# A Work Paper on Experimental Analysis of Fly-Ash mix Nano-Silica in Geopolymer Concrete for Economical Behavior of the Structure

Amir Usmani<sup>1</sup> Prof. Kamni Laheriya<sup>2</sup>

<sup>2</sup>Assistant Professor

<sup>1,2</sup>Department of Civil Engineering

<sup>1,2</sup>SSSUTMS Sehore (M. P.), India

*Abstract*— Fresh fly ash-based Nano-Silica in Geopolymer concrete has been able to remain workable up to at least 120 minutes without any sign of setting and without any degradation in the compressive strength. Providing a rest period for fresh in Geopolymer concrete after casting before the start of curing up to five days increased the compressive strength of hardened in Geopolymer concrete. The elastic properties of hardened fly ash-based Nano-Silica in Geopolymer concrete, i,e. the modulus of elasticity, the Poisson's ratio, and the indirect tensile strength, are similar to those of ordinary Portland cement in Geopolymer concrete. *Keywords:* Geopolymer concrete, Fly-Ash mix Nano-Silica, compressive strength, tensile strength, Portland Cement, Variability

#### I. INTRODUCTION

The various materials used in the production of Geopolymer concrete, cement plays a major role due its size and adhesive property. So, the produce to make Geopolymer concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as supplementary cementitious materials or SCMs are added to Geopolymer concrete improve its properties. Some of these are fly ash, blast furnace slag, rice husk, Nano-Silica fumes and even bacteria. Of the various technologies in use, Fly-Ashtechnology looks to be a promising approach in improving the properties of Geopolymer concrete.

The stress-strain relations of fly-ash based Nano-Silica in Geopolymer concrete fit well with the expression developed for ordinary Portland cement in Geopolymer concrete. The types and relative amounts of incombustible matter in the coal determine the chemical composition of fly ash. This work primarily deals with the compressive strength characteristics such as water absorption super plasticizer used in high performance in Geopolymer concrete a set of 4 different in Geopolymer concrete mixture were cast and tested with different cement replacement levels of Fly ash (FA) with nano Nano-Silica (NS) as addition by wt of Cement and/or each trial super plasticizer has been added at constant values to achieve a constant range of slump for desired work ability with a constant water-binder (w/b) ratio of 0.30.

## II. LITERATURE REVIEW

A comparative analysis of this work has been presented in the summary of this chapter which will highlight the significance of each work. Out of the numerous work done in the field only a few relevant works have been highlighted in the next section.

[Ali Nazari et.al. (2016)] studied strength and percentage water absorption of SCC containing different

amount of GGBFS and TiO2 Fly-Ash particles. The findings of the experimentation are that replacement of Portland cement with up to 45% weight of GGBNS and up to 4% weight of TiO2 Fly-Ash particles gives a considerable increase to the compressive, split tensile and flexural strength of the blended in Geopolymer concrete.

[Sekari and Razzaghi (2017)] studies the effect of constant content of Fly-Ash ZrO2, Fe2O3, TiO2, and Al2O3 on the properties of in Geopolymer concrete. The reults showed that all the Fly-Ash particles have noticeable influence on improvement on durability properties of in Geopolymer concrete but the contribution of Fly-Ash Al2O3 on improvement of mechanical properties of HPC is more than the other Fly-Ash particles.

[Girao et al., Yazdanbakhsh et al., (2019)] The incorporation of nano-additives and nano-cement replacements such as silica fume, nano-SiO 2, nano-clay, carbon nanotubes and nano-fly ash in cement matrix has significantly refined the pastes microstructure. Furthermore, it has directly improved strength to the cement pastes and enhanced the durability of mortar and in Geopolymer concrete.

[Huaqing Liu, Yan Zhang, Ruiming Tong, Zhaoqing Zhu, and Yang Lv (2020)] Surface protection has been accepted as an effective way to improve the durability of in Geopolymer concrete. In this study, nanosilica (NS) was used to improve the impermeability of cement-fly ash system and this kind of material was expected to be applied as surface protection material (SPM) for in Geopolymer concrete. Binders composed of 70% cement and 30% fly ash (FA) were designed and nanosilica (NS, 0–4% of the binder) was added. The workability of fresh in Geopolymer concrete and the compressive strength of hardened in Geopolymer concrete increase.

#### III. METHODOLOGY

The details of the properties of the materials used, the method followed to design the experiment and the test procedures followed. The theory is supplemented with a number of pictures to have a clear idea on the methods.

Physical Properties of Nat	no-Silica:							
Physical properties	Nano-Silica							
Particle shape	Multifaceted							
Appearance	Black & glassy							
Type Air	Cooled							
Specific gravity	3.51							
Bulk density at 250 C (Ton/m3)	1.8 - 2.2							
Hardness	5 – 7 Mohs							
pH	6.5							
Conductivity at 250	Nil							
Moisture Content	< 0.1%							
Chaminal Descention of Ma	C'1'							

Chemical Properties of Nano-Silica:

Chemical component	% of Chemical component
SiO2	33-35 %
Fe2O3	40-44%
A12O3	4-6%
CaO	0.8-1.5%
MgO	1-2%
Properti	es of Fly-Ash

Properties of Fly-Ash									
TEST ITEM	STANDARD	TEST							
TESTTIEM	REQUIREMENTS	RESULTS							
SPECIFIC									
SURFACE	200 + 20	202							
AREA (m2/g)									
PH VALUE	3.7 – 4.5	4.12							
LOSS ON									
DRYING @ 105	< 1.5	0.47							
DEG.C (5)									
LOSS ON									
IGNITION @	< 2.0	0.66							
1000 DEG.C (%)									
SIEVE RESIDUE	< 0. 04	0.02							
(5)	< 0.04	0.02							
TAMPED	40 - 60	44							
DENSITY (g/L)	40 - 00	44							
SiO2 CONTENT	> 99. 8	99.88							
(%)	> 77. 0	77.00							
CARBON	< 0. 15	0.06							
CONTENT (%)	< 0.15	0.00							

CHLORIDE CONTENT (%)	< 0. 0202	0.009
A12O3	< 0. 03	0.005
TiO2	< 0. 02	0.004
Fe2O3	< 0. 003	0.001

A. Proportion of Volume of Coarse Aggregate and Fine Aggregate Content:

Volume of coarse aggregate per unit volume of total aggregate (ISC: 10262-1982) = 0.64

(This is corresponding to 20 mm size aggregate and Zone III fine aggregate for water-cement ratio of 0.50)

As the water-cement ratio is lowered by 0.05, the proportion of volume of coarse aggregate is increased by 0.01 (ref. Table 6 of IS: 10262-1982)

Corrected volume of coarse aggregate per unit volume of total aggregate = (0.64+0.014) = 0.654

Volume of fine aggregate per unit volume of total aggregate = 1-0.654 = 0.346

# B. Compressive Strength Test

The compressive strength of specimens is determined after 7 and 28 days of curing with surface dried condition as per Indian Standard IS: 516-1959. Three specimens are tested for typical category and the mean compressive strength of three specimens is considered as the compressive strength of the specified category.

		IV. E	XPERIMENTAI	RESULTS							
-		7-DAY TEST RESULT									
	Sample No.	Weight (kg)	Load (ton)	Compressive Strength (MPa)							
	Specimen 1	6.68	43	18.75	1.1						
	Specimen 2	7.24	56	24.42							
	Specimen 3	7.35	52	22.67							
	Avera	age Strength (N	/IPa)	21.94							

	Table: Compressive Strength of M20 Grade with 15% Fly Ash & 0% Nano Silica												
	(	0.5% b.	w.c	<i>w.c</i> 1% b.w.c			1% b.w.c 2% b.w.c				2.5% b.w.c		
Sample	weight	load	Comp.	weight	load	Comp.	weight	load	Comp.	weight	load	Comp.	
	kg	ton	strength	kg	ton	strength	kg	ton	strength	kg	ton	strength	
S-1	6.98	52	22.67	6.92	61	26.596	7.06	66	28.764	7.12	64	27.904	
S-2	7.11	63	27.468	7.28	64	27.904	7.64	69	30.084	7.72	68	29.648	
S-3	7.02	65	28.34	7.95	66	28.776	7.98	74	32.264	8.08	71	30.956	
Avera	age Strens	gth	26.16	Av. Strength 27.76			Av. Str	ength	30.37	Av. Stre	ength	29.50	

Table: 7 days Compressive Strength in (MPa) of M20 Grade with different % of Nano-Silica & 15% Fly Ash

	14-DAY TEST RESULT										
Sample No.	Sample No. Weight (kg) Load (tonne) Compressive Strength (MP										
Specimen 1	6.92	46	20.056								
Specimen 2	7.18	56	24.416								
Specimen 3	7.22	51	22.236								
Ave	rage Strength (	MPa)	22.236								

Table: Compressive Strength in (MPa) of M20 Grade plain specimen for 14 day & 0% Nano Silica

	(	).5% b.	w.c	1% b.w.c			2% b.w.c			2.5% b.w.c		
Sample	weight	load	Comp.	weight	load	Comp.	weight	load	Comp.	weight	load	Comp.
	kg	ton	strength	kg	ton	strength	kg	ton	strength	kg	ton	strength
S-1	7.24	56	24.416	7.18	70	30.52	7.24	76	33.136	7.08	73	31.828
S-2	7.02	64	27.904	6.97	72	31.392	7.08	79	34.444	6.72	77	33.572
S-3	6.91	69	30.084	7.36	74	32.264	7.41	82	35.752	7.11	80	34.88
Avera	ige Streng	gth	27.468	Av. Stre	ength	31.392	Av. Stre	ength	34.444	Av. Stre	ength	33.42

Table: 14 days Compressive Strength in (MPa) of M20 Grade with different % of Nano-Silica & 15% Fly Ash

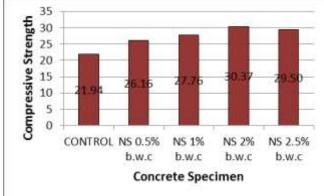
			28-DAY TEST RESULT           Sample No.         Weight (kg)         Load (tonne)         Compressive Strength (MPa)									
			Sample No.	•		Load (tonne)	Compi			Pa)		
			Specimen 1	7.38		76			.136			
	Specimen 2		7.21		74	32.264						
			Specimen 3	6.96		68			.648			
				rage Strer					1.68			
				pressive S		th of M20 Gra	de plain	-				
	(	).5% b.	w.c		1% b	.w.c		2% b.v	w.c		2.5% b.	w.c
Sample	weight	load	Comp.	weight	load	Comp.	weight	load	Comp.	weight	load	Comp.
-	kg	ton	strength	kg	ton	strength	kg	ton	strength	kg	ton	strength
S-1	6.86	76	33.136	7.36	81	35.316	7.48	84	36.624	7.42	82	35.752
S-2	7.14	71	30.95	7.52	88	38.368	7.56	91	39.676	7.54	89	38.804
S-3	7.04	80	34.88	7.24	86	37.496	7.30	94	40.984	7.28	91	39.676
Avera	age Streng	gth	32.99	Av. Stre	ength	37.06	Av. Stre	ength	39.09	Av. Str	ength	38.077
Table: 28	days Con	pressiv	ve Strength in	n (MPa) o	f M2	O Grade with d	ifferent %	6 of Na	no Nano-Sil	ica & 159	% Fly A	sh
			U	<u> </u>		DAY TEST RE					2	
		5	Sample No.	Weight		Load (tonne)		ressive	Strength (M	Pa)		
			Specimen 1	8.65		<u>62</u>			.032			
			Specimen 2	8.81		84			.624			
			Specimen 3	8.92		75			2.7			
		_		rage Strer					2.11			
	-	∟ Fahle∙ (				30 Grade plain	snecime			ano Silico	a	
		).5% b.		Sucingui	$\frac{01}{1\%}$ b		specific	$\frac{1101}{2\%}$ b.v			1 2.5% b.	WC
Sample	weight	load	Comp.	weight	load		weight	2% D.V	Comp.	weight	2.3% D. load	Comp.
Sample	-		-			-	-		-	-		-
S-1	kg	ton 76	strength	kg	ton	U	kg	ton	strength	kg 9.08	ton	strength
	9.04		33.136	9.10	78	34.008	9.18	84	38.368		82	35.752
S-2	9.12	80	34.88	9.14	84	36.624	9.45	89	38.804	9.38	86	37.496
S-3	9.0	84	36.624	9.14	87	37.932	9.26	95	41.42	9.20	91	39.676
Average Strength34.88Av. Strength36.188Av. Strength39.53Av. Strength37.641												
					MPa)	of M30 Grade	with dif					
		ys Com	pressive Stre	ength in (N	MPa) 14-1	of M30 Grade DAY TEST RI	e with dif ESULT	ferent 9	% of Nano-S	Silica & 1		
		ys Com	pressive Stre Sample No.	ength in (N Weight	MPa) 14-] (kg)	of M30 Grade DAY TEST RI Load (tonne)	e with dif ESULT	ferent % ressive	% of Nano-S Strength (M	Silica & 1		
		ys Com	pressive Stre Sample No. Specimen 1	ength in (N Weight 8.78	MPa) 14-] (kg)	of M30 Grade DAY TEST RI Load (tonne) 68	e with dif ESULT	ferent 9 ressive 29	% of Nano-S Strength (M .648	Silica & 1		
		ys Com	pressive Stre Sample No. Specimen 1 Specimen 2	weight in (N Weight 8.78 8.86	MPa) 14-1 (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86	e with dif ESULT	ferent 9 ressive 29 37	% of Nano-S Strength (M .648 .496	Silica & 1		
		ys Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3	ength in (1 Weight 8.78 8.86 9.06	MPa) 14-1 (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86 78	e with dif ESULT	ressive 29 37 34	% of Nano-S Strength (M .648 .496 .008	Silica & 1		
Ta	ıble: 7 day	ys Com	Sample No. Specimen 1 Specimen 2 Specimen 3 Ave	Weight 8.78 8.86 9.06 rage Strer	MPa) 14-1 (kg) ngth (.	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa)	e with dif ESULT Compi	ressive 29 37 34 33	% of Nano-S Strength (M .648 .496 .008 .717	Silica & 1		
Ta	ble: 7 day	ys Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G	Weight 8.78 8.86 9.06 rage Strer	MPa) 14-1 (kg) ngth (in spec	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da	e with dif ESULT Compi	ressive 29 37 34 33 Nano S	% of Nano-S Strength (M .648 .496 .008 .717 illica	Silica & 1 Pa)	5% Fly	Ash
Ta	ble: 7 day	ys Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G	Weight (1) Weight (1) 8.78 8.86 9.06 rage Strer trade plain	MPa) 14-1 (kg) ngth (.	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da	e with dif ESULT Compr Compr ay & 0%	ressive 29 37 34 33	% of Nano-S Strength (M .648 .496 .008 .717 illica	Silica & 1 Pa)		Ash
Ta	mpressive	ys Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp.	Weight 8.78 8.86 9.06 rage Strer	MPa) 14-] (kg) ngth (in spec	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) eimen for 14 da .w.c	with dif ESULT Compr Compr y & 0%	ressive 29 37 34 33 Nano S	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp.	Silica & 1 Pa)	5% Fly	Ash
Table: Con Sample	mpressive weight kg	vs Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength	Weight (1) Weight (1) 8.78 8.86 9.06 rage Strer trade plain	MPa) 14-1 (kg) ngth (1 n spec 1% b	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength	with dif ESULT Compr Compr y & 0% weight kg	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength	Silica & 1 Pa) weight kg	5% Fly 2.5% b. load ton	Ash w.c Comp. strength
Table: Con Sample S-1	mpressive	vs Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp.	Weight (1) Weight (1) 8.78 8.86 9.06 rage Strer frade plain weight	MPa) 14-] (kg) hgth (kg) n spec 1% b load ton 92	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112	with dif ESULT Compr Compr y & 0%	ferent 9 ressive 29 37 34 33 Nano S 2% b.v Ioad	6 of Nano-S Strength (M .648 .496 .008 .717 iilica v.c Comp. strength 41.42	Silica & 1 Pa)	5% Fly 2.5% b. load	Ash w.c Comp.
Table: Con Sample	mpressive	vs Com <u>5</u> <u>5</u> <u>5</u> <u>5</u> <u>5</u> <u>5</u> <u>5</u> <u>5</u>	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength	Weight (1) Weight (1) 8.78 8.86 9.06 rage Strer frade plain weight kg	MPa) 14-] (kg) ngth (( n spec 1% b load ton 92 95	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength	with dif ESULT Compr Compr y & 0% weight kg	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength	Silica & 1 Pa) weight kg 9.81 9.56	5% Fly 2.5% b. load ton	Ash w.c Comp. strength 40.548 41.856
Table: Con Sample S-1	mpressive weight kg 9.36	vs Com s s s s s s s s s s s s s	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752	weight in (1) Weight 8.78 8.86 9.06 rage Stree rade plain weight kg 9.78	MPa) 14-] (kg) hgth (kg) n spec 1% b load ton 92	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112	with dif ESULT Compr Compr y & 0% weight kg 9.84	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95	6 of Nano-S Strength (M .648 .496 .008 .717 iilica v.c Comp. strength 41.42	Silica & 1 Pa) weight kg 9.81	5% Fly 2.5% b. load ton 93	Ash w.c Comp. strength 40.548
Table: Con Sample S-1 S-2 S-3	mpressive weight kg 9.36 9.13	vs Com S Streng D.5% b. load ton 82 87 92	Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 C w.c Comp. strength 35.752 37.932	weight 8.78 8.86 9.06 rage Strer rade plain weight kg 9.78 9.41	MPa) 14- (kg) ngth (kg) ngth	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856	with dif ESULT Compr Compr V V V V V V V V V V V V V V V V V V V	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99	6 of Nano-S Strength (M .648 .496 .008 .717 .008 .717 .008 .717 .008 .717 .008 .717 .008 .717 .008 .717 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .717 .008 .496 .008 .496 .008 .717 .008 .496 .008 .496 .008 .496 .008 .496 .008 .717 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .008 .496 .496 .496 .496 .496 .496 .496 .496	Silica & 1 Pa) weight kg 9.81 9.56	5% Fly 2.5% b. load ton 93 96 97	Ash w.c Comp. strength 40.548 41.856
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s s s s s s s s s s s s s	Sample No. Specimen 1 Specimen 2 Specimen 3 Ave gth of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93	weight kg 9.78 9.78 9.06 rage Strer weight kg 9.78 9.41 9.84 Av. Stre	MPa) 14-1 (kg) ngth (kg) ngth (kg) ngth (kg) 1% b 10ad ton 92 95 96 ength	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856	with diff ESULT Compr Compr Aveight kg 9.84 9.67 9.96 Av. Street	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 97 99 ength	6 of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292	Silica & 1 Pa) Pa) weight kg 9.81 9.56 9.88 Av. Stru	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s s s s s s s s s s s s s	Sample No. Specimen 1 Specimen 2 Specimen 3 Ave gth of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93	weight kg 9.78 9.78 9.06 rage Strer weight kg 9.78 9.41 9.84 Av. Stre	MPa) 14-1 (kg) hgth (kg) hgth	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 of M30 Grade	with dif ESULT Compr Compr Veight kg 9.84 9.67 9.96 Av. Stree with dif	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 97 99 ength	6 of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292	Silica & 1 Pa) Pa) weight kg 9.81 9.56 9.88 Av. Stru	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s Com s Streng 0.5% b. load ton 82 87 92 gth vys Con	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 npressive Str	weight kg 9.78 9.78 9.06 rage Strer weight kg 9.78 9.41 9.84 Av. Stre	MPa) 14- (kg) (kg) ngth ( n spect 1% b load ton 92 95 96 ength (MPa) 28-	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 of M30 Grade DAY TEST RI	with dif ESULT Compr Compr Very & 0% Very & 0%	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292 % of Nano-S	Silica & 1 Pa) Weight kg 9.81 9.56 9.88 Av. Stro Silica & 1	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s s s s s treng 0.5% b. load ton 82 87 92 gth sys Con	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No.	weight kg 9.78 9.41 9.84 Av. Stree rength in ( Weight	MPa) 14 (kg) (kg) ngth (( n spec 1% b load ton 92 95 96 ength (MPa) 28 (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 o of M30 Grade DAY TEST RI Load (tonne)	with dif ESULT Compr Compr Very & 0% Very & 0%	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9	6 of Nano-S Strength (M .648 .496 .008 .717 bilica v.c Comp. strength 41.42 42.292 43.164 42.292 % of Nano-S Strength (M	Silica & 1 Pa) Weight kg 9.81 9.56 9.88 Av. Stro Silica & 1	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s s s s s s s s s s s s s	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 npressive Str Sample No. Specimen 1	weight kg 9.78 9.41 9.84 Av. Stree ength in ( Weight 8.82	MPa) 14-] (kg) (kg) ngth (( n spec 1% b load ton 92 95 96 ength (MPa) 28-] (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) timen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72	with dif ESULT Compr Compr Very & 0% Very & 0%	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9	6 of Nano-S Strength (M .648 .496 .008 .717 .008 .008 .717 .008 .008 .717 .008	Silica & 1 Pa) Weight kg 9.81 9.56 9.88 Av. Stro Silica & 1	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s s s s s s s s s s s s s	pressive Stree Sample No. Specimen 1 Specimen 2 Specimen 3 Ave gth of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 npressive Str Sample No. Specimen 1 Specimen 2	weight kg 9.78 9.41 9.84 Av. Stree ength in ( Weight 8.82 8.89	MPa) 14- (kg) (kg) ngth (( n spec 1% b load ton 92 95 96 ength (MPa) 28- (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) timen for 14 da .w.c Comp. strength 40.112 41.42 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89	with dif ESULT Compr Compr Very & 0% Very & 0%	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 97 99 ength ferent 9 ressive 31 38	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292 % of Nano-S Strength (M .392 .804	Silica & 1 Pa) Weight kg 9.81 9.56 9.88 Av. Stro Silica & 1	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng	vs Com s s s s s s s s s s s s s	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave gth of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3	weight 8.78 8.86 9.06 rage Strer rade plain weight kg 9.78 9.41 9.84 Av. Stre rength in ( Weight 8.82 8.89 9.06	MPa) 14-] (kg) ngth (kg) ngth (kg) 1% b 10ad ton 92 95 96 ength (MPa) 28-] (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) timen for 14 da .w.c Comp. strength 40.112 41.42 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82	with dif ESULT Compr Compr Very & 0% Very & 0%	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 97 99 ength ferent 9 ressive 31 38 35	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292 % of Nano-S Strength (M .392 .804 .752	Silica & 1 Pa) Weight kg 9.81 9.56 9.88 Av. Stro Silica & 1	5% Fly 2.5% b. load ton 93 96 97 ength	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da	vs Com s s Streng 0.5% b. load ton 82 87 92 gth vys Com	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave	weight 8.78 8.86 9.06 rage Strer rade plain weight kg 9.78 9.41 9.84 Av. Stre rength in ( Weight 8.82 8.89 9.06 rage Strer	MPa) 14-] (kg) ngth (kg) ngth (m 1% b load ton 92 95 96 ength (MPa) 28-] (kg) ngth (kg)	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa)	with diff ESULT Compr Compr Veight kg 9.84 9.67 9.96 Av. Street with diff ESULT Compr Compr	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 97 99 ength ferent 9 ressive 31 38 35 35	% of Nano-S Strength (M .648 .496 .008 .717 Silica w.c Comp. strength 41.42 42.292 43.164 42.292 % of Nano-S Strength (M .392 .804 .752 .316	Silica & 1 Pa) Weight kg 9.81 9.56 9.88 Av. Str Silica & 1 Pa) Pa)	5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly	Ash w.c Comp. strength 40.548 41.856 42.292 41.56
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da	vs Com s Streng 0.5% b. load ton 82 87 92 gth vys Con s Streng (s) (s) (s) (s) (s) (s) (s) (s)	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 npressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave ompressive Str	weight 8.78 8.86 9.06 rage Strer rade plain weight kg 9.78 9.41 9.84 Av. Stre rength in ( Weight 8.82 8.89 9.06 rage Strer	MPa) 14-] (kg) hgth () n spect 1% b load ton 92 95 96 ength (MPa) 28-] (kg) hgth () f M30	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa) O Grade plain s	with diff ESULT Compr Compr Veight kg 9.84 9.67 9.96 Av. Street with diff ESULT Compr Compr	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 99 ength ferent 9 ressive 31 38 35 35 for 28	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292 43.164 42.292 % of Nano-S Strength (M .392 .804 .752 .316 days & 0% N	Silica & 1 Pa) Weight Kg 9.81 9.56 9.88 Av. Stro Silica & 1 Pa) Nano Silic	5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly	Ash w.c Comp. strength 40.548 41.856 42.292 41.56 Ash
Table: Con Sample S-1 S-2 S-3 Avera Ta	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da	vs Com s s s s s s s s s s s s s	pressive Stree Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave ompressive S	weight kg 9.78 9.41 9.84 Av. Stree rength in ( Weight 8.82 8.89 9.06 rage Stree Strength o	MPa) 14- (kg) hgth (( n spec) 1% b load ton 92 95 96 ength (MPa) 28- (kg) (kg) hgth (( of M30 1% b	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) cimen for 14 da .w.c Comp. strength 40.112 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa) O Grade plain s .w.c	with dif ESULT Compr Compr Veight kg 9.84 9.67 9.96 Av. Straction ESULT Compr Compr Compr Av. Straction Compr Substrate Substrate Substrate Compr Compr Substrate Compr Substrate Compr	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9 ressive 31 38 35 35 for 28 2% b.v	% of Nano-S Strength (M .648 .496 .008 .717 .5ilica v.c Comp. strength 41.42 42.292 43.164 42.292 43.164 42.292 % of Nano-S Strength (M .392 .804 .752 .316 days & 0% I v.c	Silica & 1 Pa) Weight Kg 9.81 9.56 9.88 Av. Stro Silica & 1 Pa) Nano Silic	2.5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly ca 2.5% b.	Ash w.c Comp. strength 40.548 41.856 42.292 41.56 Ash w.c
Table: Con Sample S-1 S-2 S-3 Avera	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da	vs Com s s streng 0.5% b. load ton 82 87 92 gth uys Com s s s s s s s s s s s s s	pressive Stree Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave ompressive Str Sample No.	weight in (1) Weight in (1) 8.78 8.86 9.06 rage Stree irade plain weight kg 9.78 9.41 9.84 Av. Stree rength in (1) Weight in (1) 8.82 8.89 9.06 rage Stree Strength o Strength o	MPa) 14-] (kg) ngth (( n spec 1% b load ton 92 95 96 ength (MPa) 28-] (kg) ngth (( of M30 1% b load	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) 5 5 5 6 6 78 MPa) 5 5 7 8 7 8 7 8 4 7 8 7 8 7 8 4 1.12 4 1.42 4 1.56 4 1.13 0 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa) 0 Grade plain s .w.c	with dif ESULT Compr Compr Veight kg 9.84 9.67 9.96 Av. Street with dif ESULT Compr Compr Compr Specimen weight	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9 ressive 31 38 35 for 28 2% b.v load	% of Nano-S Strength (M .648 .496 .008 .717 	Silica & 1 Pa) Weight Rg 9.81 9.56 9.88 Av. Str Silica & 1 Pa) Nano Silic weight	2.5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly ca 2.5% b. load	Ash w.c Comp. strength 40.548 41.856 42.292 41.56 Ash w.c Comp.
Table: Con Sample S-1 S-2 S-3 Avera Ta Sample	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da the streng ble: 14 da	vs Com s s streng 0.5% b. load ton 82 87 92 gth uys Com s s s s s s s s s s s s s	pressive Stree Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave ompressive Str Strength	weight 8.78 8.86 9.06 rage Strer rade plain weight kg 9.78 9.41 9.84 Av. Stre rength in ( Weight ( 8.82 8.89 9.06 rage Strer Strength o Strength o	MPa) 14-] (kg) ngth (( n spec 1% b load ton 92 95 96 ength (MPa) 28-] (kg) ngth (1 of M30 1% b load ton 1% b load ton 92 95 96	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) timen for 14 da .w.c Comp. strength 40.112 41.42 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa) 0 Grade plain s .w.c Comp. strength	with dif ESULT Compr Compr Veight kg 9.84 9.84 9.67 9.96 Av. Street with dif ESULT Compr Compr Compr Specimen weight kg	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9 ressive 31 38 35 for 28 2% b.v load ton	6 of Nano-S Strength (M .648 .496 .008 .717 .008 .008 .717 .008 .008 .717 .008 .008 .717 .008 .008 .717 .008	Silica & 1 Pa) Weight Rg 9.81 9.56 9.88 Av. Str Silica & 1 Pa) Nano Silic Weight Rg	2.5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly ca 2.5% b. load ton	Ash w.c Comp. strength 40.548 41.856 42.292 41.56 Ash w.c Comp. strength
Table: Con Sample S-1 S-2 S-3 Avera Ta Sample S-1	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da ble: 14 da Tr ( weight kg 9.39	vs Com S Streng S Streng S S S S S S S S S S S S S	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave gth of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave ompressive Str Sample No. Specimen 3 Ave ompressive Str Specimen 3 Ave	weight in (1 8.78 8.86 9.06 rage Strer irade plain weight kg 9.78 9.41 9.84 Av. Stre ength in (1 8.82 8.89 9.06 rage Strer Strength of weight kg 9.91	MPa) 14- (kg) 14- (kg) 14- (kg) 10 ad ton 92 95 96 ength (MPa) 28- (kg) (kg) 1% b load 1% b load 1% b 10 ad 1% b 10 ad 10 ad	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) timen for 14 da .w.c Comp. strength 40.112 41.42 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa) 0 Grade plain s .w.c Comp. strength 40.984	with dif ESULT Compi Compi Veight kg 9.84 9.67 9.96 Av. Street e with dif ESULT Compi Compi Specimen weight kg 9.96	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9 ressive 31 38 35 35 for 28 2% b.v load ton 97	% of Nano-S Strength (M .648 .496 .008 .717 Silica v.c Comp. strength 41.42 42.292 43.164 42.292 % of Nano-S Strength (M .392 .804 .752 .316 days & 0% I v.c Comp. strength 42.292	Silica & 1 Pa) Pa) Weight kg 9.81 9.56 9.88 Av. Str Silica & 1 Pa) Nano Silic Weight kg 9.91	2.5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly 2.5% b. load ton 95	Ash w.c Comp. strength 40.548 41.856 42.292 41.56 Ash w.c Comp. strength 41.42
Table: Con Sample S-1 S-2 S-3 Avera Ta Sample	mpressive weight kg 9.36 9.13 8.98 age Streng ble: 14 da the streng ble: 14 da	vs Com s s streng 0.5% b. load ton 82 87 92 gth uys Com s s s s s s s s s s s s s	pressive Stre Sample No. Specimen 1 Specimen 2 Specimen 3 Ave th of M30 G w.c Comp. strength 35.752 37.932 40.112 37.93 mpressive Str Sample No. Specimen 1 Specimen 2 Specimen 3 Ave ompressive Str Strength	weight in (1) Weight in (1) 8.78 8.86 9.06 rage Stree irade plain weight kg 9.78 9.41 9.84 Av. Stree rength in (1) Weight in (1) Weight in (1) 8.82 8.89 9.06 rage Stree Strength of Strength of weight kg	MPa) 14-] (kg) ngth (( n spec 1% b load ton 92 95 96 ength (MPa) 28-] (kg) ngth (1 of M30 1% b load ton 1% b load ton 92 95 96	of M30 Grade DAY TEST RI Load (tonne) 68 86 78 MPa) timen for 14 da .w.c Comp. strength 40.112 41.42 41.42 41.856 41.13 of M30 Grade DAY TEST RI Load (tonne) 72 89 82 MPa) 0 Grade plain s .w.c Comp. strength	with dif ESULT Compr Compr Veight kg 9.84 9.84 9.67 9.96 Av. Street with dif ESULT Compr Compr Compr Specimen weight kg	ferent 9 ressive 29 37 34 33 Nano S 2% b.v load ton 95 97 99 ength ferent 9 ressive 31 38 35 for 28 2% b.v load ton	6 of Nano-S Strength (M .648 .496 .008 .717 .008 .008 .717 .008 .008 .717 .008 .008 .717 .008 .008 .717 .008	Silica & 1 Pa) Pa) Weight Rg 9.81 9.56 9.88 Av. Str Silica & 1 Pa) Nano Silic Weight Rg	2.5% Fly 2.5% b. load ton 93 96 97 ength 5% Fly ca 2.5% b. load ton	Ash w.c Comp. strength 40.548 41.856 42.292 41.56 Ash w.c Comp. strength

Average Strength38.94Av. Strength41.856Av. Strength42.728Av. Strength42.292Table 4.12: 28 days Compressive Strength in (MPa) of M30 Grade with different % of Nano-Silica & 15% Fly Ash

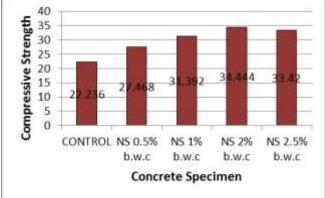
A. Comparison of Compressive Strength Results: The change in compressive strength for the blended sample (in %) for 7, 14 and 28 day is shown in Table respectively. A graphical representation of this result is shown in Fig. The change in compressive strength from 7 days 14 days to 28 day is shown.

lifferent % of Nano Nano-	1	7days	14	4 days	28 days		
Silica & 15% Fly Ash	strength (mpa)	increase in strength (%)	strength (mpa)	increase in strength (%)	strength (mpa)	increase in strength (%)	
CONTROL	21.94	-	22.236	-	31.68	-	
NS 0.5% b.w.c	26.16	19.23	27.468	23.52	32.99	4.13	
NS 1% b.w.c	27.76	26.52	31.392	41.17	37.06	16.98	
NS 2% b.w.c	30.37	38.42	34.444	54.90	39.09	23.39	
NS 2.5% b.w.c	29.50	34.45	33.42	50.30	38.077	20.19	

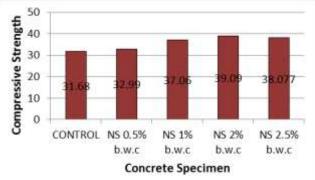
Table 4.13: Comparison of compressive strength for M20 Grade and 15% of Fly-ASH of In Geopolymer concrete



(a) compressive strength in 7days with M20 Grade and 15% of Fly-ASH of Geopolymer concrete



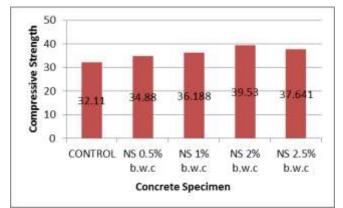
(b) compressive strength in 14 days with M20 Grade and 15% of Fly-ASH of Geopolymer concrete



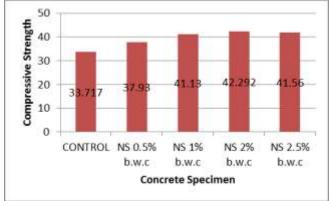
(c) compressive strength in 28 days with M20 Grade and 15% of Fly-ASH of Geopolymer Concret

different % of Nano-Silica	7	days	14	4 days	28 days		
& 15% Fly Ash	strength (mpa)	increase strength (%)	strength (mpa)	increase strength (%)	strength (mpa)	increase strength (%)	
CONTROL	32.11	-	33.717	-	35.316	-	
NS 0.5% b.w.c	34.88	8.62	37.93	12.49	38.94	10.26	
NS 1% b.w.c	36.188	12.70	41.13	21.98	41.856	18.51	
NS 2% b.w.c	39.53	23.11	42.292	25.43	42.728	20.98	
NS 2.5% b.w.c	37.641	17.22	41.56	23.26	42.292	19.75	

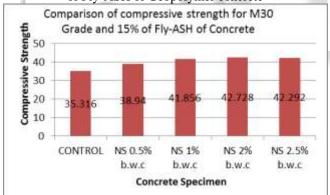
Table: Comparison of compressive strength for M30 Grade and 15% of Fly-ASH of Geopolymer concrete



(a) compressive strength in 7days with M30 Grade and 15% of Fly-ASH of Geopolymer concrete



(b) compressive strength in 7days with M30 Grade and 15% of Fly-ASH of Geopolymer concrete



(c) compressive strength in 7days with M30 Grade and 15% of Fly-ASH of Geopolymer concrete

The tables and graphs show that there is an improvement in the early strength of Geopolymer concrete blended with Fly-Ash Mix Nano-Silica but later the increase in strength is subdued.

## V. CONCLUSION

From the test results, the conclusions are justified in this section. The conclusions drawn are:

 From the compressive strength results, it can be observed that increase in compressive strength of Geopolymer concrete is observed on addition of a certain minimum quantity of Fly-Ash Mix nano SiO2. The increase in strength is maximum for NS 2% b.w.c and least for NS 0.5% b.w.c.  On addition of Fly-Ash Mix SiO2 there is a substantial increase in the early-age strength of Geopolymer concrete compared to the 28 day increase in strength.

## REFERENCES

- Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Mechanical properties of cement mortar with Al2O3 Fly-Ash Mixparticles. *Journal of American Science* 6(4), 94-97.
- [2] 2. Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz and Mohamad Amra Mohd Salleh (2010). Experimental investigation of the size effects of SiO2 Fly-Ash Mix particles on the mechanical properties of binary blended in Geopolymer concrete. *Composites: Part B 41*, 673-677.
- [3] 3. G.Quercia and H.J.H.Brouwers (2010). Application of Fly-Ash MixNano-Silica (nS) in in Geopolymer concrete mixtures. 8th fib PhD symposium in Kgs. Lyngby, Denmark.
- [4] 4. M.S. Morsy, S.H. Alsayed and M. Aqel. (2010). Effect of Fly-Ash Mix clay on mechanical properties and microstructure of Ordinary Portland Cement mortar. *International Journal on Civil Engineering & Environmental Engineeering IJCEE-IJENS Vol. 10 No.* 01.
- [5] 5. Shekari, A. H. and Razzaghi, M. (2011). Influence of Fly-Ash Mixparticles on durability and mechanical properties of SCC with GGBFS as binder. *Energy and buildings Vol.* 43, 995-1002.
- [6] 6. Givi, A. N. and Rashid, S. A. (2011). The effect of lime solution on the properties of SiO2 Fly-Ash Mixparticles binary blended in Geopolymer concrete. *Composites (Part B) Vol. 42*, 562-569.
- [7] 7. Chahal, Navneet and Rafat Siddique (2012). Influence of bacteria on the compressive strength, water absorption and rapid chloride permeability of in Geopolymer concrete incorporating siloca fume. *Construction and Building Materials 37*, 645-651.
- [8] 8. A.M. Said, M.S. Zeidan, M.T. Bassuomi and Y. Tian. (2012). Properties of in Geopolymer concrete incorporating Fly-Ash Mix-Nano-Silica. *Construction and Building Materials* 36, 838-844.
- [9] 9. Heidari, A., and Tavakoli, D. (Sept 2012). A study of mechanical properties on ground ceramic powder in Geopolymer concrete incorporating Fly-Ash Mix SiO2 particles. *Construction and Building Materials Vol. 38*, 255-264.
- [10] 10. Navneet Chahal and Rafat Siddique (2013). Permeation properties of in Geopolymer concrete made with fly ash and Nano-Silica fume: Influence of ureolytic bacteria. *Construction and Building Materials* 49, 161-174.