A study based upon the effect of polyvinyl alcohol fiber, iron slag and fly ash over the strength aspects of geo-polymer concrete

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Abstract: In this research work fly ash, iron slag and polyvinyl alcohol fiber was utilized to enhance the strength parameters of the concrete. Fly ash and iron slag were used as replacement of the cement and polyvinyl alcohol fiber was used as an additive at 0%, 2%, 3% and 4%. After this several samples were casted and then verified for numerous test. Compressive strength test was executed and it finds out that concrete containing Polyvinyl Alcohol fibers (with different curing methods) was showing increasing strength as compared to concrete deprived of Fiber. Specimens of oven cured samples shown a large increase in strength as compared to room temperature curing as shown in the result section. Compressive strength increases up to three percent of adding Polyvinyl Alcohol fiber after that strength decreasing. Flexure strength was carried on the Geo-Polymer concrete with different curing techniques and result show’s an impressive increase in flexural strength, but room temperature cured specimens show lesser growth as compared oven cured specimens. But not lower than concrete which didn’t have Polyvinyl Alcohol fiber in it. Flexural strength increases up to three percent of adding Polyvinyl Alcohol fiber in both the curing techniques and decreases at four percent as shown in the result section. Split tensile test was also carried out for both the curing techniques oven curing and room temperature curing. The samples which were cured in oven curing show impressive growth in strength. Maximum split tensile strength attained at three percent of adding Polyvinyl Alcohol fiber. With the help of UPV, it was found that the concrete that makes with the help of a Polyvinyl Alcohol Fiber is of good quality as shown in results.

Keywords: Geo-Polymer Concrete, Fly Ash, Iron Slag, Polyvinyl Alcohol Fiber, Compressive Strength

1. INTRODUCTION

1.1 Geo-Polymer Concrete

Geo-polymer concrete is basically a special type of the concrete in which numerous polymers and geo materials were utilized to improve the strength aspects of the normal or conventional concrete. Different types of polymers can be utilized for the preparation of the geo-polymer concrete, that include polyvinyl alcohol fiber, basalt fiber, glass fiber, polyethylene terephthalate fiber and many
more. Similarly Different types of geo materials are also there which can be used for the production of the geo-polymer concrete. In the present research work fly ash, and iron slag was utilized as the geometrical and polyvinyl alcohol fiber was used as a fibrous material for the preparation of the geo-polymer concrete [1–3].

In the current research we are

1.2 Fly Ash

Fly ash is utilized as one of the essential in an ingredient of robust concrete. In which assembly of OPC is of good energy and from profound factory. Electrical is the important stand for evolution of someone country. Coal is a main origin of fuel for the manufacture of electrical in huge countries in the world. In the procedure of electrical generation, huge amounts of fly ash get generate. Nowadays, regarding sixty percent power is manufactured by means of coal as fuel that results in the generation of about two hundred and twenty five million tons of ash twelve-monthly. Fly ash use diminution permeability, alkali-aggregate reaction and heat of hydration and develop the workability, improved the impediment to Corrosion and sulphate attack consequently constructing concrete mass much steady and hard-wearing and thus decline the budget of concrete. In huge of the advanced countries, Small requirements of cement despicable small release of carbon dioxide consequence in shortage in conservatory gas discharge [4,5], see figure 1.

1.3 Iron Slag

Material of Iron Industry produces slag which in the form of hard particles called as iron slag and then slag is crushed and converted into the powder from and due to its properties that match with cement properties. It can be replaced with cement. Iron Slag is a waste material and the emissions are already produced during the production of steel, so Iron Slag can also help in the reduction of emission of carbon. It is the product of iron and steel industries. Iron slag is left-over creation of the iron and steel industry and it can be used as a second cementitious material [4–7], see figure 2.
1.4 Polyvinyl Alcohol Fiber

Polyvinyl alcohol fiber (PVA) is a supreme environment-friendly cement reinforced material, which has a unique molecular structure helps against alkali and weather effect, taking on excellent resemblance to cement, very effective in prevention of crack development, enhances flexural strength, impact and crack strength, enhance permeability, impact and seismic resistance of concrete. Polyvinyl alcohol fiber could be efficiently utilized in civic and engineering constructions such as fortifications, guttering, terrazzo and transportations, connections, channels, strengthening for ridge grades. It has extraordinary strength as compared to other common natural fiber which are mainly used in reinforcing concrete. Fiber elongation is about 6-10%. PVA fiber has tensile strength of fiber ranging between 880-1600MPa below. One of the main uniqueness of PVA fiber is strong bond forming ability with cement matrix [8,9], see Figure 3.
Polyvinyl alcohol fibre, Iron Slag and fly ash. These materials are added separately in different proportions in place of cement and then checking the strength aspects of the concrete [10–14].

2. LITERATURE REVIEW

Alkaline galvanized fly ash, curative temperature plays a very vigorous role, for attaining advanced strength, samples imperiled to advanced curative temperature displayed greater mechanical strength as compared to those of minor temperature. So therefore it was conclude that the, last that for attaining maximum strength results higher temperature curing should be taken into considerations. Mainly in this work the researcher utilized the fly ash as a prime substantial for the production of the geo-polymer concrete. It was conclude that fly ash has positive impact over the strength aspects of the geo-polymer concrete [15,16].

Polyvinyl Alcoho| fiber is very useful for the cast the center void in masonry & solid waste filled in the bottle for increase compressive strength of blocks. Different bottles of the same size at 100ml placed inside the masonry unit by 10 inches long and 8 inches wide. Basically several bottle waste was used in this research work and then after casting samples these samples were cured properly. After proper curing all the samples were tested and it was conclude that with the usage of this plastic waste both all strength of the concrete enhances to a greater extent.

Iron Slag considered as an industrial waste & have many POZZOLANIC properties that good to increase the compressive strength. In this research work iron slag was used as replacement of the natural fine aggregate so as to enhance the strength aspects of the conventional concrete. Iron slag was used from 5 percent to 25 percent at an increment of 5 percent in each case. The test results showed that the maximum results were found at 10 percent usage of eh iron slag. The test result of rebound hammer test showed that the usage of the iron slag densifies the internal microstructure of the concrete.

Polyvinyl Alcohol fiber are used to the building made durable but decrease the concrete compressive strength & flexural rigidity. It comes with low modules synthetic fiber along with fiber of nylon which increases tensile strength. In this research work, basically the usage of the Polyvinyl Alcohol fiber was discussed in detail. Polyvinyl Alcohol fiber was used as an additive in concrete at 0 percent to 2 percent at an increment of 0.5 percent in each case. And from the test results it was conclude that at 1 percent usage the Polyvinyl Alcohol fiber was giving most optimum results for numerous strength of the concrete sample.

Portland concrete, the creation of crude materials for Geo-Polymer does not require an abnormal state of vitality utilization in light of the fact that the high temperature calcining isn’t required. In this research work related to the geo-polymer concrete various geological materials were used to enhance the strength aspects of the concrete. Material such as sugarcane bagasse ash was used and from the test results it was conclude that usage of geo-materials improves the strength aspects of the concrete up to a great extent. Basically sugarcane bagasse ash was utilized at different percentages as a geo material for the production of the geo polymer concrete.
3. OBJECTIVES
The objective of this study was to introduce eco-friendly concrete which does not affect our environment and reduces the various greenhouse gases emissions so that the CO\textsubscript{2} is reduced.

- Geo-Polymer concrete is such type of a concrete which does not need OPC or PPC for its preparation and it need raw or waste material i.e. fly ash and Iron Slag.
- Geo-Polymer concrete uses very less amount of water so this type of concrete which uses alternate material for its production. Future concrete it is very useful in case of prefabricated construction.
- The main aim of study was to minimize fly ash waste and iron industry waste by utilizing it in the field of construction. Iron slag is the waste and its useful life is very less as compare to the waste life span. Other hand useful life of the concrete is very high as compare to its waste life.
- In this project Polyvinyl Alcohol fiber, Iron Slag and Fly Ash was used in the Geo-Polymer concrete and mechanical properties was checked.
- To check the superiority of concrete UPV test was performed and EDX test was also performed to check the element present in the material.

4. MATERIAL AND METHODOLOGY

4.1 Fly Ash
Fly ash is basically the remains obtained after the processing of coal from the coal processing industries. It is basically obtained in powdered form and I very much cementitious in nature so can be utilized as partial spare of the OPC for improving the strength aspects of the concrete. This huge quantity of fly ash is a major concern for the environment. This fly ash polluted over rivers and soil. So by using it this concern will be reduced shown in below table 1.

| Particulars         | Class F Fly Ash |
|---------------------|-----------------|
| Fineness            | 360             |
| Specific Gravity    | 2.19            |
| Loss On Ignition    | 0.31            |
| Sulphur Trioxide    | 0.3             |
| Titanium Oxide      | 0.5             |
| Magnesia            | 1.0             |
| Lime                | 1.0             |
| Iron Oxide          | 3.0             |
| Alumina             | 28.0            |
| Silica              | 65.6            |

4.2 Iron Slag
Iron slag was acquired from INDIAMART and the specific gravity of the Iron Slag found to be 2.79. It is opulent in the content of the calcium silicate and leads to enhancement of the strength parameters of the concrete, see Table 2.
Table 2 Properties of Iron Slag

| Particulars          | Iron Slag |
|----------------------|-----------|
| Fineness             | 400       |
| Specific Gravity     | 2.79      |
| Loss On Ignition     | 2.1       |
| % Sulphur Trioxide   | 1.85      |
| % Magnesia           | 6.79      |
| % Lime               | 34.48     |
| % Iron Oxide         | 0.584     |
| % Alumina            | 16.24     |
| % Silica             | 30.61     |

5. RESULTS AND DISCUSSIONS

5.1 Compressive Strength

Compressive strength of a concrete sample is basically the resistance of the sample of the concrete against all the compressive forces that are applied over it. Compressive strength test was implemented with the help of the universal testing machine also termed as the UTM so as to determine the compressive strength of the sample of the concrete. In this research work cubes were casted depending upon the percentage of the fly ash, iron slag and fiber and then tested for the compressive strength tested after the curing period of seven days and twenty eight days, see table 3,4 and figure 4 and 5.

Table 3 Compressive Strength

| Polyvinyl Alcohol Fiber | Compressive Strength (MPA) (Oven Dry Curing) |
|-------------------------|----------------------------------------------|
|                         | 7 Days                                      |
|                         | 28 Days                                     |
| 0%                      | 19.72                                       |
|                         | 29.51                                       |
| 2%                      | 20.48                                       |
|                         | 30.63                                       |
| 3%                      | 23.69                                       |
|                         | 34.48                                       |
| 4%                      | 22.14                                       |
|                         | 31.46                                       |
Figure 4 Compressive Strength

Table 4 Compressive Strength

| Polyvinyl Alcohol Fiber | Compressive Strength (MPa) (Room Temp. Curing) |
|-------------------------|-----------------------------------------------|
|                         | 7 Days | 28 Days |
| 0%                      | 17.10  | 27.57   |
| 2%                      | 19.48  | 29.68   |
| 3%                      | 23.27  | 31.23   |
| 4%                      | 21.27  | 28.57   |

Figure 5 Compressive Strength
6.2 Flexural Strength Test

Flexural strength of the concrete sample is mainly the resistance of the sample of the concrete against the flexural forces. It was determined using flexural strength testing machine either of three point loading or of four point loading. For performing this flexural strength test several beams were casted and then tested under three point loading flexural strength testing machine after the proper curing period, see table 5,6 and figure 6,7.

| POLYVINYL ALCOHOL FIBER | FLEXURAL STRENGTH (MPA) (Oven Dry Curing) |
|--------------------------|------------------------------------------|
|                          | 7 Days                                  | 28 Days                                  |
| 0%                       | 4.13                                    | 5.11                                     |
| 2%                       | 4.78                                    | 6.23                                     |
| 3%                       | 5.53                                    | 7.67                                     |
| 4%                       | 4.89                                    | 6.35                                     |

![Figure 6 Flexural Strength](image-url)
Table 6 Flexural Strength

| Polyvinyl Alcohol Fiber (%) | Flexural Strength (Room Temp. Curing) | 7 Days | 28 Days |
|----------------------------|--------------------------------------|--------|--------|
| 0                          | 3.37 MPa                             | 4.61 MPa |
| 2                          | 3.77 MPa                             | 5.53 MPa |
| 3                          | 4.28 MPa                             | 5.90 MPa |
| 4                          | 3.92 MPa                             | 5.60 MPa |

Figure 7 Flexural Strength

6.3 Split Tensile Strength Test
Split tensile strength test was mainly performed as per Indian standard code to determine the split tensile strength of the concrete sample. Split tensile strength in general aspects is the responsive nature of the concrete sample in response to the application of the tensile forces over the concrete. For performing this test cylinders were casted depending upon the percentage of the fly ash, iron slag and the fiber. All the test results of the split tensile strength showed that the maximum tensile strength was occurring at 3 percent usage of the polyvinyl alcohol fiber and above this percentage the strength was declining, see Table 7.8 and Figure 8.9

Table 7 Split Tensile Strength
| Polyvinyl Alcohol Fiber (%) | Split Tensile Strength (Oven Dry Curing) |
|-----------------------------|----------------------------------------|
|                             | 7 Days       | 28 Days   |
| 0                           | 2.15 MPA     | 3.23 MPA  |
| 2                           | 2.56 MPA     | 3.75 MPA  |
| 3                           | 2.92 MPA     | 3.99 MPA  |
| 4                           | 2.66 MPA     | 3.55 MPA  |

Figure 8 Split Tensile Strength

Table 7 Split Tensile Strength

| Polyvinyl Alcohol Fiber (%) | Split Tensile Strength (Room Temp. Curing) |
|-----------------------------|----------------------------------------|
|                             | 7 Days       | 28 Days   |
| 0                           | 1.39 MPA     | 1.99 MPA  |
| 2                           | 1.65 MPA     | 2.40 MPA  |
| 3                           | 1.74 MPA     | 2.60 MPA  |
| 4                           | 1.58 MPA     | 2.29 MPA  |
6. CONCLUSION

Compressive strength test was executed and it finds out that concrete containing Polyvinyl Alcohol fibers (with different curing methods) was showing increasing in strength with respect to concrete without Fiber. Specimens of oven cured samples shown a large increase in strength as compared to room temperature curing as shown in the result section. Compressive strength increases up to three percent of adding Polyvinyl Alcohol fiber after that strength decreasing. Flexure strength was carried on the Geo-Polymer concrete with different curing techniques and result show’s an impressive increase in flexural strength, but room temperature cured specimens show lesser growth as compared oven cured specimens. But not lower than concrete which didn’t have Polyvinyl Alcohol fiber in it. Flexural strength increases up to three percent of adding Polyvinyl Alcohol fiber in both the curing techniques and decreases at four percent as shown in the result section. Split tensile test was also carried out for both the curing techniques oven curing and room temperature curing. The samples which were cured in oven curing show impressive growth in strength. Maximum split tensile strength attained at three percent of adding Polyvinyl Alcohol fiber. With the help of UPV, it was found that the concrete that makes with the help of a Polyvinyl Alcohol Fiber is of good quality as shown in results.

7. PRACTICAL APPLICATION

Geopolymer cement concrete is made from utilization of waste materials such as fly ash, Iron Slag and ground granulated blast furnace slag (GGBS). The use of this concrete helps to reduce the stock of wastes and also reduces carbon emission by reducing Portland cement demand. This is also the current trend for the future. As the Ordinary Portland cement is responsible for most of the pollution around the globe so it’s feasible to use geo-polymer concrete as it’s environment friendly. To enhance this, this study is continue for further research on the topic so that it can be frequently used in future and we can reduce the use of cement in concrete and make structure of green materials.
8. LIMITATIONS AND FUTURE SCOPE

In the current study we added different mixtures of various materials like polyvinyl alcohol fibre, Iron Slag and fly ash in different aspects and also we added alkaline solutions like sodium hydroxide and sodium silicate to blend fly ash and iron Slag and other replacements.

Geo-polymer is a type of concrete that will have a great demand in construction industry with the short passage of time. The binding properties and usage of smaller amount of water formulating the mixture has an optimistic forthcoming forward. Geo-polymer is latest research which has an early strength properties and use waste material from industries.

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