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DESCRIPTION OF COMPRESSIVE STRENGTH OF REACTIVE POWDER CONCRETE

SUKRAM PAL
Research Scholar
Sunrise University
Alwar, Rajasthan

DR. SANJEEV SINGH
Supervisor
Sunrise University
Alwar, Rajasthan

ABSTRACT: Reactive Powder Concrete (RPC) represents a technological leap ahead for the construction industry. Among already built outstanding structures, RPC lies at the forefront in terms of innovation, aesthetics and structural efficiency. Beginning with Richard (1995), many researchers have investigated the various aspects of RPC. However, proper selection of materials, their proportioning and process of production, influence the rheological properties and mechanical performances of Reactive Powder Concrete. For the design of RPC structural components, one of the important requirements is the stress-strain behavioral model. Not much published information is available about the stress-strain characteristics of RPC under compression and tension.

KEYWORDS: Reactive Powder Concrete, materials

INTRODUCTION

Reactive powder concrete is an ultrahigh strength concrete and generally strength is greater than 50 MPA, generally it is sad that concrete strength over 42 MPA is high strength concrete. Basically material is cement based which has an advance mechanical property and it also has an improved physical property due to which it has high durability, it is one of type of ultra-high performance concrete. Generally Reactive Powder Concrete (RPC) is a light weight concrete so the dead load of the structure also reduces while applying RPC on the structure. Generally it is sad that concrete with higher compressive strength had also a poor ductility due to cement based material but due admixture in the RPC not reduces the quality of ductility of the concrete. It also has low porosity and has a quality to show compressive strength from 50MPA-250MPA. Reactive Powder Concrete is composed of very fine powder material not more than 800 µm materials are cement (OPC), crushed quartz sand and micro silica or we can also called as silica fume. Cement content of Reactive Powder Concrete goes from 750-1000 kg/m3 higher cement content increases production cost and also cause shrinkage problem, replacing cement with mineral admixture is one of the solutions of this type of problem. Reactive powder concrete is relatively a new concrete in concrete family and the basic principal due to which RPC is developed is explained by Richard1 and Cheyrezy1.

EFFECT OF LOADING RATE IN PREVIOUS WORKS

It is well known that loading rate significantly influences the structural response. The structural response depends on the loading rate through three different effects: (1) through the creep of the bulk material between the cracks, (2) through the rate de- pendency of the growing microcracks and (3) through the influence of inertia forces, which can significantly change the state of the stresses and strains at the crack tip. Depending on the type of material and the loading rate, the first, second or third effect may dominate. For quasi-brittle materials, such as concrete, which exhibit cracking and dam- age phenomena, the first effect is important for relatively low loading rates (creep-fracture interaction). XiaoXin and et.al in (2012) tested simply supported rectangular beams to study the effect of loading rate on crack velocities at a wide range of loading rate. The peak load is sensitive to the loading rate. Under low loading rates, the rate effect is slight, while it is pronounced under high loading rates, under low loading rates, the crack velocity increases with an increase in loading rates, the loading rate effect is pronounced, whereas loading rate effect on the crack velocity is slight under high loading rates. Shiyun X. and et.al in (2012) conducted a study on the loading rate effect on the mechanical behaviors of RC beams, it was concluded that the failure configurations of five RC beams were the same at different loading rates and the width of the crack decreased with the increasing loading rates and they distributed more uniform. Georgia E. and et.al in (2014) studied experimentally influence of the loading rate on the axial compressive behavior of concrete specimens. In that study, a total of 9 prisms were tested with different loading rate. It was found that, The fast loading rate of the applied axial compressive load results in an 11% decrease of the obtained strength of unconfined prismatic specimens.

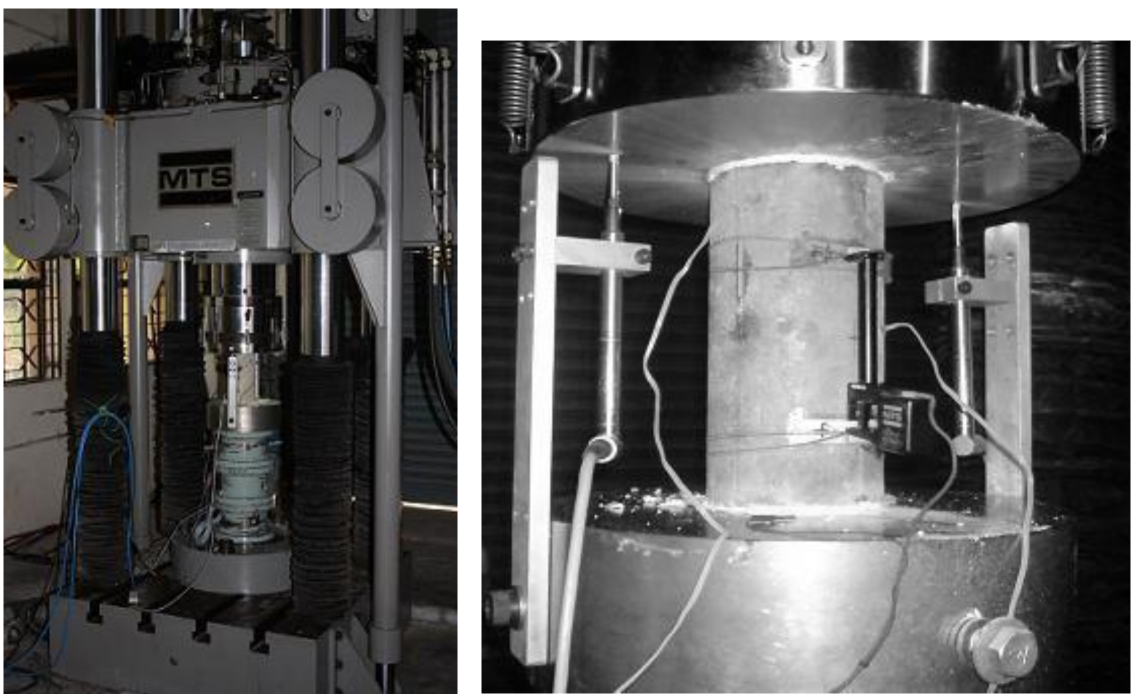
STUDY OF COMPRESSIVE STRENGTH OF RPC

Stress-strain Behaviour of UHPRC

Ultra-high performance fibre-reinforced concrete (UHPFRC) is a new class of concrete that has been developed in recent years. When compared with high performance concrete (HPC), UHPFRC exhibits superior properties in terms of compressive behavior, tensile behavior, and durability.

Testing Program

The RPC cylinders of 100mm diameter and 200mm height were cast. This experiment was carried out, to observe the improvement in compressive behavior of the RPC on addition of different volumes of 6mm and 13mm fibres.



Figs-1 & 2 Experimental set up for cylinders under uniaxial compression

The specimen for compression tests consisted of 100mm diameter by 200mm long cylinders. Both the end of the specimen were carefully leveled and coated with sulphur to get plain and parallel surfaces. The experiment is carried out in a servo controlled compression testing machine as per ASTM C 469 procedure. All the tests were conducted after 28 days of respective curing periods. The tests were controlled with 2

LVDTs with 100 gauge length attached around the specimens at 180° spacing although it is well known that axial displacement is not the best control mode. Fig. 1 and Fig. 2, show the experimental set up and instrumentation for measuring the deformation of specimen respectively.

RESULTS

The important stress-strain parameters viz., the peak stress, the corresponding strain, the elastic modulus, the ultimate strain and the toughness indices by different mixes are shown in Table 1. As seen from the Table 1, the RPC mixes showed 112.6 to 246.8% higher compressive strength compared to normal concrete. The compressive strength generally increased with increase in fibre content in case of RPC mixes with 6mm fibres and 13 mm fibres. The highest compressive strength of 171.3 MPa was recorded for 2% 13 mm fibres. However, when fibre combinations of 6mm and 13 mm fibre were used, there was a reduction in compressive strength compared to highest compressive strength obtained for single size fibres. This could be attributed to the reduced workability and lower compaction density achieved as indicated by the density ratios show in Table 1. Therefore 3% of 6mm and 2% of 13 mm seem to be the optimum fibre contents as observed from the results obtained in the present study.

No.	Mix Type	Fibre content	Density Ratio	Stress at peak load (MPa)	Elastic Modulus GPa	Compression toughness Index			Strain at peak load X 106 έp	Ultimate Strain x 106 έu	Strain Ratio, έu/έp
						Up to 0.0075	Up to έu	MTI			
1	RPC	0	1	105.0	31.5	0.56	0.56	2.64	3437	7500	2.18
2	RPC	1% 6mm	0.97	122.7	39.0	0.62	0.60	2.51	3820	9258	2.42
3	RPC	2% 6mm	0.94	145.8	42.0	0.68	0.64	3.47	4442	14600	3.29
4	RPC	3% 6mm	0.89	161.8	41.0	0.66	0.59	3.95	4851	18007	3.71
5	RPC	1%13mm	0.94	136.9	41.0	0.67	0.66	3.29	4252	12098	2.85
6	RPC	2% 13mm	0.91	171.3	41.8	0.66	0.62	3.63	4501	17232	3.83
7	RPC	2%6mm+1%13mm	0.89	156.1	38.0	0.65	0.60	2.78	4751	12541	2.64
8	RPC	2% 13mm+1% 6mm	0.86	156.3	42.0	0.64	0.64	1.65	4900	20636	1.21

The elastic modulus of RPC mixes is found to be 41.4% to 87.4 % higher than that of control concrete with the RPC mix with 2%-13mm fibre recording the highest elastic modulus of 41.8 GPa. The variation of elastic modulus is found to follow a cube root of compressive strength as recommended by Eurocode 2 rather than a square root law as recommended by most of the codes of practice. The ratio of ultimate to peak strain is the highest for fibre combination of 2% 13 mm and 1% 6mm(1.65) followed by 2% 13 mm(3.81) mix and 3% 6mm (3.73) mixes.

Toughness is a measure of the energy absorption capacity of the material and is used to characterize the materials ability to resist fracture. The toughness in compression is computed as the area under the stress-strain curve. Many no dimensional toughness indices have been proposed by the researchers for fibre reinforced concrete. Ezeldin and Balaguru [1999] defined the toughness index as the ratio of the area up to a strain of 0.15 to the area of a perfectly plastic material (expressed in MPa. mm/mm) with an yield strength equal to the peak strength and plastic strain of 0.15. Taerwe and Gysel [1996] considered a maximum strain of 0.006, while Shreekala et al [2006] used a value of 0.0075, as recommended by Japanese concrete Institute. In the present study, definition of Ezeldin and Balaguru [1999] has been used considering two strain limits 0.0075 and the ultimate strain. Ezheldin and Balaguru28 reported toughness index ranging from 0.48 for plain concrete to 0.76 for fibre concrete. However, as seen from Table 1, the values of toughness indices of RPC mixes as computed by this definition range from 0.561 to 0.675 and are of the same order as that of control concrete and HPC (0.58 to 0.66) and do not seem to show any significant variation with increase in fibre content and aspect ratio. A modified toughness index (MTI) was defined as the ratio of the area of stress-strain curve to pre-peak area of the curve. As seen from Table 1, the value of MTI ranges from 2.64 to 1.65 for RPC mixes and appears to be a better measure of the reinforcing action of fibres and their crack bridging action.

The ultimate strain values show the dominant effect of reinforcement effect and the length of fibre and it is interesting to note that 13 mm fibres enable higher ultimate strain to be reached as the 6mm fibres have a lower aspect ratio and may fail by fibre pull out rather than fibre fracture. The ratio of ultimate to peak strain is the highest for fibre combination of 2% 13 mm and 1% 6mm(1.65) followed by 2% 13 mm(3.83) mix and 3% 6mm (3.71) mixes.

CONCLUSION

Based on the results of this study, the following conclusions can be drawn: Over all Plain Reactive Powder Concrete gives the highest compressive strength as compared to ORPC and MRPC because it includes steel fiber also. MRPC which includes coarse aggregate of size 8mm gives higher strength than ORPC.– Accelerated curing is better than normal curing because it requires less time and gives higher strength also.– Reactive Powder Concrete can be used at that place where application of normal concrete is not possible.– It can be generally used as a repair material and also in the earth quake prone areas structures.

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