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STRUCTURAL BEHAVOIUR OF CONCRETE BEAMS USING FIBER OPTIC SENSOR AND REPLACEMENT MATERIALS

[1] G.SATHIYARAJ, [2] MANIVEL KRISHNAN, [3] G.SINGARAVELU, [4] C.MONAMBIGAI

[1]Assistant Professor, [2]Assistant Professor, [3] Assistant professor, [4]Assistant professor,
Department of civil Engineering
Jayalakshmi Institute of Technology, Thoppur, Dharmapuri-636352.

Abstract: Civil structures are important to society. For durable and safe service lives, good design, quality construction as well as appropriate management during service are important goals of structural engineering management and monitoring are often essential parts of managing activities. Therefore, monitoring structures from construction to the end of the service may be useful for concrete structures; this includes monitoring during the early age. In this paper we had develop a structural health monitoring using fiber optic sensor and strength of concrete improved by E-Waste. For many point view, fiber optic sensors are the ideal transducers for civil structural monitoring. Being durable, stable from the incentive to external perturbations. They are particularly interesting for the long term health. Now a day's in India the construction is slowed down due to the increase in demand and unavailability of construction materials at feasible cost. Using alternative materials will overcome this problems an effort have been made in the construction industry to use non-bio degradable components of E-waste as a partial replacement for the coarse aggregate. And manufactured sand as a fine aggregate. It is purpose made fine aggregate produced by crushing and screening or further processing i.e. washing, grading, classifying of quarried rock, cobbles, boulders or gravels from which natural fine aggregate had been removed. An experimental study is made on the utilization of E-waste particles as coarse aggregate in concrete with a percentage replacement ranging from 0% to30% with the strength criteria of M40 concrete. Compressive strength, tensile strength, flexural strength of concrete with and without concrete as a coarse aggregate and the stress and strain induced in the structural member by using optical fiber sensor was observed. Ultrasonic tests on strength properties were executed and the feasibility of utilizing E-plastic particles with partial replacement of coarse aggregate and fiber optic sensor for structural health monitoring has been presented.

Keywords:
Coarse Aggregate, Crushed E Waste, M sand, Fiber Optic Sensor, Compressive Strength, Flexural Strength, Tensile Strength, Stress Strain Curvature.

I. INTRODUCTION

The degradation of concrete structures is a major infrastructures problem in many parts of the world. In the last years there is an increasing acknowledgement of our impact on the environment due to our life style. While the need to adopt a more sustainable approach concerning our consumption habits emerges as of particular significance. Monitoring of new and existing structures is one of the essential tools for a modern and efficient management of the infrastructure network.

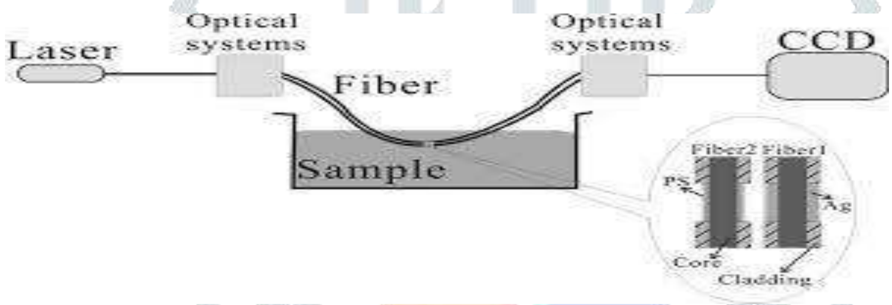
This study intended to find structural behaviour of fiber optic sensor by using replacement materials as e waste and m-sand. There are inherent advantages of fiber optic sensors which include their ability to be light in weight, very compact and small in size. Easy to launch light, low ISI, resistance to electromagnetic interference, high sensitivity, wide bandwidth and environmental ruggedness make them widely used in different fields. All these mentioned characteristic make best use of optical fiber sensor and the networks which are made up of optical fiber are very advantages in industry for long time investment. The effective ways to reutilize the electronic waste particles

(WEEE) as a coarse aggregate and manufactured sand (M-SAND) as a fine aggregate. E-waste describes loosely discarded, surplus, obsolete, broken, electrical (or) electronic devices. Rapid technology change, low initial cost has resulted in a fast growing surplus of electronic waste around the globe. Several tonnes of E-waste need to be disposed per year. Traditional landfill (or) stock pile method is not an environmental friend solution and the disposal process is also very difficult to meet EPA regulations. How to reuse the non-disposable e waste becomes an important an important research topic. Amnon and Hadassa (2006) studied the effect of high levels of fine content on concrete properties. Hudson B.P. (1997) has taken a review of various tests in his article manufactured sand for concrete. Ilangovan et.al (2006) studies the strength behaviour of concrete by using crushed rock dust as a fine aggregate. They investigated the possibility of using crushed rock as a 100% replacement for sand, with varying compaction factor. On this basis M-sand offers viable produced by crushing and screening (or) further processing i.e., washing, grading, classifying of quarried rock, cobbles, boulders (or) gravels from which natural fine aggregate had been removed.

2. Basis of Light Transmission in Optical Fiber

Snell's law and the concept of total internal reflection can explain the transmission of through light optical fiber. Snell's laws relate index of refraction and incoming and outgoing angles for light passing from one material to another by equation:

$$N1 \sin \theta 1 = N2 \sin \theta 2.$$



When a light traverse from a fiber core that has higher refractive index into the cladding with a lower refractive Index, the light wave is totally reflected back into the core.3.

3. Research Significance

3.1. E-waste-Globally about 20-50 million tons of e-waste is disposed of each year, which accounts for 5% of all municipal solid waste. When this waste ends up in landfill, it creates leaching problem which in turn contributes to the pollution of ground water resources. There are two small (WEEE) organized e-waste recycling facility in India A report of the United Nations predicted that by 2020, e-waste from old computers would jump by 500% on 2011 levels in India additionally e-waste from discarded mobile phones would be higher about 18 times in India then 2007 levels. Such prediction highlight the urgent need to address the problem of e-waste in developing countries like India, were the collection and management of e-waste and the recycling process is yet to be properly regulated printed circuit board (PCB) is a very usual part of almost every electronic product. The vast annual production of PCB waste creates environmental concerns because of the leaching of toxic chemicals into landfills when it is dumped and incineration produced dioxins and furans which persist in the environment for a long period due to the task of dealing with the disposal of non cyclable parts and the expense incurred in dealing the toxic waste, recycling is non willingly done. Hence it is necessary to arrive at a cost effective and environmental friendly solution for the disposal of PCB waste. Accordingly, this paper examines the feasibility Of utilizing the non-metallic portion of printed circuit board in concrete making.in particular waste strips from the culling of printed circuit board are taken for the work.

3.2. Manufactured sand

The main objective of the present work was to systematically study the Percentage replacement of manufactured sand by natural sand as 0%, 20%, 40%, 80%, and 100% on Strength properties of concrete. The study was carried out on M40 grade concrete with 0.45 water cement ratio. Manufactured sand can be used as replacement of fine aggregate, but it has to satisfy the technical requisites like workability and strength. On this aspect research on concrete with manufactured sand is scarce, so this paper also investigates the concrete produced with manufactured Sand.

4. Experimental Details for Replacement Materials

Property	Fine aggregate		Coarse aggregate	
	Natural sand	M sand	Coarse aggregate	E- waste
Specific gravity	2.44	2.37	2.67	1.74
Finess modulus	4.665	4.265	-	-
Impact value	-	-	8.57%	4.1%
Water absorption	6.5%	6.6%	15%	5%

Table 1: Physical properties of materials

4.1. Concrete Mixes

The E-waste and manufactured sand contents are calculated on weight basis as coarse aggregate and fine aggregate in the conventional mix: The fineness modulus of coarse aggregate with various E-waste contents is observed as 5.236.The divided particle size is assumed between 10mm and 20mm.Then E-waste particles considered as partial replacement of coarse aggregates. The fineness modulus of manufactured sand is 4.264.so, The M-sand is considered as partial replacement of fine aggregate to substitute and remaining mix ratio as the same with conventional mix are listed below in table 2. The strength criteria of M40 grade concrete mix were analyzed.

Mix specification	Control(Mix A)	A1	A2	A3	A4	A5
Proportion of E-waste	0%	4%	8%	12%	16%	20%
Manufactured sand	0%	20%	40%	60%	80%	100

Table 2: Mix specifications

4.2. Tests

Compressive strength test was conducted to evaluate the strength development of concrete containing various E-waste and M-sand contents at the age of 7, 14, 28 days respectively. Cylindrical and beam specimens were also cast for finding the split tensile strength and flexural strength of specimens on 7, 14, 28 days for each mix specification following the standard test procedures.

Mix specification	Control mix	A1	A2	A3	A4	A5
Proportion of E-waste + M Sand	0%	4%+20%	8%+40%	12%+60%	16%+80%	20%+100%
7 Days	18.5	18.6	21.0	12.0	12.2	12.3
14 Days	24.37	25.26	27.97	19.35	20.03	20.71
28 Days	39.89	37.54	39.89	38.34	38.76	39.05

Table 3: Compressive strength test results in N/mm^2

Mix specification	Control mix	A1	A2	A3	A4	A5
Proportion of E-waste + M Sand	0%	4+20%	8+40%	12+6%	16+80%	20+100%
7 Days	1.84	1.67	1.73	1.24	0.76	1.08
14 Days	1.92	1.84	1.89	1.51	1.03	1.33
28 Days	2.26	1.99	2.18	1.78	1.35	1.57

Table 4: Tensile strength test results in N/mm^2

5.Experimental Details for fiber optic sensor

A set of three reinforced concrete beams of section 1000mm 200mm 150mm and reinforced with 4 numbers of 12mm diameter rod @ top and bottom and 8mm diameter rod @ 75mm c/c distributors were casted. Prior to pouring in concrete in to form fiber optic sensor was pasted at mid span on of the bottom reinforcing bars. Concrete control cubes were tested in replacement materials and also casted to measure the concrete strength. Beams and cubes were casted in M40 mix and the beam was reinforced with Fe415 grade steel. The w/c ratio was adopted as 0.48.

5.1 Circuits Used

Circuit used in the study basically comprises of transmitter unit and receiving unit. The transmitter unit consists of a light emitting diode while the receiving unit consists of a photo-diode. The various disturbances, which may be present in the supply, are suppressed in this circuit. The final output voltage is monitored on an oscilloscope.

5.2 Optical Fiber Used

In the present experimental study multimode step index plastic fiber of 1mm diameter has been used. Although glass fibers are more precise than plastic fibers for receiving and transmitting light signal, but these are highly brittle and cannot be imbedded inside the concrete.

5.3 Sensing Technique Employed

The sensing technique in this study is simply to cleave the end of optical fiber and placing them into a capillary tube. A very small air-gap is provided between the two cleaved ends of the optical fiber in the capillary tube. Due to extended disturbance the air-gap in the tube is either shortened or widened resulting in corresponding gain or loss of light intensity passing through the optical fiber. The fiber optic sensing devices comprises of a light source for injecting a signal into the sensor fiber, a light detector for receiving the signal after the light has been modulated by the optical fiber sensor and an electronic system for processing the detected light into useful electrical quantity.

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7. Results and Discussions

Concrete mixes revealed an increase of up to 39.89 N/mm2 in compressive strength, 2.30 N/mm2 in split tensile strength and 9.25 N/mm2 in flexural strength as a result of replacement of E-waste and manufactured sand up to 8 % and 40 % as seen in Table 1,2,3 and Fig. 1,2,3 respectively. Load verses deflection curves for test beam 1, beam 2 and beam 3 respectively (Fig 4). Load verses attenuation (change in intensity of light) curves for test beam 1, beam 2 and beam 3 respectively (Fig 5). Deflection verses attenuation curves for test beam 1, beam 2 and beam 3 respectively (Fig 6). The attenuations were measured on optical fiber sensors provided in the test beams at the level of steel at mid span while the deflection was measured by dial gauge at mid span. As seen in Fig 4, load vs. deflection relation is always linear up to a load of 30 KN and the rate of change of deflection is small whereas beyond this value of the load, the deflection increases post cracking range. The same pattern is observed in the load vs. attenuation curve (Fig 5). Initially the variation is almost linear up to a load of 30 KN after which intensity losses are higher for the same increment of load. During the experiment found that at a load of about 35 KN cracks appear on the beam surface but formation (invisible) in the beam. The characteristics of optical fiber sensor can be used as a crack detection tool.before that there is a considerable loss in the intensity of light, which may be due to crack.

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