Available online at www.elixirpublishers.com (Elixir International Journal)

Cement and Concrete Composites

Elixir Cement & Con. Com. 68A (2014) 22518-22520

ISSN: 2229-712X

Flexural behavior of one way slab made using steel fibre reinforced fly ash concrete with silica fume and M sand

Jerlin.G, Sakthieswaran.N and Gopinath.R

Department of Civil Engineering, Regional centre of Anna University, Tirunelveli-627007, Tamilnadu, India.

ARTICLE INFO

Article history:
Received: 20 September 2013;
Received in revised form:
22 February 2014;
Accepted: 14 March 2014;

Keywords
Concrete,
One way slab,
Fly ash,
Silica fume,
M sand,
Steel fibre.

ABSTRACT

This paper deals on flexural strength of RCC one way slabs using fly ash, silica fume and M-sand and steel fibre. One conventional reinforced concrete one way slab and Nine steel fibre reinforced concrete one way slabs with fly ash; silica fume and M sand are casted by changing the reinforcement ratio and thickness. The slabs are size of 1.2m x 0.4m. The slabs were tested under three point loading. The ultimate load carrying capacities of slabs are found out. The results shows that load carrying capacity of slabs are increased with increase of reinforcement percentage and thickness.

Introduction

Self weight of slab is based on the materials properties. Considerable research is still to be done in the field of building materials to reduce building costs further and improved structural performance. Many researchers were interested in studying the use of SFRC in slab applications. (Meda et al., 2004) various fibre-reinforcing materials are available nowadays, but structural applications of fibre-reinforced concrete are mainly made of steel fibre. (Khaloo et al., 2005) studied the flexural behavior of small SFRC slabs by considering the influence of length and volumetric percentage of steel fibers on energy absorption. They concluded that addition of fibers did not significantly increase the ultimate flexural strength of SFRC slabs, but it improves the energy absorption capacity of the slabs. Recently, (Sorelli et al 2006) studied the structural behavior of the SFRC slabs on ground under a concentrated load.

They concluded that a relatively low content of steel fibers effectively enhances the load-carrying capacity of the slabs on ground and that a volume fraction of steel fibers higher than 0.38% slightly improves the ultimate load but remarkably enhance the slab ductility. (Hariharan et al., 2011) attempted a project study of high strength concrete containing fly ash (FA) and silica fume (SF). The compressive strength was determined at various ages up to 90 days. Result indicates addition of SF shows an early strength gaining property and that of fly ash shows long term strength.

The addition of 6% SF to different FA combination replacements has a high compressive strength than 10% SF.(Atis et al., 2007) have studied that concrete containing fly ash and steel fibre. Steel fibre improves the tensile strength, drying shrinkage, freeze – thaw resistance and reduce the workability. The addition of fly ash increase workability reduces unit weight of concrete. In addition off 1% of volume fraction o fibre increases in compressive strength 15%, tensile strength 30%. (Jadhav et al., 2012) have studied the effect of M sand in M 20 grade concrete. The compressive, split tensile, flexural strength of concrete with 60% replacement of natural sand reveals higher strength as compared to reference mix. (Shanmugapriya et al., 2012) studied that this paper present the optimization of partial replacement of manufactured sand by natural sand with silica fume in High Performance Concrete.

The percentage of increase in the compressive strength is 18.88% and the flexure strength is 13.2% at the age of 28 days by replacing 50% of natural sand with M Sand and 5% of cement by silica fume. (Parameswaran V S et al.,) monitored the performance of RC slabs statically loaded to failure and evaluated the deterioration of flexural rigidity of the specimen subjected to cyclic loading. When tested under static loads it was observed that, all specimens showed large cracks openings at the onset of failures.

The cracks initiated at the soffit and propagated vertically upwards. R. (Sivagamasundari et al., 2008) have studied the flexural behavior of one-way slabs reinforced with Glass Fibre Reinforced Polymer reinforcements under monotonic loading and two different schemes of repeated loading. Based on result increasing the thickness, grade of concrete, reinforcement ratio of the slabs, the ultimate load carrying capacities of GFRP reinforced slabs were increased and the corresponding strains in terms of deflection and crack width were reduced.

Scope and objectives

Conventional concrete and M50 grade of concrete from cement replaced by 30% of fly ash and 7% of silica fume, sand is replaced by 50% of manufactured sand, addition of 0.5% volume fraction of steel fibre have been considered for casting concrete cubes and one way slabs. Also 6 concrete cubes and 10 reinforced concrete one way slabs have been considered for M50 grade of concrete.

The objective of this project is to investigate the performance of silica fume and manufactured sand added steel fibre reinforced fly ash concrete one way slabs and its load carrying capacity, deflection and compare with corresponding conventional concrete one way slab.

Tele:
E-mail addresses: cjrcautvl@gmail.com

Materials

Cement

Ordinary Portland cement of 53 grades available in local market is used in the investigation. The specific gravity of cement was 3.15.

Fly Ash

Fly ash from Tuticorin Thermal Power Station, Tamil Nadu was used as cement replacement material. Fly Ash for used as Pozzolana and Admixture. The specific gravity was 2.20.

Silica Fume

The silica fume was partially replaced for cement. conforming to ASTM C1240. It is available in dry densified form. The density and specific gravity was found to be 640 kg/m^3 and 2.2 respectively.

Fine Aggregate

River Sand

Locally available River sand having bulk density 1860 kg/m^3 was used and the specific gravity is 2.55. The Fineness modulus of river sand is 2.925.

Manufactured Sand

M Sand was used as partial replacement of fine aggregate. It was collected from Bharath Crusher, Tirunelveli, India. The bulk density of manufactured sand was 1860 kg/m^3, specific gravity and fineness modulus was found to be 2.55 and 3.15 respectively.

Coarse Aggregate

Crushed angular granite metal of 12.5mm to 20 mm size from a local source was used as coarse aggregate. The specific gravity of 2.68 and fineness modulus 7.29 was used.

Super Plasticizer

In order to improve the workability of high-performance concrete, superplasticizer in the form of Sulphonated Napthalene Polymers complies with IS 9103:1999 and ASTM C 494 type F as a high range water reducing admixture (CONPLAST SP 430) was used. This had 40% active solids in solution. The specific gravity is 1.22.It is a brown liquid instantly dispensable in water.

Water

Fresh portable water, which is free from acid and organic substance, was used for mixing the concrete.

Steel Fibre

The fibre used in this study was corrugated steel fibre. The properties of these fibres are listed in table given below.

Table 1: Steel Fibre Properties

Average fibre length (mm)	Diameter (mm)	Aspect ratio	Tensile strength (MPa)	Specific Gravity
50	1	50	1100	7.85

Steel

TMT (Thermo Mechanically Treated) Steel bars of size 12mm, 10mm, 8mm have been used as main reinforcement and 8mm diameter bars used as a secondary reinforcement. The characteristic yield strength of steel bar is 415MPa.

Mix proportion and Mix details

IS method was adopted as the guidance for designing the concrete mixes to have a target characteristic strength of 50 N/mm^2 at 28 days. The conventional concrete mix proportion consists of cement: sand: aggregate ratio is 1:1.356:2.767 with the water cement ratio 0.32 and addition of 1% super plasticizer. Another concrete mixture contains cement replaced by 30% fly ash and 7% silica fume, sand replaced by 50% of M sand and addition 0.5% of steel fibre in volume fraction.

Experimental Program

Material Properties of slab

Ten one way reinforced concrete slabs casted with M50 grade of concrete but two different concrete mixtures were prepared. One slab consists of conventional concrete and other nine slabs consist of non conventional concrete. Control cubes measuring 150 mm x150 mm x150 mm were also tested to obtain the compressive strength of concrete. The properties of the concrete at 28 days and reinforced concrete slabs are presented in Table 3. During loading the slabs were simply supported at their ends. A dial gauge was arranged to measure the central deflection of the slabs. Two point loads were applied at the third point of the slab by means of a hydraulic Table 3: Details of one way slabs Fig.1. The test applied load increments of 5 kN.

Slab No	Length mm	Width mm	Depth mm	Span/eff. depth	Steel reinforcement: Longitudinal Reinforcement: Area of steel (mm^2)	Longitudinal Reinforcement: Area of steel (%)	Transverse Reinforcement: Area of steel (mm^2)	Transverse Reinforcement: Area of steel (%)	Tensile: Total steel area (%)	Tensile: Strength (N/mm^2)	Concrete: Compressive strength (N/mm^2)
S0	1200	400	100	14.19	339.29	1.15	301.59	1.08	2.23	415	58.1
S1	1200	400	100	14.19	339.29	1.15	301.59	1.08	2.23	415	54.3
S2	1200	400	100	14	235.62	0.79	301.59	1.06	1.85	415	54.3
S3	1200	400	100	13.82	150.8	0.5	301.59	1.05	1.55	415	54.3
S4	1200	400	80	19.44	339.29	1.57	301.59	1.51	3.08	415	54.3
S5	1200	400	80	19.09	235.62	1.071	301.59	1.48	2.551	415	54.3
S6	1200	400	80	18.75	150.8	0.673	301.59	1.45	2.123	415	54.3
S7	1200	400	60	30.88	339.29	2.5	301.59	2.51	5.01	415	54.3
S8	1200	400	60	30	235.62	1.68	301.59	2.43	4.11	415	54.3
S9	1200	400	60	29.17	150.8	1.05	301.59	2.36	3.41	415	54.3

Table 2 Details of one way slabs

Fig 1. Experimental setup

Load deflection curves

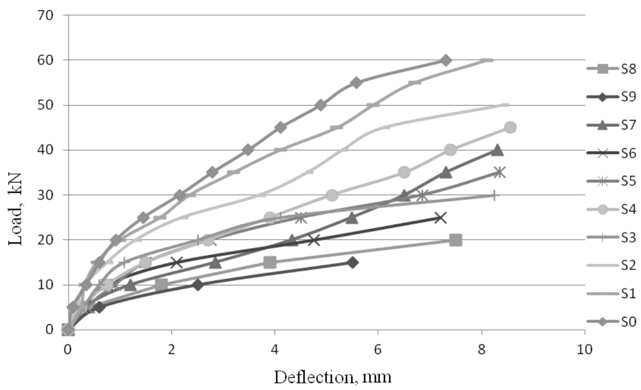

Fig.2 Load deflection curves of slabs

The load deflection curves of the slabs plotted from the test results are shown in Fig.2. Fig. 2 shows the curves for slabs were all subjected to monolithic loading to failure. Initial loading of the slabs showed approximately linear elastic characteristics until the cracking load was exceeded and the first crack developed at the bottom of the slab within the middle third where maximum bending occurred. After cracking, then gradient of the initial load–deflection curve reduced and continued to reduce gradually until the steel yielded. The post yield behavior of the steel reinforced slab then resulted in a third region of greatly reduced gradient within which strain hardening occurred such that a slight increase in load resulted in a large increase in deflection until failure occurred. The load deflection curves for the slabs subjected to monotonic loading showed different strength and ductility characteristics. Slab S0 which failed by the highest experimental failure load was the least ductile of all the slabs subjected to monotonic loading. This is because slab S7 which contained the highest main reinforcement (2.5%) was over reinforced and therefore failed in the most brittle mode of concrete crushing and shear bond splitting. Slab S3 which contained one of the minimum main reinforcement (0.5%) exhibited the most ductile behavior at failure.

Cracking loads and failure load

The cracking loads, the experimental failure loads and the theoretical failure loads of the slabs are given in table 4.

Table 4. Cracking and Failure Loads

Slab No	First Crack Load kN	Experimental Failure Load kN	Theoretical Failure Load kN	Mode of Failure
S0	18.86	62.78	46.86	Steel yielding
S1	18.86	62.3	46.86	Steel yielding
S2	18.86	48.07	34.06	Steel yielding
S3	18.86	33.35	22.69	Steel yielding
S4	12.11	45.03	32.8	Steel yielding
S5	12.11	33.59	24.34	Steel yielding
S6	12.11	23.21	16.46	Steel yielding
S7	6.86	39.24	25.77	Crushing of concrete
S8	6.86	27.87	19.49	Steel yielding
S9	6.86	19.83	13.31	Steel yielding

Discussion of Test Results

For a simply supported one-way slab subjected to equal line loads at the third points, the middle third of the span is subjected to pure bending (such that it is under zero shear and maximum bending moment); whilst the remaining sections experience maximum shear force and varying bending moment. The middle third experiences the largest strains and therefore the concrete beneath undergoes cracking first. The main reinforcement varied from 0.5% to 2.5% of the gross concrete section. According to theoretical evaluation almost all the slabs were under-reinforced with the exception of S7. Therefore the failure of the 9 under-reinforced slabs was expected to be governed by yielding of the tension reinforcement whilst the other one S7 was to fail by concrete crushing. However, many of the slabs failed by combined modes of flexural tension and flexural shear. The load carrying capacity of S0, S1 are same but cracks are more and deflection was less in control concrete slab. The load carrying capacity of slab changes based on the thickness and percentage of steel reinforcement.

Conclusion

A series of laboratory tests were performed on 10 one way simply supported steel reinforced concrete slabs. The load carrying capacity of conventional concrete slab (S0) and non conventional concrete slab (S1) are nearly same. So that addition of different materials like fly ash, silica fume, M sand, steel fibre does not affect the strength of concrete slabs. Additions of steel fibre decrease the hair line cracks and increase the energy absorption capacity of slabs. M sand is replacement of river sand but it does not affect the strength of concrete, it decreases the usage of river sand. Silica fume fills the voids in the concrete; it leads to increase the strength of concrete. Addition of fly ash increase the workability, reduce the usage of cement and it gives the long term strength to concrete. So that addition of these materials does not affect the ultimate load carrying one way slabs. The ultimate load carrying capacity of slab increases with increasing percentage of steel reinforcement and thickness of slab. Based on this study, it is found that a good agreement exists between the theoretical and experimental results.

References

1. Meda, A., and Pizzari, G., 2004. “New design approach for steel fibre-reinforced concrete Slabs-on-ground based on fracture mechanics”, ACI Structural Journal, 101 (3), pp. 298-303.

2. Khaloo, A. R. and Afshari, M., 2005,“Flexural Behavior of Small Steel fibre Reinforced Concrete Slabs,” Cement and Concrete Composites,Vol.27,No.1, pp. 141~149.

3. Sorelli, G., Meda, A., and Plizzarri, G. A., 2006. “Steel Fiber Concrete Slabs on Ground:A Structural Matter,” ACI Structural Journal, Vol. 103, No. 4, pp. 551~558.

4. A R Hariharan, A S Santhi and G Mohan Ganesh., 2011. “Study on strength development of high strength concrete containing fly ash and silica fume” An international journals of engineering science and technology.

5. Cengiz Duran Atis. Okan Karahan., 2007. ”Properties of Steel fibre reinforced fly ash concrete”, Construction and building Materials.

6. Priyanka A.Jadhav and Dilip K.Kulkarni, 2012. “An experimental Investigation on the properties of concrete containing M sand,”International Journal of Advanced Engineering Technology,P101-104.

7. T.Shanmugapriya,R.M Uma, 2012.“Optimization of partial replacement of m-sand by natural sand in high performance concrete with silica fume” International Journal of Engineering Sciences &Emerging Technologies, P73-80.

8. Parameswaran, V.S. “Introduction to Theory, Properties, And Application of Fibre Reinforced Concrete“, Notes for private circulation.

9. R.Sivagamasundari, G.Kumaran, 2008. “A comparative Study on the Flexural Behaviour One Way concrete slabs Reinforced with GFRP Reinforcements and Conventional Reinforcement when Subjected to Monotonic And Repeated Loading”, The open Civil Engineering Journals, vol 2, P24 – 34.

10. B.W. Langan, K.Weng and M.A. Ward., 2002. “Effect of silica fume and fly ash on heat of hydration of Portland cement”,cement and concrete research.

11. K.Holschemacher, T.Mueller and Y.Ribakov., 2009. ”Effect of steel fibre on mechanical properties of high strength concrete”., Materials and Design, Vol.31

12. Gilbert, 1985. “Deflection control of slab by allowable Span to depth ratio”, ACI journal, ,P 67-72.

13. Abbasy, 2003. “Minimum Thickness of one way solid slab “, Journal of engineering and applied science, p483-499.

14. Sami, 1998. “Flexural behavior of one way slabs reinforced by Fiber Reinforced Plastic Reinforcements”ACI Structural Journal, P353-365.

15. Xing Ma, 2006. “Experimental study on concrete slabs reinforced by specially shaped high-strength steel bars”, NZSEE Conference, P51-57.

16. Fatih Altun, 2008. “Combined effect of silica fume and steel fiber on the mechanical properties of high strength concretes”, Construction and Building Materials, P 1874–1880.

17. Shetty, M.S. “Concrete Technology”, Reprint (2003) S.Chand & Co., New Delhi.