Roughness Coefficient of Alkali Activated Mineral Based Concrete Composites subjected to Varying Slopes

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Abstract – *Conveying fluids through pipes made up of concrete plays a vital role. As the life of the material is found to long lasting the pipes made of concrete are prioritized. This type of pipes can access with any type of climate. Geopolymer concrete is the concrete which was influenced by its two phases – one about its long term property and the other waste minimization. While geopolymer concrete used to cast such conveyors, by which the life of the product found increased. Manning's constant is the required element by which the effective discharge of pipes was calculated. Pipes of non-reinforced category as per the standard specification made in Indian standards were adopted while casting of pipe. Mineral based geopolymer pipes were cast and tested for the measurement of Manning's constant. A separate test setup was made to measure the co-efficient effectively. The test setup measured the co-efficient effectively.*

Key Words: Geopolymer Concrete, Fly Ash, Alkaline Activator, Non-reinforced Pipes, Manning's Co-efficient

1. INTRODUCTION

"Concrete" the word without which the word "Construction" is found dormant. Concrete conquers the major and huge creations in the world. Concrete made the imagination to execute very easily. The flexibility of the concrete was well known with its architectural and mega creations. As the concrete has numerous advantages it also lags in some critical points. In order to overcome the lagging found in concrete, substitutions were evolved. To make concrete and concrete products to perform even better such substitutes are found important. Such substitutes are found economical and effective in usage, strength attainment and serviceability.

Geopolymer concrete is one such special concrete. In the application of such special concrete elimination of cement can be done completely. Cement is replaced with the source material. It is stimulated by the alkaline activator and curing temperature. Based on the literatures it can be clearly seen that there are two parameters on which the geopolymer concrete depends. They are processing parameters and synthesis parameters. Processing parameter includes molar ratio, source material to alkaline activator ratio, silicates to hydroxides ratio. Synthesis parameters includes the curing temperature, duration of application. Both the parameters play a major role in elevating the properties of geopolymer concrete.

Geopolymer concrete constitutes majorly two components: a source material and an alkaline activator or stimulator solution. Source materials should comprise of high constituents of silicates and aluminates. Fly ash, slag, rice husk ash, silica fume etc, may be used as source material. Stimulator solution is the combination of hydroxides and silicates. Common elements of stimulator solution are Sodium Hydroxides to Sodium Silicates. Application of such special concrete will lead to lead to reduction in cement production which in turn reduces the emission of carbon-di-oxide into the atmosphere. Hence it can be also said that usage of fly ash abides the reduction in carbon-di-oxide emission along with waste managing concepts.

1.1. PROCESS OF GEOPOLYMERISATION

Polymeric chains are formed during this process; the chains which resulted after the process will have high strength between the bonds. Stimulator solution is prepared by mixing two solutions: Sodium hydroxide solution and Sodium silicate solution. Out of the two solutions Sodium silicate is available in the liquid form. Sodium hydroxide solution is prepared by mixing Sodium hydroxide flakes (Pellets) with water. While mixing the Sodium hydroxide flakes with water an enormous amount of heat is liberated. Hence the solution preparation must be carried out one day prior of cast. Also the solution should be used within 24hrs after preparation. The following step by step procedure illustrate the steps of making geopolymer concrete

- Preparation of stimulator solution
- Mixing of Fly ash, stimulator solution and ingredients of concrete
- Casting in the required mould
- Curing given to the specimen for the required duration
- Collecting specimens after curing and testing to find out required parameter

For this special type of concrete curing is considered as the major element to attain the strength and durable property. Curing may be carried out in three ways – steam curing, heat curing and ambient curing. Curing fastens the polymerization process helping the concrete to attain strength faster. Based on the literatures, steam curing was found to be efficient in attaining the desired properties of concrete. For the present study heat curing was given to the specimens. Even heat curing possess the higher efficiency in attaining properties.

1.2. CONCRETE PIPES

Pipes are the conveyor of fluids from one place to other with necessary slope. Pipes transports liquids, gases even some time powders. The best suited and worldwide adapted method for better conveyance is the usage of pipes. Application of concrete in pipes increased the production and usage of concrete pipes universally. Since the casting and replacement procedure of concrete material is much simple when compared to other materials, concrete pipes are preferred much.

Sewer pipes are always designed as the non-reinforced concrete pipes which are non-pressure pipes either. Since the waste water propagates into the concrete and cause the erosion in the concrete, such type of reinforced concrete pipes are not preferred for this category.

As geopolymer concrete is well-known for its strength and durability, this study was focussed towards the application of geopolymer concrete in pipe production and measuring the roughness co-efficient.

2. MATERIALS

Source material selected was fly ash of class F with high content of silica and alumina was selected with the specific gravity of 3.14. River sand which was clean with fineness modulus of 3.22 and specific gravity of 2.43 was used as the fine aggregate. 12mm sized metal jelly was used as the coarse aggregate. Coarse aggregate with specific gravity of 2.38 was used for the study. Normal potable water available in the casting place was taken for preparing the solution and the mix. Sodium hydroxide flakes of specific gravity 1.48 were used which was mixed with the required quantity of water with 12molar of concentrating level. Sodium silicate of best purity with specific gravity 1.58 was used to prepare the stimulator solution. Design Mix of M35 was adopted along with polypropylene fibres in 0.5%, 1% and 1.5% of addition.

3. TEST PROCEDURE

The test is a new setup which consists of the following parts

- A discharge tank
- Steel stands
- Valve assembly
- Regulator
- Hydraulic jack
- LVDT
- Lifting arrangement
- Depth measuring gauge
- Collecting tank

The elements required for this test setup are arranged accordingly to measure the roughness co-efficient of the geopolymer concrete pipes. After test setup properly arranged the test run was made for a materials which roughness co-efficient was already known to check the accuracy of the setup. Two types of concrete pipes were used to find the accuracy of the test setup. Pipes made of PVC and Conventional concrete were used for test run.



a b c


d e

f g

Fig – 1: Elements of the test setup a – Discharge tank, b – Steel stand, c – Valve and regulator, d – hydraulic jack, e – LVDT, f – depth measuring gauge, g – collecting tank

The discharge tank was kept over the steel stand for the required elevation. The water from the discharge tank was operated using valve and regulator assembly. The test pipe was placed over the lifting arrangement which can be lifted for the required slope for the measurement of roughness co-efficient. A hydraulic jack was provided at the bottom of the lifting arrangement so as to lift the concrete pipe for the required slope. A LVDT is attacked to this lifting arrangement to measure the slope of the pipe from horizontal. At the delivery end of the pipe the collecting tank is placed to measure the discharge of the flow.

The pipes which discharge factor need to be measured were placed over the lifting arrangement. The pipe was lifted using the jack to the required slope. The slope was measured using LVDT. The valve assembly is opened so that the water passed from the discharge tank to flow the through the pipe. The flow is adjusted to the half depth. The depth was measured using the depth gauge. The time required for filling the required head in the collecting tank was noted. After calculating the time value of 'N' was determined from the Manning's formula for determining the discharge of the conduit.

Fig 2: Test apparatus

4. ROUGHNESS CO-EFFICIENT

Formula for determining the discharge through a pipe is,

$Q = (A/N) * (R^{2/3})*(S^{1/2})$

R = Hydraulic mean depth = A/P in m

A = Area of cross section of flow in m^2

P = Wetted perimeter in m

N = Roughness co-efficient or Manning's Coefficient

S = Hydraulic gradient equal

The term 'N' the co-efficient of roughness values change for different materials. In this study roughness co-efficient of geopolymer material was determined. The nature of roughness values with respect to slopes was also studied. With this a comparison between normal geopolymer specimens with geopolymer specimens with addition of polypropylene fibres are made. Polypropylene fibres increased the mechanical and durable property of geopolymer concrete.

5. RESULTS AND DISCUSSIONS

Table – 1: Average Roughness co-efficient values

Description	Roughness coefficient
GPC	0.0109
$GPC_{0.5}$	0.01095
$GPC_{1.0}$	0.0114
$GPC_{1.5}$	0.0113

GPC – Geopolymer concrete, $GPC_{0.5}$-Geopolymer concrete with 0.5% addition of Polypropylene fibre, $GPC_{1.0}$-Geopolymer concrete with 1% addition of Polypropylene fibre, $GPC_{1,5}$- Geopolymer concrete with 1.5% addition of Polypropylene fibre.

Slope of the pipe were varied for a vertical increment of 4mm, 6mm, 8mm, 10mm, 12mm, 14mm, 16mm, 18mm. For all the different slopes, the pipes were tested different fibre content. Average roughness coefficient was determined for the above mentioned percentages and slopes and the values are indicated in Table-1. It can be inferred from the results that as the fibre concentration increased the roughness co-efficient increased too. It can be said that the addition of fibre in the geopolymer concrete pipe will lead to decrease in discharge efficiency. This states that the loss of water during the conveyance was found more when compared to that of normal geopolymer concrete without any addition of fibres. But still the value of 0.5% of fibre content was very similar to that of normal GPC without fibre. This can be suggested that usage of 0.5% of fibre concentration will lead to minor loss in the pipe. The main aim of the addition of fibres will lead to the increase in the mechanical resistance and increase the durability of the concrete.

Figure 3 indicates the slope and N values of Geopolymer concrete without polypropylene fibre. The value N was higher at the beginning where there is little slope, the N value shows a sudden drop after a slope of 0.0087. The N value

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reaches a value of 0.0107 at a slope of 0.0131. The N value reached a steady state after this slope which can constant at 0.0107. When the slope was further increased there is a drop in roughness co-efficient.

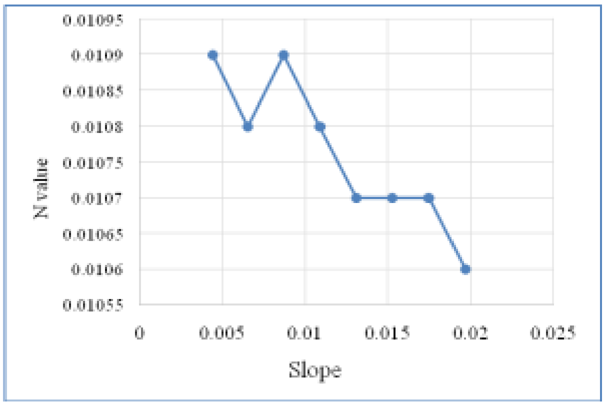

Fig 3: Chart indicating slope and N values of GPC

Figure 4 indicates the N values and slope of a geopolymer concrete with 0.5% of addition of polypropylene fibre. Same value of N was observed for the first two slopes. A steady state phase was observed between 0.087 and 0.0131. after a steady state a small drop was observed and again a steady state for three consecutive slopes. After that a small drop was observed forwarding a steady state for the forcoming two slopes and a fall to the last value of slope was observed.

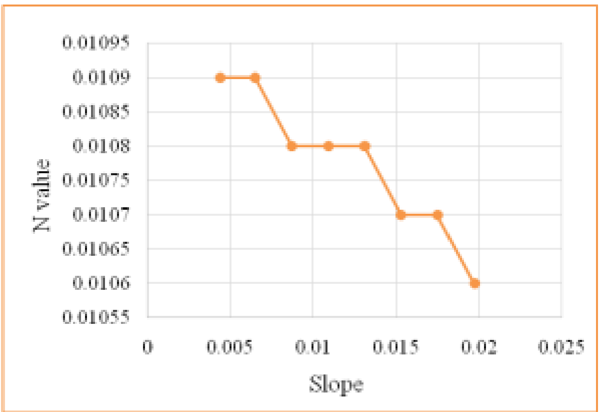

Fig 4: Chart indicating slope and N values of $GPC_{0.5}$

Figure 5 indicates slope and N values of Geopolymer specimen with 1% of polypropylene fibre. The specimen showed a higher value of N at its initial stage when compared to normal geopolymer concrete specimen. The main reason that lies beyong this was the fibres which are added in the specimen improved the circumferential strength. The graph stabilized between the slope value of 0.0109 and 0.0153. on the other phases it can be seen that drops from N values were obtained. With increase in clope value there was rapid declination in the N value for the pipe specimen.

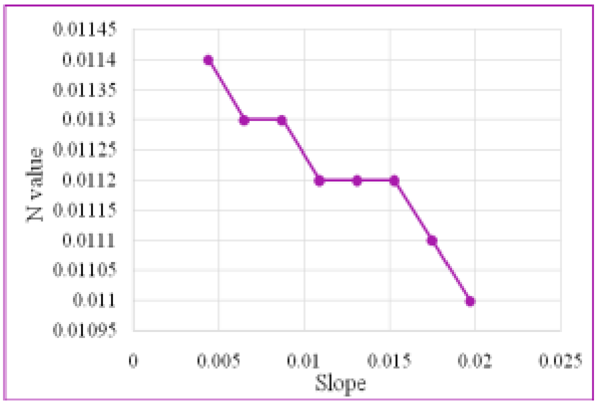

Fig 5: Chart indicating slope and N values of $GPC_{1.0}$

Figure 6 indicates the Slope and N values of Geopolymer concrete with 1.5% polypropylene fibres. The N value is higher than that of normal geopolymer concrete specimen. The fibres get projected above the surface of the concrete which offered a slight resistance against the flow. This can be reduced by providing lining with the cement concrete or by providing better compaction while cast. Anyhow more concentration of fibres led to a greater loss in water discharging. Increase in fibre content increased the loss of water to be discharged.

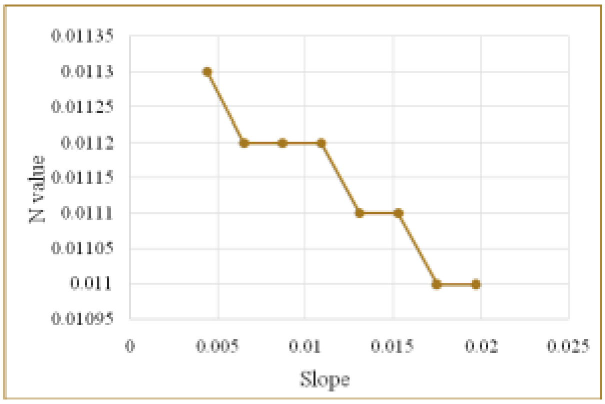

Fig 6: Chart inidcating slope and N values of $GPC_{1.5}$

6. CONCLUSIONS

- Average value of N concludes that increase in fibre content increased the N value of the material
- Slope relating N values for a geopolymer concrete indicates that drops from its initial slope to final slope.
- Chart relating slope and N values for Geopolymer concrete with 0.5% of polypropylene fibre indicates the lesser losses along with a N value relatively equal to that of geopolymer concrete without fibre concentrations.
- Chart relating slope and N values of Geopolymer concrete with 1% of polypropylene fibre indicates

several drops and different phases during its increase in slope value.

- Chart relating slope and N values of Geopolymer concrete with 1.5% of polypropylene fibre showed a higher value of N when compared to all other specimen. Heavy concentration of fibre increased the higher value of N.

- It can be finally concluded that geopolymer concrete with 0.5% of fibre concentration increase the strength and maintains the same N value as that of normal Geopolymer Concrete.

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