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# GEOPOLYMER PAVERS BY USING SEA SAND AND SEA WATER

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**Abstract -** *In this experimental study, limited River sand is replaced by the of sea Sand and used as an alternative. Where as in the laboratory investigations sea water is used instead of distilled water in the total absence of OPC.*
*Now a days Paver is used in different constructional applications. The OPC paver production requires more space for curing and large amount of water. The disposal of fly ash solid waste is the major problem. This project provides sustainability, by the use of flyash, rice husk ash, sea water and sea sand with waste sustainable management that produces a wonderful product called geo-polymer concrete pavers. The results of this experimental study shows that the geopolymer concrete paver block has an excellent compressive strength within short period of time.*

***Key Words***: **Geopolymer pavers, sea water, sea sand, fly ash, Rice husk ash, alkaline liquids, compressive strength, flexural strength.**

## 1.INTRODUCTION

In now a days concrete is predominantly used as a versatile building material with its highest consumption on the earth. Nevertheless, day by day its exigency leading to exhausting restricted natural resources in its manufacturing. It's highly essential to employ other alternative profuse materials in their place in order to prevent the degradation of these natural confined aggregates resources.

Every ton of OPC production gives equal amount of Carbon Dioxide emissions into the atmosphere and about 7% of global CO2 emissions are from the cement industry.

Freshwater resources are available in limited quantity and therefore, in some corners of the world mankind is not getting sufficient fresh water even to drink. But sea water is available in 97% in total quantity of water in earth. So by utilizing these natural resource in concrete production scarcity of fresh water is minimized.
The restricted river Sand resources are being quarried haphazardly and hence reaching to their end. While on the other hand Sea Sand is existing in huge quantity below seas and oceans.
Fly ash is the main by product obtained from coal-fired power plants by the combustion of coal. In order to dispose these waste on the land, they may take large area for disposing. So that by using these waste in the preparation concrete, land area can be developed.

India produces about 20 million tons of rice husk ash each year and it is one of a major rice producing country and produces a waste material obtained from the milling process and it is dumped on the land which poses a significant environmental threat to the land. Thus, rice husk ash are attracting considerable attention methods for making commercial use.

In present experimental investigations, the sea water is used instead of distilled water for laboratory investigations on the properties of Geopolymer concrete in the total absence of Ordinary Portland Cement and sea Sand is used as an alternative to river Sand whereas the fly ash was partially replaced by rice husk ash.

## 2. AIM AND OBJECTIVES OF THE STUDY

The fundamental objectives of this research is to consider strength properties of geo polymer concrete by using fly ash and Rice Husk Ash with the utilization of alkaline liquids contains sodium hydroxide and sodium silicate.

- To study the effects of fly ash, Rice husk ash, dissolvable alkaline liquid, sea sand and seawater by finding the compressive strength of geopolymer concrete.
- To study and determine the flexural and compressive strength of specimens prepared with with sea sand and sea water and compare the final results with the standard concrete i.e. prepared from distilled water and river sand.
- Development of high strength Geopolymer pavers fabricated with sodium silicates and Sodium hydroxides.

- To work on the attainability of the locally accessible materials i.e. sea water and sea sand in costal areas for better concstruction developments.

## 3. LITERATURE STUDY

The literature available on the effects of sea sand and sea water on cement concrete is present in below. And found that very Few researches on sea sand and sea water is used to prepare the geopolymer concrete. Therefore, this research is to investigate the comparative study of geopolymer concrete produced by using seawater and sea sand and control geopolymer concrete fabricated with distilled water and river sand.

[1]. "FEASIBILITY STUDY ON THE UTILISATION OF MARINE SAND IN CONCRETE FOR SUISTAINABLE DEVELOPMENT" this paper was entitled by M Karthikeya and V Nagarajan. In their study they prepared M30 grade concrete developed by mix proportion of 1 : 1.22 : 2.54 with a w/c of 0.42. The fine aggregate content is replaced with sea sand by 10%, 20%, 30% and 40%. the results are satisfactory up to 30% replacement. After that by using micro silica as an admixture to increase the strength further.

[2]. "STRENGTH PROPERTIES OF FLY ASH BASED GEOPOLYMER CONCRETE WITH SEA SAND" this study was entitled by Dr. K. N. Kadam, B. H. Shinde, In their examination the ocean sand (Treated and untreated) is utilized as an option in contrast to stream sand. The results show that treated sea sand gives similar results as of river sand concrete. but untreated sea sand affects the compressive strength in geopolymer concrete as same as cement concrete.

[3.] "EXPERIMENTAL INVESTIGATION ON GEOPOLYMER BRICKS/PAVER BLOCKS" this study was entitled by Sharon John, C. Banupriya, D. Vinitha, R. Suresh, and E. Divya. In their examination quarry dust on supplanted with river sand for making geopolymer bricks and paver blocks. Fly ah, GGBS, pellet type of sodium hydroxide and aggregates were combined as in suitable proportion, water was added to this mix and casted. The final results shows that GPC paver block utilizing 25% fly ash and 75% GGBS shows very good compressive strength. Geopolymer block utilizing 65% Fly Ash and 35% GGBS delivered great compressive strength.

[4]. "EXPERIMENTAL INVESTIGATION OF GEOPOLYMER CONCRETE USING FLY ASH AND GGBS" this paper was entitled by B M Jagadeesh, Manjunath M Katti, Naveen M Katti. In their trial study was attempted to examine the strength qualities of Geopolymer concrete. Ordinary Portland cement by 100% replacement of conventional concrete made by using Ground granulated blast furnace slag, class F fly ash, and catalytic liquids to produce Geopolymer concrete mixes. In this study they varying the molar concentration (6M, 8M, and 10M) and varying percentage of binding material and evaluated strength characteristics of Geo polymer concrete. The results shows that Molarity of solution decreases and the strength is increases for water curing. The increase in GGBS quantity increases the strength.

## 4. MATERIALS USED

### A) Source materials

**FLY ASH**

Fly ash was chosen as the essential primary source material on account of its high alumina and silica content. These chemical contents are good for the geopolymerization. It is a product got from ignition of coal in nuclear energy stations with rich silica and alumina content when utilized in substantial will assist with decreasing the unfavorable impact on climate as a substitution of concrete. There are two "classes" of flyash, Class C and Class F. Class F Fly Ash contains calcium hydroxide content is less contrasted with class C. Each class of flyash has its own exceptional properties. For this study Class F Fly ash is utilized.

**TABLE 4.1 : Physical Properties of Flyash**

| Sl.no | Properties | Values |
|---|---|---|
| 1 | Colour | Grey to Black |
| 2 | Apperance | Fine Powder |
| 3 | Odour | Odourless |
| 4 | Particle Size | 35 Micron |
| 5 | Specific Gravity | 2.17 |

**RICE HUSK ASH**

The RHA was taken as secondary source material and inorder to investigate the effects of RHA replacing in to the Fly ash in the proper percentage.

**TABLE 4.1 : Physical Properties of RHA**

| Sl.no | Properties | Values |
|---|---|---|
| 1 | Colour | Grey / Black |
| 2 | Apperance | Fine Powder |
| 3 | Odour | Odourless |
| 4 | Particle Size | 45 Microns |
| 5 | Specific Gravity | 2.06 |

### B) Aggregates

**FINE AGGREGATES**

The river sand and sea sand are used as a fine aggregate. River sand which is locally available natural sand and sea sand obtained from the sea shores and their size is 75 micron retained and passing through 4.75 mm sieve is used.

**Table – 4.3 : physical properties of river sand and sea sand**

| Sl no | Properties | River sand | Sea sand |
|---|---|---|---|
| 1 | Finess modulus (%) | 2.5 | 2.6 |
| 2 | Moisture content (%) | 0.16 | 0.22 |
| 3 | Water absorption (%) | 0.81 | 0.96 |
| 4 | Specific gravity | 2.6 | 2.3 |
| 5 | Zone located | Zone II | Zone II |

**Table – 4.4 : Chemical composition of river sand and sea sand**

| Composition | River sand | Sea sand |
|---|---|---|
| Alumina | 13.86 | 3.26 |
| silica | 79.98 | 42.75 |
| Potasium and sodium | 1.67 | 31.81 |
| Calcium | 0.87 | 1.11 |
| Titanium | 0.15 | 0.43 |
| Iron | 1.89 | 1.03 |
| Manganese | 1.44 | 2.15 |

**COARSE AGGREGATE**

The coarse aggregate is a Machine crushed rock obtained from a nearby Quarry place was utilized and the aggregates are places the significant constituents in concrete. They decrease shrinkage and impact value. The size between 4.75 mm to 50 mm size of aggregates are named coarse aggregates. The coarse aggregates possess about 70 to 80 % of volume of concrete. For this research 10 mm and down size aggregates are utilized.

**TABLE 4.5 : Properties of coarse aggregates**

| Sl no | Properties | Values |
|---|---|---|
| 1 | Water absorption (%) | 0.5 |
| 2 | Curshing value | 11.1 |
| 3 | Abrassion value | 30.67 |
| 4 | Impact value | 29.33 |
| 5 | Specific gravity | 2.67 |

**C) Alkaline liquids**

**SODIUM HYDROXIDE (NaOH)**

In this research work alkaline solutions of sodium silicate and sodium hydroxide are used. Sodium silicate solution and sodium hydroxide in pellets form and are used in present experimental study. We use only 6M ( Molarity ) of sodium hydroxide for this work.

The molecular weight of NaOH = 40 ( Na-23, O-16, H-1 )

To prepare 6 Molarity of NaOH solution, first weigh 240g of flakes form of NaOH can be dissolved in distilled water to form 1 litre of solution. It can be best prepared before 24 hours of the casting of specimens.

**SODIUM SILICATE ( $Na_2SiO_3$ )**

The solution of Sodium silicate solution used for this study is collected from local suppliers. Sodium hydroxide and sodium silicate mixture solution forms the active alkaline solution. The chemical formula of sodium silicate solution was $Na_2O$=8%, $SiO_2$=28%, and water 64% by mass. And Both these solution are mixed together at the time of mixing of concrete.

## D) Admixture

In the current examination a super plasticizer CONPLAST SP-430 has been utilized for acquiring useful cement at low w/c proportion. CONPLAST SP-430 depends on sulphonated naphthalene polymers and is suplied as an earthy coloured fluid in a split second dispersible in water. The measurements of plasticizers is 1.5 % by the weight of the binder.

Specific gravity = 1.20

Colour = Brown liquid

## E) Liquid materials

**SEA WATER**

Seawater marginally speeds up the early strength of cement. Yet, it diminishes the 28 days strength of cement by around 10 to 15 percent. This loss of strength could be made up by redesigning the mix or by addition of proper admixtures.

**Table 4.7 : chemical properties of sea water**

| Sl no | Composition | Total % |
|---|---|---|
| 1 | Calcium | 1.18 |
| 2 | Chloride | 55.29 |
| 3 | Magnesium | 3.69 |
| 4 | Potassium | 1.14 |
| 5 | Sodium | 30.74 |
| 6 | Sulphate | 7.75 |
| | **TOTAL** | **99.8** |

**DISTILLED WATER**

Presence of contaminations in water for substantial blend prompts decline in primary properties of cement like strength and durability generally. As far as the distinction in the setting time of the Portland concrete blends that comprises of proposed blending water when contrasted and the utilization of fresh water.

**5. EXPERIMENTAL STUDY**

This is the experimental based research study. The entire study was divided into three phases: first, The investigation of effect of fly ash and RHS with alkaline liquids by varying the fly ash amount replaced with RHS by 0%, 10%, 20% and 30% and compare the compressive strength of this with the standard OPC. Second, by taking good percentage replacement of fly ash and RHA i.e. obtained in the first invesigation is taken and this mix is used for all four different combination i.e. sea sand & sea water, River sand & distilled water, River sand & sea water, Sea sand & distilled water and compare the results of compressive and flexural strength with standard OPC. Third, by taking the good combinations the above mixes is used for casting the GPC pavers and compare the compressive strength with standard OPC pavers.

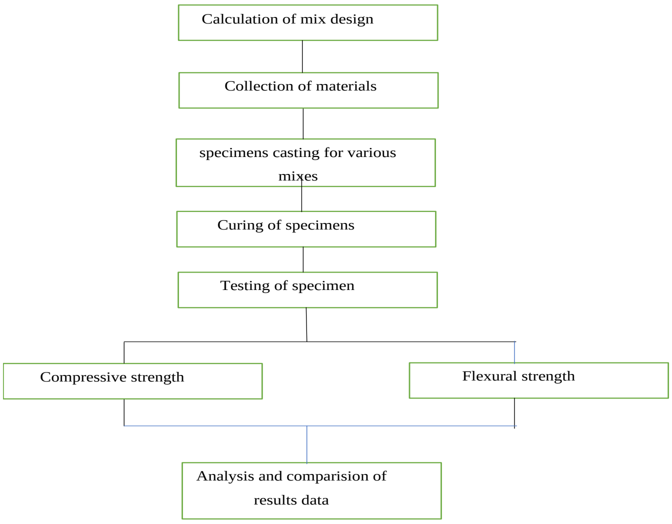


**Fig. 1 Methodology**

## 6. MIX DESIGN

There is no standard mix design approaches are yet available for Geopolymer concrete. Therefore the formulation of Geopolymer Concrete has to be done by trial and error method. The cement concrete strength is known and it is well related with its water cement ratio. This simplest formulation is not suitable for geoolymer concrete. geopolymer paste binds the fine aggregates, coarse aggregates and other unreacted materials together to produce the Geo Polymer Concrete. The GPC mixes can be often employed by concrete technology methods.

**TABLE 5.1 : Mix proportion for GPC and OPC**

| MIX ID | Binder composition | Mix proportion | W/C ratio |
|---|---|---|---|
| GPC | 100 % FA & 0% RHS<br>90 % FA & 10% RHS<br>80 % FA & 20% RHS<br>70 % FA & 30% RHS | 1: 1.36 : 2.16 | 0.65 |
| OPC | 100% cement | 1: 1.36 : 2.16 | 0.45 |

**MIX CALCULATION FOR GPC**

- Alkaline liquid to binder ratio = 0.50
- Ratio of Sodium silicate to sodium hydroxide = 2.50
- sodium hydroxide solution concentration = 6M
- Admixture dosage used = 1.5%
- Curing temp= Ambient temp
- Additional water cement = 5%

**TABLE 5.2 : Mix proportion for GPC for 1M³**

| Particulars | Quantity ( $Kg/m^3$ ) |
|---|---|
| Binder | 496.80 |
| Fine aggregate | 721.60 |
| Coarse aggregate | 1078.80 |
| NaOH | 70.97 |
| $Na_2SiO_3$ | 177.43 |
| Admixture | 7.45 |
| Water | 24.80 |

**TABLE 5.3 : Mix design for fly ash and rice husk ash under different combintion**

| Mix details ($Kg/m^3$) | GPC 1 | GPC 2 | GPC 3 | GPC 4 |
|---|---|---|---|---|
| Fly ash | 447.12 | 447.12 | 447.12 | 447.12 |
| RHA | 49.68 | 49.68 | 49.68 | 49.68 |
| Sea sand | 721.60 | - | - | 721.60 |
| River sand | - | 721.60 | 721.60 | - |
| Coarse aggregate | 1078.80 | 1078.80 | 1078.80 | 1078.80 |
| NaOH | 70.97 | 70.97 | 70.97 | 70.97 |
| $Na_2SiO_3$ | 177.43 | 177.43 | 177.43 | 177.43 |
| Admixture | 7.45 | 7.45 | 7.45 | 7.45 |
| Sea water | 24.80 | - | 24.80 | - |
| Distilled water | - | 24.80 | - | 24.80 |
| Combination | Sea sand & Sea water | River sand & Distilled water | River sand & sea water | Sea sand & Distilled water |

## 7. CASTING, CURING AND TESTING OF SPECIMENS

### 7.1 Casting of specimens

After calculating the mix design, the materials RHA, Fly Ash, Fine & Coarse aggregates were taken in the proportion 1:1.31:2.16. The fly ash was replaced by RHA in the proportion of 0%,10%,20% and 30%. All of the materials were dry mixed homogeneously. To this dry mix, required measure of Alkali liquids with required significant quality was added (alkaline liquid to binder ratio = 0.5) and the entire mix was again homogeneously mixed. Add additional water content and admiture to this mix and homogeniously mixed again. This wet concrete was filled the moulds which was compacted through hand compaction in three layers and thereafter kept into the vibrator for compaction.

Size of the moulds

The geopolymer cubes of size 100 × 100 × 100 mm (compressive strength), beams of size 100 × 100 × 500 mm (flexural strength) and Paver blocks of size 225 × 105 × 75 mm. These specimens were casted accordingly and kept it under ambient temperature for curing. After one day of casting, the specimens were de-moulded.

### 7.2 Curing of specimens

Casted specimens are de-moulded after the concrete is completely set, normally 24 hours. The de-moulded specimens are then kept for curing ambiently. Curing period considered in this study are 3days, 7days and 28 days. After the curing period of respective specimens they are tested for compression and Flexural strength.

### 7.3 Testing of specimens

The test specimens for compressive strength test were made of cube shapes cast iron steel moulds are used. To find the strength of each mix prepare three specimens and they are tested at the age 3,7 and 28 days. The test specimens for flexural strength test were made of beam shaped were casted. For each mix proportion three numbers of beams were casted and they tested at the age of 3,7 and 28 days. Moreover, pavers are casted and tested at the ageof 28 days.

**(A) Compressive strength test**

The dimensions cube specimens are 100 x100 x100 mm were prepared. They are tested for compression strength testing on 2000 kN capacity compression machine as per IS code IS 516- 1959. The compressive strength of the specimen is calculated by using the standard equation, F=P/A

Where; P=> Maximum load in N
A=> Cross sectional area in mm2
F=> Compressive stress in N/mm2

**(B) Flexural strength test**

Specimens of dimension 100 × 100 × 500 mm were prepared. They are tested on flexural testing machine. According to IS 516-1959 method of test and strength of test were estimated. The flexural strength is calculated by using the equation, PL/bd2

where, P => Applied load in N
L => Span length in MM
b => Width of beam in MM
d => Depth of beam in MM

## 8. RESULTS AND DISCUSSION

### (A) Effects of fly ash and Rice husk ash

The compressive strength of the geopolymer concrete in which cement is fully replaced with fly ash and rice husk ash. And their results of compressive strength is tabulated in below table. It can be seen that the compressive strength is gradually decreasing when the percentage of rice husk ash is increased.

**TABLE 7.1 : compressive strength of GPS**

| *MixID* | *Fly ash & RHS* | *3 days (Mpa)* | *7 days (Mpa)* | *28 days (Mpa)* |
|---|---|---|---|---|
| GC 1 | 100 % and 0 % | 17.41 | 28.30 | 39.18 |
| GC 2 | 90 % and 10% | 15.64 | 25.42 | 35.19 |
| GC 3 | 80 % and 20 % | 12.25 | 19.91 | 25.57 |
| GC 4 | 70 % and 60 % | 9.77 | 15.89 | 22.0 |
| OPC | 100 % Cement | 13.40 | 23.20 | 33.0 |

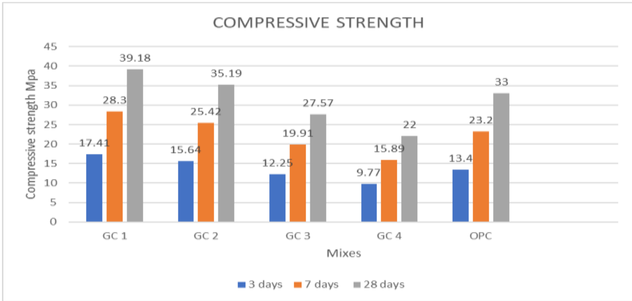


**Fig 2 : variation of compressive strength for FA and RHA Mix**

It is observed that 100% replacement of fly ash with cement gives higher compressive strength than normal OPC. And 10% replacement of fly ash with rice husk ash also gives the higher compessive strength than compare to OPC. And it is suitable for the preparation of geopolymer concrete. And remaining two mixes GC 3 and GC 4 are failed to give the compressive strength i.e. the strength is less compare to OPC mixes.

### (B) Effects of sea water and sea sand by using Fly ash and RHA

On studying the effects of fly ash and RHA in the above paragraph it shows replacement of fly ash with RHA in the percentage of 10 % variation gives good strength than that of OPC. Therefore it is suitable for GPC preparation. So in this project we use this proportion of variation of RHA (10%) and Fly ash (90%) is used. And by using this, effects of sea water and sea sand is determined by the compressive and flexural strength.

**COMPRESSIVE STRENGTH**

The compressive strength of the geopolymer concrete in which cement is fully replaced with fly ash and rice husk ash. And their results of compressive strength is tabulated in below table. The results shows that for the combination of sea sand sea water the strength is lesser compare to the OPC. But in the combination River sand and distilled water gives the higher strength compare to OPC. And also remaining two combinations such as GPC 3 and GPC 4 shows satisfactory results when compare to OPC and control geopolymer concrete made with River sand and distilled water. Therefore for these combinations of GPC is used for practical applications and their variation is shown in below figure.

**TABLE 7.2 : compressive strength of GPC by using sea sand and sea water**

| Mix | Combination | *3 days (Mpa)* | *7 days (Mpa)* | *28 days (Mpa)* |
|---|---|---|---|---|
| GPC 1 | Sea sand & sea water | 10.56 | 18.30 | 28.75 |
| GPC 2 | River sand & distilled water | 13.60 | 23.63 | 34.3 |
| GPC 3 | Sea sand & distilled water | 13.48 | 23.52 | 33.17 |
| GPC 4 | River sand & sea water | 13.52 | 23.58 | 33.62 |
| OPC | River sand & Tap water | 13.40 | 23.20 | 33.0 |

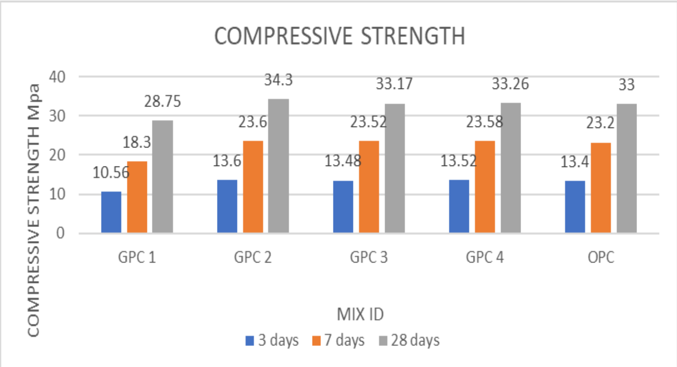


**Fig 3 : variation of compressive strength for FA and RHA Mix**

**FLEXURAL STRENGTH**

The flexural strength was determined at the age of 3,7 and 28 days for geopolymer concrete made with sea sand by river sand with partial replacement. The combinations are shown in below table. Results shows that the combination of sea water and sea sand fails to show the result. And GPC 2 shows better strength due to usage of river sand and distilled water. And in the GPC 3 and 4 shows satisfactory results comparing to Standard OPC. Therefore for these combinations of GPC is used for practical applications. And the variation of flexural strength is shown in fig. In this project by using these GPC mix combinations we prepare the one wonderful product i.e. used for practical application is called GPC pavers.

**TABLE 7.3 : compressive strength of GPC PAVERS**

| *MIX* | *Comination* | *3 days (Mpa)* | *7 days (Mpa)* | *28 days (Mpa)* |
|---|---|---|---|---|
| GPC 1 | Sea water & sea sand | 2.20 | 3.25 | 4.20 |
| GPC 2 | River sand & distilled water | 2.60 | 3.68 | 4.82 |
| GPC 3 | Sea sand & distilled water | 2.58 | 3.66 | 4.76 |
| GPC 4 | River sand & sea water | 2.62 | 3.66 | 4.80 |
| OPC | River sand & tap water | 2.56 | 3.65 | 4.74 |

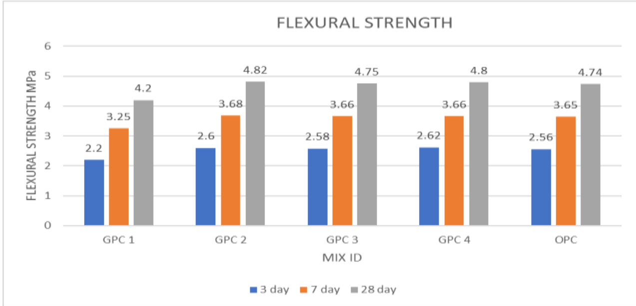


**Fig 4 : variation of compressive strength for GPC by using sea sand and sea water**

### (C) Strength characteristics of GPC pavers

In this project by using these GPC mix combinations we prepare the one wonderful product i.e. used for practical application is called GPC pavers. In this combination GP 1 and GP 2 mix is choosen and in their sea sand & distilled water is used in first combination and River sand & sea water is used in second combination. For both the combinations the resulting compressive strength of GPC paver is higher than the standard OPC pavers.

**TABLE 7.4 : Strength characteristics of GPC pavers**

| **MIX** | **Material combination** | **3 days** *(Mpa)* | **7 days** *(Mpa)* | **28 days** *(Mpa)* |
|---|---|---|---|---|
| GP 1 | Sea sand & distilled Water | 14.80 | 24.20 | 33.54 |
| GP 2 | River sand & sea water | 15.12 | 25.15 | 33.62 |
| OPC P | River sand & Tap water | 14.50 | 24.19 | 33.50 |

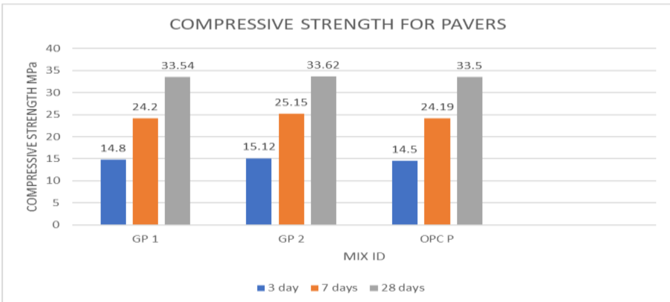


**Fig 5 : variation of compressive strength for GPC pavers**

## 9. CONCLUSIONS

[1]. The substitution of 0%, 10%, 20% and 30% of RHA with the fly ash used geopolymer concrete, and 10 % replacement of Fly ash with Rice husk ash based geopolymer concrete shows higher compressive strength than that of other replacements. Also the compressive strength is more than the compressive strength of ordinary portland cement. This provides to the geopolymer concrete with the gain of high and early strength.

[2]. The flexural strength and compressive strength is significantly decreased and fails to shows the good strength results in geopolymer concrete manufactured with sea sand and sea water used in the same mix .

[3]. Using sea sand & distilled water and River sand & seawater in such combination of mixes the flexural and compressive strength is satisfactory compared to control geopolymer concrete made by River sand & distilled water. And also the strength is more than that of compressive strength of the ordinary portland cement. In every single such combination, the subsequent compressive strength for 7-day was higher than the compressive strength at 28-day comparing ordinary OPC concrete. So these type of combinations are used for practical applications.

[4]. The geopolymer concrete Pavers contains low calcium fly ash includes incredible compressive strength within a short period and appropriate for useful applications, The GPC paver block accomplished higher strength at seventh day than the OPC pavers at 28 days. So it tends to be reasoned that the GPC paver accomplish early strength than OPC pavers.

[5]. The GPC pavers prepared from the combinations, such as in first combinaton sea sand & distilled water is used and in second combination River sand & sea water is used. In such combinations the strength is more compare to OPC pavers. So these pavers are used for practical applications.

[6]. It clears that the usability of locally available materials such as sea water and sea sand is used in the preparation of geopolymer concrete and mortar for the construction in coastal areas.

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