International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Experimental Study on Hardened State Properties of Self-Curing Concrete

K. Vishnu[1], K. Jagannatha Rao[2], V. Bhikshma[3]

[1]Research scholar, Department of Civil Engineering, University College of Engineering, Osmania University, Hyderabad, India.
[2]Professor & Head of Civil Engineering Department, Chaitanya Bharathi Institute of Technology, Hyderabad, India.
[3]Professor, Department of Civil Engineering, University College of Engineering, Osmania University, Hyderabad, India.

Abstract

Concrete is the mostly used construction material in the modern world. However, with the rise of urbanization, heavy use of concrete has started to threaten the humankind due to its disastrous effect on environment. Steel and concrete industries are one of the major CO2 producing industries. Statistics show that an average person uses 1 m3 of concrete in a year making it the most used material and the cement production on global scale may reach 4800 Million Metric tons by 2030 and India being the second largest producer in 2018 with 290 million metric tons. To control this a new environment-friendly structural materials should be utilized instead of ordinary concrete to cope with environmental problems. This has led to the search for alternate sustainable materials to replace Cement.

With good success, mineral admixtures have been used to partially replace cement. The technical advantage of using these mineral admixtures is the improvement of many properties in the fresh and hardened phases, including enhanced durability in acidic environments and higher ultimate strength of Concrete. GGBS (Ground granulated blast furnace slag) reaction is both hydraulic and pozzolanic because of the particle shape and increased hydration, GGBS concrete has greater particle packing.

Curing of concrete place a major role on strength development and durability of concrete. Improper curing can affect the concrete performance and durability easily. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. Water is maximum utilized commodity and because of this the day- by-day level of the water table is going down. If water has to be purchased for construction works, the cost of construction rises much higher. Also, in case of concreting works done at heights, vertical members, sloped roofs and pavements, continuous curing is very difficult.

The performance of self-curing concrete using PEG as self-curing agent with different molecular weights concluded that addition of hydrophilic chemicals in water which is mixed in concrete reduces the evaporation of water.

The research identifies Durability properties of the concrete higher for mix C20G1.5P at 7, 14, and 28 days for M20 and M40 grades, However, for the M60 grade, the mix ratio C10G1P demonstrates the highest strength, suggesting the influence of concrete grade in combination with Ground Granulated Blast Furnace Slag (GGBS) and Polyethylene Glycol (PEG 400). Increasing the supplementary cementitious material and self-curing agent strength and durability of concrete increases and up to certain point and then decreases. In addition, the micro structural analyses have been carried out for specimens of optimum level using the Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD).

Keywords: Supplementary cementitious Self-curing concrete; Conventional concrete; Polyethylene glycol (PEG-400); GGBS; Durability

I INTRODUCTION

1.1 General

In the present world, concrete is one of the most widely used construction materials. This can be due not alone to the large choice of applications that it offers, however, besides, its behavior, strength, affordability, durability, and flexibility play vital roles. Therefore, constructing- building works have faith in concrete as a secure, strong, and simple object. It is utilized in all sorts of buildings (from residential to multi-story workplace blocks) and infrastructure. Concrete like other engineering materials needs to be designed for properties like strength, durability, workability. With advent of new generation admixtures, it is possible to achieve higher strength of concrete with high workability levels economically. Curing is the maintaining of a satisfactory moisture content and temperature in concrete during its early stages so that desired properties (of concrete) may develop. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete.

1.2 Self-curing of concrete using self-curing agents

In the current concrete industry, self-curing of concrete has gained a lot of reputation among the available curing techniques. Apart from having the comfort of not using water, Self-Curing concrete offers many advantages over conventional concrete. It includes the quality, durability and strength of concrete while reducing the shrinkage. The included Self-Curing agents utilize the internal water inside the concrete for curing purposes. A proper composition of coarse aggregates and Self-Curing agents are required to achieve the optimum curing process.

1.3 Objectives

Keeping in view of requirement of the need for study, the following aims and objectiveshave been set out.

- To study the Sulfuric acid effect on self-curing concrete and compare with conventional concrete.
- To study the Sodium chloride effect on self-curing concrete and compare with conventionalconcrete.
- To study the chloride penetration in to self-curing concrete and compare with conventionalconcrete.
- To study the water penetration of self-curing concrete and compare with conventional concrete.

II LITERATURE REVIEW

The use of self-curing agents in concrete has gained significant attention in recent years due to their potential to enhance the durability and performance of concrete structures. To evaluate the effectiveness of self-curing concrete, various tests have been conducted to assess its properties and durability. This literature review provides an overview of the common tests used for evaluating the durability of self-curing concrete, highlighting their significance and findings.

Sowdambikai S et al. (2021) reported on experimental and analytical study onproperties of self-curing concrete. An improved mechanical property was found in specimens were cured under air than in water. The retained water helps in hydration process of cement resulting in reduced pores and voids and greater bonding between molecules. The Compressive strength is increased up to 13% on an average. The highest value of split tensile strength is 3.68N/ mm2 when 1.5% PEG is added. The strength increases by 21.85% from the conventional concrete to self-curing concrete.

Rachana L et al., (2021) impact of self-curing chemical on GGBS replacement's concrete's mechanical qualities. Curing is important for the development of concrete's strength; adequate curing is required to achieve the desired strength. The specimens for mixtures containing polyethylene glycol 400 as a self-curing agent are set aside and air cured at room temperature. At age 7 days, compressive strength has increased by 15.4%. Cementitious material, fine aggregate, coarse aggregate, and water are the basic components of concrete. Different amounts of Polyethylene Glycol 400 (0.2, 0.3, and 0.4%) by weight of cement and cement are employed as self-curing agents. 40% of the cement in M20 and M35 grades of concrete was replaced with GGBS, which produced good strength.

George Jasmine et al. in (2021) Concrete is one of the most widely utilized building materials in the world, which is understandable given how much it has altered the appearance of rural areas. Five forms of conventional curing are commonly categorized. Results for all four blends' compressive strength and workability are compared in this section. Compared to concrete mix with conventional curing, self-curing concrete's compressive strength rose by 13%. The concrete will have the maximum early age strength when poly-vinyl alcohol is added as a curing component, followed by poly-ethylene glycol- 400 and liquid paraffin wax.

Kumar C et al. (2021) reported that according the Compressive strength of concrete of M30 Grade with water-binder ratio as 0.40 and mix proportion of 1 : 2.12 : 3.75 with addition of self-curing agents PEG as 1%. As the blended self-curing concrete mix which exhibits the amount of heat of hydration have been increased steadily with time. M30 concrete mixes blended with 65 % OPC +25 % FA +10 % Ground Granulated Blast Furnace Slag optimally blended mix grade tends to produce both necessaryworkability and predicted compressive strengths. Either GGBS and Silica fume will be incorporated to optimize the opportunities of micro-filler functionality in M30 grade fly ash integrated concrete mixes.

Ali khan R et al., (2022) in this study, calcium lignosulfonate was used as a self-curing agent. The hardened concrete with and without calcium lignosulfonate was cured at ambient conditions and the properties were compared. The results show an increase in the slump with the increase in calcium lignosulfonate. However, 0.3% calcium lignosulfonate is identified as the optimum and the durability under a saline environment is studied.

III EXPERIMENTAL PROGRAME

MATERIALS USED

The different materials used in this investigation are

3.1 Cement: Cement used in the investigation was 53 grade ordinary Portland cement confirming IS: 12269: 1987.

3.2 Fine aggregate: The fine aggregate used was obtained from a nearby river source. The fine aggregate conforming to zone II according to IS: 383-1970 was used.

3.3 Coarse aggregate: Crushed granite was used as coarse aggregate. The coarse aggregate according to IS: 383-1970 was used. Maximum coarse aggregate size used is 20 mm.

3.4 Water: Potable water was used in the experimental work for both mixing and curing purposes.

3.5 Ground Granulated Blast Furnace Slag

Blast furnace slag is produced as byproduct during iron production. Iron ore, as well as scrap iron, is reduced to a molten state by burning coke fuel with fluxing agents of limestone or dolomite. The molten slag from the furnace is rapidly chilled by quenching in water to form glassy sand like material. GGBS is produced by grinding the granulated slag to less than 45µm size to obtain a fineness of 400-600 m2/kg. For the present study, GGBS is obtained from M/s. JSW steel works Ltd., Coimbatore, India.

3.4 Polyethylene Glycol-400: Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula $H(OCH_2CH_2)nOH$, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weight. One common feature of PEG appears to be the water-soluble nature. The PEG-400 use in the investigation have Molecular Weight 400.

3.6 Super Plasticizer: Conspalt SP 430 used as a Super plasticizer.

3.7 Research Methodology

The experimental program was designed to investigate the strength of self-curing concrete by adding poly ethylene glycol PEG400 @0%, 0.5%, 1%, 1.5% and 2% by weight of cement to the concrete and Ground granulated blast furnace slag (GGBS) @0%, 10%, 20%, 30% and 40% replaced cement by weight. The experimental program was aimed to study the durability studies of M20, M40 and M60 Grade of concrete.

Table 1: Mixes M20, M40 and M60 were considered.

Grade of Concrete	Cement	Fine aggregate	Coarse aggregate	Water	GGBS	Polyethylene glycol (PEG)	Super plasticizer
M20	320	739	1200	160	0-40	0 -2	-
M40	394	679	1226	150	0-40	0 -2	-
M60	534	609	1194	144	0-40	0 -2	1%

Table 2 : Mix Notations for M20, M40 and M60 type of Concrete

Mix type	Cement (%)	GGBS (%)	PEG 400 (%)
C00G00P	100	00	00
C00G0.5P	100	00	0.5

C00G1.0P	100	00	1.0
C00G1.5P	100	00	1.5
C00G2.0P	100	00	2.0
C10G00P	90	10	00
C10G0.5P	90	10	0.5
C10G1.0P	90	10	1.0
C10G1.5P	90	10	1.5
C10G2.0P	90	10	2.0
C20G00P	80	20	00
C20G0.5P	80	20	0.5
C20G1.0P	80	20	1.0
C20G1.5P	80	20	1.5
C20G2.0P	80	20	2.0
C30G00P	70	30	00
C30G0.5P	70	30	0.5
C30G1.0P	70	30	1.0
C30G1.5P	70	30	1.5
C30G2.0P	70	30	2.0
C40G00P	60	40	00
C40G0.5P	60	40	0.5
C40G1.0P	60	40	1.0
C40G1.5P	60	40	1.5
C40G2.0P	60	40	2.0

3.8 TESTING

3.8.1 Acid Attack Test

Acid attack test was carried out on 150X150X150 mm concrete cubes after 28 days of curing Cube specimens were weighed and immersed in water diluted with 3% H_2SO_4 (by weight) for 28 days and 90 days continuously. Then, the specimens were taken out from the acid solutions and surfaces of the cubes were cleaned. Again, the weight loss of the specimens was found out, the percentage changes in weight and strength loss for 28 days and 90 days were also calculated.

3.8.2 Chloride Attack Test

Chloride attack test was carried out on 150X150X150 mm concrete cubes after 28 days of curing. Cube specimens were weighed and immersed in 3% NaCl solution (by weight) for 28 days and 90 days continuously. Then, the specimens were taken out from the acid solutions and surfaces of the cubes were cleaned. Again, the weight loss of the specimens was found out, the percentage changes in weight and strength loss for 28 days and 90 days were also calculated.

3.8.3 Rapid Chloride Ion Penetration Test

According to ASTM C1202, test was carried out on 100 mm diameter and 50 mm thick concrete cylinnder. The side of 50 the cylindrical specimen was coated with epoxy, and after the epoxy was dried, it was put in a vacuum chamber for three hours. The specimen was vacuum saturated for one hour and allowed to soak in solution for 18 hours. It was then placed in the test device. The left-hand side (–) of the test cell was filled with 3% NaCl solution. The right-hand side (+) of the test cell was filled with 0.3 N NaOH solution. The system was then connected and a 60- volt potential was applied for 6 hours. Readings were taken at every 30 minutes intervals. At the end of six hours the sample was removed from the cell and the amount of charge passed through the specimen was calculated.

Charge passed (Coulombs)	Rapid Chloride ion permeability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible

$$Q = 900[I_0+2(I_{30}+I_{60}+\ldots\ldots\ldots\ldots I_{300}) +I_{360}]$$

Where Q = Charge Passed (Coulombs)

I0 = Current (amperes) instantly behind voltage is applied,

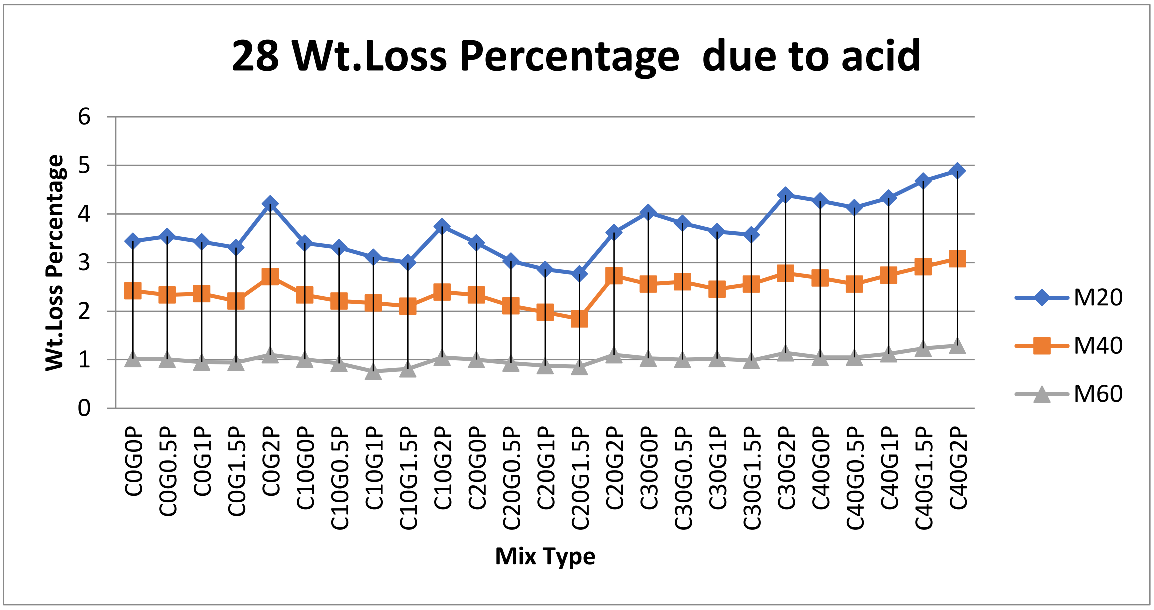
It = Current (amperes) at t Min. following voltage is applied

3.8.4 Water Penetration Test

Prepare concrete specimens of size 150 mm x 150 mm x 150 mm. Cure the concrete specimens under standard laboratory conditions for a specified period, typically 28 days. After curing period apply a suitable sealant or epoxy coating to the sides of the specimens to prevent water leakage during testing. Penetration test apparatus which typically consists of a testing cell, water reservoir, pressure system. Fill the water reservoir with distilled water. Apply a constant pressure, typically 5 kg/cm^2 to the testing cell using the pressure system. Allow the water to flow through the specimen for a specified duration, usually 72 hours. During the test, monitor and record the volume of water passing through the specimen at regular intervals using the data acquisition system. Remove the specimens after 72 hours and test in compressive testing machine by keeping steel rod on the top of specimen. Break the specimens into two parts and mark water depth penetration. Use scale to measure depth of penetration in millimetres.

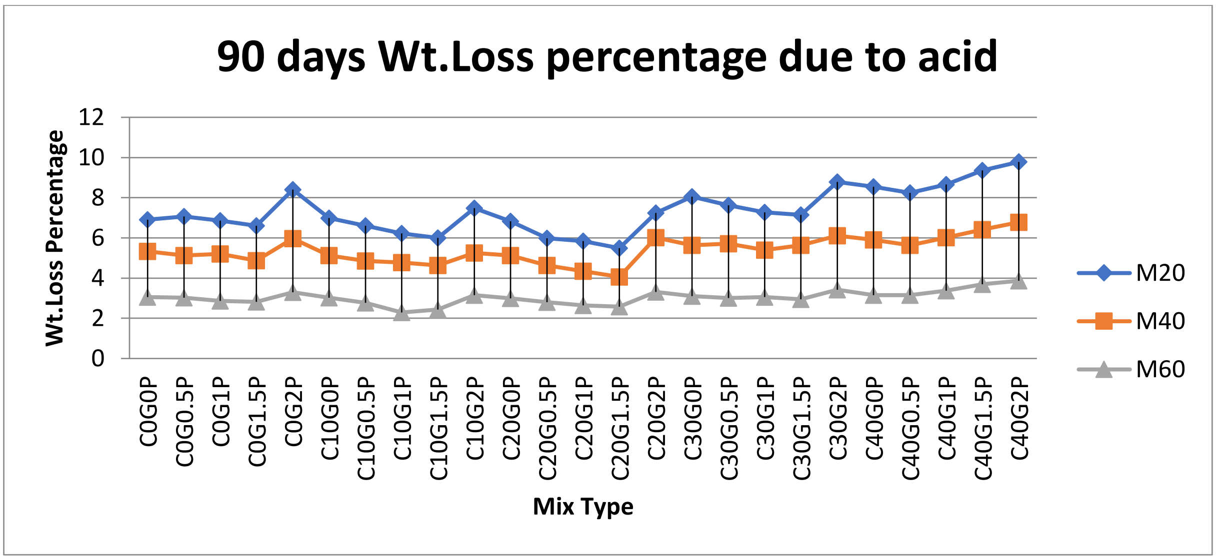
International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

IV RESULTS AND DISCUSSIONS



Comparison of Acid Resistance Wt.loss percentage for 28 Days for M20, M40 and M60 grade of concrete

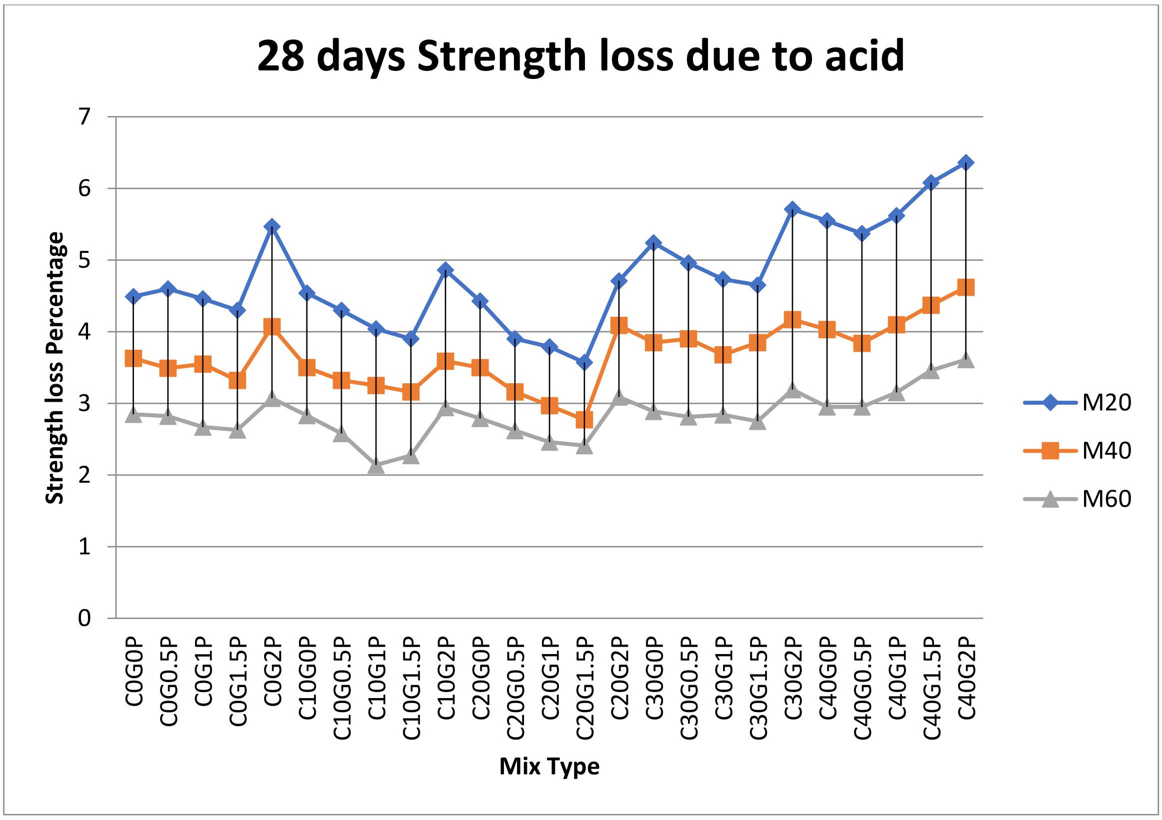
The weight loss percentage due to immersion in acid of all the specimens of various replacement levels of GGBS and addition of PEG400 with cement has been tested at ages of 28 days after immersion in acid. From the above table and graph, it is noticed that weight loss percentage decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. Weight loss percentage decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum weight loss percentage observed at C20G1.5P, 2.77% for M20, 1.84% for M40 grade of concrete and at C10G1P got minimum weight loss percentage 0.76% for M60 Grade of concrete. With increasing grade of concrete its weight loss percentage decreases.



Comparison of Acid Resistance Wt.loss percentage for 90 Days for M20, M40 and M60 grade of concrete

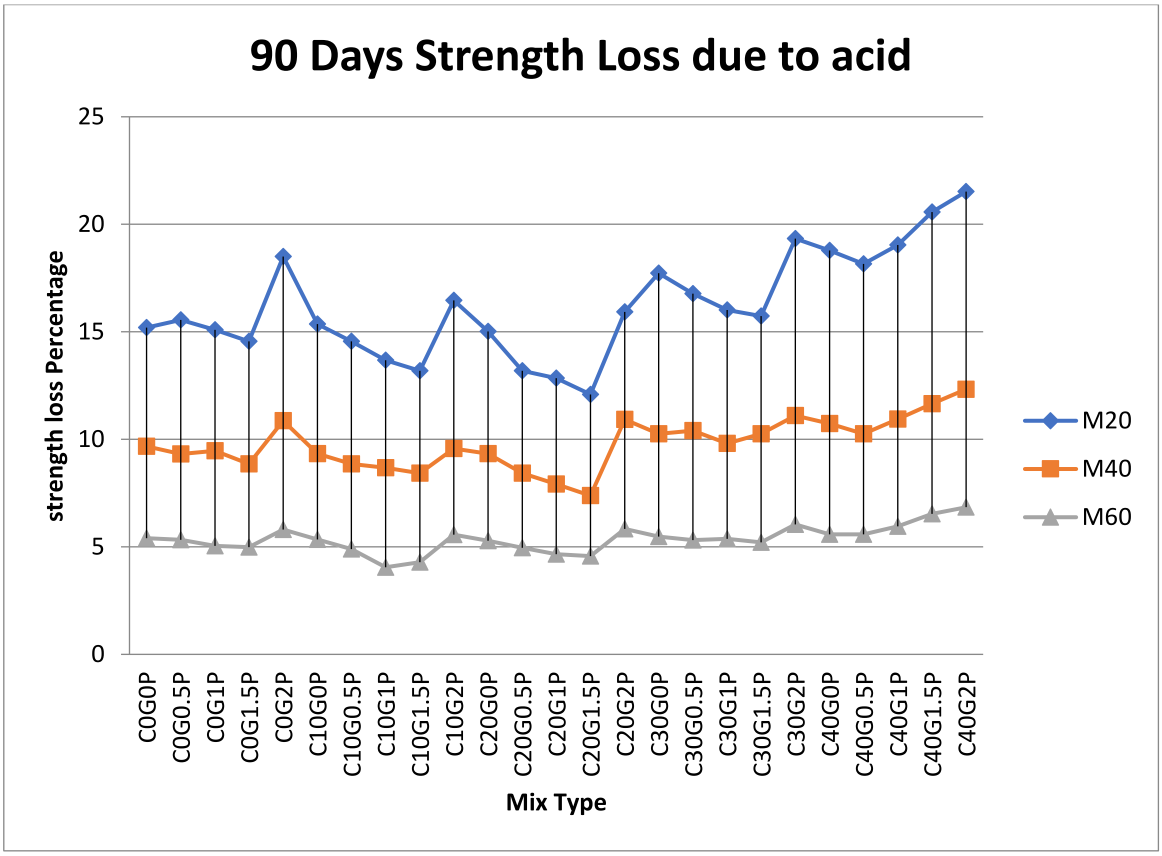
International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

At 90 days after being put in acid, all of the samples with different percentages of GGBS replacement and PEG400 addition have been checked for the percentage of weight loss caused by the acid. From the table and graph above, we can see that the percentage of weight loss decreases as the percentage of GGBS and PEG 400 increases up to 20% GGBS and 1.5% PEG400. After that, the percentage of weight loss increases as the percentage of GGBS and PEG 400 increases for M20 and M40 grade concrete. For M60 grade concrete, the weight loss rate goes down as the percentage of GGBS and PEG 400 goes up up to 10% GGBS and 1% PEG400. After that, it goes up as the percentage of GGBS and PEG 400 goes up. The least percentage of weight loss was seen at C20G1.5P, where it was 5.49 percent for M20, 4.06 percent for M40, and 2.58 percent for M60. At C10G1P, the least percentage of weight loss was 2.29 percent for M60. As the grade of concrete goes up, the rate of weight loss goes down.



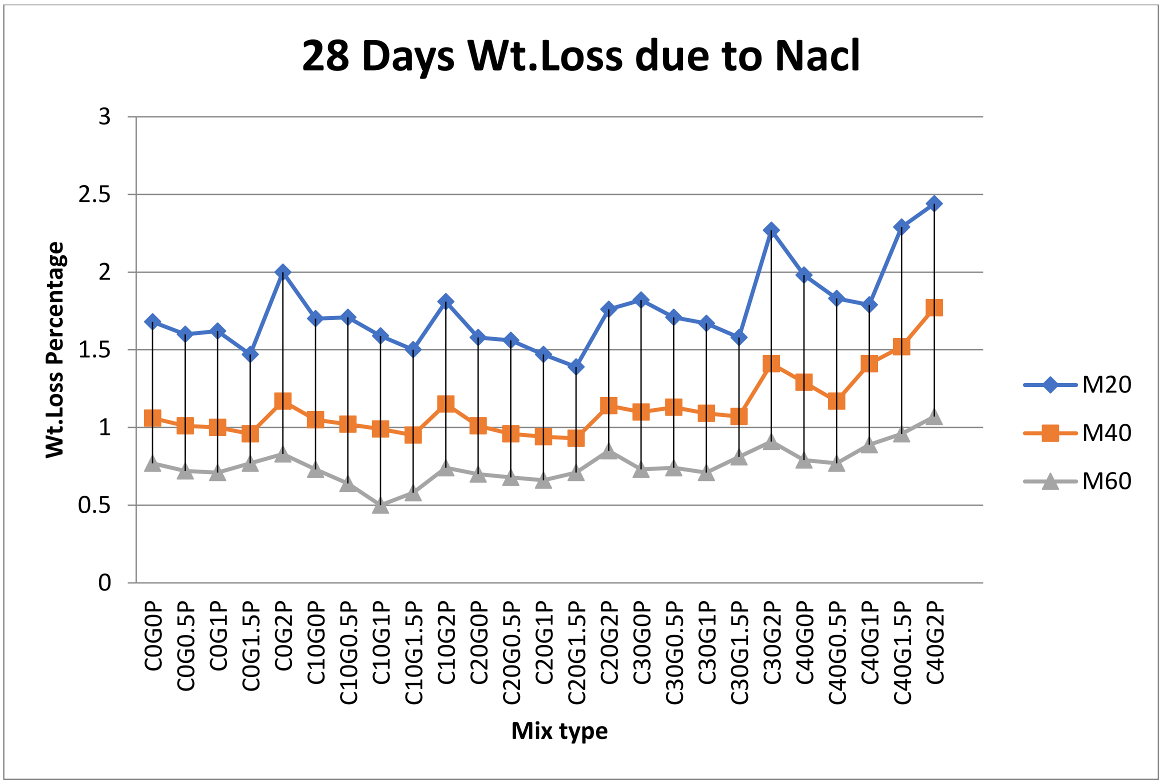
Comparison of Acid Resistance Strength loss percentage for 28 Days for M20, M40 and M60 grade of concrete

The strength loss percentage due to immersion in acid of all the specimens of various replacement levels of GGBS and addition of PEG400 with cement has been tested at ages of 28 days after immersion in acid. From the above table and graph, it is noticed that strength loss percentage decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. Strength loss percentage decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum strength loss percentage observed at C20G1.5P, 3.57% for M20, 2.77% for M40 grade of concrete and at C10G1P got minimum strength loss percentage 2.14% for M60 Grade of concrete. With increasing grade of concrete its strength loss percentage decreases.



Comparison of Acid Resistance Strength loss percentage for 90 Days for M20, M40 and M60 grade of concrete

The strength loss percentage due to immersion in acid of all the specimens of various replacement levels of GGBS and addition of PEG400 with cement has been tested at ages of 90 days after immersion in acid. From the above table and graph, it is noticed that strength loss percentage decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. Strength loss percentage decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum strength loss percentage observed at C20G1.5P, 12.09% for M20, 7.38% for M40 grade of concrete and at C10G1P got minimum strength loss percentage 4.05% for M60 Grade of concrete. With increasing grade of concrete its strength loss percentage decreases.

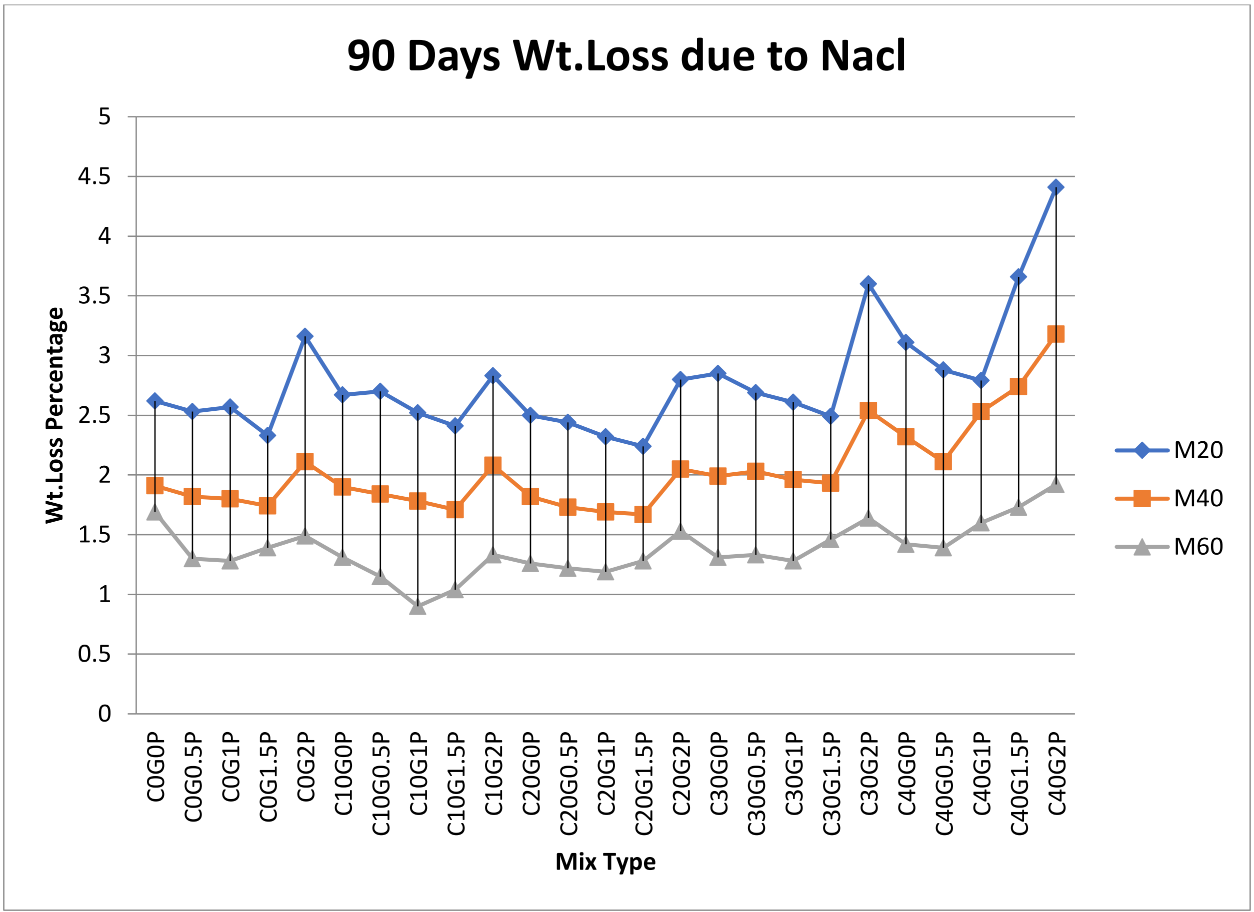


Comparison of Sodium chloride Resistance Wt.loss percentage for 28 Days for M20, M40 and M60 grade of concrete

After 28 days of immersion in NaCl solution, the weight loss % that was caused by immersion in NaCl solution and evaluated on all of the specimens of varied replacement levels of GGBS and additions of PEG400. It can be seen from the table and graph that are shown above that the percentage of weight loss drops as the percentage of GGBS and PEG 400, but after reaching 20% GGBS and 1.5% PEG400, the percentage of weight loss rises along with the rising dose of GGBS and PEG 400 for M20 and M40 grade concrete. For M60 grade of concrete, the percentage of weight loss falls as the percentage of GGBS and PEG 400 added rises up to 10% GGBS and 1.0% of PEG400; beyond that, the percentage of weight loss increases as the percentage of GGBS and PEG 400 added grows. At C20G1.5P, the percentage of minimum weight loss was recorded; it was 1.39% for M20 grade of concrete, 0.93% for M40 grade of concrete, and at C10G1P, the percentage of minimum weight loss was 0.50% for M60 grade of concrete. The proportion of the concrete's weight that is lost drops with each grade that is added.

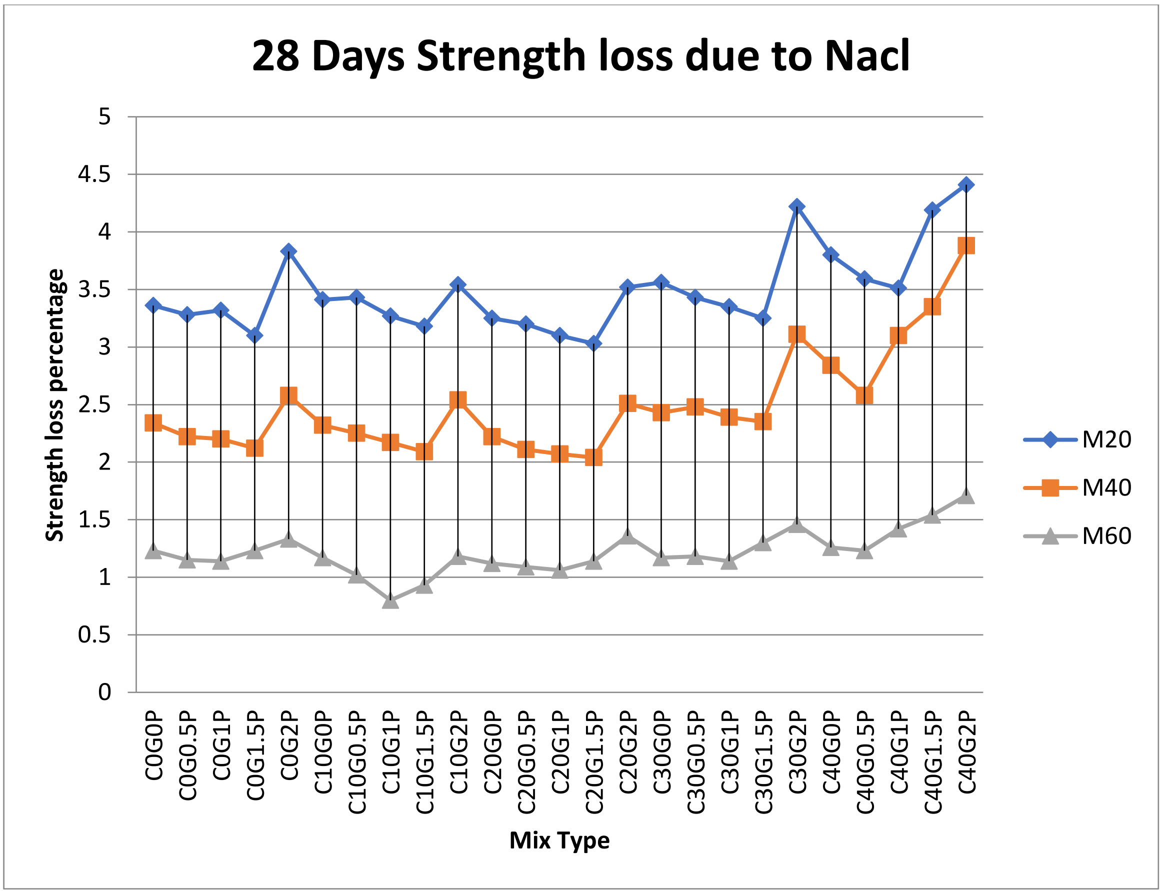
International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com



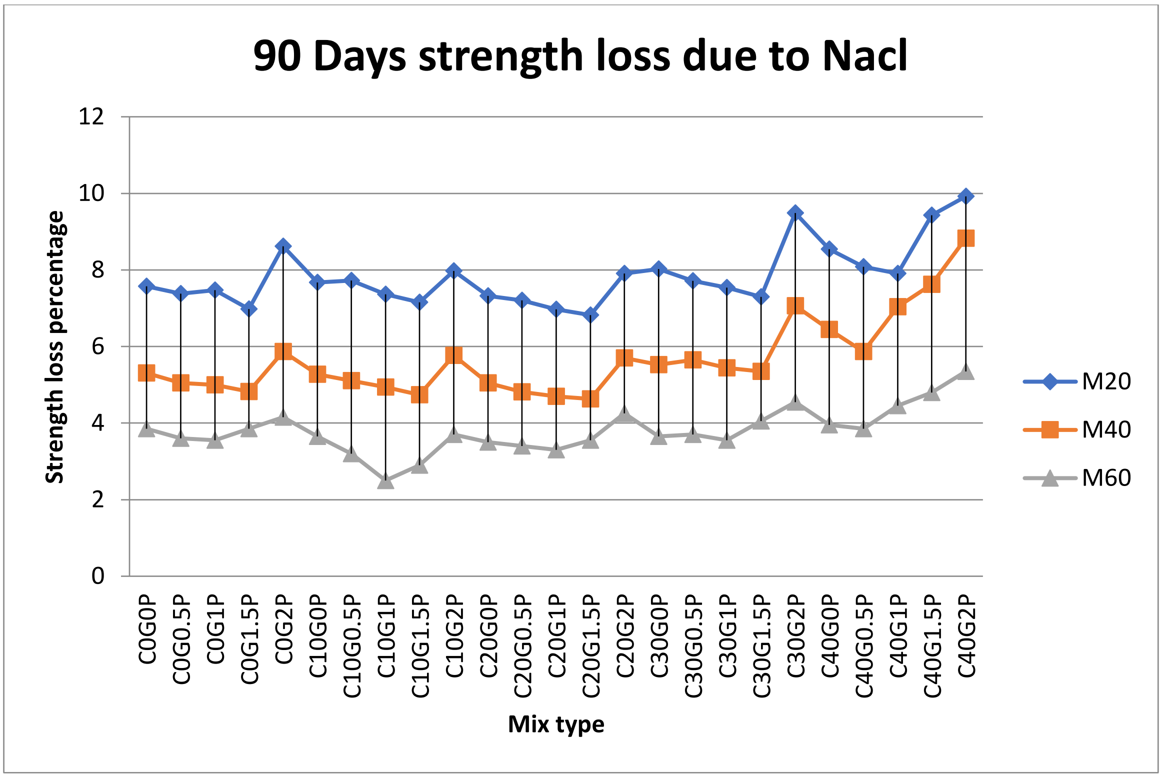
Comparison of Sodium chloride Resistance Wt.loss percentage for 90 Days for M20, M40 and M60 grade of concrete

The Weight loss percentage due to immersion in Nacl solution of all the specimens of various replacement levels of GGBS and addition of PEG400 with cement has been tested at ages of 90 days after immersion in Nacl solution. From the above table and graph, it is noticed that weight loss percentage decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. Weight loss percentage decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum weight loss percentage observed at C20G1.5P, 2.24% for M20, 1.67% for M40 grade of concrete and at C10G1P got minimum weight loss percentage 0.90% for M60 Grade of concrete. With increasing grade of concrete its weight loss percentage decreases.



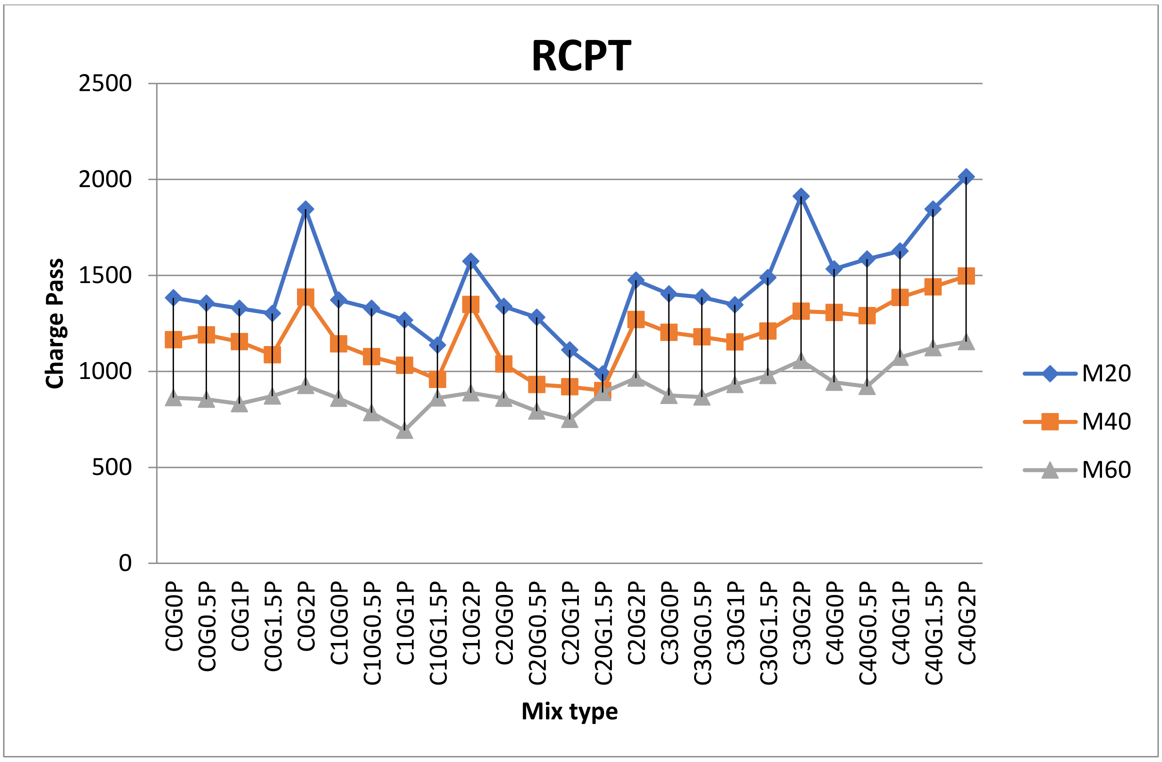
Comparison of Sodium chloride Resistance Strength loss percentage for 28 Days for M20, M40 and M60 grade of concrete

The strength loss percentage due to immersion in NaCl solution of all the specimens of various replacement levels of GGBS and addition of PEG400 with cement has been tested at ages of 28 days after immersion in NaCl solution. From the above table and graph, it is noticed that strength loss percentage decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. Strength loss percentage decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum strength loss percentage observed at C20G1.5P, 3.03% for M20, 2.04% for M40 grade of concrete and at C10G1P got minimum strength loss percentage 0.80% for M60 Grade of concrete. With increasing grade of concrete its strength loss percentage decreases.



Comparison of Sodium chloride Resistance Strength loss percentage for 90 Days for M20, M40 and M60 grade of concrete

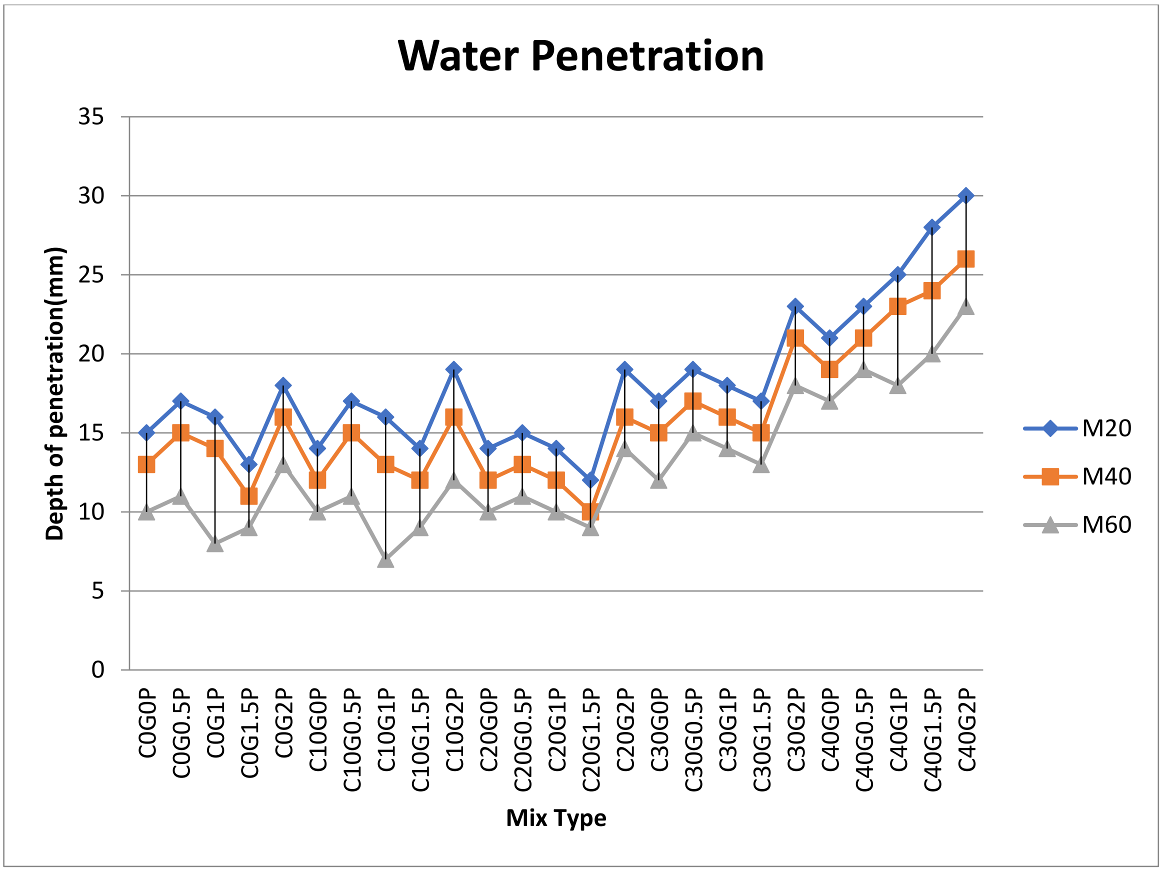
At 90 days after immersion in NaCl solution, all of the samples with different percentages of GGBS replacement and PEG400 addition to cement were tested for the percentage of strength loss due to immersion in NaCl solution. From the table and graph above, we can see that the percentage of strength loss drops as the percentage of GGBS and PEG 400 increases up to 20% GGBS and 1.5% PEG400. After that, the percentage of strength loss increases as the percentage of GGBS and PEG 400 increases for M20 and M40 grade concrete. For M60 grade concrete, the percentage of strength loss goes down as the percentage of GGBS and PEG 400 goes up up to 10% GGBS and 1% PEG400. After that, it goes up as the percentage of GGBS and PEG 400 goes up. The least percentage of strength loss was seen at C20G1.5P, which was 6.82% for M20, 4.63 % for M40 grade of concrete, and 2.50 % for M60 grade of concrete at C10G1P. As the grade of concrete goes up, the percentage of strength loss goes down.



Comparison of RCPT for M20, M40 and M60 grade of concrete

In rapid chloride penetration experiment it was proved that using of GGBS and PEG400 prevent chloride ions permeability more compared to normal concrete. Accordance to increased replacement of GGBS and PEG400 may be resulted in less charge passed values, which reduces along with increase in curing period. The charge passing for all the specimens of various replacements levels of GGBS and addition of PEG400 with cement has been tested at ages of 28 days of casting. From the above table and graph, it is noticed that charge passing decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. charge passing decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum charge passing observed at C20G1.5P, 986 for M20, 900 for M40 grade of concrete and at C10G1P got minimum charge passing 692 for M60 Grade of concrete. With increasing grade of concrete the charge passing through concrete decreases.

International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com



Comparison of Depth of penetration for M20, M40 and M60 grade of concrete

The depth of water penetration for all the specimens of various replacements levels of GGBS and addition of PEG400 with cement has been tested at ages of 28 days of casting. From the above table and graph, it is noticed that depth of water penetration decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M20 and M40 grade of concrete. Depth of water penetration decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases with increasing dosage of GGBS and PEG 400 for M60 grade of concrete. Minimum depth of water penetration observed at C20G1.5P, 12 mm for M20, 10 mm for M40 grade of concrete and at C10G1P got minimum depth of water penetration 7 mm for M60 Grade of concrete. With increasing grade of concrete the depth of water penetration of concrete decreases.

V CONCLUSIONS

The following conclusions can be drawn from the experimental investigation

1. For M20 grade of concrete (C20G1.5P) weight loss due to immersed in sulphuric acid for 28 and 90 days are 2.77% and 5.49%. Similarly strength loss 3.57% and 12.09% reduced and for conventional concrete weight loss for 28 and 90 days are 3.44% and 6.90%. Similarly strength loss 4.49% and 15.19% reduced.
2. For M40 grade of concrete (C20G1.5P) weight loss due to immersed in sulphuric acid for 28 and 90 days are 1.84% and 4.06%. Similarly strength loss 2.77% and 7.38% reduced and for conventional

concrete weight loss for 28 and 90 days are 2.42% and 5.33%. Similarly strength loss 3.63% and 9.68% reduced.

3. For M60 grade of concrete (C10G1.0P) weight loss due to immersed in sulphuric acid for 28 and 90 days are 0.76% and 2.29%. Similarly strength loss 2.14% and 4.05% reduced and for conventional concrete weight loss for 28 and 90 days are 1.02% and 3.06%. Similarly strength loss 2.85% and 5.40% reduced
4. For M20 grade of concrete (C20G1.5P) weight loss due to immersed in sodium chloride for 28 and 90 days are 1.39% and 2.24%. Similarly strength loss 3.03% and 6.82% reduced and for conventional concrete weight loss for 28 and 90 days are 1.68% and 2.62%. Similarly strength loss 3.36% and 7.57% reduced
5. For M40 grade of concrete (C20G1.5P) weight loss due to immersed in sodium chloride for 28 and 90 days are 0.93% and 1.67%. Similarly strength loss 2.04% and 4.63% reduced and for conventional concrete weight loss for 28 and 90 days are 1.06% and 1.91%. Similarly strength loss 2.34% and 5.31% reduced
6. For M60 grade of concrete (C10G1.0P) weight loss due to immersed in sodium chloride for 28 and 90 days are 0.5% and 0.9%. Similarly strength loss 0.8% and 2.50% reduced and for conventional concrete weight loss for 28 and 90 days are 0.77% and 1.69%. Similarly strength loss 1.23% and 3.85% reduced
7. In RCPT test charges passing in coulombs are 986, 900 and 692 mm for M20, M40 and M60 grade of self-curing concrete and 1383, 1164 and 863 for same grade of conventional concrete respectively.
8. Depth of penetrations are 12 mm, 10 mm and 7 mm for M20, M40 and M60 grade of self-curing concrete and 15 mm, 13 mm and 10 mm for same grade of conventional concrete respectively.
9. Weight loss and strength loss percentage decreases with increase of GGBS and PEG 400 up to 20% GGBS and 1.5% of PEG400 after that increases for M20 and M40 grade of concrete. Similarly decreases with increase of GGBS and PEG 400 up to 10% GGBS and 1.0% of PEG400 after that increases for M60 at 28 days and 90 days.

VI REFERENCES

1. Al Saffar D. M., Al Saad A. J. K., and. Tayeh B. A, ‘Effect of internal curing on behavior of high performance concrete: An overview’, Case Studies in Construction Materials, vol. 10, p. e00229, Jun. 2019, doi: 10.1016/j.cscm.2019.e00229.
2. Aziz A A , M M O Elhibir , N Abu Bakar and N A Safiee, 2018, Compressive Strength and Water Absorption Behavior of Self-Curing Fiber Reinforced Concrete, Materials Science and Engineering 431 (2018) 042008 doi:10.1088/1757-899X/431/4/042008.
3. Bashandy A 2016 Self-Curing Concrete Under Sulfate Attack- Volume: 52 Issue: 02.
4. Di Bella C., Villani C., Phares N., Hausheer E., and Weiss J., ‘Chloride Transport and Service Life in Internally Cured Concrete’, pp. 686–698, Jul. 2012, doi: 10.1061/9780784412367.062.
5. Elahi A., P.A.M. Basheer, S.V. Nanukuttan, Q.U.Z. Khan 2010 Mechanical and durability properties of high performance concretes containing supplementary cementitious materials - Construction and Building Materials, vol.24, pp.292-299.
6. Rafat Siddique & Rachid Bennacer 2012, ‘Use of iron and steel industry by-product (GGBS) in cement paste and mortar’, Journal of Resources, Conservation and Recycling., vol. 69, pp. 29-34.

7. Sabaoon AM and Singh N 2019 Experimental investigation of self-curing concrete by using natural and chemical admixtures Indian Journal of Science and Technology 12 1-6.
8. Susanto Teng, Tze Yang Darren Lim, Bahador Sabet Divsholi 2013 Durability and mechanical properties of high strength concrete incorporating ultra-fine Ground Granulated Blast-furnace Slag-Construction and Building Materials Volume 40, Pages 875-881.
9. Vadivel, D. T. S, Goud E. G. P., Nagarjuna S., Doddurani M., and. Geethu A. P, 'Behavioural Study on Self Curing Concrete Using Poly Ethylene Glycol and Silica Fume', International Journal of Engineering & Technology, vol. 7, no. 3.35, Art. no. 3.35, Sep. 2018, doi: 10.14419/ijet.v7i3.35.29148.
10. Yumnam Robert 2020-An experimental study on mechanical and durable properties of self-curing concrete by adding admixture-Volume 33, Part 1, 2020, Pages 496-501.