate load (kN)	Compressive strength (N/mm^2)	Weight of cubes in kg	Density in kg/m^3
0%	713.25	31.7	8.15	24141.81
5%	657.67	29.23	7.56	2240.702
10%	576.22	25.61	7.23	2143.14
15%	480.05	21.34	6.51	1928.88
20%	373.72	16.61	6.34	1879.933

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

Replacement %	Cement (kg)	Water in litres (W/c = 0.50)	Fine aggregates (kg)	Coarse aggregates (kg)	Rubber aggregates (kg)
0%	364.81	225.17	610.43	1239.64	–
5%	437.77	224.2	590.03	1177.65	23.30
10%	437.77	224.2	590.03	1115.67	46.73
15%	437.77	224.2	590.03	1053.69	70.101
20%	437.77	224.2	590.03	991.71	93.46

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