Experimental Investigation on The Effect of Binary Blended Cement on Structural Concrete Exposed To Aggressive Environment

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Abstract- *Pozzolanic concretes are used extensively throughout the world where oil, gas, nuclear and power industries are among the major users. The search for alternative binders, or cement replacement materials, has been carried out for decades. They have forced to focus on recovery, reuse of natural resources and find other alternatives. Ceramic powder is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials.. On the other hand the important biogenic waste is the palm oil fuel ash (POFA)* **-** *generated as by-product from palm oil mills. The production of POFA increases every year, it is disposed for landfills without any return value and now becomes a burden. It contains a non-crystalline silicon dioxide with high specific surface area and high pozzolanic reactivity. Reducing the use of cement which is one of the major production of Carbon Dioxide (CO2) gas emissions. . This project reports the results of an experimental study on the partial replacement of (OPC) cement with POFA of 0%, 5%, 10%, 15% and 20% by weight of cement after getting optimum cement replaced with ceramic waste powder and Concrete mixtures were produced, tested of compressive strength to the conventional concrete. These tests were carried out to evaluate the properties for 7, 14 & 28 days. The moulds prepared are as follows 150mm X 150mm X 150mm cubes and 300 X 150 mm cylinders for each concrete mix. Fresh concrete tests like compaction factor test and hardened concrete tests like compressive Strength at the age of 7 days and 28 days was obtained and also durability aspect of modified concrete for chloride and sulphate attack was tested. These tests were carried out to evaluate the properties for the test results of 7, 14, 28days for compressive strength and tensile strength in normal water and in MgSO4 and HCL solution of 1%, 3% and 5%. Also, the durability aspect of modified concrete with cement for HCL solution was tested.*

Keywords- Palm oil fuel ash (POFA), Ceramic powder, workability, compressive strength, split tensile strength test, Durability studies.

I. INTRODUCTION

In the last decades, environmental sustainability has become one of the most important issues. Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country's development. it's known that some industrial waste product like nano silica are having some building material and silicious properties. So the use of the commercial and agricultural wastages in concrete part as cement replacement, scale back the price of constructing concrete, additionally causes improvement within the properties of concrete

Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country's development. It's known that some waste product like nano silica and metakaolin are having some building material and siliceous properties. The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials.

Palm oil fuel ash could be a byproduct of the palm oil extraction industries found when burning palm kernal pulp that itself is found when the extraction of all economical oil from palm kernals. The disposal of this material is already inflicting environmental issues round the palm oil factories. Plain concrete members cannot sustain tensile stresses developed thanks to the applied forces while not the addition of reinforcing components that are able to stand up to tensile stresses. The propagation of small cracks and macro cracks, however, still can't be in remission or slowed by the only real use of distinct reinforcement like steel and composite rebars.

It's believed that the blending of willy-nilly spaced discontinuous tiny fibers helps in stunning the propagation of the small cracks and macro cracks.

The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pit refill, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use of ceramic waste produced. Ceramic waste can be used in concrete to improve its strength and other durability factors. Ceramic waste can be used as a partial replacement of cement or as a partial replacement of fine aggregate sand as a supplementary addition to achieve different properties of concrete.

In the last decade, construction industry has been conducting research on the utilization of waste products in concrete; each waste product has its own specific effect on properties of fresh and hard concrete. There is a huge usage of ceramic tiles in the present constructions is going on and it is increasing in day by day construction field. And also in other side waste tile is also producing from demolished wastes from construction. Indian tiles production is 100 million ton per year in the ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present, however the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces so, we selected these waste tiles as a replacement material to the basic natural aggregate to reuse them and to decrease the solid waste produced from demolitions of construction. Waste tiles are collected from the surroundings.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength and impact resistance of concrete with different percentages replacement of cement with palm oil fuel ash and ceramic waste powder and to study the tensile behaviour.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

1. Workability
2. Compressive strength
3. Flexure strength
4. Tensile strength

II. REVIEW OF LITERATURE

Considering above background, an experimental investigation was carried out to consider the both types and amount of contents of different types of cement and sand replacement materials on the properties of concrete. A lot of work has been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Literature review of metakaolin and concrete exposure to severe acidic environment is presented in the following sections.

Deb, P. S., Nath, P., & Sarker, P. K. (2014): Ground granulated blast furnace slag (GGBS) with mixture of flyash content showing huge improve in the consequences of workability and high strength contrasted with Ordinary Portland Cement (OPC). By changing dissimilar (0%,10% and 20%)contents of Ground granulated blast furnace slag (GGBS) with various proportions of flayash content showing a few blemishes, One of them is with increment in GGBS content workability is diminishing simultaneously strength is expanding. By keeping up silicates to alkaline proportions of 1.5 to 2.5 and following ACI 318 and AS 3600 codes for curing we can accomplish above outcomes when contrasted with OPC.

Junaid, M. T., Kayali, O., Khennane, A., and Black, J. (2015): In this paper he decided the mix proportions geopolymer concrete (GPC) by utilizing Calcium Class F Flay Ash and Alkaline solutions of sodium silicates and sodium hydroxide. For the distinctive mix plans he discovered ideal substance of alkaline fluid to fly ash (AL/FA) proportion, water to geopolymer concrete (W/GPS) proportion and Alkaline to water (AL/W) proportion.

Patankar, S. V., Ghugal, Y. M., and Jamkar, S. S. (2015): Geopolymer concrete is made by utilizing different evaluations of fly ash and consistent sodium hydroxide with 13M focus. In view of experimentation he accomplished the ideal proportions like water to geopolymer (W/GPC) connection of 0.35, Alkaline to fly ash proportion of 0.35, sodium silicate to sodium hydroxide proportion of 1. Later he discovered workability, compressive strength for the plan mix of geopolymer concrete, the outcome came palatable for the above mix plan.

S. M. AlamgirKabir (2015) investigation concerns the use of the optimum mix proportion of two locally available pozzolanic waste materials, namely, ground granulated blast furnace slag (GGBS) and palm oil fuel ash (POFA), together with metakaolin (MK) as binders. In addition, another local waste material, manufactured sand (M-sand), was used as a replacement for conventional sand in the development of green geopolymer mortar. Twenty-four mortar mixtures were designed with varying binder contents and alkaline activators. The oven dry curing was also kept consistent for all the mix proportions at a temperature of 65°C for 24 hours. The highest 28-day compressive strength of about 48 MPa was obtained for the mortar containing 20% of MK, 35% of GGBS, and 45% of POFA. The increment of MK beyond 20% leads to reduction of the compressive strength. The GGBS replacement beyond 35% also reduced the compressive strength. The entire specimen achieved average 80% of the 28-day strength at the age of 3 days. The density decreased with the increase of POFA percentage. The finding of this research by using the combination of MK, GGBS, and POFA as binders to wholly replace conventional ordinary Portland cement would lead to alternate eco-friendly geopolymer matrix.

Goriparthi, M. R., & TD, G. R. (2017): He arranged geopolymer concrete consolidating fly ash and Ceramic waste powder (CWP) as a limiting material, Alkaline materials Sodium silicate (Na_2SiO_3) and Sodium Hydroxide (NaOH) as activators. And contrasted the consequences of both OPC and geopolymer concrete and closed the accompanying aftereffects of two evaluations of concrete GPC20 AND GPC50. Significant boundaries of corrosive mass misfortune factor (AMLF) by submerging in 5% of H_2SO_4 solution and strength properties (Compressive, Tensile and Flexure) were resolved.

MallikarjunaRao, G., &GunneswaraRao, T. D. (2018): In this paper a broad research was done to discover the plan mix and routine properties of geopolymer concrete. Mr. MallikarjunaRao got ideal outcomes with 30% replacement of CWP with fly ash. Proportion between alkaline solution and binder of 0.5 invigorated better workability and compressive. He got effective to take out broiler curing and supplanted it with encompassing curing interaction to try not to cure issues related with it by supplanting CWP in the spot of fly ash. It is seen that CWP and fly ash based geopolymer concrete is giving preferred outcomes over fly ash based geopolymer concrete. Various molarities were tried and best economic molar focus is discovered alongside strength and workability.

A.N.Dancygier and Z.Savir studied the influence of nylon fiber on flexural performance of high strength concrete beam with low longitudinal reinforcement magnitude relation, that tried that nylon fiber enhance crispiness of beam compared to it of beam with minimum longitudinal reinforcement magnitude relation. Compared to nylon fiber concrete, the hybrid fiber with completely different kind and size will improve effectively strength and toughness of concrete, kind hybrid result throughout completely different fiber, play various useful influence from completely different level. However, few researches on flexural performance of hybrid fiber strengthened RC beam were studied.

Sasikumar&Tamilvanan Performed an Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. The main parameters investigated in this study is M30 grade concrete with partial replacement of cement by silica fume0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when the silica fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % silica fume replacement level. As well the split tensile strength is high when using 25% silica fume replacement for cement.

Ghutke&Bhandari Examine the Influence of silica fume in concrete. Results indicated that the silica fume is a better replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage is varying from 10% to 15% replacement level.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Aggregates
3. Palm oil fuel ash
4. Ceramic waste powder
5. Admixtures
6. $MgSO_4$ and HCL

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Ceramic waste powder

Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. It is most essential to develop eco-friendly concrete from ceramic waste.

5. Palm Oil Fuel Ash

Palm kernel shell is a waste product of the palm mill industry; this industry extracts oil from oil palms fruits. The palm kernel shell used in this current work was supplied by a local contractor. Palm kernel shell are hard, flaky and of irregular shape. The most important aspects of using palm kernel shell as aggregate replacement was to ensure that the palm kernel shells are properly prepared. This is of extreme importance during the mixing of material for the various mixes. First, pre-treatment of the palm kernel shell was carried out by removing oil coating with detergent and water, washing and sieving the palm kernel shell into the required particle sizes for the current work.

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M35.

V. RESULTS AND DISCUSSIONS

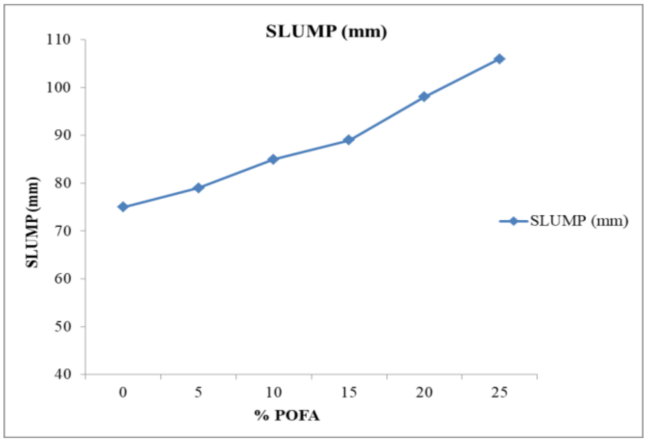
This session provides an outline of the experimental results and endeavors to draw some conclusions. The take a look at result covers the workability, mechanical properties and sturdiness properties of concrete with and while not admixtures. The results of the experimental investigation on palm oil fuel ash and ceramic waste powder concrete wherever palm oil fuel ash and ceramic waste powder has been used as partial replacement of cement in concrete mixes. On commutation cement with completely different percentages of POFA the workability, compressive strength is studied then to the optimum share of palm oil fuel ash, keeping POFA constant the ceramic waste powder is replaced and studied the compressive strength, flexural strength for various mixes were studied.

5.1 REPLACEMENT DETAILS

The replacement details of cement with POFA of 0%, 5%, 10%, 15% and 20% by weight of cement after getting optimum cement replaced with ceramic waste powder

5.2 VARIATION OF SLUMP VALUES FOR PERCENTAGE REPLACEMENT OF PALM OIL FUEL ASH

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability. Critical mix has high workability compared to other mixes which may be due to the particle size of POFA and CWP is lesser than cement. So in short, mixes with high percentages of palm oil fuel ash are more workable than the control one.

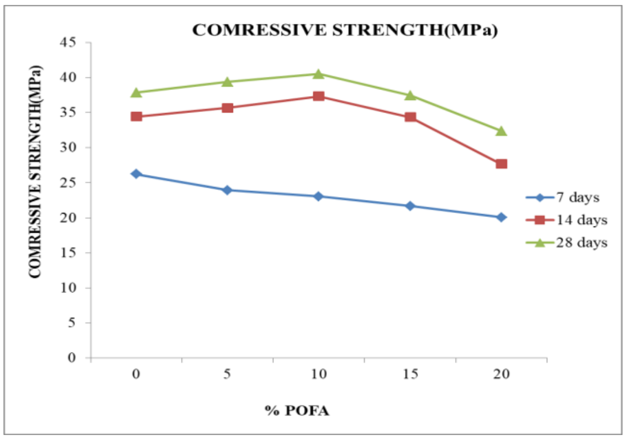


Graph 5.1 Plot shows the Variation of Slump Values for % replacement of POFA

5.3 COMPRESSIVE STRENGTH

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal.

Cubes are prepared of size 150 mm x 150 mm x 150 mm are checked for compressive strength. The specimens tested for 7, 14 and 28 days. The specimen were tested for compressive strength parallel to the plane of the board by applying increasing compressive load until failure occur. The arrangement of load is applied to the specimen by placing the specimen length vertical between the surfaces of the testing machine.



Graph 5.2 Plot shows the Variation in Compressive Strength for % Replacement of POFA

5.4 VARIATION OF COMPRESSIVE STRENGTH FOR ADDITION OF CWP TO OPTIMUM PERCENTAGE OF PALM OIL FUEL ASH

Compressive strength of concrete keeping 10% palm oil fuel ash as constant and with different percentages of CWP for curing period of 7-days, 14-days and 28-days respectively and Table shows the summarized Compressive strength Results for CWP to optimum percentage of palm oil fuel ash for curing periods– M35 grade.

Compressive strength tests were conduct on specimens per mixture at 7, 14, and 28days

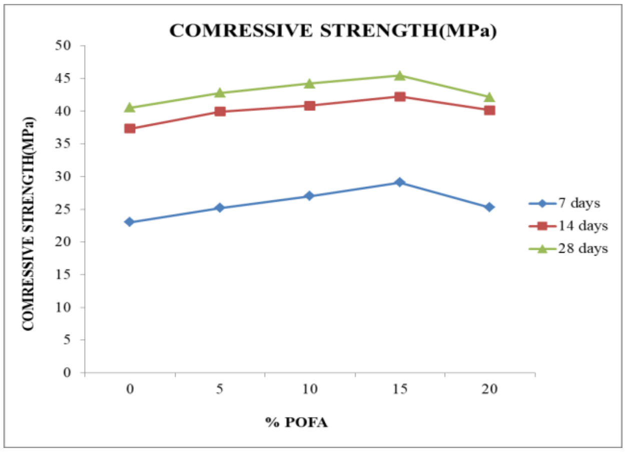


Fig 5.3 Plot shows the Variation in Compressive Strength for % Replacement of CWP

5.5 SPLIT TENSILE STRENGTH

Specific strength illustrates the rate at which a density of material will be able to resist stress depending on the strength of the material. The procedure was achieved actually base on

Compressive strength and density values obtained from the experiment. The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cubes are used to determine splitting tensile strength of concrete and were tested as per as per IS 516 (1959) and IS 5816 (1999).

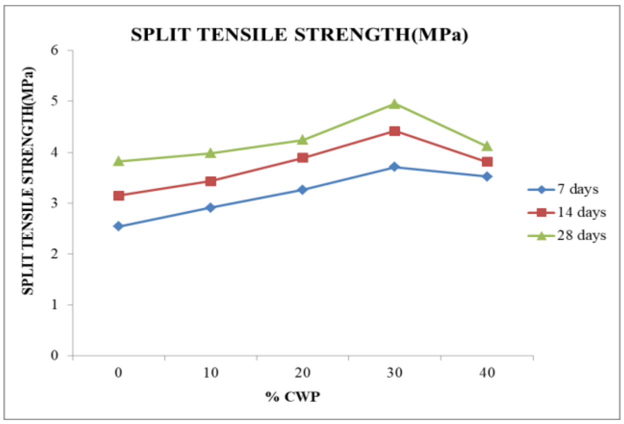


Fig 5.4: Plot shows the Variation in Split Tensile strength for different percentages of CWP

5.6 FLEXURAL STRENGTH TEST

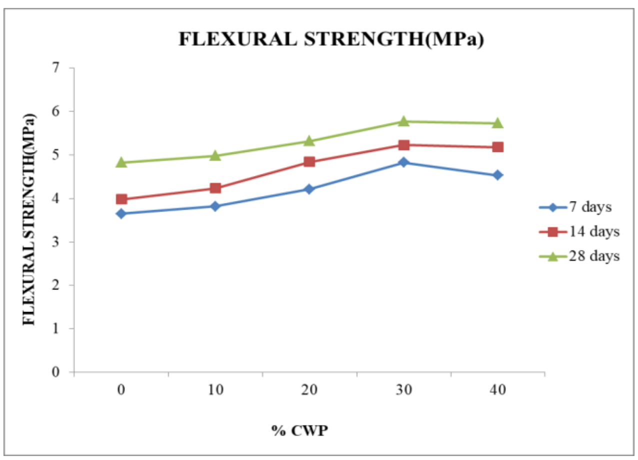
In the flexural strength test theoretical maximum tensile stress reached at the bottom fibers of the test beam is known as the modulus of rupture. When concrete is subjected to bending stress, compressive as well as tensile stresses are developed at top and bottom fibers respectively. If the largest nominal size of aggregate does not exceed 20mm, the dimension of specimen may be 150mm×150mm×700mm.

$$f = \frac{M}{Z} = \frac{(PL/6)}{(bd^2/6)}$$

$$f_b = \frac{PL}{Bd^2}$$

When 'a' greater than 20 cm for a 15cm specimen,

$$f_b = \frac{3Pa}{bd^2}$$



Graph 5.5Plot shows the Variation in Flexural strength for different percentages of CWP

5.7 DURABILITY STUDIES

The main objective of the present experimental investigations is to obtain specific experimental data, which helps to understand the Bacterial concrete and its characteristics (Strength and Durability)

Effect of HCl and MgSO4 acid on pore structure Based on the previous research, damage impact of various de-icing chemicals and exposure conditions on concrete materials was studied and resulted that various de-icing chemicals penetrated at different rates into given paste and concrete, resulting different degree of damage. In present study, the percentage concentration of HCl and MgSO4 is 1%,3%,5% concentration. The compressive strength and split tensile strength of concrete were tested for different concentrations for a period of 7 Days, 14 Days and 28 Days.

5.7.1 Sulphate Test

The internal Sulphate attack occurs in an environment that is free from Sulphate ions. This attack is generated by the late Sulphate ions that are released from the contaminated source of aggregates with cement. On the other hand, the internal Sulphate attack generated by the late release of Sulphate ions is related to the thermal decomposition of the primary ettringite and also the release of Sulphate from C-S-H.

5.7.2 Chloride Test

HCl damages concrete through dissolution process, soluble salts are formed and the concrete will be leached because of them. The color of the external surface of the sample was yellow whereas the color of their inner surface was brown. This was due to differences in the amount of Fe (OH)3.

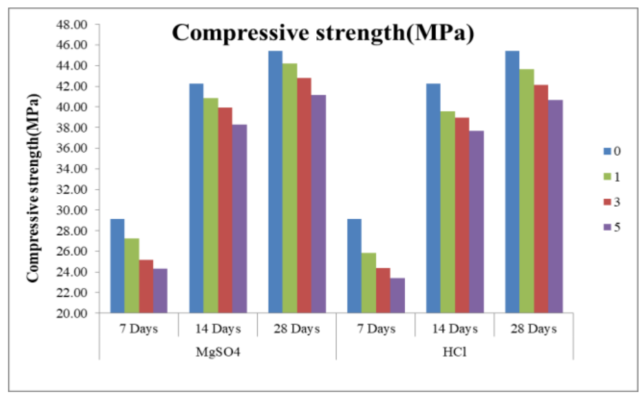


Fig 5.6: Plot shows summarized compressive strength subjected chloride and Sulphate test for different curing periods

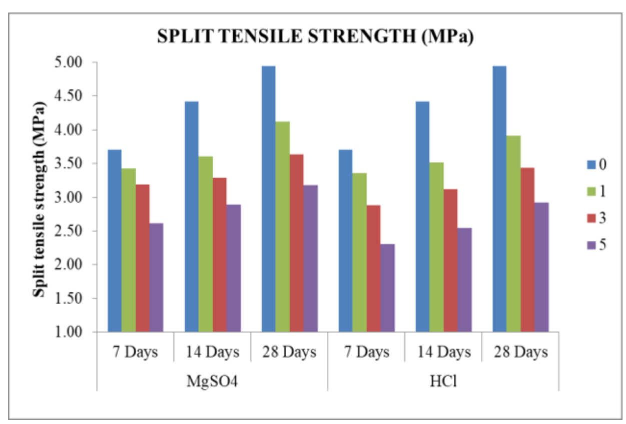


Fig 5.7: Plot shows summarized flexural strength subjected chloride and Sulphate test for different curing periods

VI. CONCLUSIONS

The results of this project and experiments are summarized and the use of Palm oil fuel ash and ceramic waste powder as a cement replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

- It has been observed that by the incorporation of Palm oil fuel ash & Ceramic waste powder as partial replacement to cement in fresh and plain concrete increases workability.
- Palm oil fuel ash concrete performed better when compared to ordinary concrete up to 10% replacement of palm oil fuel ash. Compressive strength of 7.11% increases in the strength was observed when compared with conventional concrete for 28 days. Increase of strength is mainly to presence of high amount of Silica in POFA.
- The mix with replacement of cement with 10% Palm oil fuel ash and 30% Ceramic waste powder has shown good strength properties like compressive and tensile and flexural strength. This may be due to the fact that the CSH gel formed at this percentage is of good quality and have better composition.
- The highest compressive strength value i.e. 45.43 MPa, was obtained for a mix having 10% palm oil fuel ash and 30% Ceramic waste powder. It is evident from the present investigation that the replacement of cement with 10% palm oil fuel ash and 30% Ceramic waste powder to concrete improve compressive strength, split tensile strength, flexural strength etc. of the mix.
- Compressive strength is decreased for concrete cured in 5% HCL and 5% $MgSO_4$ solution when compared to the concrete cured in normal water.
- Compressive strength and split tensile strength is increased for 7, 14 and 28 days when cured in normal water, but compressive strength and split tensile strength is reduced very low acid attack after cured of 28 & 60 days in $MgSO_4$ solution when compared to HCL solutions.
- It is observed that effect on concrete decreases when exposed to Hcl solution. The use of Palm oil fuel ash and Ceramic waste powder combined is economic when compared to cement in concrete. Likewise saves a great deal of waste disposal problems and reduces the cement price rise and intensities of CO_2 release by the cement production. Also these materials make the concrete more sustainable, light weight and low energy emitting which is noble.

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