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Shear Behavior of Reactive Powder Concrete Beams Improvement with Steel Fibers

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Abstract: Extensive research is going on now a days on the structural performance with steel fibers along silica fume as an extension of the recent advances in concrete technology. This research presents a study in this direction to investigate the shear behavior as well as determining the cracking and ultimate shear capacities of with steel fibers and silica fume beams. In the this study consist three simply supports beams and an additional with steel fibers along silica fume. Measurements were recorded for the cracking load, the ultimate shear load, midspan deflection, maximum crack width, concrete strains at important locations and pattern of failure. The variables considered in this experimental program was the steel fibers Volumetric ratio V_f. It was establish that the rise of steel fibers (V_f) from (1-2%) improved the diagonal cracking load (Pcr) from 22-63% and growing ultimate shear load (Pu) from 51.21-180.46% correspondingly as associated to nonfibrous beams.

Key words: Reactive powder, steel fibers, cracking and load-deflection, measurements, maximum crack width, experimental

INTRODUCTION

Reactive Powder Concrete (RPC) is a exhibitions great performance properties such as bounded shrinkage and creep, low permeability, ultra-high strength and improved protection from corrosion. The properties of RPC make it a revolutionary material in the field of concrete technology with possibilities for use in a wide range of structural and non-structural applications (Bonneau *et al*., 1996). The improvement of RPC has the potential to revolutionize intention in precast. Aamer (2014) investigated the experimental effects on the loading and deformation performance of typical strength and reactive powder concrete. Two kinds of beams were considered regular and reactive the investigational exertion complicated (8) beams. Iqbal *et al*. (2015) conducted of adding of steel fibers to concrete, the properties are improved from hard to yielding.. Balaji and Thirugnanam (2018) examined the flexural performance of beams with slurry penetrated fibrous concrete at many positions in the beam.

MATERIALS AND METHODS

Experimental program: The purpose of the experimental tests carried out in this research is to examine the structural performance and shear capacity of beams improvements with steel fibers along silica fume having various geometrical and material variables. The material properties studied included compressive strength, flexural tensile strength, splitting tensile strength, compressive stress-strain characteristics and modulus of elasticity.

Variables and specimen dimensions: RPC beams intended to fail in shear involves of three beams (RPS1, RPS2 and RPS3), RPC beams the control beam (RPS1) was values of steel fibers volume fraction equal to (0%). (RPS2, RPS3) beams values of steel fibers Volume fraction (V_f = 1.0 and 2.0%) all beams were the ratio (a/d) shear span to the effective depth (d) was equivalent to 3 for these slender beams. The experimental program involved casting and testing three beams. All confirmed beams and imperiled to two point loads Fig. 1. Each beam had 1300 mm total length and 1200 mm span between the supports. The total depth of tested beam was 250 mm and tested. The beam information are presented in Fig. 1 and Table 1.

Fibers-Volume fraction (V_f): The consequence of straight steel fibers satisfied on the shear asset of beams, three values of fibers-Volume fraction (V_f = 0, 1.0 and 2.0%) were used in casting the beams.

Mixes: Pervious researches, Hannawayya (2010) several mix quantities were strained in this analysis to catch maximum compressive strength consulting to ASTM (Anonymous, 1999, 2005; ASTM, 2003a-c). Table 2 shown five types of RPC mixes. The mixes were the volume ratio

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Table 1: Details of beam and concrete properties

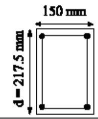
Beams	a (mm)	d (mm)	V_f (%)	SF (%)	a/d	Cross section
RPS1	435	217.5	0	25	2	
RPS2	435	217.5	1	25	2	
RPS3	435	217.5	2	25	2	

Table 2: Types of RPC mixes

Types of mix	Cement (kg/m^3)	Sand (kg/m^3)	Silica fume (*%)	Silica fume (kg/m^3)	w/c	Flocrete PC260 content (**%)	Fiber content (V_f) (%***)	Steel fiber content (kg/m^3)
M0, 25	1000	1000	25	250	0.2	3.0	0	0
M1, 25	1000	1000	25	250	0.2	3.0	1	78
M2, 25	1000	1000	25	250	0.2	3.0	2	156
M2, 15	1000	1000	15	150	0.2	3.0	2	156
M2, 20	1000	1000	20	200	0.2	3.0	2	156

*Proportion of cement weight; **Proportion of (cement+silica fume) weight; ***Proportion of mix volume

Table 3: Properties of hardened RPC

Types of mix	Fiber content (V_f) (%)	Silica fume SF (%)	Compressive strength (f'c) (MPa) ASTM C39-86 (ASTM, 2003a)	Splitting tensile strength (f_t) (MPa) ASTM C496-86 (ASTM, 2003b; BSI, 1881)	Modulus of rupture (f_r) (MPa) ASTM C78-84 (ASTM, 1989)	Modulus of Elasticity (E_c) (GPa) ASTM C469-87a (ASTM, 2003c)
M0, 25	0	25	101	5	5.2	44.87
M1, 25	1	25	127	14.7	15.3	49.88
M2, 25	2	25	148	19.8	21.0	53.92
M2, 20	2	20	139	17.3	19.0	52.90
M2,15	2	15	130	16.4	18.6	51.13

Table 4: The shear strength for (cracking-V_{cr}) and (ultimate-V_u) for test beams

Beams	V_f (%)	SF (%)	a/d	f'_{cf} (MPa)	Shear strength (kN) V_{cr}	Shear strength (kN) V_u	$\frac{V_{u,\ test}}{V_{cr,\ test}}$	Mode of failure
RPS1	0	25	2	98	27.0	46.22	1.81	DT
RPS2	1	25	2	118	33.0	69.89	2.35	DT
RPS3	2	25	2	138	44.0	129.63	3.07	DT

*DT: Diagonal Tension failure

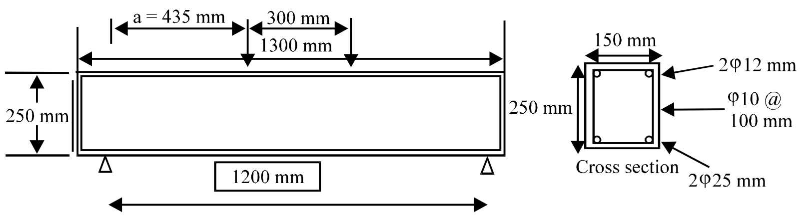


Fig. 1: Details of a typical test beam

of steel fibers V_f (0, 1 and 2%) and the ratio of Silica Fume (SF) (15, 20 and 25%). The mix type M0, 25 was adopted as a reference mix which had no steel fibers and 25% silica fume ratio.

Hardened properties of beams: To calculate the properties of all kinds of concrete cast-off in this effort. Four properties are estimated shown in Table 3 and 4.

RESULTS AND DISCUSSION

This part contains the results of the tests carried out on RPC-beams and to determine their structural performance as well as assessing their shear capacity also includes the results of the tests conducted on the associated control specimens to specify their mechanical properties. For each tested beam, the diagonal cracking load, ultimate shear strength, crack pattern, crack width, mode of failure and load-deflection behavior are all recorded.

Load-crack width relationship: Figure 2-5 are presented the load-crack width figures for all the confirmed RPC beams.

Load-deflection behavior: Figure 6-10 appearance the load-deflection curves for all beams it was observed that

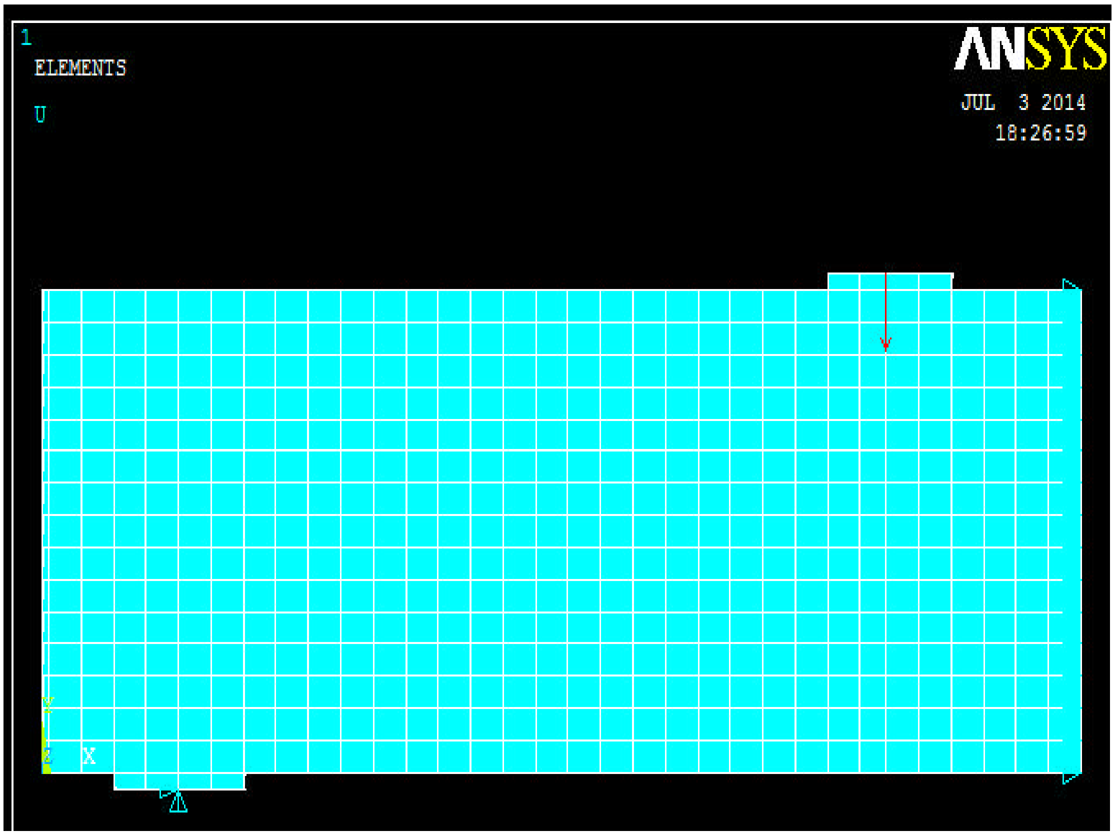


Fig. 2: Typical half symmetry finite element model

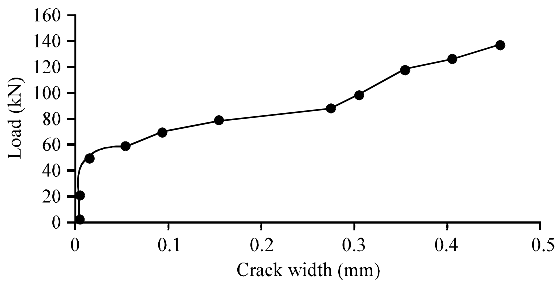


Fig. 3: Beam-RPS1

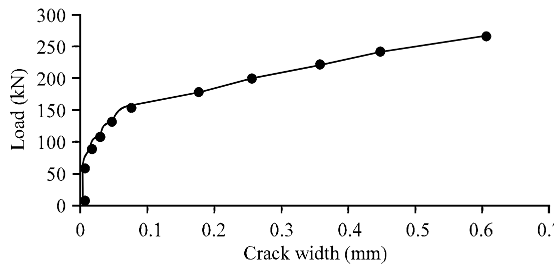


Fig. 5: Beam-RPS3

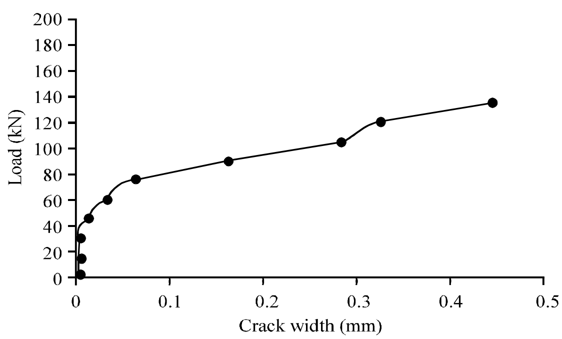


Fig. 4: Beam-RPS2

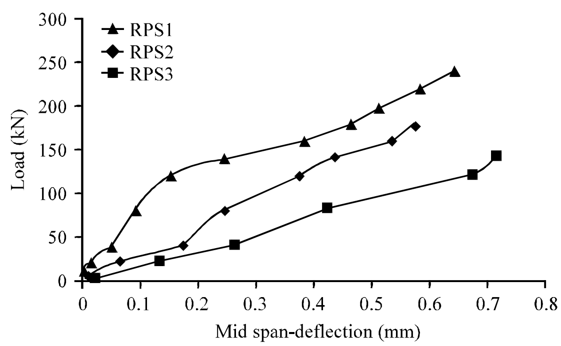


Fig. 6: Load-midspan deflection curves of beams

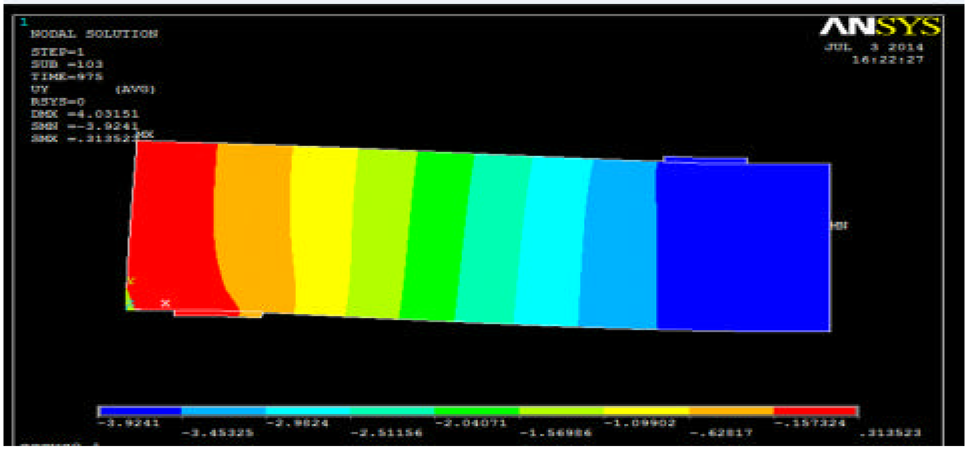


Fig. 7: RSP1 beam (Y-direction)

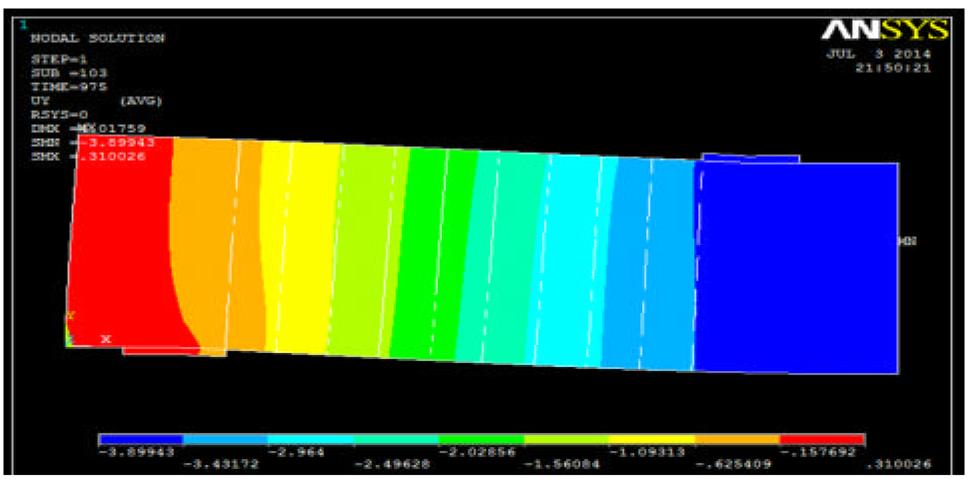


Fig. 8: RSP2 beam (Y-direction)

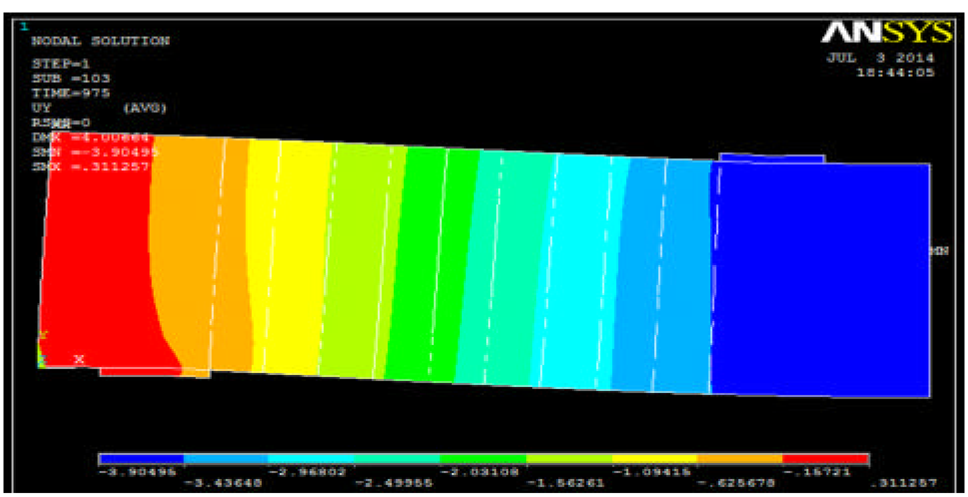


Fig. 9: RSP3 beam (Y-direction)

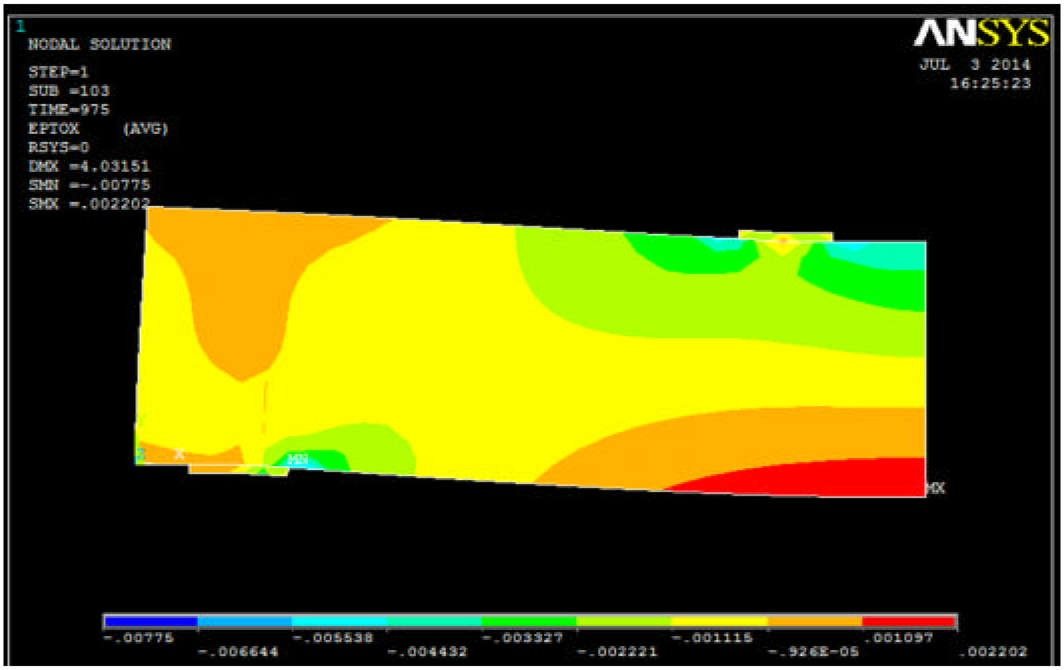


Fig. 10: RSP1 beam (X-direction)

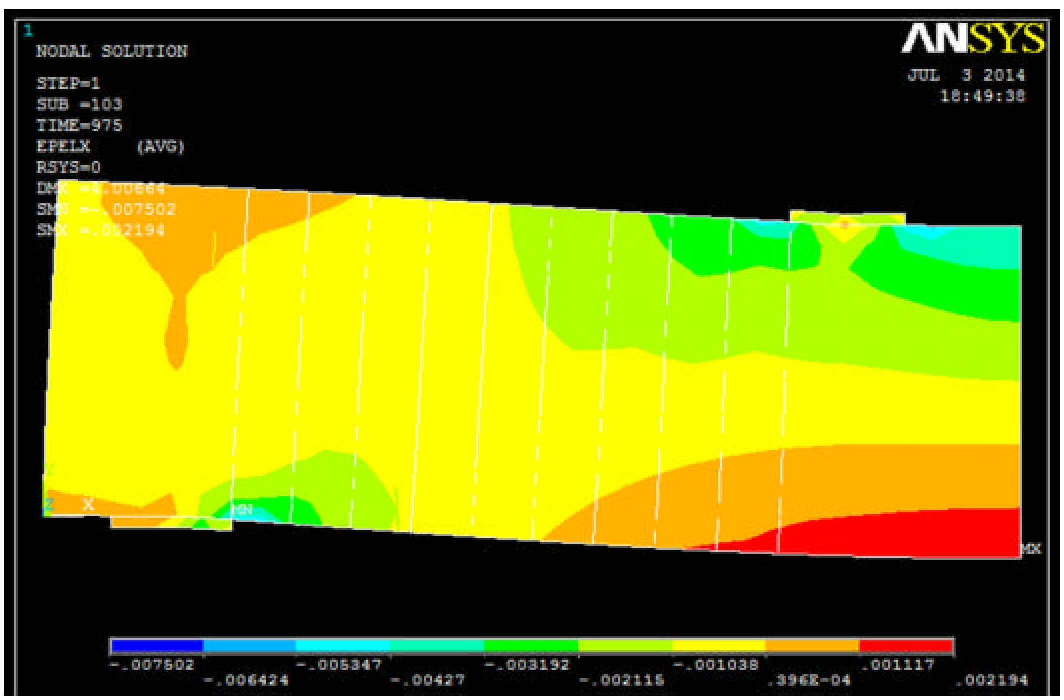


Fig. 11: RSP2 beam (X-direction)

the attendance of steel fibers improved the performance of (RPS2, RPS3) associated with the reference beam by expanding the ultimate strength and reducing the ultimate central deflection. Figure 7-12 expressions the numerical strain distribution of beams.

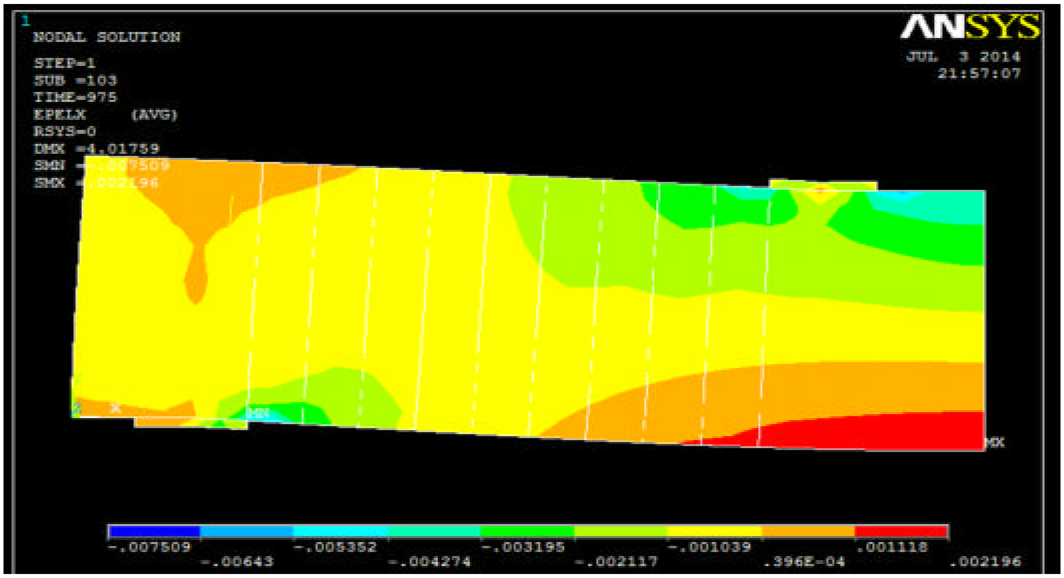


Fig. 12: RSP3 beam (X-direction)

CONCLUSION

From this study, different conclusions are achieved which can be outlined under different headings as follows.

Material properties of RPC: For the mixes used in this research, the highest compressive strength (f'_c) was 138 MPa which was recorded for V_f = 2% and SF = 25%. RPC mixes containing steel fibers of ratio V_f = 1-2%) showed 20.40-40.80% higher compressive strength (f'_c) at 28 days age, than that corresponding to nonfibrous RPC mix. Noting that adding of steel fibers in RPC mixes variations their brittle approach of disappointment when hardened into a extra flexible and develops the concrete ductility. The addition of steel fibers to RPC mixes resulted in a higher improvement of splitting tensile strength than of compressive strength. The splitting tensile strength of RPC cylinders was found to increase by 246% as steel fibers volume ratio increased from 0-2% and increased by 13% as silica fume content increased from 15-25%. In the splitting test, the nonfibrous RPC, failed when their tensile strength was reached. Fiber-RPC cylinders behaved differently they showed higher load resistance even after the formation of cracks with vertical compressive stresses being parallel to any cracks caused the fiber reinforcement bridge the cracks and carry higher load prior to pulling out of the RPC matrix.

Growing steel fibers ratio from 0-2% increases modulus of rupture by 257.69% while growing silica fume contented (15-25%) rises modulus of rupture by lone 12.9%. Conventional steel fibers rise concrete tensile strength by attractive cracks. Conferring to the results, the elastic of the material nonfibrous was 44.87 GPa. The adding of 1.0 and 2.0% volume fraction of steel fibers increased the value of E_{cf} to 49.88 and 53.92 GPa which represents an increase of 11.16 and 20.16%, respectively.

Experimental results of RPC beams: Referring to the experimental results given in the following remarks be able to remain established. The quantity of fibers cast-off in the concrete mixture did not meaningfully distress the cracking load of RPC beams but had a important effect on the rate of crack broadcast and on the value of the failure load. The presence of RPC beams contents steel fibers caused in improved toughness, concentrated width of crack and decreased amount crack circulation. At disappointment, the fibrous RPC beams behaved in a flexible mode as associated with the nonfibrous beam and greatest of the steel fibers were pulled out of the cement conditions.

The addition of steel fibers caused in a important improved ductility. Using steel fibers with V_f =1-2% increased the diagonal cracking and ultimate shear strength by about 22.22-51.21% and 62.96-180.46%, respectively. Increasing the silica fume content SF from 15-20% and 25% in RPC T-beams having V_f = 2% showed a lesser maximum crack width at a specific load level beyond the cracking load. Increasing the silica fume content SF from 15-20 and 25% in RPC beams resulted in a decrease in the value of the mid-span deflection corresponding to ultimate load by 3.12 and 4.57%, respectively.

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