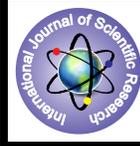


Experimental Investigation on Steel Fibre Reinforced Concrete Slab With Partial Replacement of Coarse Aggregate



Engineering

KEYWORDS : one way slab, Fibre Reinforced Concrete, RCA, Steel Fibre

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ABSTRACT

Concrete is a composite material consisting of mortar and coarse aggregate. An existing problem of RC slab is formation of cracks. In this study steel fibres are added in concrete to control the crack formation and development in RC slabs. 1% of steel fibre is added in concrete, which is the efficient percentage of addition in reinforced concrete. In addition to that to overcome the scarcity of conventional coarse aggregate now-a-days usage of Re-Cycled Aggregate is highly recommended. A conventional method is proposed by using Re-Cycled Aggregate (RCA) as partial replacement of coarse aggregate to its weight with addition of 1% of steel fibre to the volume of concrete in specimen. One-way slab of size 1350 x 500 x 100 mm is casted and tested, which is designed according to Indian standard codes. The flexural properties of the slabs are compared between control specimen and 0%, 20% and 40% partially replaced re-cycled aggregate specimens.

INTRODUCTION:

Concrete is known as a brittle material with low bearing capacity for deformation under tensile stress. The development of these tensile stresses are mechanical loading, harmful reactions and environmental loading. Cracks which affect the structural performance of the concrete are caused mainly due to this stress. In order to control the formation of and development of these cracking fibre are introduced in concrete.

Use of steel fibre concrete has steadily increased during the past years. Considerable developments have taken place in the field of steel fibre reinforced concrete. The current field of application of steel fibre reinforced concrete in highway and airfield pavement, bridge decks, hydraulic structures, tunnel linings etc. There are many research works done on adding steel fibre in concrete to increase the structural properties of the concrete.

It is proved that addition of steel fibres in concrete increases many of the engineering properties in mortar and concrete. Flexural strength, fatigue strength, tensile strength and the ability to resist cracking and spalling are also enhanced.

The most suitable volume fraction values for concrete mixes are 0.5% to 2.5% by volume of concrete. The most optimum percentage of mix to be added in concrete is 1% as addition more amount of steel fibre increases the efficiency but the workability of concrete is reduced.

Over 1 billion tonnes of construction and demolition waste (C&DW) is generated every year worldwide. The large-scale depletion of natural aggregate and the increased amounts of C&DW going to landfill sites are causing significant damage to the environment and developing serious problems, denting the public and the environmentalist's aspirations for a waste-free society. The use of the Re-Cycled Aggregates created from processing construction and demolition waste in new construction has become more important over the last two decades. There are many factors contributing to this, from the availability of new material and the damage caused by the quarrying of natural aggregate to the increased disposal costs of waste materials.

Recently, these aggregates started to be used for intermediate utility applications, such as foundations for buildings and roads. The advantages of recycling construction and demolition waste are it reduces the amount of construction and demolition waste entering landfill sites; and it reduces the use of natural resources in construction, contributes to the environment, provides a renewable source of construction material, and, if used in situ, reduces haulage costs. For economical and environmental reasons and because of the increased amount of Re-Cycled Aggregates, there has been a growing global interest in maximizing the use of Re-Cycled Aggregates in construction. In view of the increased volumes of construction, demolition waste, and industrial by-products such as fly ash (FA) and the advantages offered by the use of admixtures in modern concrete, it is considered very beneficial from different prospects with similar performance characteristics to natural aggregate concrete. When proved successful, recycled aggregate concrete (RCA) can be substituted for natural aggregate concrete in many concrete applications. In this study an attempt is made to experiment the flexural behaviour of the steel reinforced concrete slabs with a replacement in aggregate with Re-Cycled aggregates.

2. EXPERIMENTAL PROGRAM:

2.1 MATERIALS USED:

2.1.1 CEMENT

Cement is a powdered material that serves as a binder in mortar or concrete after reactions of lime or lime compounds have taken place with appropriate medium-usually water. Portland cement is one of such materials, composed largely of calcium and aluminum silicates, in which the former upon reaction with water produces the new compound capable of imparting stone like quality to the mixture. While the specific gravity of Portland cement ranges from 3.12 to 3.16, its unit weight varies with the degree of compaction. The chemical, physical and mechanical properties of cement are attributed to the basic constitutive compounds, the fineness to which the cement is ground and the ambient condition during the hardening process. In cement chemistry, it is customary to report the results of the chemical analysis in terms of the oxides of the elements present, although such compounds do not occur as oxides, nor do the oxides form the unit cell of the crystal-

line structure of the major cement compound. The basic constitutive elements are lime (CaO), silica (SiO₂), alumina (Al₂O₃), iron (Fe₂O₃ or FeO), gypsum (CaSO₄·2H₂O), magnesia (MgO), and alkalis (Na₂O) and K₂O). The characteristic compounds in Portland cement are shown below. The relative composition of the chemical compounds in Portland cement results in different types of cement such as normal Portland cement, high-early-strength cement, sulfate resisting cement etc, which could be meant for different purposes

2.1.2 AGGREGATES

Aggregate is one component of FRC, which is connected into a cohesive whole by means of binding materials-the cement paste. Aggregates are usually inert materials or artificially manufactured from industrial products, which are added to cement paste in order to improve strength, durability and structural performance of concrete. Those aggregates from natural sources are conventionally adopted as concrete materials, and those from artificial ones are either light in weight or high density, developed for specific structural applications and also for solving part of the problems related to the shortage of naturally occurring aggregates. Aggregates can be explained with respect to petrological (rock type), mineralogical, and geological examinations, of which the later two basis are of great helpful in recognizing properties and qualities of aggregates for our purpose.

2.1.3 FINE AGGREGATE

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The most common of sand is Silicon di- Oxide, usually in the form of Quartz. Normally river sand is used as fine aggregate for preparing concrete. An Individual particle in this range is termed as sand grain. These sand Grains are between Gravel (2 mm – 64mm) and silt (0.004mm – 0.0625mm). Aggregate most of which passes 4.75mm IS sieve is used. Locally available river sand Zone III having a specific gravity of 2.62, fineness modulus of 2.75 is used.

2.1.4 COARSE AGGREGATE

Aggregates are the most mined material in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Gravel of Size 20mm is sieved and used. Crushed granite coarse aggregate of maximum size 20 mm and having a specific gravity of 2.387, fineness modulus of 6.64 is used.

2.1.5 WATER

In the production of concrete, water is used for mixing, washing of aggregate and curing of the final concrete product. Mixing water should contain no substances that can have an appreciably harmful effect on the process of hydration or upon the durability of concrete during its service period. Water having appreciable amounts of impurities-silt, oil, acids, alkalis, salts of alkalis, organic matter and sewage may have an injurious effect upon concrete. The reduction in strength of concrete through the use of water suspected of undesirable substances could be as high as 10% [29]. The effect of same amount of impurities in water for washing aggregate is much greater than that of mixing water. Such water if used for washing aggregate causes deleterious coatings (silts, salts or organic materials) on the surface of aggregate particles. Water containing sufficient amount of acidic or organic substances should be regarded with suspicion to be used for curing of concrete.

2.1.6 STEEL FIBRE

Steel fibre is one of the most commonly used fibre. Gener-

ally round fibres are used. The diameter may vary from 0.25 to 0.75mm. The steel fibre sometimes gets rusted and lose its strength. But investigations have proved that fibres get rusted only at surfaces. It has high modulus of elasticity. Use of steel fibres makes significant improvements in flexure, impact and fatigue strength of Concrete. It has been used in various types of structures.

Table 1. Properties of steel fibre

PARAMETERS	VALUES
Length (mm)	50
Diameter (mm)	1
Density (Kg/mm ³)	7680
Modulus of elasticity (GPa)	200
Tensile strength (MPa)	1100

2.1.7 RE-CYCLED AGGREGATES:

The re-cycled aggregates (RCA) used in this work is collected from the nearby site. It was collected from an old office building of an oil mill. The collected debris is sieved by using 12.5 mm sieve and complete mortar is removed from the RCA. Then the collected aggregates are grinded for removal of mortar. The aggregates are again sieved in 20 mm and 12.5 mm sieve. Then the aggregates are soaked in water for 24 hours before concreting. Then the dried aggregates are used in concrete.

2.2 MIX DESIGN:

M25 grade concrete was used for the study. The ratio attained from the mix design is 1:1.67:2.41. The mix design was obtained according to the IS code method. The water cement ratio is taken as 0.5. The quantity arrived for per cubic meter of concrete is given below

Table 2 mix ratio

MATERIALS	CEMENT	FINE AGGREGATE	COARSE AGGREGATE	WATER
WEIGHT	437.78 Kg/m ³	730.23 Kg/m ³	1056.56 Kg/m ³	197
RATIO	1	1.67	2.41	0.45

2.3 EXPERIMENTAL SETUP:

A total of three one way slabs are casted and tested upto failure. The slabs were 1350mm long X 500mm wide X 100mm deep. These dimension were chosen according to the study repairing reinforced concrete slabs using composite layers done by M.Ghasemi. The supports were placed 75mm for each end of the slab. Four point bending is given to the slabs. The slabs are tested under the 100 ton capacity loading frame. LVDT is provided in mid-span to identify the displacement in the mid-span and also dial gauge is provided in the loading points. The electrical strain gauge is placed on the mid-span of the compression zone in the slab, to find the strain at compression zone. The slabs were designed according to is codal provision providing minimum number of main and distribution bars.

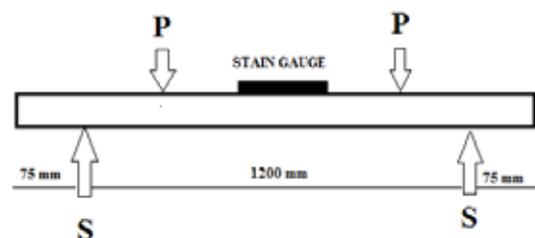


Fig 1 Loading condition of slab



Fig 2 Load setup

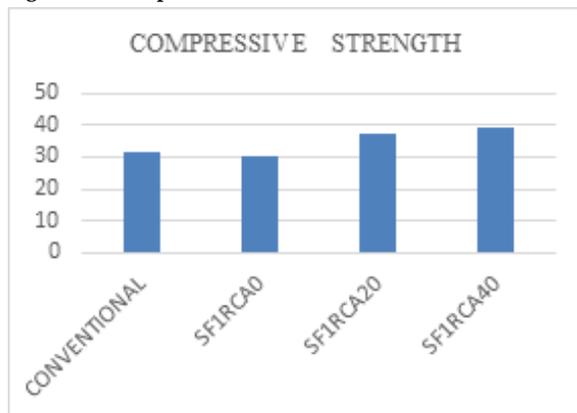


Fig 3 compressive strength of specimen

4. RESULTS

4.1 COMPRESSIVE STRENGTH

The compressive strength of the steel fibre reinforced concrete with replaced RCA showed better results than normal concrete replaced with RCA. The cube size is 150 mm x 150 mm were casted and cured for 28 days. The cubes were tested in Universal Testing Machine (UTM) of 2000kN capacity having a least count of 0.01kN. It was found that increase in replacement of RCA in concrete increases the compressive strength of the concrete the compressive strength of normal concrete with 1% steel fibre and replaced RCA are shown below.

SPECIMEN	COMPRESSION STRENGTH (KN)	AVERAGE (KN)
CONVENTIONAL CONCRETE	32.6	31.2
	30.5	
	30.78	
SF0RAC0	36	35.83
	36.2	
	35.3	
SF1RCA20	38.7	37.56
	36.5	
	37.56	
SF1RCA40	39.24	39.06
	38.44	
	39.5	

Table 3 compressive test of specimen

4.2 LOAD-DEFLECTION:

The deflection distance of a member under a load is directly related to the slope of the deflected shape of the member under that load and can be calculated by integrating the function that mathematically describes the slope of the member under that load. In

testing a gradual increase of 1kN is provided for the slab and the corresponding deflections are noted at three points mid span and at the two support conditions. The results are as follows.

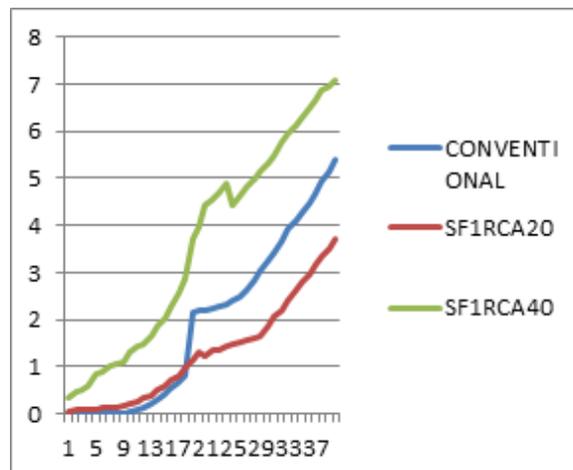


Fig 4 load deflection curve

4.3 BEHAVIOUR OF SLAB:

During the test the crack pattern and crack formation is noted down. According to literature review done it was found that addition of steel fibre increases the crack formation in the members and addition of RCA will reduce the strength of the member. But when both are added in the concrete certain behaviour is found out. The ultimate load of conventional concrete with 1% added steel fibre was found to be 40kN. Whereas the ultimate load of SF1RCA20 and SF1RCA40 was found to be 52kN and 38kN respectively. Hence through the ultimate load we are able to know that the bearing capacity of members containing steel fibre and RCA increases upto 20% of replacement of RCA and decreases in more addition of RCA. The crack formation of slabs were found at 20kN in conventional slab, 18kN in SF1RCA20 and 16kN in SF1RCA40.

4.4 STIFFNESS DUCTILITY:

The stiffness ductility is defined as the ratio between ultimate load and ultimate deformation. Less stiff the material more ductile the material would be. Hence the stiffness ductility of slabs is as follows. The stiffness of conventional slab is 7.43kN/mm, the stiffness values of SF1RCA20 and SF1RCA40 are 9.932kN/mm and 5.65kN/mm. It is found that as the percentage of RCA is increased in concrete the stiffness is reduced.

4.5 DEFLECTION DUCTILITY:

The deflection ductility is defined as the ratio between ultimate deflection by yield deflection. The deflection ductility shows the ability of a member to withstand the load. Increase in deflection ductility increases the strength of the member. The deflection ductility of the specimens are

Table 4 deflection ductility of slabs

SPECIMEN	DEFLECTION DUCTILITY
CONTROL	9.78
SF1RCA20	2.46
SF1RCA40	3.078

5. CONCLUSION:

From all the above test done the following conclusions are arrived. Introducing steel fibres in concrete increases the flexural properties of the one-way slabs. And also partial replacement of RCA also increases the properties of the slab. But increase of RCA more 20% in concrete decreases the strength of concrete.

The crack formation of slabs are controlled and reduced in SF1RCA20 type slabs.

The stiffness ductility and deflection ductility are optimum in SF20RCA20 slabs compared to other slabs

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