Effect of SiO_2 on Rice Husk Ash- Slag based Geopolymer Composites

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Abstract*: In the planet, cement is most adaptable, enduring, reliable, and essential material used for edifice. After water, Concrete is most widely used material on the earth. But concrete is not eco-friendly due to large carbon footprint of cement. In current work a new eco-friendly standby of cement called as Geopolymer is worked out. The use of waste material like Rice Husk Ash (RHA), Ground Granulated Blast-Furnace Slag (GGBS) etc. and polymeric binder with no use of OPC is considered. In the present work experimental investigation is performed like Compressive strength (7 and 28 days) at ambient curing condition. Effect of SiO_2 on compressive strength is evaluate in present work. The variation of SiO_2 (6 %, 7 %, 8 %) and Fixed value of Na_2O and different combination of RHA and GGBS (variation from (10 % to 50 %, increases 10 % in each step) was used in this paper.

***Keywords*: Rice Husk Ash, GGBS, Geopolymer, SiO_2, Ambient Curing.**

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I. Introduction

Geopolymers are a class of mineral binders synthesized by activation of a source material, natural or by-product, which is abundant in alumina and silica with a metal hydroxide solution at moderate temperatures. These binders have been reported to possess better properties than ordinary Portland cement (OPC). Huge amount of construction and demolition waste, industrial waste and agricultural waste are generated every year in developing countries and conventional methods of dumping this waste are causing a catastrophic condition to the environment with additional carbon liberation. [1-2]. Along with these concerns extensive utilization of cement is promoting sharp increase in CO_2 emission worldwide [3]. Currently, geopolymers are attracting widespread attention for their potential as an alternative to ordinary Portland cement (OPC) in a variety of applications. It is becoming popular for its early development of higher strength as well as its superior durability properties besides being environmental friendly [4]. The inorganic aluminosilicate polymers termed as geopolymers suits the best fully replacement of OPC [5]. Researchers investigated different waste materials having aluminosilicate in crux such as fly ash, GGBS, clays, and other by products [6-19]. To have a complete understanding of the possibilities of applications in different areas, a study on geopolymer paste containing RHA and GGBS is discussed.

II. Materials used

Rice Husk Ash (RHA) is used as a primary aluminosilicate source materials in the current study. Granulated blast furnace slag (GGBS) is used as a modifier.

The mixture of sodium hydroxide (NaOH) with sodium silicate (Na_2SiO_3) was used as alkali solution with NaOH pellets (purity 98.9%)

III. Synthesis of Geopolymer Composite

Followings steps were used for the synthesis of geopolymer composite.

A. *Preparation of Alkaline Activator*

Initially, required quantities of NaOH pellets and water were mixed depending on the desired Na_2O content of the activator to make sodium hydroxide solution. It was then mixed with required quantity of sodium silicate solution for a desired SiO_2 content. The resulting activator solution was left in ambient temperature for one day before using in the preparation of geopolymer mix. [15].

B. *Sample Preparation*

At First, RHA and GGBS were mixed with the desired percentage in dry state until homogenous color does not appear in the powder. Now alkaline activator prepare 24 hours before was mixed with mixture of RHA and GGBS. Mixing was done until homogenous geopolymer paste not formed and there are no lumps left in this geopolymer paste. The mixing procedure followed was after Thakur and Ghosh and curing was done at ambient temperature [20].

IV. Effect of SiO_2 on Behavior

The SiO2 effect on the compressive strength of geopolymer composites specimens is shown in Table from 5.11 to 5.15 and graph from 5.2 to 5.7. The SiO2 content varies from 6% to 8% with increase in 1 % each step, with the fixed value of Na2O content (6 %, 7 %, 8 %) and GGBS as (10%, 20 %, 30 %, 40 %, 50 %) to form different combinations, as shown in tables below. The compressive strength at 7 and 28 days was evaluated for the commitment of SiO_2 effect.

TABLE 1:: Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 10 %

Mix ID	% Na_2O in activator (a)*	% SiO_2 in activator (b)*	Water/Source materials (RHA+GGBS)	RHA (gm)	GGBS (gm)	Compressive strength (MPa)	
						7 days	7 days
GP1.10	6	6	0.35	900	100	4.80	6.00
GP2.10	6	7	0.35	900	100	5.20	6.40
GP3.10	6	8	0.35	900	100	5.60	6.80
GP4.10	7	6	0.35	900	100	6.20	7.40
GP5.10	7	7	0.35	900	100	7.60	8.60
GP6.10	7	8	0.35	900	100	8.20	9.60
GP7.10	8	6	0.35	900	100	10.20	11.60
GP8.10	8	7	0.35	900	100	12.20	13.60
GP9.10	8	8	0.35	900	100	14.20	15.60

Figure 1 Influence on Compressive strength with regarding to SiO2 content of Geopolymer composite specimen at GGBS = 10 %

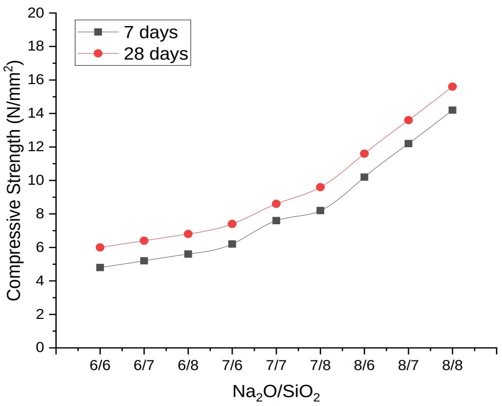


Figure 1 shows SiO2 effect on compressive strength using line graph, in graph compressive strength at the curing period of 7 days and 28 days is shown. The percentage of GGBS keep constant at 10 % and also content of Na2O keep constant (6 %, 7 %, 8%) to form different combination with the variation of SiO2 (6 %, 7 %, 8%) content, as shown in figure on X-axis. Compressive strength varies from 4.80 MPa to 14.20 MPa at duration of curing 7 days at ambient curing and 6.00 MPa to 15.60 MPa duration of curing 28 days at ambient curing. So, it is concluded that with increases the SiO2 content in RHA based geopolymer composite, the compressive strength also increases. The maximum compressive strength is noted that 15.60 MPa at duration of curing 28 days with ambient curing conditions, of sample with mix id GP9.10

TABLE 2:: Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 20 %

Mix ID	% Na_2O in activator (a)*	% SiO_2 in activator (b)*	Water/Source materials (RHA+GGBS)	RHA (gm)	GGBS (gm)	Compressive strength (MPa)	
						7 days	7 days
GP1.20	6	6	0.35	800	200	5.20	6.40
GP2.20	6	7	0.35	800	200	7.20	8.80
GP3.20	6	8	0.35	800	200	7.40	9.60
GP4.20	7	6	0.35	800	200	8.40	10.60
GP5.20	7	7	0.35	800	200	10.40	12.20
GP6.20	7	8	0.35	800	200	12.80	13.60
GP7.20	8	6	0.35	800	200	14.60	16.20
GP8.20	8	7	0.35	800	200	16.40	18.40
GP9.20	8	8	0.35	800	200	19.40	20.40

Fig. 2 Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 20 %

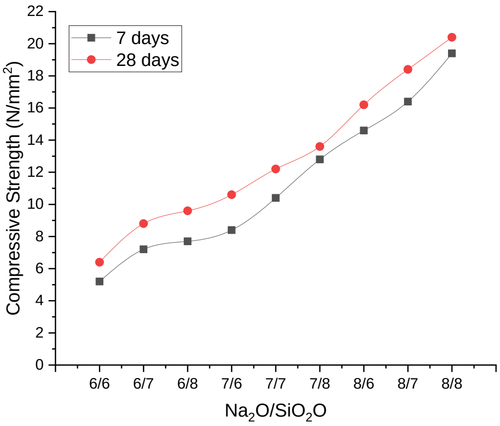


Figure 2 shown SiO2 effect on compressive strength using line graph, in graph compressive strength at the curing period of 7 days and 28 days is shown. The percentage of GGBS keep constant at 20 % and also content of Na2O keep constant (6 %, 7 %, 8%) to form different combination with the variation of SiO2 (6 %, 7 %, 8%) content, as shown in figure on X-axis . Compressive strength varies from 5.20 MPa to 19.40 MPa at duration of curing of 7 days at ambient curing and 6.40 MPa to 20.40 MPa at duration of curing 28 days at ambient curing So it is concluded that with increases the SiO2 content in RHA based geopolymer composite, the compressive strength also increases. The maximum compressive strength is noted that 20.40 MPa at duration of curing of 28 days with ambient curing conditions, of sample with mix id GP9.20

TABLE 3:: Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 30 %

Mix ID	% Na_2O in activator (a)*	% SiO_2 in activator (b)*	Water/Source materials (RHA+GGBS)	RHA (gm)	GGBS (gm)	Compressive strength (MPa)	
						7 days	7 days
GP1.30	6	6	0.35	700	300	8.00	9.60
GP2.30	6	7	0.35	700	300	11.30	13.20
GP3.30	6	8	0.35	700	300	14.20	16.20
GP4.30	7	6	0.35	700	300	15.20	17.40
GP5.30	7	7	0.35	700	300	17.20	21.40
GP6.30	7	8	0.35	700	300	20.40	24.40
GP7.30	8	6	0.35	700	300	23.40	25.70
GP8.30	8	7	0.35	700	300	25.40	28.40
GP9.30	8	8	0.35	700	300	29.40	31.40

Fig. 3 Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 30 %

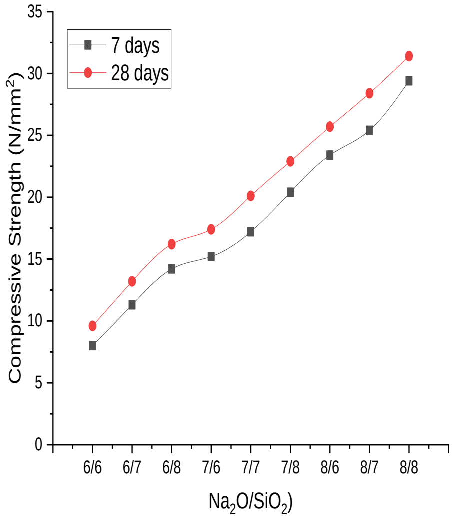


Figure 3 shown SiO2 effect on compressive strength using line graph, in graph compressive strength at the curing period of 7 days and 28 days is shown. The percentage of GGBS keep constant at 30 % and also content of Na2O keep constant (6 %, 7 %, 8%) to form different combination with the variation of SiO2 (6 %, 7 %, 8%) content, as shown in figure on X-axis. . Compressive strength varies from 8.00 MPa to 29.40 MPa at duration of curing of 7 days at ambient curing and 9.60 MPa to 31.40 MPa at duration of curing 28 days at ambient curing So it is concluded that with increases the SiO2 content in RHA based geopolymer composite, the compressive strength also increases. The maximum compressive strength is noted that 31.40 MPa at duration of curing of 28 days with ambient curing conditions, of sample with mix id GP 9.30

TABLE 4:: Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 40 %

Mix ID	% Na_2O in activator (a)*	% SiO_2 in activator (b)*	Water/Source materials (RHA+GGBS)	RHA (gm)	GGBS (gm)	Compressive strength (MPa)	
						7 days	7 days
GP1.40	6	6	0.35	600	400	17.00	18.80
GP2.40	6	7	0.35	600	400	17.60	19.80
GP3.40	6	8	0.35	600	400	19.20	21.80
GP4.40	7	6	0.35	600	400	20.80	22.20
GP5.40	7	7	0.35	600	400	22.80	25.20
GP6.40	7	8	0.35	600	400	25.80	28.20
GP7.40	8	6	0.35	600	400	28.80	31.20
GP8.40	8	7	0.35	600	400	30.80	34.20
GP9.40	8	8	0.35	600	400	35.80	37.20

Fig. 4 Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 40 %

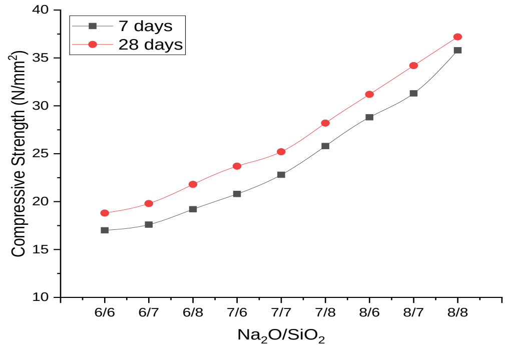


Figure 4 shown SiO2 effect on compressive strength using line graph, in graph compressive strength is represented at the curing period of 7 days and 28 days. The percentage of GGBS keep constant at 40 % and also content of Na2O keep constant (6 %, 7 %, 8%) to form different combination with the variation of SiO2 (6 %, 7 %, 8%) content, as shown in figure on X-axis . Compressive strength varies from 17.00 MPa to 35.80 MPa at the duration of 7 days ambient curing and 18.80 MPa to 37.20 MPa at duration of curing 28 days in ambient curing environment. So, it is concluded that with increases the SiO2 content in RHA based geopolymer composite, the increment in compressive strength appears. The maximum compressive strength is noted that 37.20 MPa at duration of curing 28 days, using ambient curing conditions, of sample with mix id GP9.40

TABLE 5:: Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 50 %

Mix ID	% Na_2O in activator (a)*	% SiO_2 in activator (b)*	Water/Source materials (RHA+GGBS)	RHA (gm)	GGBS (gm)	Compressive strength (MPa)	
						7 days	7 days
GP1.50	6	6	0.35	500	500	20.80	24.00
GP2.50	6	7	0.35	500	500	23.20	24.80
GP3.50	6	8	0.35	500	500	24.20	25.60
GP4.50	7	6	0.35	500	500	25.60	28.60
GP5.50	7	7	0.35	500	500	28.60	31.20
GP6.50	7	8	0.35	500	500	32.60	33.40
GP7.50	8	6	0.35	500	500	34.20	35.80
GP8.50	8	7	0.35	500	500	36.40	37.60
GP9.50	8	8	0.35	500	500	38.20	39.80

Fig. 5 Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at GGBS = 50 %

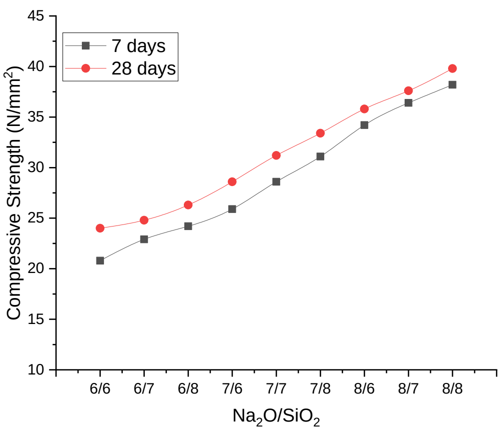
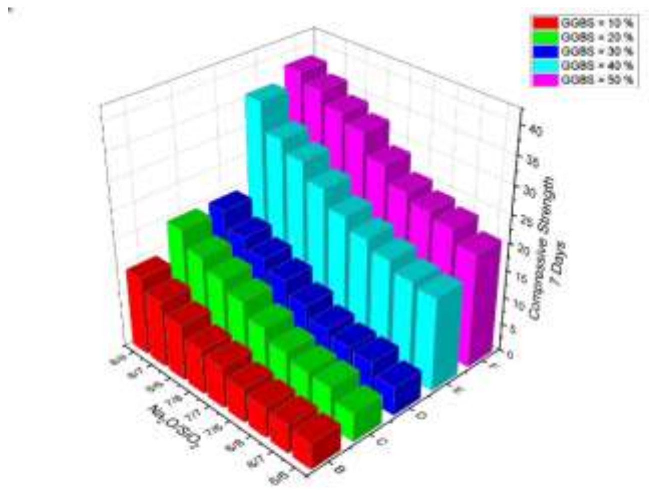


Figure 5 shown SiO2 effect on compressive strength using line graph, in graph compressive strength at the curing period of 7 days and 28 days is shown. The percentage of GGBS keep constant at 40 % and content of Na2O keep constant (6 %, 7 %, 8%) to form different combination with the variation of SiO2 (6 %, 7 %, 8%) content, as shown in figure on X-axis. Compressive strength varies from 20.80 MPa to 38.20 MPa at duration 7 days ambient curing and 24.00 MPa to 39.80 MPa at duration of curing 28 days ambient curing. So, it is concluded that with increases the SiO2 content in RHA based geopolymer composite, increment in compressive strength also appears. The maximum compressive strength is noted that 39.80 MPa at curing period of duration of curing 28 days using ambient curing conditions, of sample with mix id GP9.50

Fig. 6 Influence on Compressive strength with regarding to SiO_2 content of Geopolymer composite specimen at various GGBS content at 7 days



V. EFFECT OF SiO_2 ON BEHAVIOR

Based on the present research on strength aspects of RHA based geopolymer composite, the following conclusions are drawn.

- Compressive Strength increases with the increases the SiO2 content in alkaline activator.
- Incorporation of GGBS in geopolymer enhancement of polymerization at ambient curing condition, results in better compressive strength.
- Compressive Strength increases with the increases the percentage of GGBS in source material and maximum compressive strength was found at 50 % GGBS with mix id GP.9.50 as 39.80 MPa at the curing of 28 days with ambient environment.

RHA used in geopolymer not only saves costs considerably, but also provides environmental benefits.

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