

# Resistance of Acid Attack on Geopolymer Concrete Developed With Partial Replacement of Course Aggregate by Recycled Aggregate



T.Srinivas, S.P.Raju Vundi, N. V. Ramana Rao, Deepak Kumar Shinde

**Abstract:** Geopolymer concrete is one of the major developments in recent years resulting in utilization of fly ash in huge quantities and eventually reducing cement consumption and ultimately reducing emission of greenhouse gases. The geopolymer concrete is produced by using activated fly ash as binder material instead of cement. Geopolymer concrete accomplishes great strength and looks similar to conventional concrete. Recycled coarse aggregate (RCA) which is coming from demolition of construction of old and existing structures has been used in this study. The durability property; acid attack resistance with partial replacement of coarse aggregate by recycled aggregate in geopolymer and conventional concrete for the different composition such as 10, 20, 30 and 40 percentage for a period of 15, 45, 75 and 105 days has been evaluated. From the results it was observed that in both natural and recycled aggregate of Geopolymer concrete is highly resistant to acids such as sulphuric acid and hydrochloric acid compared to conventional concrete of respective aggregates.

**Key words:** Geopolymer Concrete, Recycled Aggregate, Acid attack Resistance, sulphuric acid and hydrochloric acid.

## I. INTRODUCTION

Concrete durability is the most vital property which will indicate whether the concrete is good or not through its life. When the concrete is subjected to environment there may be major effect on concrete physical properties due acid attack, sulphate attack, corrosion etc. Among all acid attack may play very important role on the life of the concrete. So in this study, researcher has concentrated on this parameter for different concentration.

### 2.1 Ordinary Portland Cement

The 53-grade of OPC has been used in this study, which is tested as per IS: 4031-1968 for physical properties and confirmed with IS 12629-2009.

### 2.2 Fine Aggregate

The fine aggregate i.e. which is a river sand free from impurities, physical properties have been tested as per IS 383-1970 and confirmed to be zone II.

### 2.3 Coarse Aggregate

The coarse aggregate, which is procured from local crushers of angular in shape and free from impurities and the physical properties have been tested as per IS: 2386-1963.

### 2.4 Fly Ash

In this study of work, the low calcium Class F-fly ash is utilised, which is obtained from Vijayawada thermal power station in Andhra Pradesh.

### 2.5 Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) is a by-product of the steel industry. Blast furnace slag is comprising basically of calcium silicates and other bases

that is developed in a molten condition simultaneously with iron in a blast furnace". Nearly 15% by mass of binders was replaced with GGBS.

### 2.6 Recycled Coarse Aggregate (RCA)

Recycled coarse aggregate (RCA) is gathered from construction and demolition waste and it is a better replacement for Natural coarse aggregate which is up to 40 percent of all waste generated worldwide. Recycled coarse aggregate and Natural coarse aggregate are taken at a proportion of 40% and 60% for this study to validate compressive strength, Split tensile strength, and flexural strength. By adding recycled coarse aggregate it reduces foot print on environment by improving sustainable development. The strength of ordinary Portland cement concrete utilizing recycled aggregate depends great extent on the percentage of recycled aggregate used. Utilizing recycled aggregate can result in less mineral depletion.

### 2.7 Water

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

### 2.8 Sodium Hydroxide

Sodium Hydroxide is one of the major ingredients of geopolymer concrete which is most commonly used as an alkaline activator for geo polymerization and this material is procured from the local laboratory chemical vendors in Hyderabad. The physical appearance of sodium hydroxide pellets are in white solids.

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\* Correspondence Author

**Dr.T.Srinivas\***, Professor, Department of Civil Engineering, GRIET, Hyderabad-500090 Email-srinu.tumala@gmail.com.

**Mr.S.P.Raju Vundi**, Asst.Professor, Department of Civil Engineering, GRIET, Hyderabad-500090.Email-sprajuv@gmail.com.

**Dr.N.V.Ramana Rao**, Director of NITW Professor of Civil Engineering, JNTUH, Hyderabad-500085,Email-rao.nvr@gmail.com.

**Mr.Deepak Kumar Shinde**, Student, Department of Civil Engineering, GRIET, Hyderabad-500090.

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## 2.9 Sodium Silicate Solution

Sodium silicate solution is a type of alkaline liquid plays an important role as an activator in the geo-polymerisation process, it also reduces porosity. If excess amount of  $\text{Ca}(\text{OH})_2$  is present in concrete then it binds with surface thereby increasing durability and water resistance. This material is procured from the local laboratory chemical vendors in Hyderabad.

## 2.10 Super Plasticizer

Super plasticizer (MasterRheobuild920SH) was used as water reducing admixture, it increases workability. It is added in 1.5% to the binder.

## 3. EXPERIMENTAL INVESTIGATION

### 3.1 General

The objective of this paper is to study the durability property, i.e. acid attack resistance with partial replacement of coarse aggregate by recycled aggregate in geopolymer and conventional concrete for the different composition such as 10, 20, 30 and 40 percentage for a period of 15, 45, 75 and 105 days, this study of acid attack is one of the major concern of concrete from the durability point of view.

### 3.2 Mixing and Casting of Geopolymer Concrete

Geopolymer concrete specimens have been developed as like as the procedure adopted for conventional concrete. In the laboratory, by using a pan mixer the fly ash and the aggregates were mixed together in dry form for two minutes, then add the alkaline liquid ( The ratio of  $\text{Na}_2\text{SiO}_3$  to  $\text{NaOH}$  is 2.5 and  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  is 2.09) which has been made 30 minutes before added to the mix.. The mixing of alkaline liquid, the dry material, super plasticizer and extra

water if required are being continued usually for additional two minutes. The fresh concrete was cast and compacted by the standard methods utilized in the case of conventional concrete. The workability of the fresh concrete was measured by means of the conventional slump test.

## II. ACID RESISTANCE METHODOLOGY

The sulfuric acid and hydrochloric acid resistance of geopolymer concrete is evaluated by casting 100 mm x 100 mm x 100 mm cubes. To carry the acid attack an immersion techniques has been adopted. After casting and curing specimens have been immersed in acid solutions. The concentration of sulphuric acid and hydrochloric acid solutions are 5%.. The tests are conducted after 15, 45, 75 and 105 days from the date of immersion. Solutions are kept at room temperature. The solution is replaced at regular intervals of 15 days to maintain concentration of solution throughout the test period. The weight loss, compressive strength loss in percentage is evaluated. The weight of geopolymer concrete decreases when the acid concentration increases and the same effect is reflected after 105 days of immersion in acid. The comparison of compressive strength of specimens with Conventional M40 grade concrete is shown in the following figures

## III. TEST RESULTS

The test results for various composition of mix from 15 days to 105 days of immersion period in acids at 5% concentration of HCL and  $\text{H}_2\text{SO}_4$  for the weight and strength loss has been given in the below figures.

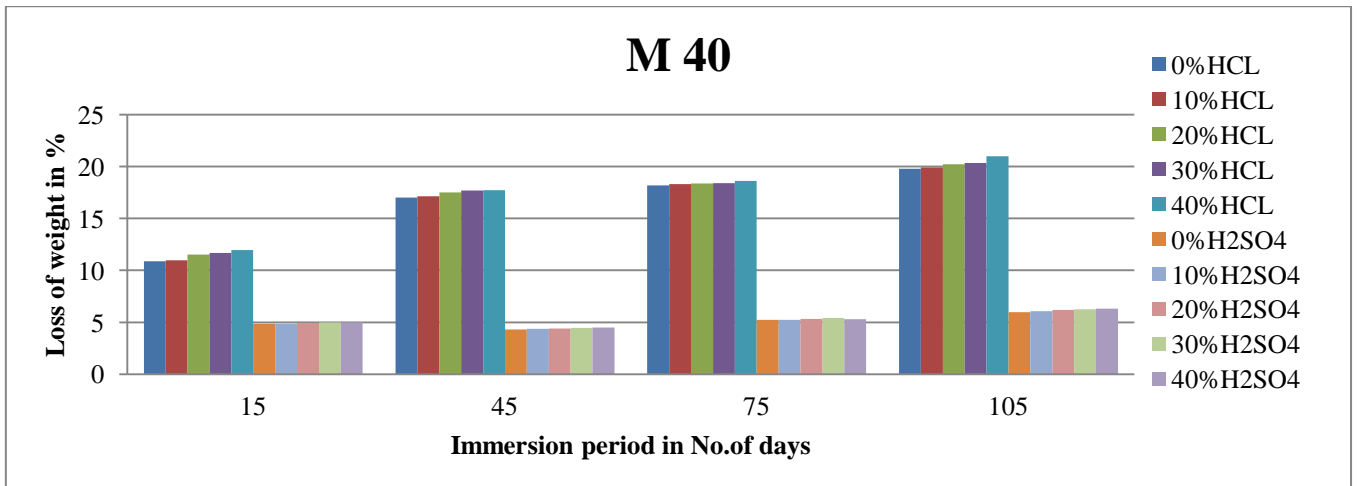


Fig : Loss of weight in Percentage of Controlled concrete (M40) when immersed in 5% concentration

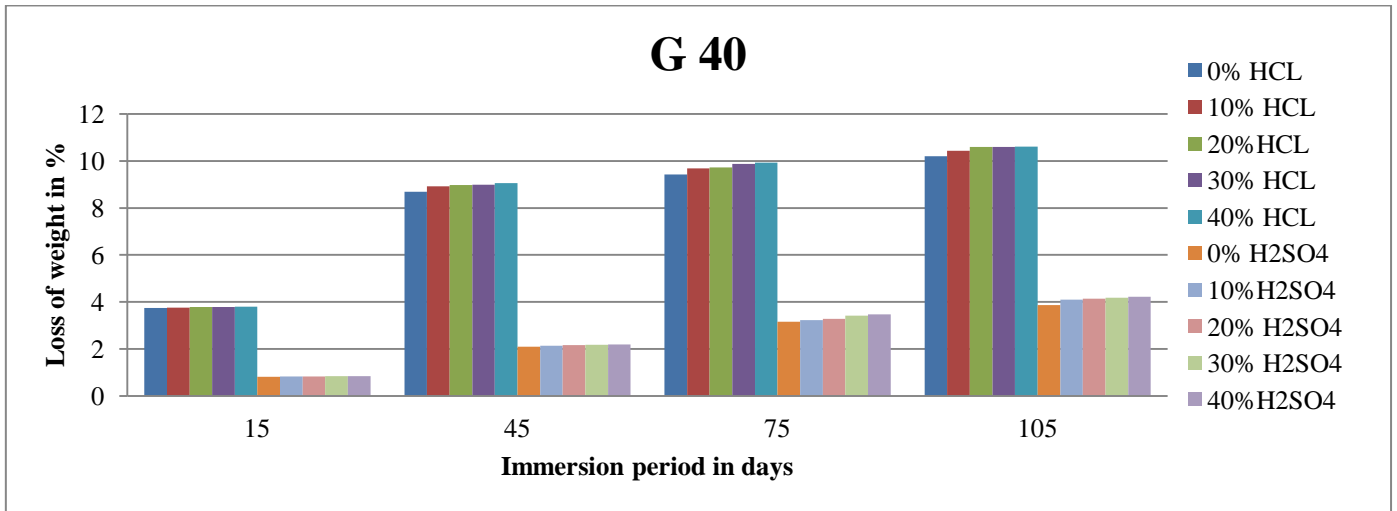


Fig : Loss of weight in Percentage of Geopolymer concrete (G40) when immersed in 5% concentration

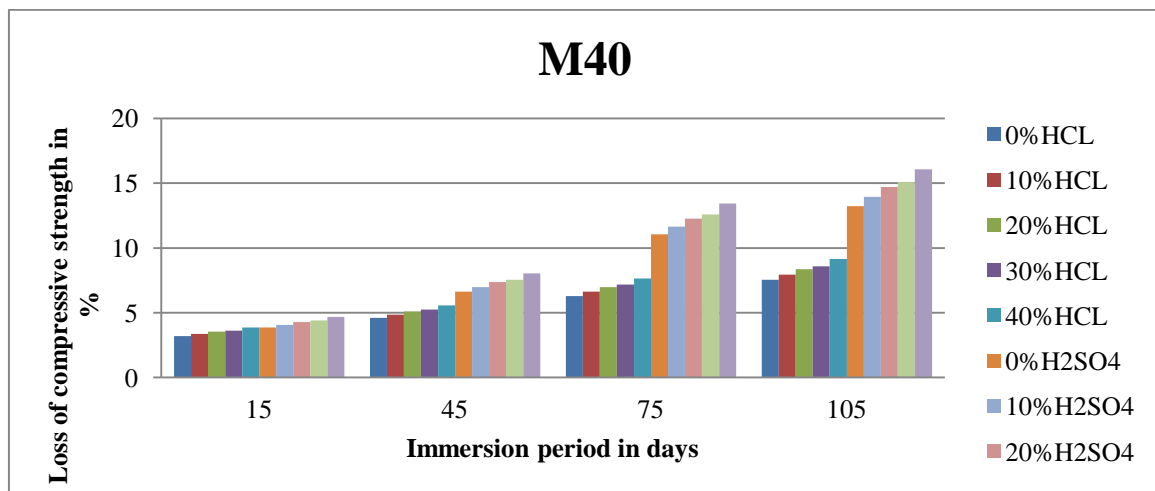


Fig : Loss of compressive strength in Percentage of M40 when immersed in 5% concentration

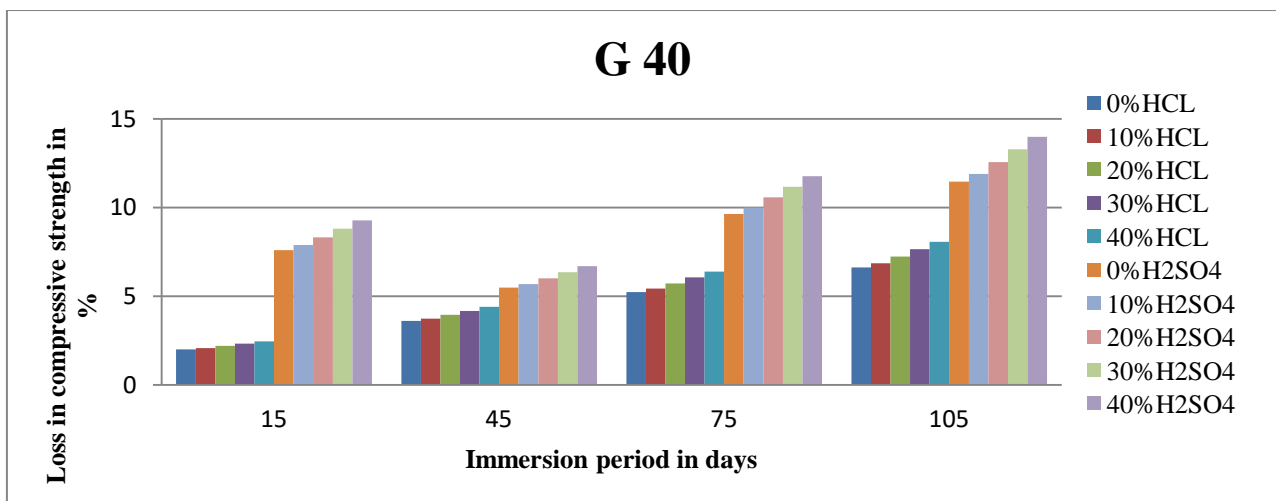
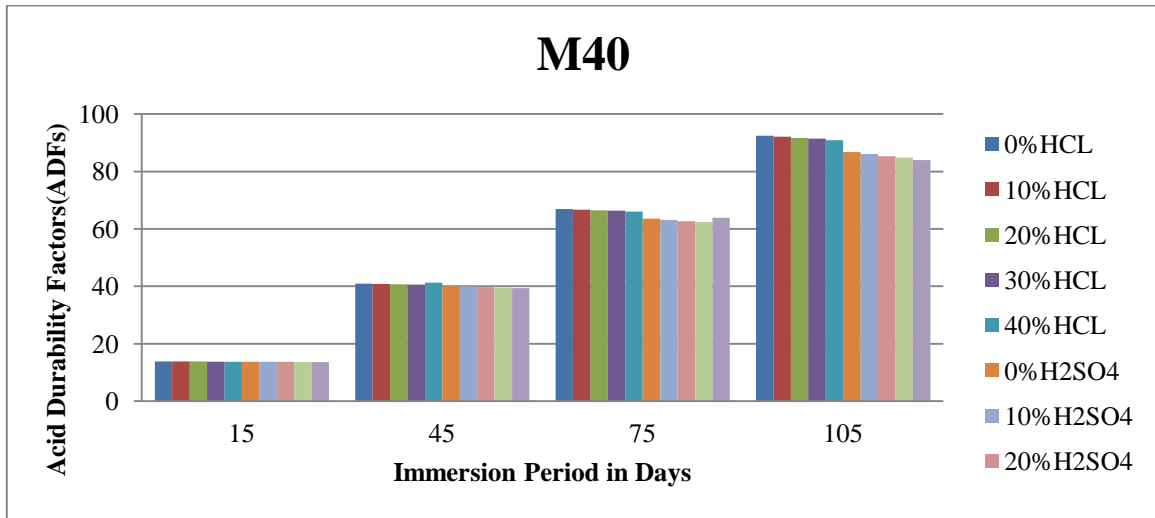
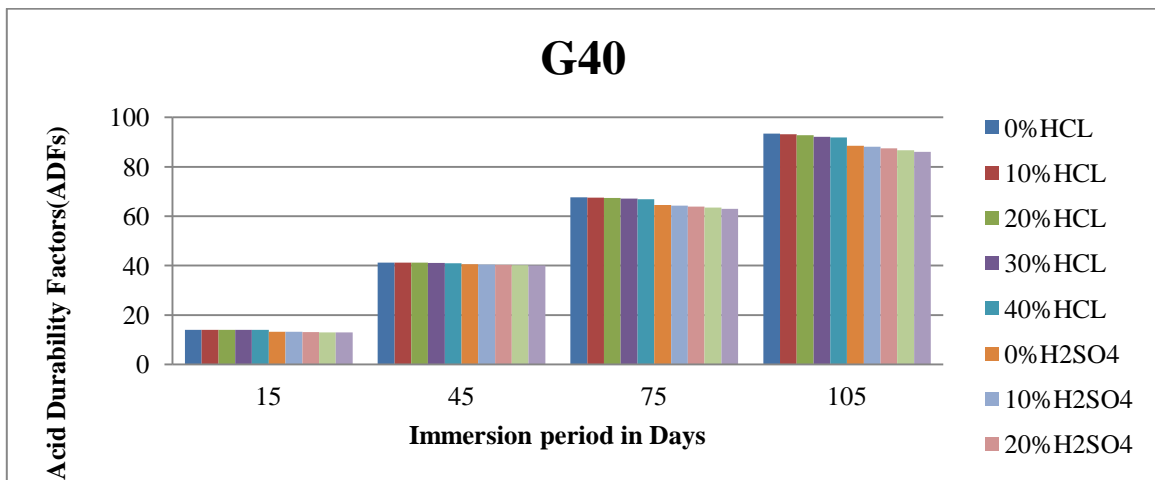


Fig : Loss of compressive strength in Percentage of G 40 when immersed in 5% concentration

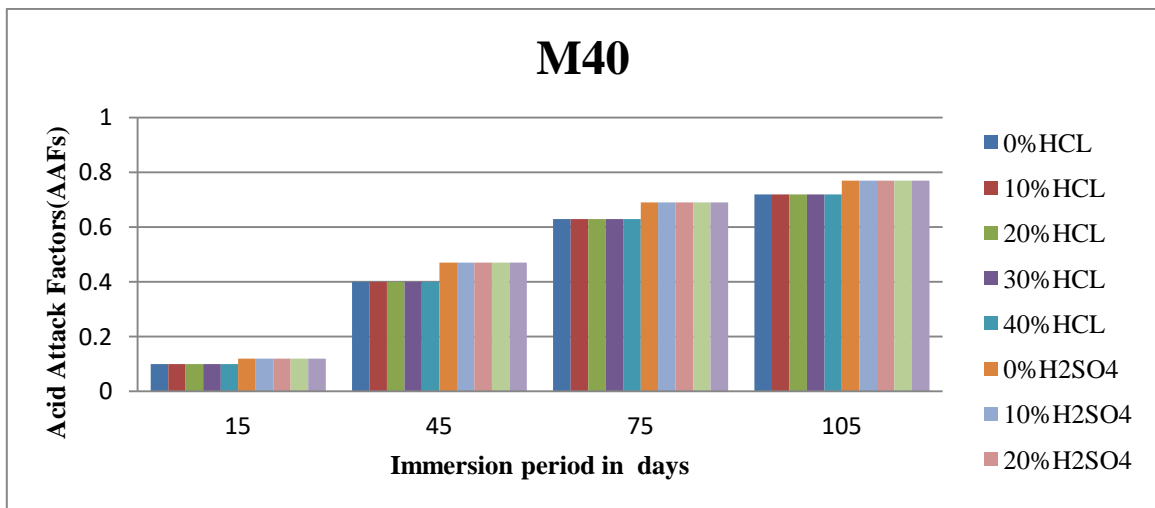
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**Fig : Acid Durability Factors of M 40 when immersed in 5% concentration of Acids**



**Fig : Acid Durability Factors of G 40 when immersed in 5% concentration of Acids**



**Fig : Acid Attack Factors(AAFs) of M 40 when immersed in 5% concentration of Acids**

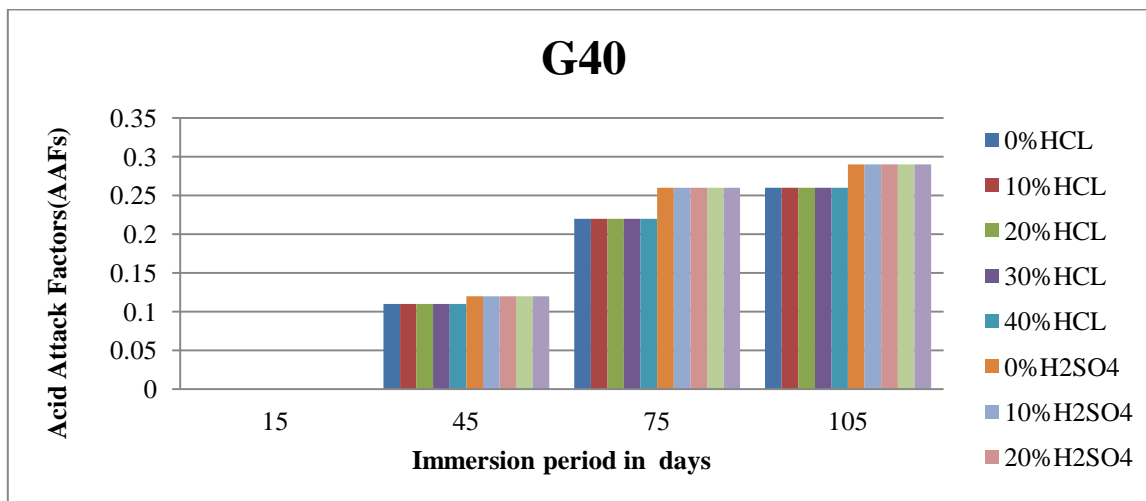


Fig : Acid Durability Factors of G 40 when immersed in 5% concentration of Acids

#### IV. CONCLUSIONS

- i. There is more loss of weight in controlled specimens than that of geopolymer specimens when exposed to hydrochloric acid and sulphuric acid. Thus geopolymer concrete has more resistance to loss of weight than that of controlled concrete.
- ii. The loss of compressive strength is less in geopolymer concrete which is in ranges of 7.81 to 13.99 percentage compared to controlled concrete in range of 3.86 to 16.07 percentage when exposed to HCL. Thus it can be said that geopolymer concrete is more resistance than controlled concrete.
- iii. The loss of compressive strength is less in geopolymer concrete which is in ranges of 2.81 to 8.07 percentage compared to controlled concrete which is in range of 3.19 to 9.15 percentage, when exposed to H<sub>2</sub>SO<sub>4</sub>. Thus it can be said that geopolymer concrete is more resistance than controlled concrete
- iv. GPC can be recommended for structural application because of more strength, durability in terms acid resistance and there is no visible signs of surface deterioration compared to controlled concrete.
- v. The maximum value of compressive strength in RCA is observed at 30% of coarse aggregate replacement there after decreasing.
- vi. There is a better performance of GPC than that of controlled concrete in acidic environment and Geopolymer concrete has an excellent resistance to sulphate attack.

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#### AUTHORS PROFILE



**Dr. T.Srinivas** ' is working as a professor in the Department of Civil Engineering , Gokaraju Rangaraju Institute of Engineering and Technology , Hyderabad , Telangana , India . His areas of research interest are mainly focused on the utilization of coal ash ( fly ash and bottom ash ), special concrete .



**Mr. S.P.Raju Vundi** is working as an assistant professor in the Department of Civil Engineering Gokaraju Rangaraju Institute of Engineering and Technology , Hyderabad , Telangana , India . His areas of research interest are mainly focused on special concrete.



**Dr. N V Ramana Rao**' is the Director of NTTW and professor of civil engineering at JNTUH College of Engineering. Hyderabad. His research interests include special concretes , structural design , finite element analysis , analysis and design of complex structures , computer application and structural optimization



**Deepak Kumar Shinde** ' is pursuing B Tech Civil Engineering in Gokaraju Rangaraju Institute of Engineering and Technology , Hyderabad Telangana , India