Shear Strength of Monolithic Geopolymer Concrete by ACI 318

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Introduction

The making of Ordinary Portland Cement involves enormous size of energy consumption, leading to a mammoth discharge of carbon di-oxide to the air, which is being a great task to the sustainable advance. Efforts are required to grow an environmental sociable construction material to reduce release of green-house gases to the atmosphere. One of the effort to reduce the carbon foot print, waste by products are used as alternative binders to the cement. Using fly ash, ground granulated blast furnace slag (GGBS) etc. as binders along with alkaline activated solution forms a matrix called "Geopolymer concrete" (GPC). Structural members fail in flexural and shear. Flexural is avoided by providing flexural reinforcement. Elements with shear reinforcement will carry tension and compression by concrete struts. To envisage shear strength of different concrete to concrete layers shear friction model is one of the method.

Shear friction started as a theory for a design of concrete connections. From basic mechanics theory, shear transferred $Vu = N \tan \phi$, where Vu is maximum shear force transferred and N is normal force acting at interface and $\tan \phi$ is contact friction coefficient. This paper presents a study on the shear strength of monolithic GPC interface. 18 push-off specimens with and without transverse reinforcement at interface were cast and tested. The test shear strength of GPC is compared with the shear strength assessed by different editions of ACI 318 and are conservative in evaluating the shear strength of GPC.

Materials and Methods

Shear friction theory along layers is resisted by Cohesion and after crack Cohesion is lost and transfer is in combination of shear – friction and dowel action. ACI Committee 711 proposed shear resistance of unreinforced interfaces are equal to allowable shear stress of unreinforced beam. Research based on shear friction started since 1960's because of accurate test data fits this analogy number of test specimens. Mast developed first shear friction chapter for American Concrete Institute ACI 318 – 1971. Based on the research Cohesion term, which is dependent on type of aggregate was included along with friction term and with minimum clamping force in ACI 318-1983 was introduced. The same expression was considered for shear strength capacity as per shear friction model till 2014. Only upper limit for shear capacity is adopted based on type of interfaces in ACI 318 – 2008. Shear friction equation omits cohesion term and only friction term is considered as per latest edition i.e., ACI 318 – 2014.

Fly ash and GGBS are considered as binders, Fine Aggregate of river sand conforming to Zone-2 of IS: 383-2016. Coarse Aggregate is well graded aggregate conforming to IS: 383-2016 with 20mm nominal size of granite. Potable water was used in the experimental work. Alkaline Solution consists of Sodium Silicate to Sodium Hydroxide (8 Molarity) with ratio 2.5:1 and stored at room temperature (25 ± 2^oC) for 24 hours and relative humidity of 65% before using it in the casting of GPC push off specimens.

Mix proportion for GPC push off specimens was adopted from procedure given by G Mallikarjuna Rao et al and mix quantity shown in Table.1 after making different trials having different strengths.

Table 1. Materials used in GPC (per Cu.m)

S. No	Grade of GPC	Materials						
		Coarse Agg. (kg)	Fine Agg. (kg)	Fly Ash (kg)	GGBS (kg)	NaOH Sol. 8 Molarity (kg)	Sodium Silicate (kg)	SP* (kg)
1	A20	965	812	294	126	66	165	4.2
2	B30	965	812	252	168	66	165	4.2
3	C40	965	812	210	210	66	150	4.2

*SP: Super plasticizer (SP 430, Make: Fosroc Chemicals).

Sizes of the push-off specimens considered for investigation are shown in Figure 1. The samples were cast with and without reinforcement through the shear interface as shown in Figure 2. The samples were loaded axially till failure. The Push-off models with and without reinforcement across the slip plane, tested and failed by developing a crack along the interface.

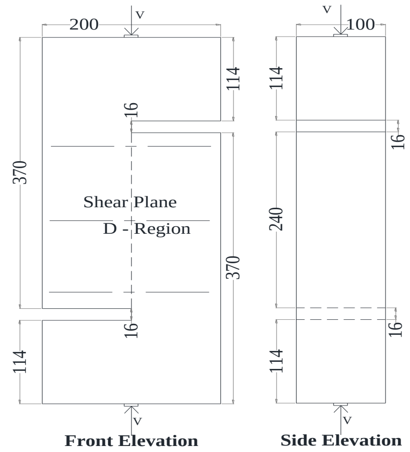

Figure 1. Push off Specimen

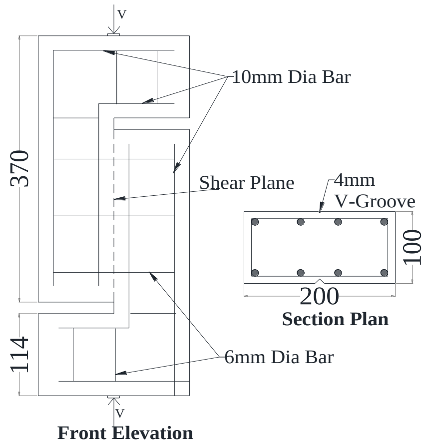

Figure 2. Reinforcement Details for Push -Off specimen

Results and Concluding Remarks

The push-off specimens has ruptured along the interface. In case of specimens without reinforcement across the interface, failed suddenly and reinforced specimens showed visible cracking along the shear plane at about 70 to 80 percent of the ultimate loads. Due to the provision of suitable reinforcement in the L shape of specimen, early flexural failure was not seen in none of the specimens in vertical or horizontal arms of specimens In the event of reinforced shear interfaces the shear strength has increased about 28% of the corresponding compression strength.

The comparison of shear strength of GPC obtained with the shear strength of normal concrete predicted by different editions of ACI 318 shear-friction equations. The comparative study indicates that the available normal concrete shear strength prediction models are highly conservative in estimating the shear strength of unreinforced and reinforced monolithic shear interfaces in GPC. ACI 318 – 1983 to ACI 318 – 2008 seems to give better forecast of shear strength of GPC in the case of unreinforced and reinforced monolithic interfaces respectively

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