Studies on stress- strain behaviour of concrete mixes confined with BFRP rebars

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Abstract. In the present study, the stress-stain behaviour of confined concrete made with basalt fibre reinforced polymer bars (BFRP) were taken up. The stress-strain behaviour was studied for the concrete mixes confined with steel rebars and BFRP rebars. The confinement was given in the form of steel hoops in the cylinders, 3 hoops (0.8%), 4 hoops (1.1%), 5 hoops (1.3%) and 6 hoops (1.6%). The addition of basalt fibres along with confinement of concrete with steel and BFRP hoops enhanced the compressive strength, indicating further confinement effect in the concrete. It is observed that the addition of fibres is helpful in lower confinements only. Beyond 1.1% confinement, the addition of any type of basalt fibres doesn't show any effect on compressive strengths. From the stress-strain behaviour of all types of concrete mixes, it is concluded that the ultimate load-carrying capacity and strains at peak stresses are more in concrete with BFRP hoops for mixes up to 1.1% confinement. The addition of basalt fibres to concrete has increased the ductility in both confined and unconfined states

1 Introduction

The Studies on Stress-Strain behaviour of concrete are essential in determining the parameters like energy absorption, toughness, plasticity index and they are very useful in design of structures using such concretes. Further modelling the stress-strain behaviour helps in predicating their behaviour. In the present study, the stress-stain behaviour of confined concrete made with basalt fibre reinforced polymer bars (BFRP) were done.

2 Methodology

In this phase of investigations, the stress-stain behaviour of concrete confined by steel and BFRP rebars were taken up. The confinement was given in the form of steel hoops in the cylinders, 3 hoops (0.8%), 4 hoops (1.1%), 5 hoops (1.3%) and 6 hoops (1.6%) as shown in Fig 1. The tests were carried out on the standard cylindrical specimens of diameter 150mm and height 300mm. After casting, the cylinders were capped with cement mortar and cured for a period of 28 days in curing tanks. The specimens were then taken out and made surface dry. The samples were placed in a microprocessor strain controlled universal testing machine of 1000 kN capacity and tested under uni-axial compression as per IS 516:1959. The stress–strain behaviour as obtained was plotted.

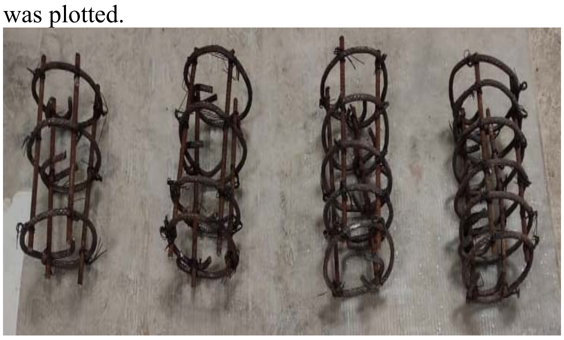

Fig.1. Cylinders with different Confinements

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Table 1. Percentage of confinement by volume

		Volume of confinement percentage
C0	Confinement 0 hoops	0.00
C3	Confinement 3 hoops	0.80
C4	Confinement 4 hoops	1.1
C5	Confinement 5 hoops	1.3
C6	Confinement 6 hoops	1.6

Table 2. Stress-strain values of concrete confined with steel bars

CONFINED WITH STEEL BARS									
M30-C0-STEEL		M30-C3-STEEL		M30-C4-STEEL		M30-C5-STEEL		M30-C6-STEEL	
Strain	Stress	Strain	Stress	Strain	Stress	Strain	Stress	Strain	Stress
0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
0.0000	0.17	0.0001	4.50	0.0000	0.66	0.0000	0.26	0.0002	8.61
0.0000	0.34	0.0003	8.36	0.0001	4.80	0.0001	5.93	0.0004	14.09
0.0001	4.48	0.0005	13.93	0.0002	8.95	0.0002	11.35	0.0005	19.57
0.0003	8.97	0.0007	18.43	0.0003	12.66	0.0003	15.22	0.0006	23.22
0.0005	12.59	0.0008	22.29	0.0005	18.56	0.0004	19.08	0.0008	30.26
0.0007	16.72	0.0010	26.79	0.0006	22.93	0.0005	23.73	0.0010	34.96
0.0008	20.52	0.0012	30.21	0.0007	26.42	0.0006	26.81	0.0011	38.61
0.0010	23.62	0.0013	33.86	0.0008	31.00	0.0008	31.45	0.0013	42.52
0.0012	27.24	0.0015	36.43	0.0010	34.72	0.0009	36.08	0.0015	45.39
0.0013	29.48	0.0016	37.93	0.0011	37.55	0.0010	38.91	0.0016	48.00
0.0016	34.48	0.0017	40.07	0.0012	39.30	0.0012	42.51	0.0017	49.30
0.0017	36.90	0.0018	42.21	0.0014	44.54	0.0014	45.33	0.0019	51.13
0.0019	36.90	0.0020	42.00	0.0015	44.76	0.0014	45.32	0.0020	52.17
0.0021	34.66	0.0021	41.14	0.0016	43.01	0.0015	46.60	0.0022	50.61
0.0022	31.38	0.0023	38.79	0.0017	40.39	0.0016	47.37	0.0022	48.78
0.0023	28.28	0.0024	36.00	0.0018	37.55	0.0017	44.50	0.0024	45.13
0.0025	25.86	0.0025	33.00	0.0019	35.59	0.0019	41.37	0.0025	41.74
0.0025	24.14	0.0026	30.86	0.0019	34.06	0.0021	39.29	0.0026	37.57
0.0026	22.07	0.0027	28.29			0.0022	37.45		

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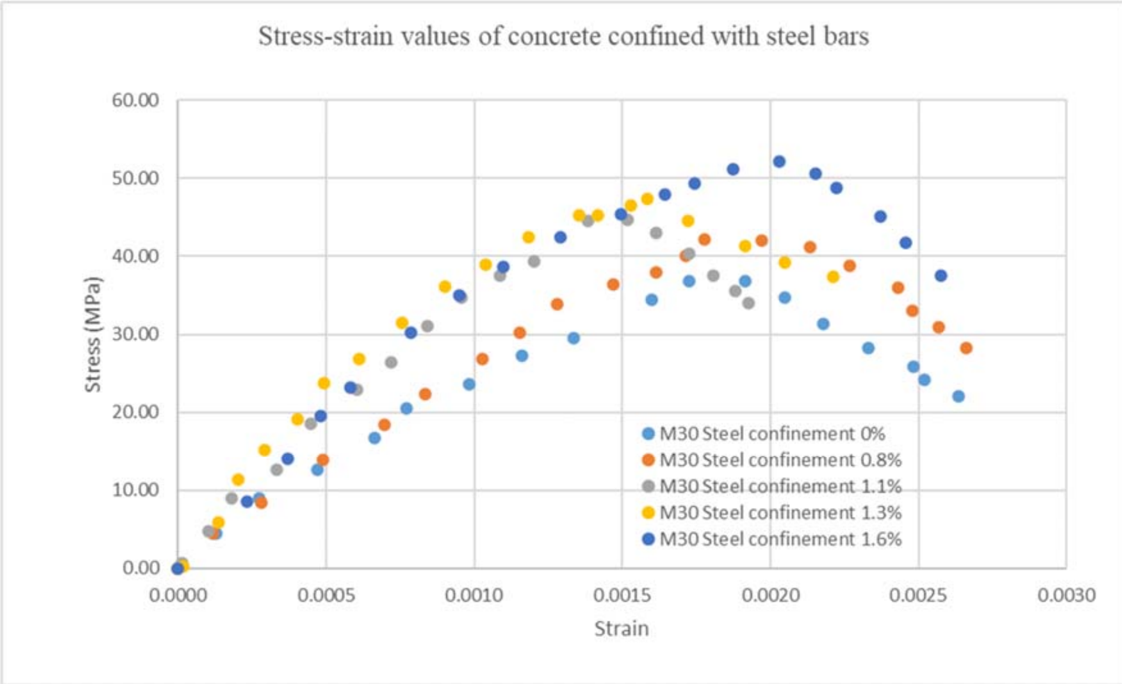

Fig. 1. Stress-strain values of concrete confined with steel bars

Table 3. Stress-strain values of concrete confined with BFRP bars

CONFINED WITH BFRP BARS									
M30-C0- BFRP		M30-C3- BFRP		M30-C4- BFRP		M30-C5- BFRP		M30-C6- BFRP	
0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
0.0001	8.66	0.0002	7.27	0.0002	6.90	0.0002	7.79	0.0000	0.87
0.0003	13.85	0.0004	16.28	0.0004	19.47	0.0002	14.29	0.0001	7.42
0.0005	19.74	0.0006	24.94	0.0008	27.63	0.0003	21.21	0.0002	13.52
0.0006	25.97	0.0008	32.55	0.0011	39.71	0.0005	26.41	0.0003	20.49
0.0007	29.44	0.0009	37.06	0.0015	50.93	0.0006	31.60	0.0005	29.21
0.0009	34.63	0.0011	40.52	0.0018	62.14	0.0006	36.80	0.0006	37.05
0.0011	41.90	0.0012	45.71	0.0021	68.15	0.0008	41.99	0.0006	41.42
0.0014	46.75	0.0014	49.87	0.0025	74.14	0.0010	47.19	0.0008	45.79
0.0015	52.29	0.0015	54.72	0.0026	76.71	0.0011	51.95	0.0009	54.51
0.0016	54.72	0.0017	60.26	0.0028	80.13	0.0012	57.58	0.0010	58.87
0.0018	59.57	0.0020	64.42	0.0030	82.28	0.0013	62.34	0.0011	62.80
0.0020	64.42	0.0022	67.88	0.0031	84.41	0.0015	67.53	0.0013	68.92
0.0021	64.76	0.0024	73.42	0.0033	83.93	0.0017	71.86	0.0014	72.85
0.0022	68.57	0.0027	73.42	0.0035	79.54	0.0018	78.35	0.0016	77.66
0.0024	74.46	0.0029	67.19	0.0037	72.97	0.0020	80.95	0.0017	82.03
0.0028	69.61	0.0031	60.95	0.0038	65.53	0.0022	83.98	0.0020	86.87
0.0028	65.11	0.0031	55.76			0.0024	85.71	0.0022	88.63
0.0029	59.22	0.0032	49.52			0.0025	87.45	0.0023	90.82
0.0030	54.03					0.0026	86.15	0.0025	93.90
0.0033	51.95					0.0027	84.85	0.0026	95.66
						0.0029	83.98	0.0028	96.57
						0.0030	79.22	0.0029	90.50
						0.0031	72.29	0.0030	86.16
								0.0030	78.77

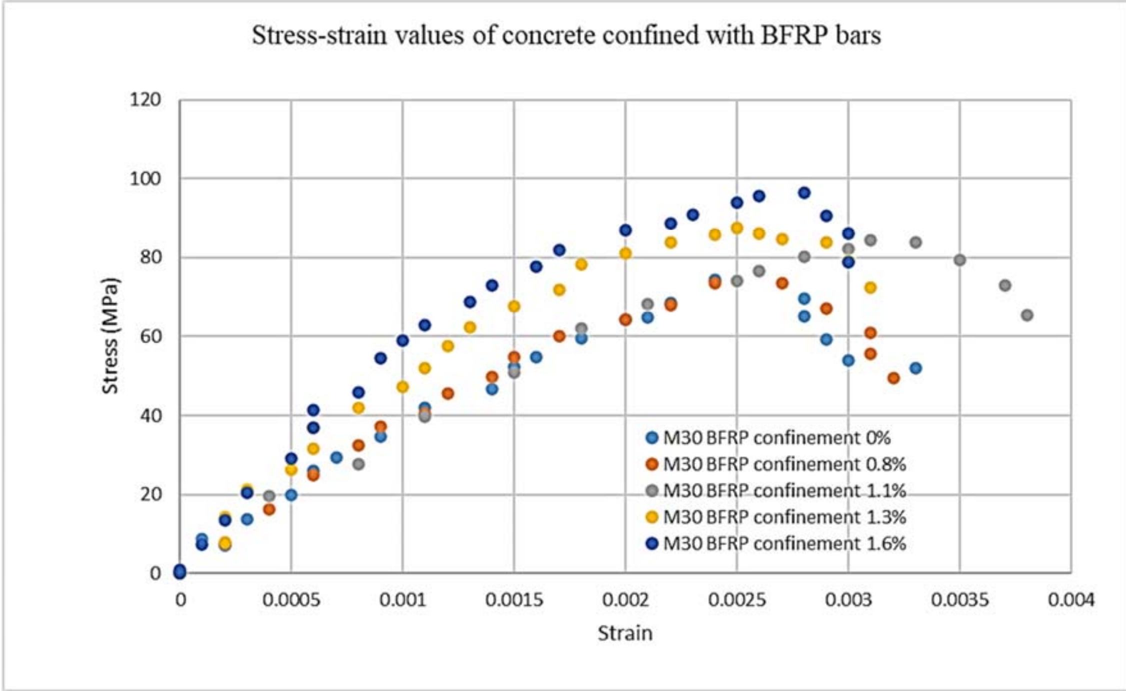

Fig. 2. Stress-strain values of concrete confined with steel bars

Table 4. Peak stresses of concrete confined with STEEL and BFRP bars

Type	Name	Strain at peak stress	Peak stress (MPa)
NORMAL CONCRETE CONFINED WITH STEEL	M30-C0-STEEL	0.0019	36.90
	M30-C3-STEEL	0.0018	42.21
	M30-C4-STEEL	0.0015	44.76
	M30-C5-STEEL	0.0016	47.37
	M30-C6-STEEL	0.0020	52.17
BASALT FIBRE CONCRETE CONFINED WITH BFRP BARS	M30-C0- BFRP	0.0024	74.46
	M30-C3- BFRP	0.0027	73.42
	M30-C4- BFRP	0.0031	84.41
	M30-C5- BFRP	0.0025	87.45
	M30-C6- BFRP	0.0028	96.57

3 Conclusions

1. The addition of fibres along with confinement of FRSCC with steel hoops enhanced the compressive strength, indicating further confinement effect in the FRSCC.
2. It is observed that the addition of fibres is helpful in lower confinements only. Beyond 1.1% confinement, the addition of any type of fibres doesn't show any effect on compressive strengths.
3. From the stress-strain behaviour of all types of FRSCC, it is concluded that the ultimate load-carrying capacity and strains at peak stresses are more in SFRSCC and HFRSCC for mixes up to 1.1% confinement.
4. The addition of fibres to SCC has increased the ductility in both confined and unconfined states.

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