SERVICE LOAD, ULTIMATE LOAD AND MOMENT of GPC BEAMS

Dr R B Khadiranaikar[1] Aslam hutagi[2] Girish Yavagal[3]*

1 (Professor, Department of Civil Engineering, BEC Bagalkot.)
2 (Research Scholar, Department of Civil Engineering, BEC Bagalkot)
3(M Tech Student, Department of Civil Engineering, BEC Bagalkot

**Corresponding Author: aslam.hutagi@gmail.com*

ABSTRACT

Geopolymers are showing great potential and several researchers have critically examn ed the various aspects of their viability as binder system.Geopolymer concretes (GPCs)are new class of building materials that have emerged as an alternative to Ordinary Portl
and cement concrete (OPCC) and possess the potential to revolutionize the building c onstruction industry.Considerable research has been carried out on development of Ge opolymer concretes (GPCs), which involve heat curing. A few studies have been repor ted on the use of such GPCs for structural applicaions. In this paper, studies carried ou t on the behaviour of room temperature cured reinforced GPC flexural members are reported. A totaltwelve beams were tested in flexure. Three conventional concrete mixe s and six GPC mixes of targetstrength ranging from 40 to 60 MPa and having varyin g combinations of fly ash and slag in the binder phase were considered. The limit state theory considered in IS:456-2000 takes into account this behavior in addition to taking care of ultimate strength criterion as well as serviceability criterion (limiting the deflection and cracking at working loads.) The variation of experimental and theoretical service loads is well established in table 1 and figure 4 below.

INTRODUCTION

In the Limit state theory failure is define in terms of limiting strain or stress in concrete and steel making use of complete stress strain relationship and a functional failure criterion. In case of flexural members limiting strain of failure, as defined by IS:456-2000 is 0.0035 and (fy/1.15Es)+0.002 for concrete and steel respectively. The same limiting values are used in the theoretical calculations of this investigation. By using the Limit state theory the strength and deformation properties of a section can be observed for a complete spectrum of loading from zero to the ultimate and beyond if it has a physical meaning. Ultimate stage or failure is defined as the loading condition at which a section reaches its maximum capacity i.e. maximum moment or load. The effects of loading rate, lateral reinforcement, sectional behavior etc. are automatically taken in to account by the adoption of general stress strain relationship of concrete.

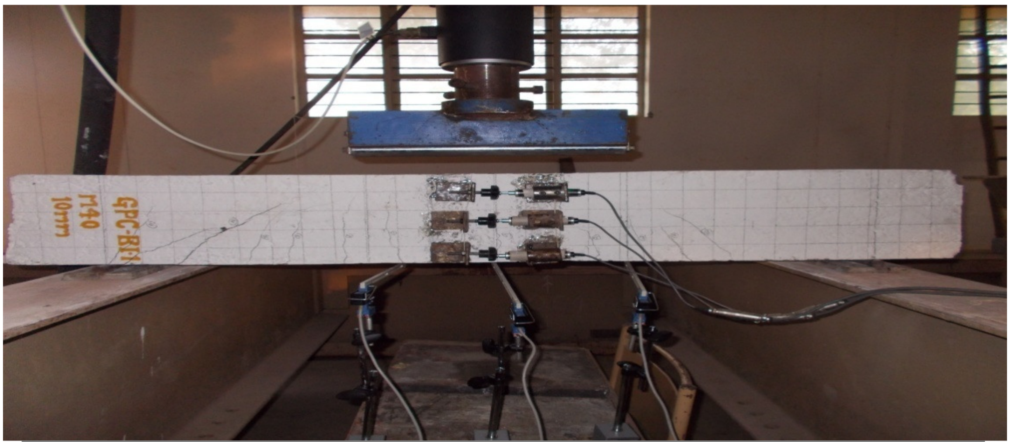
However, in our experimental program the theoretical ultimate strength is based on the criterion of limit state theory and during experiments the observed ultimate strength are recorded for each beam. Functional failure to carry any more load, rather than the limiting strain values is visualized and recorded as ultimate strength.

RESULTS AND DISCUSSIONS

Table 1 reports the experimental and theoretical ultimate loads (P_{UE} and P_{UT}) and ratio P_{UE} / P_{UT} of the beams tested. Experimental and theoretical ultimate loads are compared using bar charts in Fig. 1.

All the beams are provided with adequate web reinforcement for a good flexural behavior and assured flexural failure. Ratios of Pu (experiment) to Pu (theoretical) for reinforced geopolymer concrete beams (ratios varies from 1.09 to 1.32) and all these ratios are close to 1.20 indicating that experimental ultimate loads is almost 1.20 times the theoretical ultimate load.

Magnitude of experimental ultimate loads is found to be higher than theoretical ultimate load to an extent of 9 percent in all cases of beams. Both series II and series III beams exhibits higher ultimate load than series I showing that the performance will be better when concentration of NaOH increased and compressive strength increased.



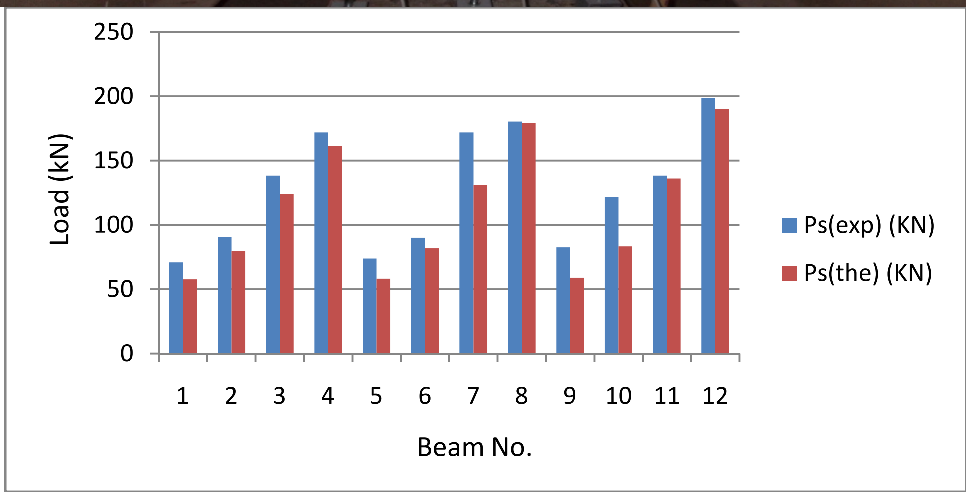


Figure 1 Comparison of Theoretical and Experimental Service loads for RGPC beams

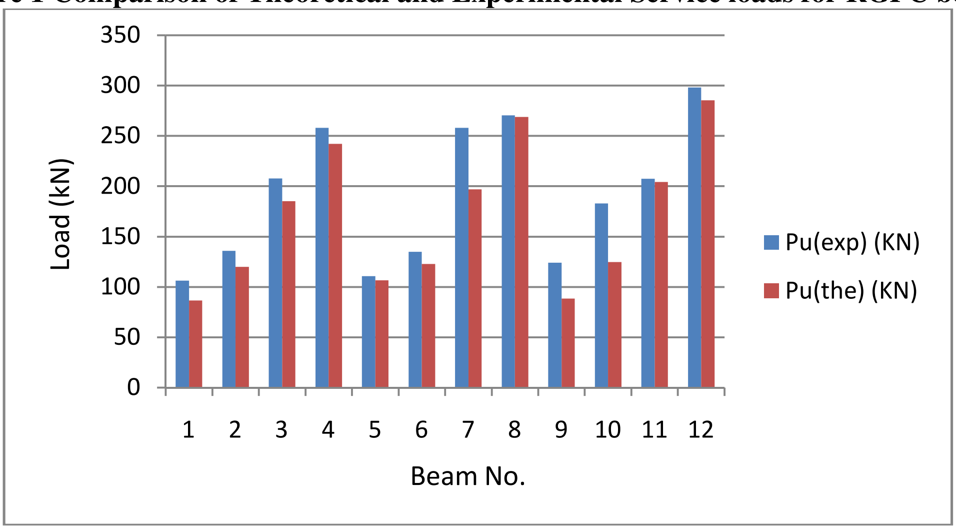


Figure 2. Comparison of Theoretical and Experimental Ultimate Loads for RGPC beams

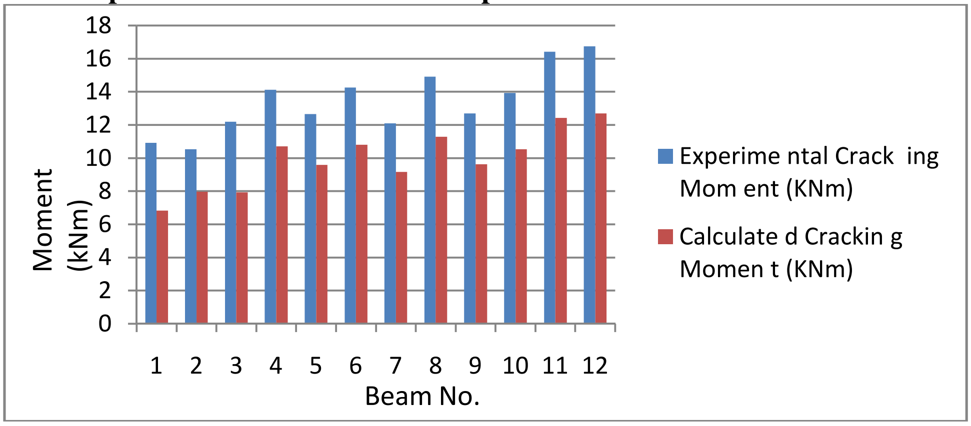


Figure 3. Comparison of Theoretical and Experimental Cracking Moments for RGPC beams

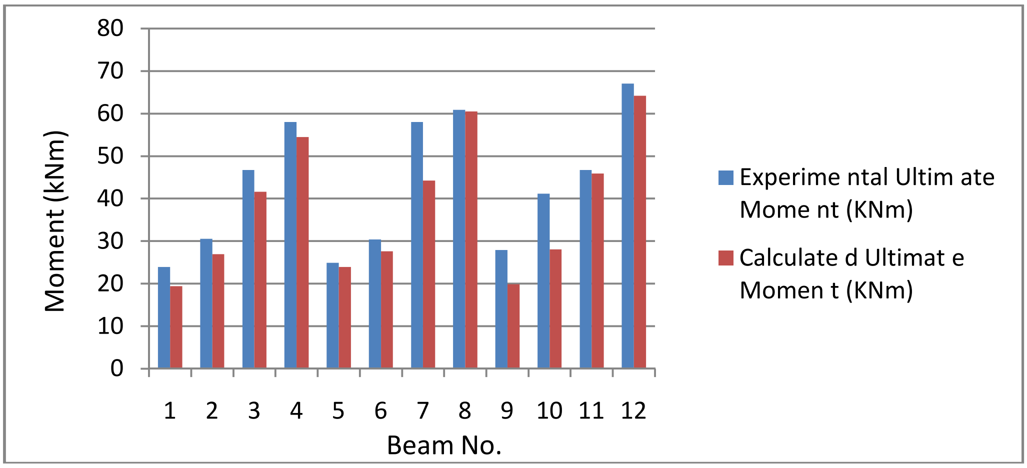


Figure 4. Comparison of Theoretical and Experimental Ultimate Moments for RGPC beams

Table No. 1 Experimental and theoretical values of Service loads.

Beam Designation	Case	Percentage Reinforcement	Experimental Service Load(kN)	Theoretical Service Load(kN)	Ratio of $Pser_{exp}$ $/Pser_{the}$
B1-1	Series-I	0.75%	70.89	57.64	1.229
B1-2	Series-I	1.34%	90.50	79.89	1.134
B1-3	Series-I	1.89%	138.4	123.9	1.117
B1-4	Series-I	2.69%	172	161.5	1.06
B2-1	Series-II	0.75%	73.80	58.23	1.26
B2-2	Series-II	1.34%	90.03	81.82	1.100
B2-3	Series-II	1.89%	172	131.2	1.31
B2-4	Series-II	2.69%	180.4	179.3	1.01
B3-1	Series-III	0.75%	82.64	58.90	1.40
B3-2	Series-III	1.34%	121.9	83.24	1.46
B3-3	Series-III	1.89%	138.4	136.1	1.016
B3-4	Series-III	2.69%	198.6	190.2	1.044

Table No. 2 Experimental and theoretical values of Ultimate Loads.

Beam Designation	Case	Percentage Reinforcement	Experimental Ultimate Load P_{ue}(kN)	Theoretical Ultimate Load P_{ut}(kN)	Ratio of P_{ue}/P_{ut}
B1-1	Series-I	0.75%	106.33	86.46	1.229
B1-2	Series-I	1.34%	135.75	119.83	1.132
B1-3	Series-I	1.89%	207.7	185.085	1.122
B1-4	Series-I	2.69%	258	242.25	1.065
B2-1	Series-II	0.75%	110.7	106.46	1.044
B2-2	Series-II	1.34%	135.04	122.73	1.100
B2-3	Series-II	1.89%	258	196.8	1.31
B2-4	Series-II	2.69%	270.6	268.95	1.007
B3-1	Series-III	0.75%	123.96	88.35	1.39
B3-2	Series-III	1.34%	182.85	124.86	1.47
B3-3	Series-III	1.89%	207.6	204.15	1.01
B3-4	Series-III	2.69%	298.2	285.3	1.045

Table No.3Experimental and theoretical values of Cracking Moments.

Beam Designation	Case	Percentage Tensile Reinforcement	Experimental Cracking Moment M_{Cre}(kNm)	Theoretical Cracking Moment M_{Crt}(kNm)	Ratio of M_{Cre}/M_{Crt}
B1-1	Series-I	0.75%	10.91	6.83	1.597
B1-2	Series-I	1.34%	10.53	7.97	1.321
B1-3	Series-I	1.89%	12.19	7.92	1.597
B1-4	Series-I	2.69%	14.13	10.70	1.320
B2-1	Series-II	0.75%	12.66	9.58	1.315
B2-2	Series-II	1.34%	14.26	10.8	1.320
B2-3	Series-II	1.89%	12.10	9.17	1.319
B2-4	Series-II	2.69%	14.91	11.29	1.320
B3-1	Series-III	0.75%	12.69	9.62	1.319
B3-2	Series-III	1.34%	13.92	10.54	1.320
B3-3	Series-III	1.89%	16.41	12.42	1.321
B3-4	Series-III	2.69%	16.75	12.69	1.319

Table No. 4 Experimental and theoretical values of Ultimate Moments.

Beam Designation	Case	Percentage Tensile Reinforcement	Experimental Ultimate Moment M_{ue}(kNm)	Theoretical Ultimate Moment M_{ut}(kNm)	Ratio of M_{ue}/M_{ut}
B1-1	Series-I	0.75%	23.92	19.45	1.229
B1-2	Series-I	1.34%	30.54	26.96	1.132
B1-3	Series-I	1.89%	46.73	41.64	1.122
B1-4	Series-I	2.69%	58.05	54.50	1.065
B2-1	Series-II	0.75%	24.90	23.95	1.039
B2-2	Series-II	1.34%	30.38	27.61	1.100
B2-3	Series-II	1.89%	58.05	44.28	1.310
B2-4	Series-II	2.69%	60.885	60.51	1.006

B3-1	Series-III	0.75%	27.89	19.87	1.403
B3-2	Series-III	1.34%	41.14	28.09	1.464
B3-3	Series-III	1.89%	46.71	45.93	1.016
B3-4	Series-III	2.69%	67.09	64.19	1.04

Table 1 gives the experimental and theoretical cracking moments of the beams tested, they are compared in the bar charts. In figure 4.16 below.

For all the beams, the experimental first crack moment is more than the respective theoretical first crack moment. The ratio varies between 1.09 to as high as 1.30 for all specimen. with a general value being 1.20. The theoretical values of cracking moments are calculated on the basis of modulus of rupture or the first crack loads.

Table 3 reports the experimental and theoretical ultimate moments (M_{UE} and M_{UT}) and ratio M_{UE} / M_{UT} of the beams tested. Experimental and theoretical ultimate moments are compared using bar charts in Fig. 2.

The magnitude of experimental ultimate moments is found to be higher than theoretical ultimate moment to an extent of 9 percent in all cases of beams. Both series II and series III beams exhibits higher ultimate moments than series I showing that the performance will be better when concentration of NaOH increased and compressive strength increased.

CONCLUSIONS

Magnitudes of experimental ultimate deflections are found to be 1.2 times that of the theoretical deflections. It can be concluded that the clauses and the design provisions of IS 456 - 2000 for the design of flexure suffices and holds good for the design of Reinforced Geopolymer Concrete beams also.

REFERENCES

[1] V. Bhikshma, M. Koti Reddy and T. Srinivas Rao "An Experimental Investigation on Properties of Geopolymer Concrete (no cement concrete) ", Asian Journal of Civil Engineering(building and housing) Vol. 13, No. 6 Pages 841-853 , 10 December 2011.

[2] Ganapati Naidu, N.Prasad, S.Adiseshu, P.V.V.Satayanarayana," A Study on Strength Properties of Geopolymer Concrete with Addition of G.G.B.S", International Journal of Engineering Research and Development EISSN : 2278-067X, PISSN : 2278-800X)Vol. 2, Issue 4, PP. 19-28 , July 2012.

[3] M.D.J.Sumajouw and B. V. Rangan, "Low-Calcium Flyash Based Geopolymer Concrete: Reinforced Beams and Columns", Research Report GC Faculty of Engineering Curtin University of Technology Perth, Australia 2006.

[4] B. Vijaya Rangan*, Dody Sumajouw, Steenie Wallah, Djwantoro Hardjito, "Reinforced Low-Calcium fly Ash-Based Geopolymer Concrete Beams and Columns" , 31st Conference on" Our world in Concrete & Structures", Singapore , Vol. 16, August 2006.

[5] Deepa Raj S., Ruby Abraham, N. Ganesan, Divya Sasi, "Fracture Properties of Fibre Reinforced Geopolymer Concrete ",International Journal of Scientific & Engineering Research Vol. 4, Issue 5, May-2013.

[6] Djwantoro Hardjito, Chua Chung Cheak & Carrie Ho Lee Ing ," Strength and Setting Times of Low Calcium Fly Ash-Based Geopolymer Mortar ", CCSE Journal of Engg & Devolopment, Vol. 2 No 4, Aug-2008.

[7] K. Vijai , R. Kumuthaa and B.G.Vishnuram," Experimental Investigations on Mechanical Properties of Geopolymer Concrete Composites", Asian Journal of Civil Engineering (building and housing) Vol. 13, Pages 89-96 , December-2012

[8] S. Kumaravel, S.Thirugnanasambandam, Kumaravel, Et Al "Flexural Behaviour of Geopolymer Concrete Beams", International Journal of Advanced Engineering Research and Studies Vol.3, September- 2006.
[9] K.Kanappiran, T. Sujatha and S. Nagan, et al " Flexural Behaviour of Reinforced Geopolymer Concrete Beams", International Journal of Civil and Structural Engineering Volume 2, June-2011.
[10] IS 9103: 1999 “Concrete Admixtures – Specifications”, first revision, Bureau of Indian Standards.
[11] IS 516: 1959 (reaffirmed 1999) “Methods of Tests for Strength of Concrete”, Incorporating Amendment No.1 and 2, Edition 1.2 (1991- 2007), Bureau of Indian Standards.