



DURABILITY STUDIES ON LIGHTWEIGHT FIBER REINFORCED CONCRETE BY INCORPORATING PALM OIL SHELLS

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Abstract

In this present research work, durability studies like Sulphide attack, Acid Attack, and Chloride Attack are studied for the lightweight fiber reinforced concrete (LWFRC) by incorporating palm oil Shells (POS). Fiber-reinforced concrete is achieved by introducing 0.5% ECR – Glass fibers to the volume of the concrete and it will improve the ductility. Coarse aggregates are replacing with POS up to 50% (0, 10, 20, 30, 40 and 50) to achieve the Light Weight Concrete (LWC). To reduce the greenhouses from cement industries, the Cement is replaced with Palm oil Fuel Ash (POFA) and Ground Granulated Blast furnace Slag (GGBS) up to 50% (0, 10, 20, 30, 40 and 50) separately. By using all ingredients LWFRC is prepared and tested for the chemical attacks.

Keywords : Light Weight Concrete, Fiber Reinforced Concrete, ECR – Glass Fibers, Sulphide Attack, Chloride Attack, Magnesium Attack, GGBS, POFA, POS, and Durability.

I. Introduction

Durability is the aptitude to oppose weathering act, chemical assault, abrasion or any other development of weakening to remain its unique form. The main durability problems in concrete counting alkali-aggregate response, chemical attacks, steel deterioration, and freeze and thaw behavior.

The durability of concrete depends largely on the transport properties, which generally are influenced by the pore system within the bulk of the cement matrix and also the zones near the aggregate–paste interface. The thermal conductivity of concrete augmented when cement pleased is enlarged. On the former tender, to diminish the cement pleased recommended the introduction of entrained air into the lightweight aggregate concrete mix.

II. Light Weight Fiber Reinforced Concrete (LWFRC)

Durability characteristics between polyvinyl alcohols treated OPS and underdone OPS concrete. In this investigation aggregates are replaced by PVA treated Oil Palm Shells which increases water absorption, VPV, chloride permeability

compared to raw OPS concrete. Also resistance to corrosion increases [II]. That aggregates are replaced by Oil Palm Shells which affects porosity, air permeability, and thermal conductivity. Due to higher volume fraction and large size of OPS porosity of OPSLC increases which acts as permeable. Hence results showed that OPSLC can be used as a lightweight concrete in construction [IV]. Almogradi explained the replacement of aggregates by date palm seeds which provide an alternative solution to stone aggregates. DPS is used in concrete which led to studies on lightweight aggregates in concrete. On investigation of durability studies of DPS aggregate concrete acts normal compared to conventional lightweight concrete.

Durability characteristics like water permeability, VPV, RCPT are better compared to conventional lightweight concrete. Resistance to corrosion can be enhanced when adequate cover and proper curing is adopted [III]. Increased workability of OPS HSLWC due to the addition of the age category of OPS aggregates. Due to the addition of silica fume to OPS HSLWC permeability decreases. Increase the density of concrete due to the addition of OPS. Water absorption also falls within the range of good concrete [XII]. The effects due to OPS aggregate in concrete. By growing the period of heat action of OPS aggregates increase workability. Compressive strength of warmth treated and non treated OPSC increases. Water amalgamation of heat-treated and not treated OPSC vary from 3.08 - 6.02%. Reduction shows the results improved for heat-treated OPSC compared to non treated OPSC [XIII].

Strength and frost resistant properties of properly heat treated concrete at a low down water-cement ratio. They have been experiential potency of low water-cement ratios heat-cured concrete has equal or better than conventionally cured concrete. In fresh concrete by the proper increase of delay in heat curing, the tensile strength increases due to reduction pore size thereby cracking and loss of strength also decreases [X]. The complete substitute of coarse aggregate with oil palm shells and compressive potency of concrete. Investigate the substitute of OPS from 10% to 40% with an interval of 10% with a water-cement ratio of 0.45 and 0.50 at an age of 7, 14 and 28 days of curing. The compressive strength decrease with the addition of OPS substitutes [XIV].

Performed properties of metakaolin on blended oil palm shells with lightweight concrete. Here, metakaolin replaced with cement at 5-20%. Compressive strength, flexural strength, and split tensile strength were done and maximum Strength was shown at 10% of replacement. Also, the strength efficiency of OPSC with MK has exhibits and max. The strength obtained at 20% of replacement [VI]. The oil palm shell as a coarse aggregate replacement based on mechanical and durability properties. Here, OPS was replaced from 0 to 100% with an interval of 20% with 7 and 28 days of curing. the results show that 60% of replacement shows max. Strength in comparisons with conventional concrete [XI]. The effect of the fly ash content towards sulfate resistance with lightweight concrete. Investigates that fly ash replaced with sand at 0.10.20, 30 and 40% subjected to sulfate solution with an era of 5 months. Maximum strength was obtained at 10% of fly ash with better sulfate confrontation [VII]. The mechanical and durability property of green star concrete. Green star concrete consists of blast furnace slag, second-hand coarse aggregate, concrete bathe water. Compressive strength, tensile strength, elastic modulus, water absorption, sorptivity, and chloride permeability are performed at 7 and 28 days of

curing. Results illustrate that the mechanical and durability properties of green star concrete are lesser while compare to organize concrete [V].

The water refrigerated copper slag aggregate of mechanical and durability properties of concrete. Here, water-cooled copper slag squander was incompletely or completely replaced with fine aggregate at two diverse water-cement ratios. Durability kind shows that water-cooled slag has variable belongings resulting in hardened properties of concrete. Therefore, water-cooled copper slag is considered as an appropriate fine aggregate for concrete [IX]. The mechanical and Microstructural properties of concrete with Agro-waste. Here, cement incompletely replaced with areca-nut shell, fine aggregates with coconut case powder and coarse aggregates with oil palm shell. Determination of Compressive, tensile, flexural and rapid chloride diffusion test with 28 days of curing. Best results show that 10% of areca nut ash, 5% of coconut shell charcoal powder, 5% of oil palm shell due to the attendance of CSH gel and $\text{Ca}(\text{OH})_2$ attribute on strength and former properties [I].

In this present research, POS introduced as coarse aggregates and POFA and GGBS are as binding in lightweight concrete and produced 12 – Concrete mixes. For all concrete mixes, chemical attacks are studied.

III. Mix Design

In this present works, the Mix is designed for M30 grade concrete. In this Concrete are the ingredients are Binding material (Cement, GGBS and POFA), Coarse aggregates (Gravel and POS), fine aggregates (River sand), fibers (ECR – Glass fiber), water (Portable water) and superplasticizer. The lightweight concrete is achieved with replacing of coarse aggregates with POS up to 50% (0%, 10%, 20%, 30%, 40% and 50%). In this work total, three types of concretes are used they are Normal Concrete (N1 and N2), Light Weight Fiber-reinforced Concrete (LWFRC) with GGBS (G1, G2, G3, G4, and G5) and Light Weight Fiber-reinforced Concrete (LWFRC) with POFA (P1, P2, P3, P4, and P5). The detailed notations are explained in Table: 1.

Table: 1 Percentage of Material replacements

MIX ID	CEMENT	GGBS	C.A	POS	FA	GF	W/C	SP
N1	100	0	100	0	100	0.00	0.45	0.01
N2	100	0	100	0	100	0.50	0.45	0.01
G1	90	10	90	10	100	0.50	0.43	0.01
G2	80	20	80	20	100	0.50	0.43	0.01
G3	70	30	70	30	100	0.50	0.43	0.01
G4	60	40	60	40	100	0.50	0.43	0.01
G5	50	50	50	50	100	0.50	0.43	0.01
P1	90	10	90	10	100	0.50	0.43	0.01
P2	80	20	80	20	100	0.50	0.43	0.01
P3	70	30	70	30	100	0.50	0.43	0.01
P4	60	40	60	40	100	0.50	0.43	0.01
P5	50	50	50	50	100	0.50	0.43	0.01

All the ingredients are experienced in a laboratory before mix design as per the Indian Standards. All mixes are calculated by using the IS code method of Mix design as per IS: 10262-2009 and IS 456-200. The mix percentages are tabulated in Table: 2.

Table: 2 Mix Quantities for all the Mixes

MATERIAL	MIX QUANTITIES (kg/m ³)											
	MIX ID											
	N1	N2	G1	G2	G3	G4	G5	P1	P2	P3	P4	P5
CEMENT	351	351	374	332	291	249	208	374	332	291	249	208
GGBS	0	0	42	83	125	166	208	0	0	0	0	0
POFA	0	0	0	0	0	0	0	42	83	125	166	208
C A	1234	1234	1061	941	822	704	585	1054	929	806	685	566
POS	0	0	52	103	155	206	257	51	102	152	201	249
F A	713	713	679	678	677	676	675	675	669	664	658	652
G F (0.5%)	0	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
S P (1%)	3.51	3.51	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15
WATER	158	158	178	178	178	178	178	178	178	178	178	178
W/C	0.45	0.45	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43

IV. Experimental Investigation

For durability studies standard sizes of cubes, 150 mm x 150 mm x 150 mm is equipped. The specimens are cast as per the standard procedure and leave hardening. After 24-hours the specimen is Demould and reserved for normal water curing. After 28 days of water curing, the specimens are taken out furthermore cleaned with running water and kept for 2-hours air drying. Before placing specimens for solutions curing the specimen's weights is taken. After that, the specimens are placed in Magnesium sulfate, Sodium chloride and Sulphuric acid solutions shown in Figure.1. After 28, 56 and 90 days of curing period in Magnesium sulfate, Sodium chloride, and Sulphuric acid solutions, and the specimens are taken out and cleaned with running water, after that kept for air drying. After air-drying, the weight of the specimens is recorded and tested for compressive strength. For each curing period on a standard of 3- cubes are experienced. Details of all attacks presented in table.3.

Table: 3 Details of Chemical Attacks

S.No	Acid attack	Sulfide Attack	Chloride Attack
Chemical	Sulphuric acid (H ₂ SO ₄)	Magnesium sulfate (MgSO ₄)	Sodium chloride (NaCl)
Percentage	3	5	3.5
pH Value	8	2	7

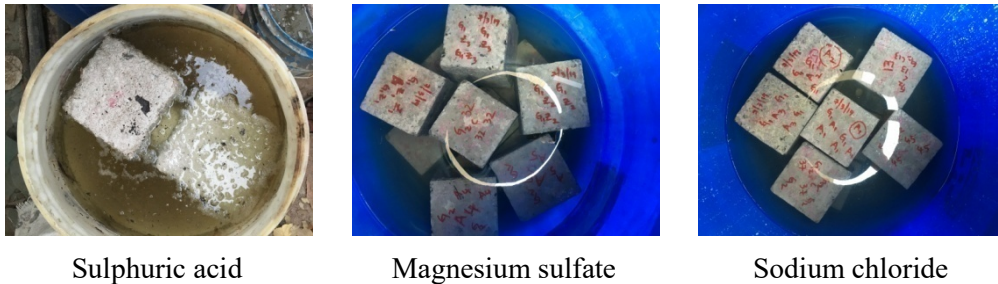


Fig:1 Chemical Curing

After all the experiments the results are initiated. From the above chemical attacks Weight variance, the compressive strength of the specimen's for individual attacks, strength variance and density variance are calculated.

a. Weight Variance:

All specimens (N1 to P5) cured in H_2SO_4 , $MgSO_4$ and $NaCl$ are weighed before curing and also weighed before testing for 28, 56 and 90 Days. Both the weights are compared for weight variance in all curing ages. The clear statistics represented as follows.

i. Acid Attack (H_2SO_4):

- Specimens which are cured in H_2SO_4 , they are losing their weight in all the mixes.
- Weight loss is increasing the coarse aggregates and binding material percentages are shown in Figure.2.
- It is observed in all the acid curing ages, specimens which are taken out, the coarse aggregates and POS are exposing to the environment shown in Figure.5.
- Binding material is replaced with POFA showing less weight loss compared to the GGBS replacement in all the curing ages.
- The weight loss is a minimum of 4.39% and a maximum of 20.28% in GGBS replacement. Whereas POFA replacement weight loss is a minimum of 0.1% and a maximum of 7.91%.

ii. Sulfide Attack ($MgSO_4$):

- It is observed that specimens that are cured in the $MgSO_4$ solution are gaining their weight after curing is represented in Figure.3.
- A maximum of 5.2% weight is gained in GGBS replacement and a maximum of 5.99% weight is gained in POFA replacement.

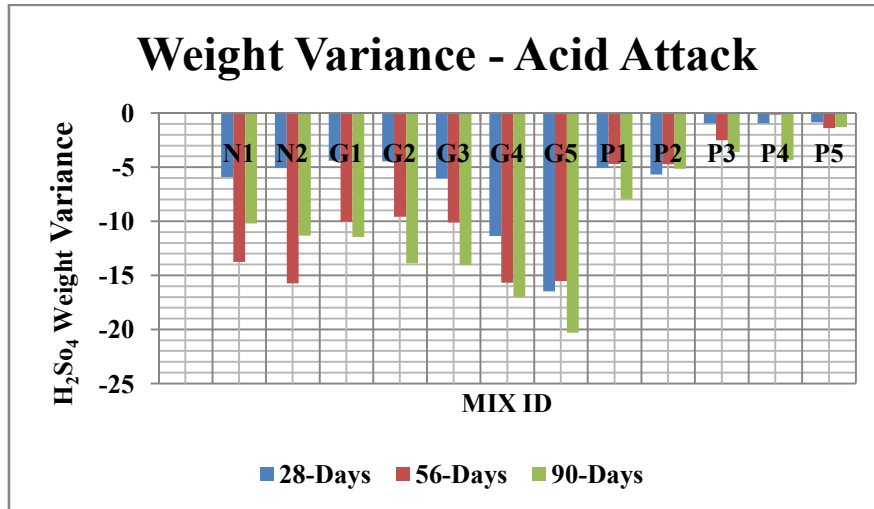


Fig: 2 Weight Variance - Acid Attack

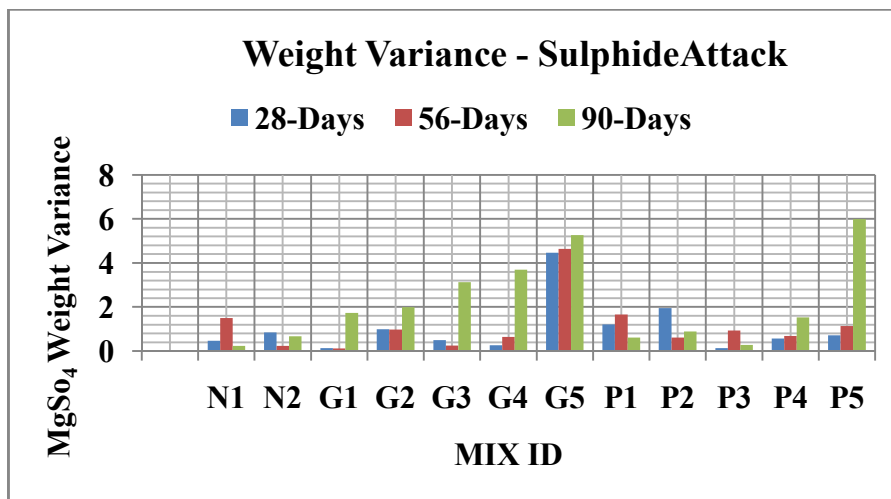


Fig: 3 Weight Variance – Sulphide Attack

iii. *Chloride Attack (NaCl):*

- It is observed that the specimens which are cured in the NaCl solution show the gained weight shown in Figure.4.
- In GGBS specimens the weight variance is maximum 6.197% and POFA specimens 5.96%
- The variance is more in GGBS specimens compared with POFA specimens.

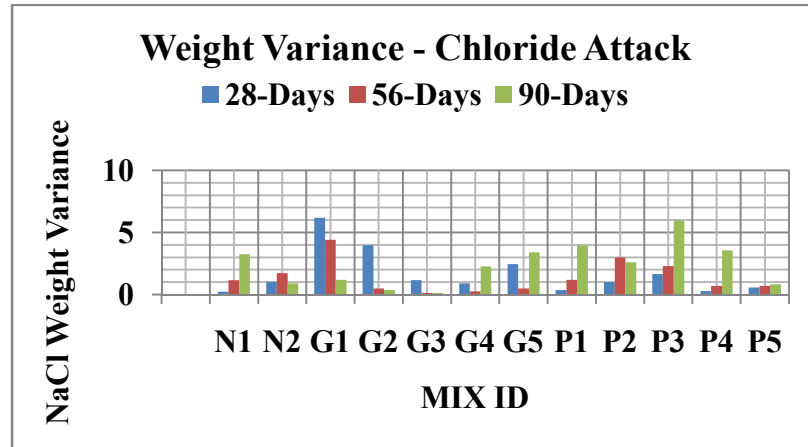


Fig:4 Weight Variance - Chloride Attack

b. Effect of Compressive strength:

The compressive strengths are calculated for different chemical attacks (H_2SO_4 , $MgSO_4$, and $NaCl$) for different curing periods under the Compressive Testing Machine (CTM) are shown in Figure 5. The clear statistics are plotted as follows.



Cube after Acid Curing



CTM

Fig:5 Acid Curing specimen Testing

i. Acid Attack (H_2SO_4):

The effect of acid attack is explained in Figure.6, the X-Axis is representing the Mix Id and the Y-Axis is Represented the Compressive strength. The compressive is calculated for 28, 56 and 90 days age of curing in Sulphuric acid.

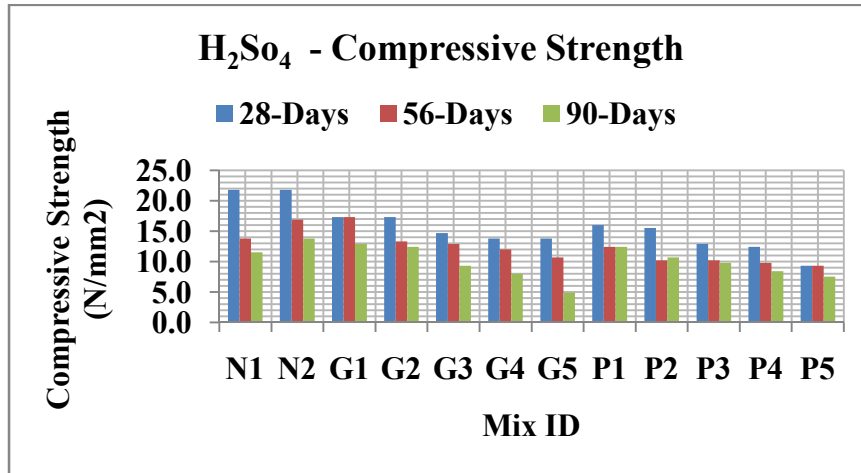


Fig:6 H₂SO₄ - COMPRESSIVE STRENGTH

ii. *Sulfide Attack (MgSO₄):*

The effect of the sulfide attack is explained in Figure.7, the X-Axis is representing the Mix Id and the Y-Axis is Represented the Compressive strength. The compressive is calculated for 28, 56 and 90 days age of curing in Magnesium sulfate.

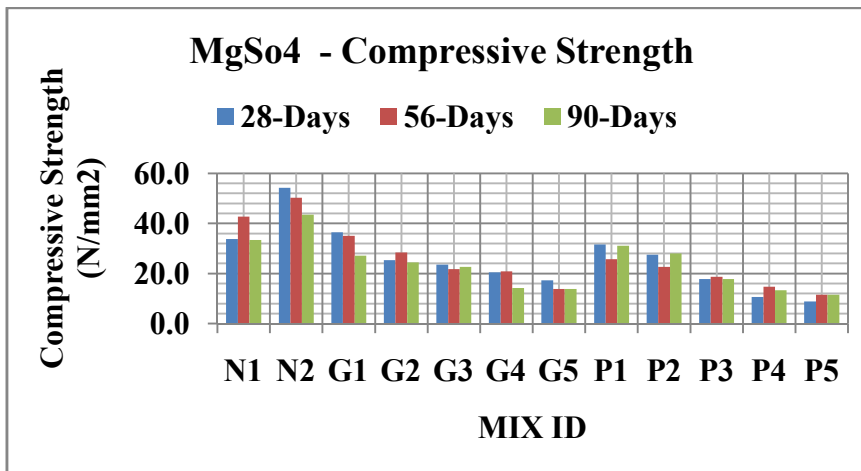


Fig: 7 MgSO₄ - Compressive Strength

iii. *Chloride Attack (NaCl):*

Effect of Chloride attack is explained in Figure.8, the X-Axis is representing the Mix Id and the Y-Axis is Represented the Compressive strength. The compressive is calculated for 28, 56 and 90 days age of curing in Sodium chloride.

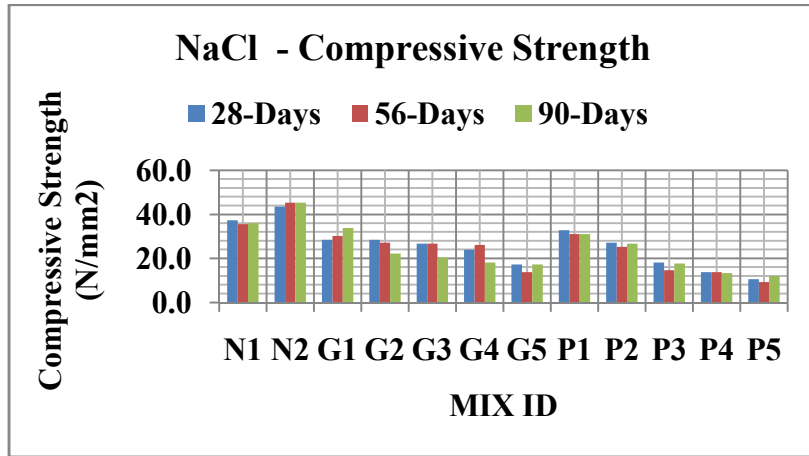


Fig:8 NaCl - Compressive Strength

C. Effect of Strength Variance:

The specimens which are cured in water and chemicals (H_2SO_4 , $MgSO_4$, and NaCl) tested for compression under CTM in all curing periods (28, 56 and 90 Days). The strength variance is calculated for both curing agents (Water and Chemicals). The clear statistics showed in Figure.9.

c. Effect of Density Variance:

The dry mass and Demould density are calculated separately designed for every 12- Mixes. The Density variance is calculated for all the curing agents and 90- Days curing periods. The clear statistics presented in Figure.10.

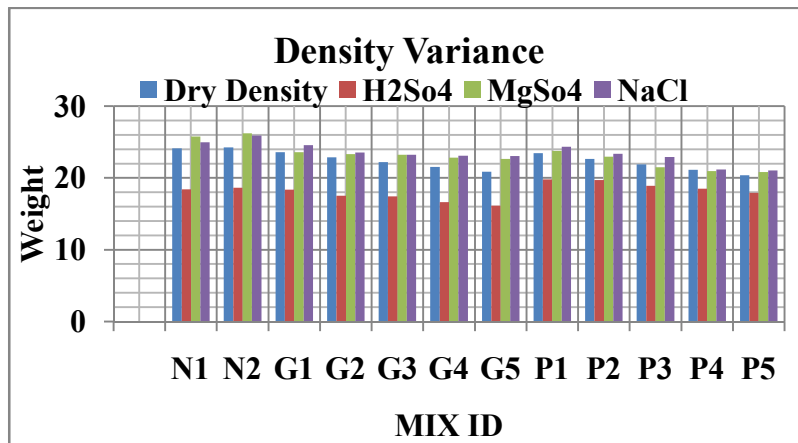


Fig: 10 Density Variance

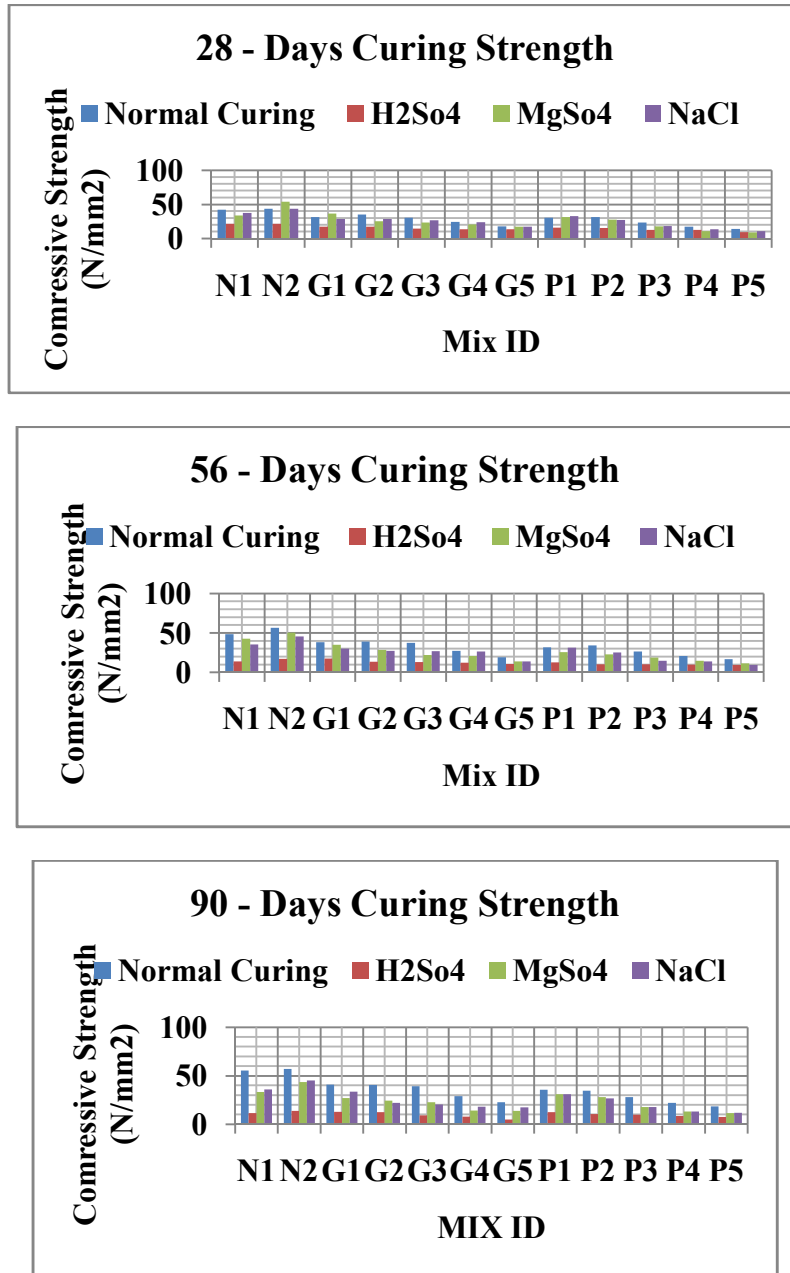


Fig: 9 Strength Variance

V. CONCLUSION

From above all durability studies for 12 – concrete mixes the following conclusions are drawn:

- a. To achieve the LWFRC up to 30% of POS replacement in coarse aggregates is recommended.

- b. Increase the percentage of replacement materials (POS, GGBS, and POFA) the density and strength are decreases.
- c. In Acid Attack the density is decreasing and for Sulphide and magnesium attacks increasing the density with curing age and percentage of POS.
- d. Almost in all the chemical attacks the compressive strength of concrete is less with comparing to the normal water curing.
- e. The LWFRCC is recommended for structural elements construction but up to 30% of POS replacement is allowed.

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