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# Permeation Properties of Geopolymer Concrete Made with Partial Replacement of Recycled Coarse Aggregates

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***Abstract:*** ***Concrete is themost generally used construction material inthe world due to, wonderful durability, straight forward accessibility of its constituent materials, its low price, straightforward formability to any shape, etc. There are many ecological problems connected with the manufacture of OPC, at a similar time accessibility of natural coarse aggregate is additionally changing into scarcity and on the other side, the disposal of C&D wastes is additionally changing into a significant environmental issue . Hence, it is unavoidable to find an alternative material to the existing most resource consuming Portland cement and natural aggregates. GPC is a construction material of innovation concrete which shall be produced by the chemical action of inorganic molecules and made up of fly ash, GGBS, FA, CA, and an alkaline solution of NaOH and $Na_2SiO_3$, plays a significant role in its environmental control of greenhouse effects. The main objective of this paper is to study the permeation properties such permeability, sorptivity etc.,of geopolymer concrete of grade G40 when natural coarse aggregate is replaced with recycled aggregate in different proportions such as 10%, 20%, 30%, and 40% and also to compare the results of geopolymer concrete made with recycled coarse aggregates with geopolymer concrete of natural coarse aggregate and controlled concrete of respective grade. It has been observed that the permeability and sorptivity properties are better in geopolymer concrete, both in natural coarse aggregate and recycled coarse aggregate up to 30% replacement when it is compared with the same grade of controlled concreterespectively.***

***Keywords : Geo-polymer Concrete, Recycled Aggregate, Sorpitivity, Water permeability, Permeation Properties.***

## I. INTRODUCTION

Inthe previous few decades, PCC has been the highest-volumeof factory-made product within the world. These materials contain high reliable performance, min cost, skillfulness and widespread availableness of raw materials. Climate change and global warming are increasingly important issues. The most harmful greenhouse gases with 65th of worldwide warming caused by CO2. Portland cement contributes considerably to greenhouse gas emissions close to zero.8-1 ton of CO2 per ton of cement. Expanded focus is additionally being set on reusing as the universal resources are being depleted, drained and the measure of waste being discarded landfill is expanding comprehensively Therefore, as the industrial development process continues, the re-use of C & Dwaste is becoming increasingly important and for high volumetric use of recycled concrete various kind of solutions has been researched. For Portland cement geopolymer is a alternative promising binder. It is produced mostly from byproduct materials such as fly ash and blast furnace slag. There are several efforts are being created to reduce the use of Portlandcement in concrete by finding different binders to Portland cement this include the utilization of supplementary cementing materials fly ash, CA, Slag & metakaoline. The name geopolymer's is given by "Joseph Davidovits" in 1972.Geopolymer concrete can be made by the following pozzalona's like clays, metakaolin , fly ash or metallurgical slag along with alkalic solution.

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## II. MATERIALS

### A. Ordinary Portland Cement

In this experimental investigation the cement used was OPC of 53-grade. The properties of cement are specific gravity 3.15and found to be conforming various specifications of IS 12629-1987.

### B. Fine Aggregate

Locally available river sand which is passed through 475mm IS sieve and having a specific gravity of 2.67, water absorption 2.8% and grade zone-II as per IS: 383 – 1970 was utilized.

### C. Coarse Aggregate

CA of crushed granite are obtained of max size 20 mm angular shaped were used. The specific gravity of coarse aggregate is 2.67

### D. Fly Ash

In the present study of work, the fly ash is taken from thermal power station of Vijayawada in Andhra Pradesh

### E. Ground Granulated Blast Furnace Slag

GGBS is a byproduct of the steel industry. Here binder replaced with GGBS about 15% by mass.

### F. Recycled Aggregate Concrete (RCA)

For the replacement of the natural aggregate (coarse aggregate) the recycled concrete aggregate is used as it is the best possible substiute which is produced from demolished construction waste. Utilizing recycled aggregate can result in around 60 percent less waste and 50 percentages less mineral depletion per cubic metre of concrete produced. The strength of ordinary Portland cement concrete utilizing recycled aggregate depends largely on the percentage of recycled aggregate used.

### G. Water

Water free from oils, chemicals and other forms of impurities is used for mixing of concrete as per IS:456:2000.

### H. Sodium Hydroxide

Sodium Hydroxide is one of the major ingredients of geopolymer concrete. The following are the specifications of Sodium hydroxide and this material is procured from the local laboratory chemical vendors in Hyderabad, which is in the form of pellets. Specifications are tabulated in table 1 as given bythe suppliers

**Table 1: Shows Physical properties of NaOH.**

| | |
|---|---|
| Molar mass | 40 gm/mol |
| Appearance | White solid |
| Density | 2.1 gr/cc |
| Melting point | 318Oc |
| Boiling point | 1390Oc |
| Amount ofheat liberated whendissolved in water | 267 cal/gram |

### I. Sodium Silicate Solution

Sodium silicate solution is a type of alkaline liquid plays an important role in this polymerization process. This material is procured from the local laboratory chemical vendors in Hyderabad. Specifications are tabulated in table 2 as given by the suppliers

**Table 2: Properties of Na2SiO3 Solution**

| | |
|---|---|
| Specific gravity | 1.57 |
| Molar mass | 122.06 gm/mol |
| $Na_2O$ (by mass) | 14.35% |
| $SiO_2$ (by mass) | 30.00% |
| Water (by mass) | 55.00% |
| Weight ratio ($SiO_2$ to $Na_2O$) | 2.09 |
| Molarity ratio | 0.97 |

### J. Super Plasticizer

MASTER RHEOBUILD 920SH is additioned to improve the serviceability of concrete. In this study superplasticizer utilized was 1.5% of binder.

## III. EXPERIMENTAL INVESTIGATION

### A. General

An objective of this paper is to study the permissible properties of geopolymer concrete of grade G40, Where recycled coarse aggregate is replaced in natural coarse aggregate in different proportions such as 10%, 20%, 30%, and 40% and also to compare the results of geopolymer concrete made with recycled coarse aggregates with geopolymer concrete of natural coarse aggregate and controlled concrete of respective grade. The size of cubes were cast has 100mm×100mm×100mm and after 24hours rest period, the specimens were cured for a period of 24hours at 60°C in oven and the rest of the period cured under the ambient curing.

### B. Mixing and Casting of Geopolymer Concrete

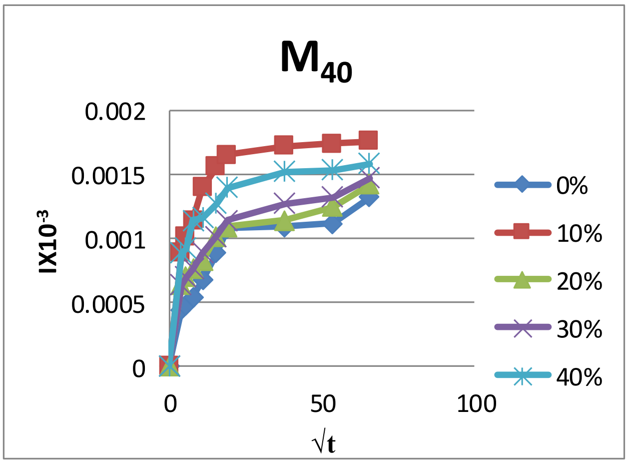
Geopolymer concrete is prepared byusing a similar procedure whatever is used within the conventional concrete. In the laboratory, the fly ash, GGBS and also the aggregates were mixed together in dry by utilizing a panmixer for 2minutes, thenthe alkaline liquid is added with the superplasticizer and additional water if needed. The liquid material is then added to the dry mix and also the mixture proceeded for 2minutes. The fresh concrete was casted by the standard strategies as of CC. The fresh concrete workability is measured by slumptest.

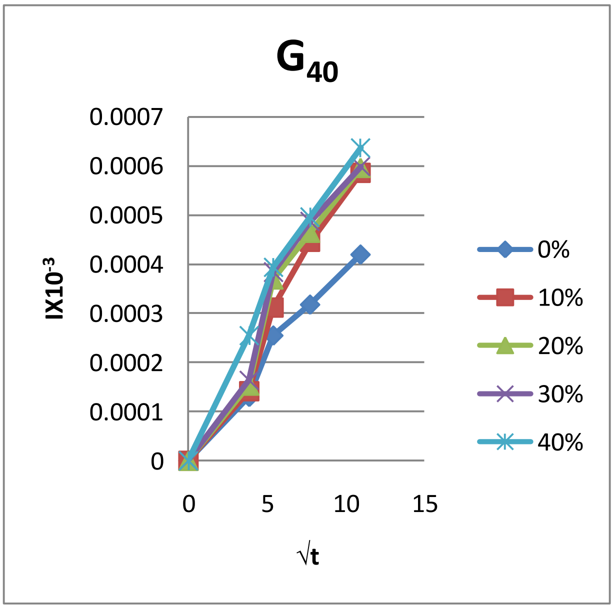
### C. SORPITIVITY TEST

The objective ofthis test toworkout sorptivity of GPC of M40 grade. Sorptivity is that the accumulative modification in volume of W/A against the √t . The test was done on l specimen of size 100mm diameter and 50mm thickness. when 28 days of solidification, the specimens were oven dried at $110^0$C for 24hrs. Edges of specimens are sealed with duct tape or sealing material. And suction face and also the opposite surface to it should be unbroken &opened. The specimens were arranged as shown within the figure below. The rate of water absorption or sorptivity

The rate of sorptivity K = slope of I vs√t graph

I = W/ (A x d); where W= the amount of water absorbed in kilogram A= C/S of the specimen is in contact with water, d = density of specimen when immersed ($1000kg/m^2$in case medium is water).



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**Sorptivity Coefficients of Controlled and Geopolymer Concrete**

| | Type of specimen | **Sorptivity Coefficient (k) x $10^{-3}$ m/min$^{0.5}$** | **Percentage Decreased** |
|---|---|---|---|
| 0% | CC | 0.083 | - |
| | GPC | 0.068 | 18.07 |
| 10% | RAC | 0.087 | - |
| | RAGPC | 0.069 | 20.68 |
| 20% | RAC | 0.089 | - |
| | RAGPC | 0.070 | 21.34 |
| 30% | RAC | 0.092 | - |
| | RAGPC | 0.072 | 21.73 |
| 40% | RAC | 0.094 | - |
| | RAGPC | 0.074 | 21.27 |

## D. WATER PERMEABILITY

waterpermeability test of Concrete is carried out as per IS 3085:1965. The porosity tester was utilized a 3-cell tester consisting of 3testcell, a chamber of pressure and compressed air , water supply to the test samples below needed pressure. GPC specimens and CC specimens of dia& height 150mm are casted and cured for twenty eight days. Then they're the specially designed cells are loaded and a constant air pressure of 15kg/cm2 ismaintained byusing air compressor throughout the test for a given time interval. The pressure head to be applied is of standard to the water ought to be 10kg/cm$^2$. The quantity of percolated water collected is measured at periodic intervals. in the starting, the speed of water intake is larger than the rate of outflow, because the steady state of flow is approached, the 2 rates tend to become equal and therefore theoutflow reaches most andstabilizes. With additional passageof your timeeach flow and outflow typically register agradual drop. Porosity testshall be continued for regarding hundred hrs after the steady state of flow has been reached and also the outflow shall be thought-about as average of all the outflows measured throughout theperiod of 100hours.Then the constant of porosity supported Darcy's law of a falling water head, that is of steady state flow with applied conditions, may be calculated on 28days aged specimens, along subsequent formula

$$K = \frac{Q}{A \times T \times (H / L)}$$

Here
K=coeff of porosity inm/sec
Q = Quantity of water collected in ml over the complete test period
T = Time in seconds over that Q is measured = 100*60*60 sec = 360000 sec
A = Areaof the specimen face in m2 = 0.01767 m$^2$
Water pressure =10 kg/cm2 = 106 Pa
1Pascal of pressure = 0.0001m of pressure head
Pressure Head = 100 m (throughout the test it will be constant)
H/L = the ratio between Pressure head to thickness of the specimen each expressedin meter = 100/0.15 = 666.67

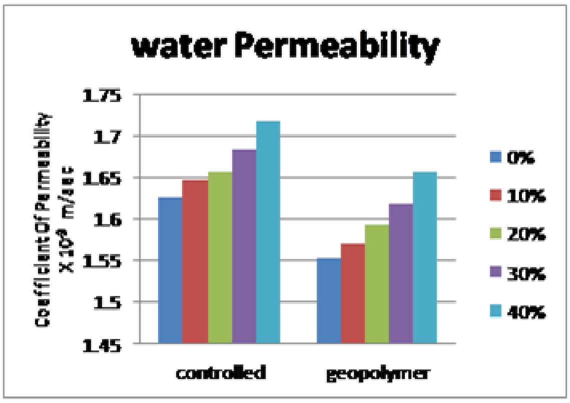
**Table: Coef of Permeability for Controlled and Geopolymer Concrete at Age 28 days**

| | **Type Of Specimen** | **Pressure Head H (m)** | **Quantity Of Water Collected (m)** | **Coefficient Of Permeability X 10-9 m/sec** | **% Decreased** |
|---|---|---|---|---|---|
| 0% | CC | 100 | 6892 | 1.625 | - |
| | GPC | 100 | 6584 | 1.552 | 4.46 |
| 10 % | RAC | 100 | 6984 | 1.646 | - |
| | RAGPC | 100 | 6676 | 1.57 | 4.41 |
| 20 % | RAC | 100 | 7023 | 1.656 | - |
| | RAGPC | 100 | 6759 | 1.593 | 3.75 |
| 30 % | RAC | 100 | 7143 | 1.684 | - |
| | RAGPC | 100 | 6865 | 1.618 | 3.89 |
| 40 % | RAC | 100 | 7289 | 1.718 | - |
| | RAGPC | 100 | 7023 | 1.656 | 3.64 |

**Table : Coef of Water Permeability Ranges as per IS: 3085-1965**

| **Water Permeability** | **Very Low** | **Low** | **Medium** | **High** |
|---|---|---|---|---|
| Coef ofpermeability (x $10^{-9}$ m/sec) | < 0.5 | 0.5-1.0 | 1.0-2.0 | >2.0 |

**Variation of Coefficients of Permeability for Controlled and Geopolymer Concrete Specimens of Age 28 days**




## IV. CONCLUSIONS

i. It is observed that the permeability of CC with RA is 3.5% more than that of Conventional concrete with Natural Aggregate at 30% replacement, but still it is in considerable range as per IS3085-1965.
ii. The permeability of GPC with RA is 4.08% more than that of Geopolymer concrete with Natural Aggregate at 30% replacement, but still it is in considerable range as per IS3085-1965.
iii. It is seen that the sorpitivity of Conventional concrete with Recycled Aggregate is 9.78% more than that of Conventional concrete with Natural Aggregate at 30% replacement, but still it is in considerable range as per IS3085-1965.
iv. The sorptivity of Geopolymer concrete with Recycled Aggregate is 5.55% more than that of Geopolymer concrete with Natural Aggregate at 30% replacement, but still it is in considerable range as per IS3085-1965.
v. The permeation properties such as sorptivity, water permeability of geopolymer concrete are affected to some extent with addition of Recycled Aggregates. However, these properties are better than Ordinary Portland Cement concrete containing same amount and type of RCA.
vi. The replacement of recycled aggregates in concrete gives better results till 30% replacement, so it is an alternative solution for disposal of C&D waste.
vii. The geopolymer concrete gives an early strength when cured in an oven, so it can be preffered wherever early strength is required.

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