Prefabricated wall panels

ABSTRACT

The topic for this project was chosen by our group with enthusiasm because we felt it was a step towards a more beautiful, happy and sustainable environment. There are many inventions and discoveries made which have changed the pace of development in past few decades. In the field of civil engineering there are many ground breaking discoveries made till date that have largely benefitted almost all the countries on the earth in development of their infrastructure.

Whether it may be rail network, road network or airway connectivity, Civil engineering has always helped us humans in achieving all the goals and helped in improving human life. In this fast pace world where there are many developing countries who have a key role to play in developing global as well as regional economy, the very essence of human-nature co-existence is somewhat under threat. The usage of natural resources is increasing every passing year.

Global temperature is on rise due to excessive carbon emission. The forest cover is depleting. It is necessary for every human being to understand the problems we are causing to nature and must be addressed with sincere and continuous efforts.

The problem of climate change, global warming is yet in its initial stages but we just can't wait for things to get worse because we might not find any spare time to react then. Therefore we must go by the saying "stitch in time saves nine". We must remember that we are from nature and not vice versa.

We as civil engineers have a lot of duties towards nature. We need to innovate our practices in constructruction industry. Since the contribution of carbon in atmosphere is largely from manufacture of cement and other construction activities. We have planned to introduce a new type of construction practice, "Prefabricated Wall panels".

We all know usage of prefabricated structures is quite old but, this is a new concept where we are planning to make wall panels which are non degradable, threat to nature. We are going to use Geopolymer concrete, steel, plastic granules, thermocol, if possible, we might use steel fibers.

We want to make construction as simple as boiling a glass of water. We aim to reduce the dependency on natural resources. We want to make housing sustainable. And we believe that if

human race must survive the worst results of climate change and global warming, we have to keep our focus on sustainable energy more than ever before.

CHAPTER-1

INTRODUCTION

1.0 GENERAL

Construction industry is one of the industries which has constantly accepting, recognizing and encouraging to implement on field. This industry is one of the most magnificent, challenging, magical and innovative industries ever. The end to this industry is depended upon the creative and innovative thinking of Engineer, architect.

Construction of any structure involves Planning of project and availability of raw material near to the project site. We came up with a little innovative thought of simplifying construction with waste around us and usage of environment-friendly materials.

Usage of excess of natural resources is not a good sign to any country or state. It leads to Climate change and pollution. Whether it is manufacturing of cement or manufacturing paint, Excessive usage of natural resources is not a good thing. We are sitting on a dangerous time bomb where we are just waiting for bad things to happen to human civilization. We will discuss how we can avoid nature's unexpected response to us as a punishment.

The Indian economy has witnessed considerable progress in the past few decades. Most of the infrastructure development sectors moved forward, but not to the required extent of increasing growth rate up to the tune of 8 to 10 per cent. The Union Government has underlined the requirements of the construction industry.

With the present emphasis on creating physical infrastructure, massive investment is planned in this sector. The Planning Commission has estimated that investment requirement in infrastructure to the tune of about ₹ 14,500 billion or US$320 billion during the 11th Five Year Plan period.

This is a requirement of an immense magnitude. Budgetary sources cannot raise this much resources. Public Private Partnerships (PPP) approach is best suited for finding the resources.

Better construction management is required for optimizing resources and maximizing productivity and efficiency.

CHAPTER-2

2.0 CEMENT

The cement industry is the India's second highest payer of Central Excise and Major contributor to GDP. With infrastructure development growing and the housing sector booming, the demand for cement is also bound to increase.

The Cement Industry globally has immense forward and backward linkages with a Nation's economy. For a developing and transitioning economy such as India, the value proposition of the Cement Industry is even greater given the immense infrastructure requirements of a growing and urbanizing country, as well as its contributions by way of direct and indirect employment. The Government of India has emphasized its focus on infrastructure development with the announcement of several schemes that cut across manufacturing, housing and education. At the heart of all the planned infrastructure development is the cement sector and, as part of the Country's bouquet of eight core industries, the Cement sector's value proposition for laying the foundations of a new India is unique.

Accounting for over 7% of the global installed capacity, the Indian Cement sector is the second largest cement industry in the world, second only to China. It plays a binding and pivotal role in both the infrastructure and socio-economic development of the Country; moreover, the Indian Cement Industry is the fourth-largest revenue contributor to the exchequer and the second-largest revenue contributor to the Indian Railways — it contributes nearly US$ 7.14 billion (INR 50,000 crore) per annum to Government via taxes and levies, and about US$ 1.29 billion (INR 9,000 crore) per annum to the Indian Railways by way of freight revenue.

The total installed capacity in the Indian cement sector is approximately 500 million tonnes per annum, while cement production is approximately 280 million tonnes per annum, signifying a capacity utilization of around 59%.

In 2003-04, 11,400 million kWh of power was consumed by the Indian cement industry. The cement industry comprises 130 large cement plants and more than 300 mini cement plants. The industry's capacity at the beginning of the year 2008-09 was about 198 million tonnes. The cement demand in India is expected to grow at 10% annually in the medium term buoyed by housing, infrastructure and corporate capital expenditures.

Considering an expected production and consumption growth of 9 to 10 per cent, the demand supply position of the cement industry had improved from 2008-09 onwards. Coal-based thermal power installations in India contribute about 65% of the total installed capacity for electricity generation. In order to meet the growing energy demand of the country, coal-based thermal power generation is expected to play a dominant role in the future as well, since coal reserves in India are expected to last for more than 100 years. The ash content of coal used by thermal power plants in India varies between 25 and 45%.

However, coal with an ash content of around 40% is predominantly used in India for thermal power generation. As a consequence, a huge amount of fly ash (FA) is generated in thermal power plants, causing several disposal-related problems. In spite of initiatives taken by the government, several non-governmental organizations and research and development organizations, the total utilization of FA is only about 50%. India produces 130 million tonne of FA 2 annually which is expected to reach 175 million tonne by 2012. Disposal of FA is a growing problem as only 15% of FA is currently used for high value addition applications like concrete and building blocks, the remainder being used for land filling.

Globally, less than 25% of the total annual FA produced in the world is utilized. In the USA and China, huge quantities of FA are produced (comparable to that in India) and its reported utilization levels were about 32% and 40%, respectively, during 1995. FA has been successfully used as a mineral admixture component of Portland pozzolanic blended cement for nearly 60 years.

2.1 GEO-POLYMER CONCRETE

As our earth is facing many challenges from the man-made activities, it is very important for us to think for alternative of cement usage. We luckily have one, which is used not heavily, but used as an option. Our team personally thinks, this must not be an option but a priority to fulfill our demands. It is Geopolymer concrete.

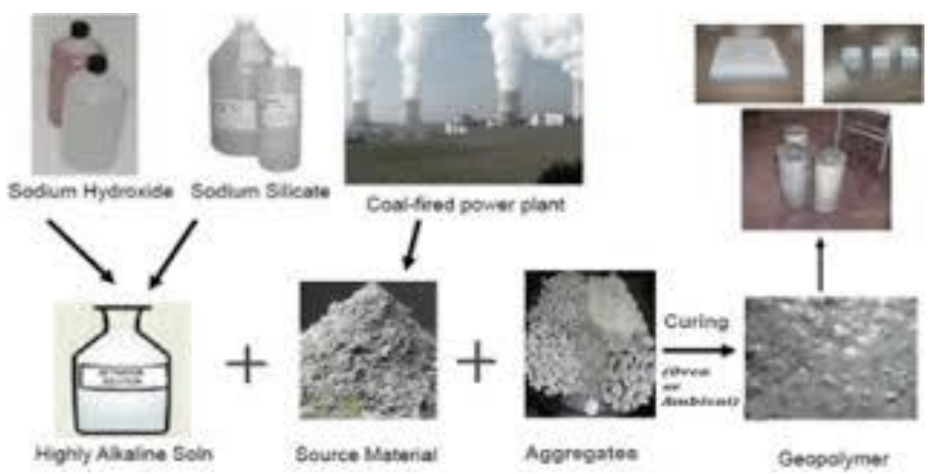
Geopolymer was the name given by Daidovits in 1978 to materials which are characterized by chains or networks or inorganic molecules.Geopolymer cement concrete is made from utilization of waste materials such as fly ash and ground granulated blast furnace slag(GGBS). Fly ash is the waste product generated from thermal power plant and ground granulate blast furnace slag is generated as waste material in steel plant.

The main constituent of geopolymers source of silicon and aluminum which are provided by thermally activated natural materials (e.g. kaolinite) or industrial byproducts (e.g. fly ash or slab) and an alkaline activating solution which polymerizes these materials into molecular chains and networks to create hardened binder. It is also called as alkali-activated cement or inorganic polymer cement.

2.1.1Composition of Geopolymer Cement Concrete Mixes

Following materials are generally used to produce GPCCs:

i. Fly ash,
ii. GGBS,
iii. Fine aggregates and
iv. Coarse aggregates
v. Catalytic liquid system (CLS): It is an alkaline activator solution (AAS) for GPCC. It is a combination of solutions of alkali silicates and hydroxides, besides distilled water. The role of AAS is to activate the geopolymeric source materials (containing Si and Al) such as fly ash and GGBS.



2.2 Other Properties of Geopolymer Concrete:

- The drying shrinkage of is much less compared to cement concrete. This makes it well suited for thick and heavily restrained concrete structural members.
- It has low heat of hydration in comparison with cement concrete.
- This concrete has chloride permeability rating of 'low' to 'very low' as per ASTM 1202C. It offers better protection to reinforcement steel from corrosion as compared to traditional cement concrete.

Coal-based thermal power installations in India contribute about 65% of the total installed capacity for electricity generation. In order to meet the growing energy demand of the country, coal-based thermal power generation is expected to play a dominant role in the future as well, since coal reserves in India are expected to last for more than 100 years. The ash content of coal used by thermal power plants in India varies between 25 and 45%. However, coal with an ash content of around 40% is predominantly used in India for thermal power generation. As a consequence, a huge amount of fly ash (FA) is generated in thermal power plants, causing several disposal-related problems. In spite of initiatives taken by the government, several non-governmental organizations and research and development organizations, the total utilization of FA is only about 50%. India produces 130 million tonne of FA annually which is expected to reach 175 million tonne by 2012. Disposal of FA is a growing problem as only 15% of FA is currently used for high value addition applications like concrete and building blocks, the remainder being used for land filling. Globally, less than 25% of the total annual FA produced in the world is utilized. In the USA and China, huge quantities of FA are produced (comparable to that in India) and its reported utilization levels were about 32% and 40%, respectively, during 1995. FA has been successfully used as a mineral admixture component of Portland pozzolan blended cement for nearly 60 years. There is effective utilization of FA in making cement concretes as it extends technical advantages as well as controls the environmental pollution.

Ground granulated blast furnace slag (GGBS) is a by-product from the blast-furnaces used to make iron. GGBS is a glassy, granular, non metallic material consisting essentially of silicates and aluminates of calcium and other bases. Slag when ground to less than 45 micron from coarser, popcorn like friable structure, will have a specific surface of about 400 to 600 m2/kg (Blaine). GGBS has almost the same particle size as cement. GGBS, often blended with Portland cement as low cost filler, enhances concrete workability, density, durability and resistance to alkali-silica reaction.

Alternative but promising gainful utility of FA and GGBS in construction industry that has emerged in recent years is in the form of Geopolymer cement concretes' (GPCCs), which by appropriate process technology utilize all classes and grades of FA and GGBS; therefore there is a great potential for reducing stockpiles of these waste materials.

2.3 Mechanical Properties

Compressive Strength: With proper formulation of mix ingredients, 24 hour compressive strengths of 25 to 35 MPa can be easily achieved without any need for any special curing. Such mixes can be considered as self curing. However, GPCC mixes with 28 day strengths up to about 60-70 MPa have been developed at SERC.

Modulus of Elasticity: The Young's modulus or modulus of elasticity (ME), Ec of GPCC is taken as tangent modulus measured at the stress level equal to 40 percent of the average compressive strength of concrete cylinders. The MEs of GPCCs are marginally lower than that of conventional cement concretes (CCs), at similar strength levels.

Stress Strain Curves: The stress-strain relationship depends upon the ingredients of GPCCs and the curing period.

Rate of Development of Strength: This is generally faster in GPCCs, as compared to CCs.

We discussed till now about geopolymer cement concrete. We will now be seeing the other part of our project that is Prefabrication

CHAPTER-3

3.0 PREFABRICATION

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the construction practice of transporting the basic materials to the construction site where all assembly is carried out. structure is to be located. The term is used to distinguish this process from the more conventional

The term *prefabrication* also applies to the manufacturing of things other than structures at a fixed site. It is frequently used when fabrication of a section of a machine or any movable structure is shifted from the main manufacturing site to another location, and the section is supplied assembled and ready to fit. It is not generally used to refer to electrical or electronic components of a machine, or mechanical parts such as pumps, gearboxes and compressors which are usually supplied as separate items, but to sections of the body of the machine which in the past were fabricated with the whole machine. Prefabricated parts of the body of the machine may be called 'sub-assemblies' to distinguish them from the other components.

The conventional method of building a house is to transport bricks, timber, cement, sand, steel and construction aggregate, etc. to the site, and to construct the house on site from these materials. In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roof are prefabricated (assembled) in a factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and bolted together.

Prefabricated sections are produced in large quantities in a factory and then shipped to various construction sites. This procedure may allow work to continue despite poor weather conditions and should reduce any waste in time and material at the site. Precast concrete units are cast and hardened before being used for construction. Sometimes builders cast components at the building site and hoist them into place after they harden. This technique permits the speedy erection of structures.

3.1 History of Pre-fabricated structures

Prefabrication has been used since ancient times. For example, it is claimed that the world's oldest known engineered roadway, the Sweet Track constructed in England around 3800 BC, employed prefabricated timber sections brought to the site rather than assembled on-site. Sinhalese kings of ancient Sri Lanka have used prefabricated buildings technology to erect giant structures, which dates back as far as 2000 years, where some sections were prepared separately and then fitted together, specially in the Kingdom of Anuradhapura and Kingdom of Polonnaruwa.

After the great Lisbon earthquake of 1755, the Portuguese capital, especially the Baixa district, was rebuilt by using prefabrication on an unprecedented scale. Under the guidance of Sebastião José de Carvalho e Melo, popularly known as the Marquis de Pombal, the most powerful royal minister of D. Jose I, a new Pombaline style of architecture and urban planning arose, which introduced early anti-seismic design features and innovative prefabricated construction methods, according to which large multistory buildings were entirely manufactured outside the city, transported in pieces and then assembled on site. The process, which lasted into the nineteenth century, lodged the city's residents in safe new structures unheard-of before the quake.

Also in Portugal, the town of Vila Real de Santo António in the Algarve, founded on 30 December 1773, was quickly erected through the use of prefabricated materials en masse. The first of the prefabricated stones was laid in March 1774. By 13 May 1776, the Centre of the town had been finished and was officially opened.

In 19th century Australia a large number of prefabricated houses were imported from the United Kingdom.

The method was widely used in the construction of prefabricated housing in the 20th century, such as in the United Kingdom as temporary housing for thousands of urban families "bombed out" during World War II. Assembling sections in factories saved time on-site and the lightness of the panels reduced the cost of foundations and assembly on site. Colored concrete grey and with flat roofs, prefab houses were uninsulated and cold and life in a prefab acquired a certain stigma, but some London prefabs were occupied for much longer than the projected 10 years.

The Crystal Palace, erected in London in 1851, was a highly visible example of iron and glass prefabricated construction; it was followed on a smaller scale by Oxford Rewley Road railway station.

3.2 Modernization in Prefabricated structures in India

Prefabrication will be a key enabler in mission “Digital India” and play a vital role in all infrastructural development.

‘Building it brick by brick’ to ‘build it before you build it’, transformative technologies being led primarily by Prefabrication are now beginning to blur lines between the construction and manufacturing sectors in India. Slated to have the world’s third largest construction industry by 2025 by an individual survey, India is witnessing a high uptake of modular techniques with its construction sector slowly transforming and behaving more like the business of manufacturing.

The last two decades are testament to the fact that from Supercomputing to Space and Pharma to Biotech, India has always taken the lead to brace innovation and tech adoption be it any sector or industry. Today, the way things are being made is causing widescale disruption across industries including construction of buildings and infrastructure – Future of Manufacturing Things (FoMT). Riding the prefabrication wave and clocking a CAGR of 7-8 per cent, the Indian construction sector today stands at the threshold of a huge opportunity to leapfrog into FoMT and prefabrication or modular construction remain at the heart of it.

3.2.1 Importance of Prefabricated structures

Eco-Friendly

Modular construction is often commended for energy efficiency and sustainable construction. Traditional construction methods require extra materials that lead to increased waste. However, since prefabricated sub-assemblies are constructed in a factory, extra materials can be recycled in-house. This is a considerable improvement over sending waste directly to a landfill from a traditional construction site. Also, the controlled environment of a factory allows for more accurate construction, tighter joints and better air filtration, which in turn allows for better wall insulation and an increase in energy efficiency. For more on the benefits of green technology in the construction industry .

Financial Savings

One of the greatest advantages of prefabricated construction would be financial savings. Although the perception of custom-made pieces may seem expensive, with prefabricated or modular construction, this is not the case. Modular construction targets all budgets and price points, creating an affordable option. Prefabrication manufacturers often receive bulk discounts from material suppliers which then trickles down to the cost of a construction project. Modular construction also sidesteps the possibility of unreliable contractors and unproductive staff. Additionally, the reduction in construction time can significantly save on construction financing costs.

Consistent Quality

Since prefabricated construction occurs in a controlled manufacturing environment and follows specified standards, the sub-assemblies of the structure will be built to a uniform quality. Construction site-built structures are dependent upon varying skill levels and the schedules of independent contractors.With prefabrication, each sub-assembly is built by an experienced crew in a weather-resistant factory, with multiple quality checks throughout the entire process.

Short Construction time

Shorter construction times allows construction companies to take on multiple projects at once, allowing businesses to grow rather than putting all their focus and resources on one or a few projects at a time. Portable construction takes significantly less time to build than on-site construction. In many instances, prefabrication takes less than half the time when compared to traditional construction, due to better upfront planning, elimination of on-site weather factors, subcontractor scheduling delays and quicker fabrication as multiple pieces can be constructed simultaneously.

3.3 Our proposed plan of prefabricating

We plan to make prefabricated structure which will be made of geopolymer concrete. There are many firms today working towards making prefabrication more easier and sustainable, but we are innovating this product keeping in mind all the challenges possibly faced on fields.

Main components of any structure are its foundation, columns, slab and beams and walls. We plan to first start making prefabricated wall panels which will be made with geopolymer concrete, reinforced-steel, Plastic fibers, Glass and other waste product which just pile up as waste and are dumped into seas.

We have been working on this idea passionately, just to make housing affordable,eco-friendly, simple and quick. We started with the wall panels because we wanted to assess the challenges on field as well as, making it in factory. As there is not much research work involved in building walls in traditional way also, we tried to replicate the appearance of the structure as a wall part but with different materials. If there is a chance of making a pilot project, it would be easier to consider using wall panels as slab panel and floor pane.

If the pilot project is successful, we would like to invest our time, blood and sweat in further research of other components like, beam, slab, floor etc. We want to make it a completely self sufficient. There must be less dependence on the outside power and water requirement. We would be further discussing in detail about the making of prefabricated wall panel.

CHAPTER-4

4.0 METHODOLOGY

- Mix design for M30
- Materials
- Tests on materials
- Mixing
- Casting
- Curing
- Testing

4.1 Mix design for M30

Grade = M30

Cement = OPC

Size of aggregate = 20mm

Exposure = Moderate

Nominal size of aggregate = 20mm

Assuming type of sand = zone-II

Assuming true slump = 75

Specific gravity of cement =3.15

Specific gravity of fine Aggregate = 2.65

Specific gravity of coarse aggregate = 2.74

Using OPC of 53 grade

Density

Assuming density of Cement= 1440kg/m^3

Target mean strength

Fck' =fck +1.65*s

= 30+1.65*5 = 38.25 n/mm^2

Fck'=fck +x = 30+ 6.5 = 36.8 n/mm^2

Volume of aggregate

=((1-0.01)-(0.123+0.191)) =0.676m^3

Mass of coarse aggregate

=0.676*0.62*2.74*1000=1148.36kg

Mass of fine aggregate

=0.676*0.38*2.65*1000=680.732kg

M30 ratio

1:1.74:2.94

For 1m^3 quantity

- Cement=390kg/m^3
- Fine aggregate=681kg/m^3
- Coarse aggregate=1149 kg/m^3
- Water = 192kg/m^3
- Water cement ratio=0.492

Min cement content for moderate condition as per code= 300kg/m^3

Calculations of aggregate:

For 20mm nominal maximum aggregate and zone-II

Volume of coarse aggregate 1unit

Volume of total aggregate = 0.62

Volume of fine aggregate=1-0.62= 0.38

Mix calculations:-

Total volume=1m3

Volume of entrapped air in wet concrete = 0.01m^3

Volume of cement=389.39/3.15 *1/1000 =0.123m^3

Volume of water = 191.58*1/100 = 0.191m^3

Design mix

Cement =390*0.023=8.97kg

Fine aggregate=681*0.023=15.63kg

Coarse aggregate= 1149*0.023=26.427kg

Water = 192* 0.023=2.116kg

Water cement ratio = 0.492

(While casting 0.5 liters extra water was used)

4.2 Materials

The properties of various ingredients such as Cement, fly ash, GGBS Fineaggregate, coarse aggregate, alkaline solutions used in the GPC and FRGPC arepresented in this section.

- ## Fine aggregate

Sand generally greater than 70 micron and less than 4.75 mm is used as fineaggregate in concrete. It is a granular form of silica. In concrete, sand acts as a fillingmaterial, which fills the gap between coarse aggregate. This will provide carbon dioxiderequired for hydration. This gives additional strength to concrete and prevents it fromshrinkage and cracking due to creep etc. Locally available River sand is used as fine34aggregate andis tested for various properties required. The sand passing through IS sieve2.36mm was taken. The fine aggregate used in the investigation complied with therequirements of IS 383:1970. The river sand conforming to grading Zone III of IS383:1970 was used as fine aggregate.

- ## Coarse aggregate

This may be uncrushed, crushed or partially crushed gravel or stone.They should be hard, strong, dense, durable, clear and free from veins and adherentcoatings and free from injurious amounts of disintegrated pieces, alkali organic matter.Tests are conducted to determine its physical properties. The aggregates passingthrough are 20mm sieved and retaining on 12.5mm sieve were taken for theexperimental procedures. The coarse aggregate used in the investigation complied with the requirements of IS 383: 1970.

- ## GGBS

GGBS is that the ground granulated blast furnace slag produced in thermalindustries obtained by quenching molten iron slag (a by-product of iron andsteel-making) from a blast furnace in water or steam, to produce a glassy, granularproduct that is then dried and ground into a fine powder. The chemical composition of slag varies considerably depending on the composition of the raw materials in the ironproduction process. The Silicate aluminates impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag. In thecase of pig iron production the flux consists mostly of a mixture of lime stoneand forsterite in some cases dolomite the chemical and physical compositions.

- ## Fly ash

Fly ash is the waste obtained as a residue from burning of coal in furnaces andlocomotives. It is obtained in the form of powder. It is a good pozzolanic. The color of fly ash is light grey. In the present experimental work, low calcium Class F fly ash is usedand it is obtained from Navayug Ready Mix Concrete Suppliers, Patancheru.

- Robo sand

- Alkali activates
  a) Sodium silicate (Na_2sio_3)

  (Na_2SiO_3) sodium silicate usually known as "water glass" or “liquid glass”, is well-known due to wide commercial and industrial application. It is mostly composed ofoxygen-silicon polymer backbone lodging water in molecular matrix pores. GeopolymerConcrete treated with a sodium silicate solution helps to significantly reduce porosity inmost products such as concrete. This substance involves a combination of sodium carbonate(Na_2CO_3) and silicon dioxide (SiO_2) under conditions sufficient to melt both reactants.Sodium silicate is produced by this method with sufficient efficiency to be commercialese.

($Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2$)

b) Sodium hydroxide

Generally the sodium hydroxides are available in solid state by means of pelletsand flakes. The cost of the sodium hydroxide is mainly varied according to the purity ofthe substance. In this investigation the sodium hydroxide pellets of purity 97 % were used.

- Super plasticizer
  High range water reducing (Conplast 430) super plasticizer was used in themixtures at the rate 3% of fly ash to improve the workability and flow ability of the freshfiber reinforced geopolymer concrete.
  SP Conplast 430

4.3 Tests on material

Before going to make a concrete, first we have to det ermine the properties of materials. A number of tests have been performed on cement, fine aggregate and coarse aggregate to know the various physical properties, such as specific gravity, fineness,normal consistency, compressive strength etc. of each material.

Test on fine aggregate

• Specific gravity of fine aggregate

Code: IS 2386 Part-III

Apparatus: Pycnometer

Description: Specific gravity test is used to find the specific gravity of fine aggregate sample by determining the ratio of weight of given volume of aggregate to the weight of equal volume of water. Aggregate specific gravity is needed to determine weight-to-volume relationships.

Specific gravity = D/(A-(B-))

A = Weight of SSD sand sample = 33 g

B = Weight of pycnometer + partly filled sand + rest filled with water = 1500 g

C = Weight of pycnometer full with water = 1482 g

D = Weight of dry sample = 37 g

Result: Specific gravity of fine aggregate is 2.50

IS limit: As per code specific gravity of fine aggregate has to range between 2.5-2.6

- ## Fineness Modulus of Fine Aggregate:

Code: IS 2386 Part-1

Apparatus: sieves, sieve analysis machine.

Description: Fineness modulus (FM) is defined as an empirical figure obtained by

Adding the total percentage of the sample of an aggregate retained on each of a specified

Series of sieves, and dividing the sum by 100. In general fineness modulus is defined as

Size of the aggregate.

IS limits: As per code fineness modulus should range from 2-4

Hence ok.

- ## Bulking of sand

  Code: IS 2386 Part-1
  Apparatus: Measuring cylinder, weighing balance, steel rule.
  Description: Bulking of sand means increase in its volume due to presence of surface moisture. The volume increases with increase in moisture content. Due to moisture ineach particle of sand, sand gets a coating of water due to surface tension which keeps the particles apart. This causes an increment in volume of sand known as Bulking.
  Empty weight of cylinder
  Height of Cylinder
  Height of sand = 2/3rd Height of Cylinder
  Weight of sand + cylinder
  Weight of sand

Test on coarse aggregate

- ## Specific gravity of coarse aggregate

Code: IS 2386 part-III

Apparatus: Pycnometer

Description: Specific gravity test is used to find the specific gravity of coarse aggregate sample by determining the ratio of weight of given volume of aggregate to the weight of equal volume weight-to-volume relationships.

$G = C/(B-A)$

A = weight of aggregate in water = 400.8 g

B = weight of aggregate in saturated surface dry condition = 650 g

C = weight of dry coarse aggregate = 645 g

Result: specific gravity of coarse aggregate is 2.58

IS limit: As per code specific gravity of coarse aggregate ranges between 2.6-2.7

Hence ok.

Fineness Modulus of Coarse Aggregate

Code: IS 2386 Part-1

Description: Fineness modulus (FM) is defined as an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves, and dividing the sum by 100. In general fineness modulus is defined assize of aggregate.

Result: the fineness modulus of coarse aggregate is 7.58

IS limit: As per code the fineness modulus of coarse aggregate should range from 5.5-8

Hence ok.

4.4 MIXING (PROCEDURE)

Firstly, the prepared solution of sodium hydroxide was mixed with sodium silicate solution one day before mixing the concrete to get the desired alkalinity in the alkaline activator solution. Another solution was prepared similarly to the first solution but potassium hydroxide was used instead of sodium hydroxide.

Then fine aggregates, fly ash and coarse aggregate were dry mixed in a horizontal pan mixer or on a flat ground surface for three minutes.

After dry mixing, alkaline activator solution was added to the dry mix and wet mixing was done for 4 minutes.

Finally extra water along with super plasticizer was added to get workable concrete.

In the present experimental work the mechanical Properties are investigated for 7 &28days. The compressive split & flexural tests has been conducted for 3 specimens for 7& 28 days.

This experimental work is carried by arranging required amount ofgeopolymer constituents are calculated in Kgs. After mixing the fresh concrete is to betested for slump in a slump cone apparatus which has been properly greased and fitted tothe base plate.

After the top layer is tamped, the concrete is struck off level with trowel and tamping rod .themould is removed from concrete immediately by raising it slowlyand carefully in vertical direction. The fresh concrete is placed in slump cone in 3 layerseach layer is been tamped 25 times by a tamping rod.

The entire constituents are added upand allowed to mix for 3-4 minutes in the concrete mixer. The sodium hydroxide (NaOH) pellets of 12 molarity concentration was prepared a day before the mix.

After all the solidparticles get dissolved NaOH and Na2SiO3 is added while the mixer is allowed to rotatefor 3-4 minutes until it form a concrete paste. Required amount of water is been added to form concrete.

After a couple ofminutes super plasticizer assumed 3 % of sp 430 is added which acts as water reducerhence the mixer is rotated until it forms a concrete.

Mixer is rotated with all constituent until it attains semi liquid state thus the mixer is lifted. The cubes mouldswere applied grease and then concrete is dispersed into the moulds.

These specimens areproperly cleaned and tightened. It was damped with damping rod until the concrete getswell settled in the specimens. The specimens are demoulded after 24 Hrs and kept in the hot over for 24Hrs at temperature of 60°c.

This procedure is carried for all respectivemixes. The Weight of all specimens is recorded for every mix. These casted moulds arecarefully wrapped with a polythene cover and then placed in oven for curing. Theexperimental work was carried out in systematic way in three different steps like mixing, casting and curing.

4.5 Casting:-

Cubes of size 150*150*150(mm) were casted.

After the sample has been mixed properly, fill the moulds after applying grease to all the faces.

The concrete is poured in three layers are compacted with manual strokes by applying 25 blows to each layer with the help of tamping rod.

Then the mould can be placed on a vibrating table for further compaction.All abrasion specimen of size 300mm dia and100mm thickness were casted for plain GPC and FRGPC.

The mix was poured into themoulds as three layers of equal thickness each layer should be tampered by giving 25strokes continuously.And six moulds of 100mm dia and 50mm thickness were casted forplain GPC and FRGPC.

4.6 Curing:-

After casting, the specimens should be kept in a mould for 1 day. The specimens were demoulded after 1 day.

The moulds were cured using accelerated curing method by placing the moulds in an oven for 24hours by maintaining a temperature of 60 degree centigrade and allowed to cool down slowly at room temperature to prevent formation of cracks.

Theterm rest period indicates the time taken from the completion of casting of test specimensto the start of curing at an elevated temperature.

After one day the specimens are coveredwith polythene sheet and cured in oven at 60°C for 24 hours and then demoulded thespecimens after 24 hours or until testing.

4.7 Testing:-

Workability (slump cone test)

Workability is the ease with which the concrete can be measured. As we increasethe amount of water in the concrete mix (if water to cement ratio is increased) then theconcrete is more workable.

Workability is measured using Slump cone. There are 3 typesof Slumps true, shear, and collapse Slumps. If true Slump is attained, then the concretemix is good.

Shear Slump indicates that the concrete is non-cohesive and showssegregation of concrete. Collapse Slump indicates failure of mix.

The Slump cone wasfilled with freshly mixed geopolymer concrete and was compacted with a tamping bar in four layers. The top of the Slump cone was leveled off, then the cone was liftedvertically up and the Slump of the sample was immediately measured.

Compression test

The cube specimens of size 150 mm x 150 mm x 150 mm were tested inaccordance with IS: 516 – 1969. The testing was done on a compression testing machineof 2000kN tonnes capacity.

Before subjected to thetest, weight of each specimen was recorded and density of each specimen was calculatedby dividing the weight of the specimen by its volume.

Specimens were placed in themachine in such a manner that the load shall be applied to opposite sides of the cubes ascast, that is, not to the top and bottom.

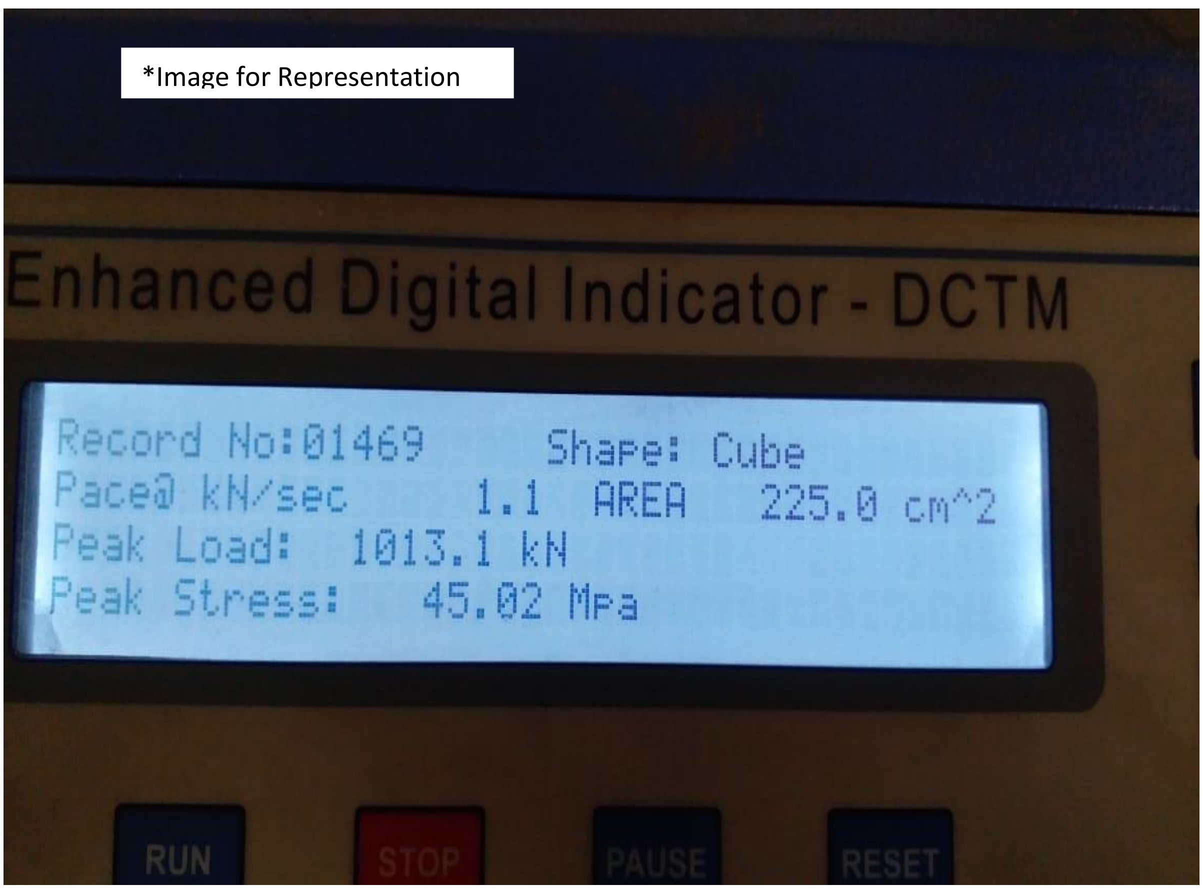


*Image for Representation

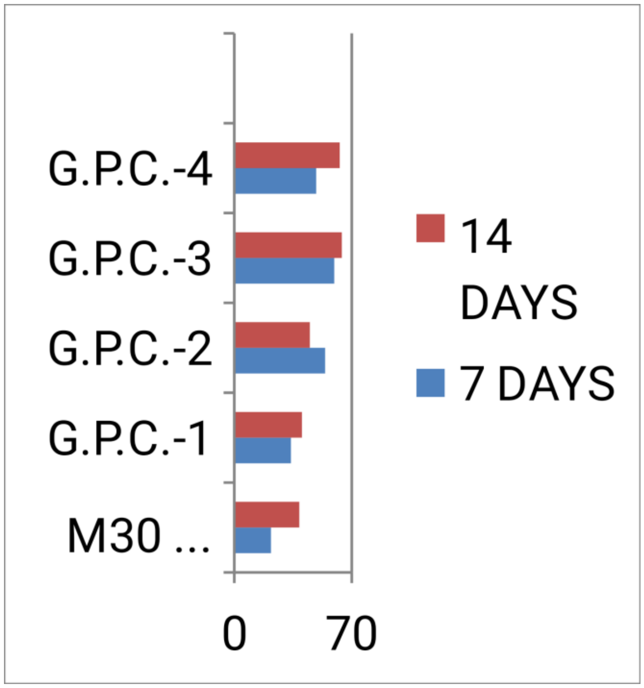
Test set up is shown in Figure. The load was applied without shock and increased continuously at a rate of approximately 14 N/mm2/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.

The maximum load applied to the specimen was recorded. The compressive strength of the specimen was calculated using the equation fck= P/A Where fck is the compressive strength, P is the maximum load applied to the specimen,

A is the cross-sectional area of the specimen.

5.0 Results:-

CUBE TYPE	7 DAYS	14 DAYS
M30 STD CONC	=491.5 KN =21.84 MPa	=871.2 KN =38.72 MPa
GPC 1	=759.3 KN =33.74 MPa	=906.9 KN =40.30 MPa
GPC- 2	=1219.1 KN =54.118 MPa	=1013.1KN = 45.02MPa
GPC-3	=1340.3 KN =59.56 MPa	=1441.6KN =64.07MPa
GPC-4	=1097.9 KN =48.79 MPa	=1413.7KN =62.83MPa



Material/ Concrete type	Cement (kg/ m^3)	Fly-ash (kg/ m^3)	G.G.B.S. (kg/ m^3)	Fine aggregate(river sand) (kgs)	Fine aggregate(Quarry dust) (kg/m^3)	Natural coarse aggregate (kgs)	Plastic granules (kg/m^3)	Alkali activators			Water (kg/m^3) +Conplast	Density of the cubes (7 days and 14 days respectively)
								KoH (kg/ m^3)	NaoH(kg /m^3)	Na2Sio3 (lts)		

M30 std concrete	389.3	-	-	681	-	1149	-	-	-	-	191.58	For 7-days 2427.85 kg/m3 For 14 days 2369.18 kg/m3
G.P.C.-1	-	188.64	188.64	655.2	-	1216.8	-	-	43.06	107.65	130	For7 days- 2427kg/m3 For 14 days- 2410kg/m3
G.P.C.-2	-	188.64	188.68	-	327.6	1216.8	-	-	43.06	107.65	130	For7 days- 2427kg/m3 For 14 days- 2410kg/m3
G.P.C. 3	-	188.64	188.68	-	327.6	1216.8	-	43.06	-	107.65	130	For7 days- 2466.37kg/m3 For 14 days- 2466.37
G.P.C.-4	-	188.64	188.68	655.2	-	1216.8	-	43.06	-	107.65	130	For7 days- 2380.4kg/m3 For 14 days-

												2406.2kg/ m3

1. The above results represented in graph are of the cubes casted with different trial mixes.
2. The first trial mix is of standard concrete of M30 grade, which is taken as reference mix trial.
3. The next results, following the standard concrete, are different trial mixes of Geo-polymer concrete which includes KOh and NaOh.

Chapter-6

6.0 LITERATURE

6.1 IJITE; ISSN: 2278-3075, Volume-8, Issue-9S2, July 2019; A Research Article on "Geopolymer Concrete"; Shashikant, Prince Arul raj G.

- Concrete is used in more than any other man-made material in the world; in fact it is the second most consumed substance in the world after water.
- The production of concrete is the reason for the emission of 5% of total global CO2 emission.
- So to replace the cement considerable attempts were made, one of those is GPC, which is successful enough to fully replace the cement nut with certain limitations.
- GPC is synthesized from waste materials like fly ash, rice husk, silica fume, etc , along with binding solution and is free of cement .
- The main constituent of geopolymer concrete is silicon and aluminum which are provided by thermally activated natural materials (eg : Fly ash) and an alkaline activating solution which polymerizes these materials into molecular chains and networks to create hardened binder .
- Curing temp is an important factor from strength point of view in GPC.
- The chemical reaction of GPC takes place with the temperature imposed to it during the curing period.
- So we can say that temperature and GPC if give longer curing time then it gains higher compressive strength.
- If the curing temperature is elevated then setting time decreases.
- Limitations or areas to be overcome are :
    - ✓ Curing methodology of concrete.
    - ✓ Molarity of the alkaline solution.
    - ✓ Use of fly ash and other materials.
    - ✓ Variation in incubation period and incorporation of cement as partial replacement.

6.2 CURING METHODOLOGY OF GPC

- ➢ Ukesh Praveen Pand Srinivasan K
- ➢ 2017
    - ✓ Reported that contribution of GGBS (ground granulated blast furnace slag) helps the self-compacting GPC attain with high compressive strength at ambient room temperature than fly ash based GPC .
    - ✓ It is recommended that sodium hydroxide and sodium silicate solutions should be prepared at least 24 hours before use.

- ➢ Manimaran. E and Mohan Kumar. G

- 2017

  - ✓ Hot curing may be employed in case of fabrication of precast units.

- Patankar S. Vetal.
- 2018

  - ✓ In fly ash based GPC, when the content of sodium hydroxide is increased the compressive strength of GPC increases.

- Deepa Balakrishan Setal
- 2013

  - ✓ Fly ash GPC is significant, when heat cured for 72 hours it is equal to 90 day ambient cured.

- Satpute Manesh Betal
  2012

  - ✓ Fly ash GPC if given 6 to 24 hours of currying time produces higher compressive strength.
  - ✓ The rate of increase in strength is rapid up to 24 hours of curing time, beyond 24 hours; the gain in strength is only moderate.

- Zhang H Y et al
- 2018

  - ✓ When GPC is exposed to temperature above 300 degrees C then bond strength of geopolymer concrete was found to decrease at the same rate as that of splitting tensile strength with temperature, but this degradation is at a higher pace than that of the compressive strength.

6.2 MOLARITY

- In fly ash GPC higher concentration of NaOH reduces slump value and extra water needed for workability.

- In fly ash GPC combinations of sodium hydroxide and sodium silicate solutions can be used as a sustain ate repair binders and its application is very attractive.

6.3 USES OF FLY ASH AND OTHER INDUSTRIAL WASTES

- Deepa Polakrishna
  - ✓ The change in strength of heat cured specimen is nominal with the variation of fly ash content is varied from 395 to 425 kg/m3 of concrete.
  - ✓ Fly ash GPC is a sustainable material for future construction works.

- B V Rangan
- 2008
  - ✓ Heat-cured low calcium fly ash based geopolymer concrete offers several economical benefits over Portland cement concrete.
  - ✓ The price of one ten of fly ash is only a small fraction of the price of one ton of Portland cement.
  - ✓ Therefore, after allowing for the price of alkaline liquids needed to the make the geopolymer concrete, the price of fly ash based geopolymer concrete is estimated to be about 10 to 30 percent cheaper than that of Portland cement concrete.

- Ma C K et al
- 2018
  - ✓ Types of GPC :
  - Fly ash based
  - Metakaolin based
  - Slag based
  - Rice husk ash based
  - High calcium wood ash based
  - And combination of either two of the earlier mentioned.
  - ✓ Among these types fly ash based GPC is the most popular and widely tested also through review of

papers found that GPC is suitable for structural elements.

- Albitar Metal
- 2017

  - ✓ Sulphuric acid impact in compressive strength is that OPC = 26.6% decrease, fly ash GPC = 10.9% decrease.

- Al-Majidi M H et al
- 2016

  - ✓ Geopolymer mixes with increased GGBS content had considerably improved flexural and direct tensile strength, even without any heat curing treatment.

6.4 DURABILITY AND ENVIRONMENTAL CONSIDERATIO AND RESULT

- Albitar M et al
- 2017

  - ✓ OPC suffers 15.4% deterioration and GPC suffers 13.4% deterioration due to sodium sulphate exposure.

- Daniel A Sales et al
- 2018

  - ✓ Production of GPC entails a potential environmental advantage over cement concrete.
  - ✓ The global warming potential of geopolymer concrete under these conditions is 64% lower than that of cement concrete.

6.5 WATER TOGEOPOLYMER SOLID RATIO

- Ferdow M W et al
- 2013

  - ✓ Compressive strength of the fly ash based GPC decreased linearly with increase water to geopolymer solids ratio.

- Fan F et al
- 2017

  - ✓ They reported that the compressive strength of the geopolymer with water / ash ratio of 0.25 and 0.3 are very close, and the residual strength of geopolymer matrix after 500 degree C heating with the water / ash ratio of 0.3 is higher than that of water / ash ratio of 0.25, which indicates that the water / ash ratio of 0.3 might be the optimal mixture ratio.