



Analyse the Advantages of Self Curing and Self Compacting Geopolymer Concrete

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ABSTRACT

This research study “ANALYSE THE ADVANTAGES OF SELF CURING AND SELF COMPACTING GEOPOLYMER CONCRETE” gives the solutions to the many problems facing during curing and compaction of the concrete in high rise structures. The main advantages for such type of construction are High workability, Fast construction, and Heat resistance and require less manpower thus reducing the overall cost of construction.

To make self curing concrete some specific water-soluble chemicals added during the preparation of the concrete which can also reduces water-evaporation losses during the hardening of concrete, making it a Self Curing type of concrete. These chemicals must have the capacity to reduce the water-evaporation losses from the concrete solution and thus to improve the water retention in the concrete.

Self Compacting Concrete is a flowing concrete that does not require vibration. It uses plasticizers to significantly increase the rate of flow of concrete. It is able to flow under its own weight, completely filling form-work and achieving full compaction, even in the presence of congested reinforcement.

Geo – Polymer concrete is made-up from waste materials such as ground granulated blast furnace slag and fly-ash. Such type of concrete will also be resistive to the heat as well other damaging chemicals.

Combination of such types of concretes will have the 1.5 times the strength of ordinary or normal concrete, require less water and time for curing and also requires less water for the mixing. In present modern world it will be the solution for many problems that we are facing in the construction of skyscrapers and mass concrete structure. It also makes construction much faster, stronger, safer and economical.

INTRODUCTION

1.1 General:

Concrete is the second most used material by humans after the use of water. World without concrete is impossible to imagine. Concrete is provide to resist the compressive, tensile as well as little axial load acting on the structures. Concretes have similar composition just like mortars which are generally used for bond unit masonry. Mortars, however, generally prepared from sand as the sole aggregate, whereas concretes contain both fine as well as large size aggregates that is why Concrete normally have greater strength as compare to mortars and hence for concrete we found much wider range of structural and Construction Uses/applications such as in pavements, pipes, footings, unit masonry, floor slabs, columns, beams, tanks, dams and walls.

Mineral admixtures are normally the very-fine Sized grain in-organic materials having latent hydraulic or pozzolanic properties are added with the concrete mix and mixed properly to improve the required properties of the concrete. Some mineral admixtures are Silica fume, Fly ash, Ground Granulated Blast Furnace Slag that is (GGBFS) etc.

Concrete is the very strong & one of the most versatile/ easily mouldable construction material. It consists of various types of cements, sand and aggregate (Such as gravels or the crushed rock) properly mixed with water. The cement and water mixed in a definite ratio to form a paste/ gel which coats the sand as well as aggregates. When the cement reacts chemically with the water (We called it hydration), it hardens at particular specified time and binds the whole mix together. The initial process of hardening reaction normally occurs within a few hours. Some weeks are required for the concrete to reach its appropriate level of hardness and strength. But normally few years required for the Concrete to gain maximum hardness and strength.

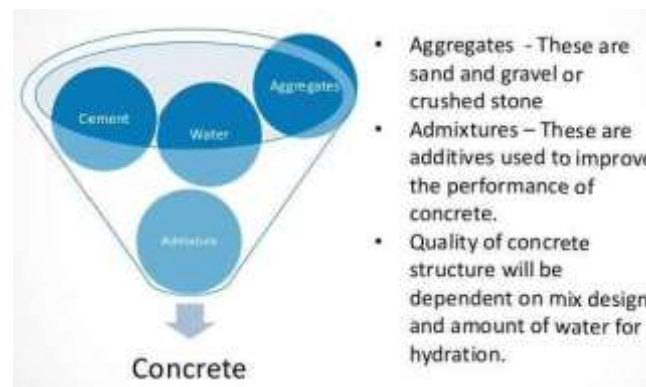


Fig. 1.1, Concrete Preparation

Research Methodology

Depending on the way of getting final results and conclusions based on our objective and importance of the problem that is going to be researched we divide the methods of doing research in the following 3 types:

Quantitative research methodology:

Quantitative research is a research which is related to the numbers and measurements. the main aim is to create numerical data or the data that can be converted into statistical form of information. Here we examined the measurable data/information to formulate the facts as well as uncover- patterns in the research work. The methods for the collection of Quantitative data includes various forms of tests and surveys (different types of surveys and laboratory as well as field tests), telephone interviews, face to face interview, longitudinal studies, online polls, website interceptors and systematic observations.

Qualitative research methodology

Qualitative research is a types research work that is based on unstructured as well as/ or non numerical Information or data. Such type methods are designed in a way that it will help us in revealing the perception and behavior of a targeted audience/population with reference to the specified research topic. Different types of qualitative-research methods are available such as focus groups, in-depth interview, content analysis, ethnographic research, case study researches that are generally used

Mix research methodology

The mixed research methodology is the combination of the quantitative as well as qualitative research methodology. This type of method must be preferred when there is a need and requirements to investigate the research work or problem from various point of views, angles or less information about the topic that we have studied.To make the perfect use of the above discussed research methods successfully we must have good understanding of their distinctive features and suitability.

2.1 Methodology Used in our research:

We have calculated mathematical as well as statistical data and we also use concepts and past knowledge about problems related to cement and concrete, From that data and information we came to the point that we have to used **Mix Research Methodology**. With the help of Mix Research Methodology we can handle and solved broader range of question/ Problems and more complex range of the research related questions.Mixed research methodology highlighted, encourages and make easy to the gather the more in depth evidence for the research related problems. Moreover, this type of research methodology assisting us to answer the questions that were not previously was answered under either quantitative or qualitative methods. Here we can also say that by this method we can do the research work that included numerical as well as conceptual information related to research areas.In our case we Mixed methods of research is more Suitable and favorable because it Promotes multiple world views However many researchers claimed it more easy and practical to apply in the research work. It also guaranteed us to solve more intricate and complex study work. With the help of this type of research methodology we can tackled down the information gathered from the larger audiences. It has grown through many phases such as: a formative-stage, a paradigm-contest, the procedural-phase and the developing interest in federal-endowment, journals, different disciplines of study areas as well as unique workshops.We have done many lab tests and also uses mathematical formulas to get required results for that particular lab tests. We have also uses old concepts from different people and sources about concrete and mix that knowledge with our lab test results to create best concrete which will be self compacted, self cured and geopolymer concrete

SELF CURING CONCRETE

Self curing concrete can be prepared by replacing a part of aggregates by light weighted aggregate or adding some suitable chemical admixtures. The self curing method of concrete taking place from the direction of inside to outside, thus reduces the autogenous shrinkage and self desiccation for the high performance concrete with low water-binder ratios.

Due to the effect of atmosphere continuous evaporation of water/ moisture take place from the external surface of the concrete. That is why polymers will added to the concrete mix that mainly form hydrogen-bonds or H- Bonding with water molecules that reduces the vapor pressure which eventually reduces the rate of evaporation losses from the Concrete surface.

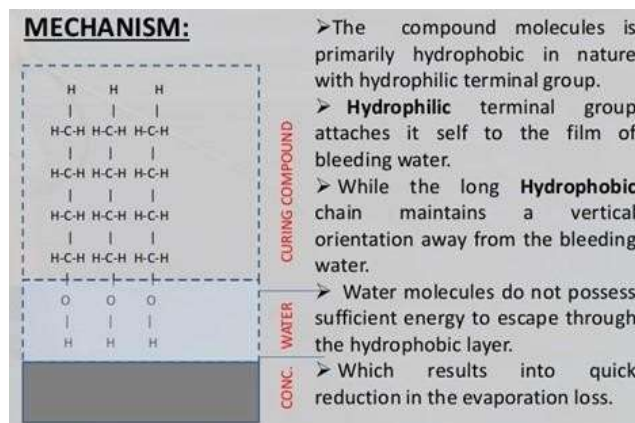


Fig. 3.1, Mechanism of Self Curing Concrete.

Continuous water evaporation takes place from the outer surface that is exposed to atmosphere. It is because of differences in chemical potentials also know as free energy between the vapor & liquid-phases.

3.1 Chemicals/Materials Used:

Adding of POLYETHYLENE GLYCOL as an admixture in the conventional or ordinary concrete helped in better hydration process that enhance the strength of any type of concrete. Polyethylene- Glycol is a condensed type of polymer of ethylene-oxide and the H₂O/water and its general chemical formula is H(OCH₂CH₂)_nOH, Here 'n' is a number of repeating oxy ethylene group and here its values varies from 4 to 180. The abbreviation that are (PEG-600 and PEG-1500) is represent with a numeric suffix which denotes the average molecular-weights. PEGs also have a variety of application in pharmaceutical industries because of the following features:

- Water soluble in nature,
- Odorless, Nontoxic and neutral (Non Reacting) in nature,
- Good Lubrication as well as Nonirritating and Non Volatile properties also associated with it.

3.2 Slump Flow Test:

The slump flow test is used assess the horizontal free flow of self compacting concrete in the absence of obstructions. It gives a good assessment of filling ability. 6liter concrete required to perform the slump test.

Since we measure the flow at 500mm/50cm this test also called as T50CM test.

SELF COMPACTING CONCRETE

Self-compacting concrete with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste.

Now imagine a foundation having large area and very dense reinforcement. In this case you cannot use formwork vibrator since the area is large. Also because of dense reinforcement the needle of needle vibrator cannot penetrate through the reinforcement cage into concrete.

So here comes our savior self compacting concrete. No external source required to compact this concrete. The name itself suggests it can compact itself.



Fig. 4.1, Mechanism of Self Compacting Concrete

4.1 Material Used:

- 1) All types of cement are suitable. Selection of the type of cement will depend on the overall requirements for the concrete, such as strength, durability etc.
- 2) Crushed or rounded sands can be used. Siliceous or calcareous sands can be used.
- 3) Crushed aggregates are used it improves overall strength.
- 4) The most important admixtures are the super plasticizers (high range water reducers), used with a water reduction greater than 20%.
- 5) The fine fly ash particles help to improve the filling of the internal concrete matrix with fewer pores. This improves the quality and durability of the SCC structures.
- 6) Silica fumes helps to increase the mechanical properties of the self compacting concrete structure.

4.2 U-shaped or Box-shaped apparatus Test:

U-shaped test is done to evaluate the self-compactability of the fresh concrete mix. It provides a good direct assessment of filling ability and passing ability of concrete mix.

About 20 liter of concrete is needed to perform the test

Equipment for U Box Test

1. U box of a stiff non absorbing material
2. Scoop
3. Trowel
4. Stopwatch

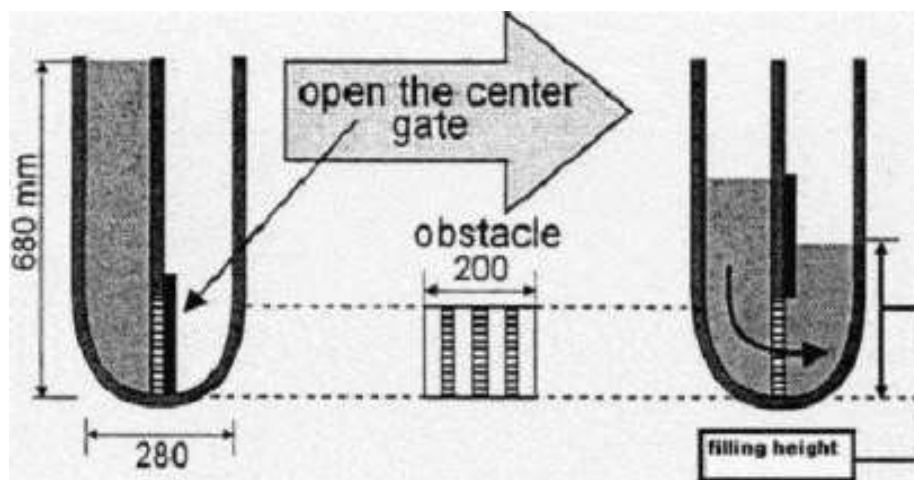


Fig. 4.2, U-Shaped Apparatus and its Arrangements

Procedure for U Box Test on Self Compacting Concrete

1. Levelled the apparatus on ground, ensure that the sliding gate can open freely and then close it.
2. Moisten the inside surface of the apparatus, remove any surplus water, fill the vertical section of the apparatus with the concrete sample.
3. Leave it stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the other compartment.
4. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1).
5. Measure also the height in the other equipment (H2). Calculate $H1-H2$, the filling height. The whole test has to be performed within 5 minutes.

Results

In our case both the side height of the concrete mix become equal means concrete flows as freely as water and $H1-H2=0$. Indicating the better flow and passing ability of the concrete.

4.3 Advantages of Self Compacting Concrete:

1. Its highly workable due to its low water-cement ratio, which gives rapid strength development, more durability, and best quality.
2. SCC can be placed easily in complicated formwork and dense reinforcement.
3. Its construction is faster and requires less manpower reduce the overall cost of production.
4. As it is self-compacted there is no need to use any vibrator.
5. Bleeding and segregation problems are almost nil.
6. It produces a smooth and well-finished surface at the end of concreting.
7. Thinner concrete slabs can be cast easily.
8. Working procedure is totally safe.
9. It is environment-friendly because it saves water.

4.4 Disadvantages of Self Compacting Concrete:

1. SCC requires high fluidity in tight joints formwork, which slowdowns the casting rate.
2. Due to its low water-cement ratio, plastic shrinkage cracks may occur. But this can be avoided by curing properly.
3. Highly skilled and experienced workers are required for the production of SCC.

GEOPOLYMER CONCRETE

The Geopolymer Cement Concrete is made from the utilization/uses of waste materials such as ground granulated blast furnace slag (GGBS) and the fly ash. Thermal power plants produces Fly Ash as a waste product with their normal running activities and The waste product/ material produced in the steel manufacturing plant are ground granulate blast furnace slag, Thus we can get both the product as a waste products from other industries also solve their waste disposal problems

Both Ground Granulated Blast Furnace Slag GGBS and fly ash are processed with a best suitable and appropriate technology after that we can used them for concrete construction works in the form of geopolymer concrete. The use of this type of concrete construction helps us to reduce the stock of waste produced from Steel and Thermal Power Plants & It will also reduced Portland cement demand and so the Carbon Emission also reduces.

The main difference in between the Portland cement concrete and the geopolymer concrete is binder. The silicon & aluminum oxide in a low calcium fly ash reacted with alkaline liquid to form the geopolymer- paste and it will act as a binder for The fine aggregates, the loose coarse aggregates and other Un- reacted Building materials together to form the geopolymer concrete just like The Portland cement concrete. The fine and the coarse aggregates occupy approximately 75% of the mass of geopolymer concrete. we can create The designed mixtures using the tools that currently available for the Portland cement concrete.

The workability and The compressive strength of geopolymer concrete are effected by the properties and the proportions of the constituent materials from that we prepared the geopolymer paste. Conventional techniques can be used for manufacturing the Portland cement concrete as well as Geopolymer concrete.

In the laboratory, The aggregates and the fly ash firstly mixed together than left for drying in a pan mixer for almost 3 minutes. The alkaline liquid mixes with super plasticizer & extra water. Then we have to add liquid components of the given mixture to the dry materials, After that mixing that mixer continuously for another 4 minutes making a perfect Mix. The fresh concrete can be used within 120 minutes without any sign of setting/Hardening & without any decrease in the compressive strength of the Concrete. The fresh concrete will be compacted and cast by the Ordinary methods that we used in the case of Portland cement concrete. Finally we get the geopolymer concrete which is Fresh fly ash based and it is normally cohesive in nature.

Conventional Slump Test can be used to measure the workability of the fresh concrete. Wet-mixing time of the concrete also effects the compressive strength of the geopolymer concrete. Conventional Slump Test results show that the compressive strength increased as the wet-mixing time increased.

5.1 Preparation:

Thermally activated natural materials (Such as kaolinite) or industrial byproducts (Such as fly ash/ slag) are the main Constituents for the Geopolymer source of the Silicon & Aluminium. The alkaline activated solution that polymerizes these materials into the molecular-chains & networks to create the Strong and hardened binder. Such type of cement also called as the alkali- activated cement which is also called as inorganic polymer cement.

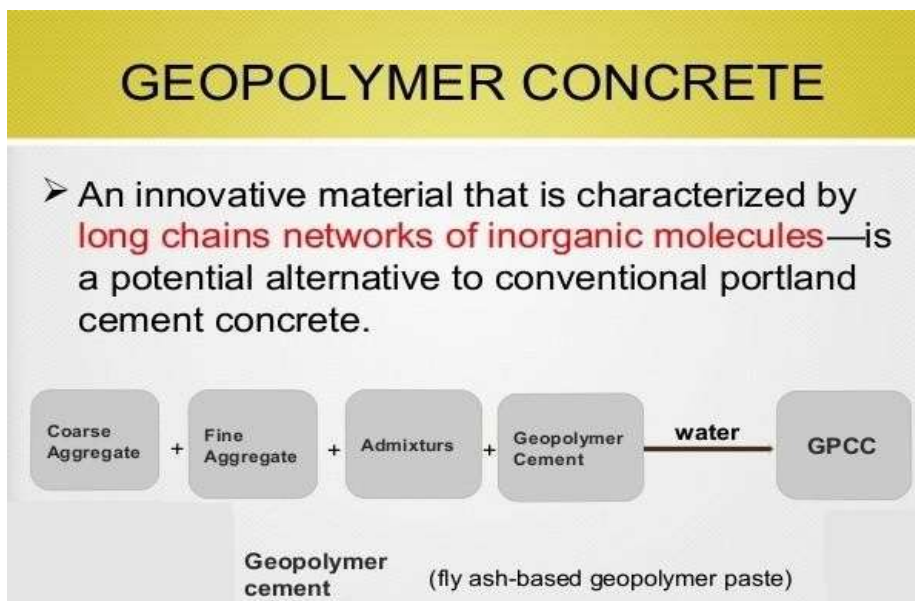


Fig. 5.1, Preparation of Geopolymer Concrete

5.2 Material Used:

1. Fly ash, a byproduct of thermal power plant.
2. Ground granulated blast furnace slag (GGBS), It is one of the byproduct from the steel plant.
3. Aggregates (Fine aggregates & coarse aggregates) are required for adding in the normal concrete.

5.3 Fineness Test of Fly Ash:

Fineness test of fly ash is done to find out the particle size of the fly ash.

Finer the fly-ash particle the best will be the fly ash and on the other hand the coarser the particle it will not be that good.

The fineness of fly ash is determined by Sieving Method

Importance of Fineness

1. It can decrease bleeding.
2. It can increase the final strength of Concrete.
3. Fineness can also affect workability.
4. Fineness test indirectly measures the surface area of the particles of Fly Ash per unit mass.
5. Fineness increases the strength development in the concrete during its first seven days.
6. It increases the rate of hydration.

Procedure

1. Take 1000 grams (1 Kg) of Fly Ash for the test sample and name it as (w1).
2. Rub the Fly Ash particle well with your hands so that no lumps are left.
3. Now pour the 1 Kg Fly Ash content in the sieve and close it perfectly with the sieve lid.
4. Put the sieve in the shaking machine and start the machine for 15 minutes.
5. Brush the sieve base gently with the bristle brush so that nothing is left on the sieve surface.
6. Now just weight the retained amount of cement on the sieve and note it as (w2 = 17 gm).
7. Now you need to find the percentage of the weight of Fly Ash -retained on the 45 m sieve.

Result

Percentage of retained weight of Fly Ash = $(w_2/w_1) * 100 = (17/1000) * 100 = 1.7\%$. It indicates Fly ash we used is of great and required quality.

5.4 Specific Gravity Test of Fly Ash:

The **Specific Gravity** for any Material is the ratio of "Density of the substance to the Density of reference substance" at the fixed temperature. We can calculate the specific gravity of any Building Material/ substance to know its behavior in the water.

Using this test we can know the Building material will floats or sink in water. All the materials present in our environment have a fixed value for specific gravity. The usual range for Specific Gravity is 1-100. If the specific gravity is more than 1, then it will sink in the water and if its value is lesser than 1 than it will floats on the water. Thus if we known the specific gravity of any substance, Than we can also known about the materials suitability according to the place of our work.

Required Materials & Apparatus

Apparatus and materials for the specific gravity test are mentioned below:

1. Kerosene
2. Fly Ash Sample
3. Pycnometer of 100 ml
4. Weighing Machine

Test Procedure

The specific gravity test procedure contains following four steps.

1. The Flask should be free from the liquid that means it should be fully dry. Weigh the empty flask. It is W1 (0.7 kg).
2. Next, fill the Fly Ash on the bottle up to half of the flask around 500gm and weigh with its stopper. And it is W2 (1.2 kg).
3. Add Kerosene to the Fly Ash up to the top of the bottle. Mix well to remove the air bubbles in it. Weigh the flask with Fly Ash and kerosene. And it is W3 (1.68 kg).
4. Empty the flask. Fill the bottle with kerosene up to the top and weigh the flask for named W4 (1.45 kg).

Specific Gravity Calculation

Cement specific gravity formula:

$$S_g = (W_2 - W_1) \text{ Divided By } [(W_2 - W_1) - (W_3 - W_4) * 0.79]$$

$$= 1.2 - 0.7 / [(1.2 - 0.7) - (1.68 - 1.45) * 0.79]$$

$$= 2.34$$

(Means Specific Gravity of Fly Ash is more than thrice the Specific Gravity of kerosene which 0.79, it indicates that it will increase the strenght of final product and we will have less porosity in our structure)

5.5 Advantages of Geopolymer Concrete:

1. It has a high compressive strength that showed higher compressive strength than that of ordinary concrete. It also has rapid strength gain and cures very quickly, making it an excellent option for quick builds.
2. Geopolymer concrete does not hydrate; it is not as permeable and will not experience significant shrinkage
3. It has the ability to stay stable even at temperatures of more than 2200 degrees Fahrenheit.
4. It is also resistant to freezing.
5. It has a very strong chemical resistance. Acids, toxic waste and salt water will not have an effect on geopolymer concrete. Corrosion is not likely to occur with this concrete as it is with traditional Portland concrete.

5.6 Disadvantages of Geopolymer Concrete:

1. Geopolymer concrete requires special handling needs and is extremely difficult to create. It requires the use of chemicals, such as sodium hydroxide, that can be harmful to humans if not handled carefully.
2. Skilled Labor Required.
3. Generally available in pre mix form due to special handling and use of skilled labor.

Result:

Self curing and Self compacting Geopolymer concrete gives the solutions to the many problems facing during curing and compaction of the concrete in high rise structures. The main advantages for such type of construction are Fast construction, High workability, Heat resistance and Requires less manpower thus reducing the overall cost of construction.

Sample Size (150mm X 150mm X 150m) Propylene Glycol + Fly Ash + Crushed Aggregates + Ordinary Portland Cement (Total 6 sample prepared)	After 7 days compressive strength (N/ mm ²)	After 28 days compressive strength (N/ mm ²)
Sample 1	37.10	38.20
Sample 2	39.40	39.90
Sample 3	38.80	40.20

Table 6.1, Crushing Strength of the Sample

Self curing and Self compacting Geopolymer concrete types of concretes will have 1.5 times the strength of ordinary concrete, requires less water for mixing, require less water and time for curing. In present modern world it will be the solution for many problems that we are facing in the construction of skyscrapers and mass concrete structure. It also makes construction much faster, safer, stronger and economical.

6.1 Conclusion:

Self curing and Self compacting Geopolymer concrete types of concretes will have 1.5 times the strength of ordinary concrete, requires less water for mixing, require less water and time for curing. In present modern world it will be the solution for many problems that we are facing in the construction of skyscrapers and mass concrete structure. It also

makes construction much faster, safer, stronger and economical. Self curing and Self compacting Geopolymer concrete gives the solutions to the many problems facing during curing and compaction of the concrete in high rise structures. The main advantages for such type of construction are Fast construction, High workability, Heat resistance and Requires less manpower thus reducing the overall cost of construction. Some important points about Self curing and Self compacting Geopolymer concrete are given are as follows:

1. Self Curing Concrete save time as well as water used in constructional work of concrete Structures.
2. Self Compacting or Self Consolidated Concrete does not required vibrator. It flows by action of self weight and gravity.
3. Self Curing and Self Compacting Concrete used Super Plasticizers to fulfill our requirement.
4. Geopolymer Concrete uses waste materials from steel manufacturing plants and Thermal power plants.
5. In geopolymer concrete, more curing required at higher temperature (40 - 60 degree Celsius), this problem solved by super plasticizer that we add initially.

When we will create combination of self curing, self compacting and geopolymer Concrete there uses and advantages will be tremendous. Their admixtures also solve problems to other combinations and it have much more improved strength, workability and uses to common structures and super structures like Dams, High Rise Structures etc.

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