An Experimental Investigation on Grancrete

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Abstract - *The research undertaken to investigate and evaluate the effectiveness of a new proposed system called "Grancrete". Grancrete is a new cementitious material that resists fire, it can be used as a spray able coating for protection of structures from severe environmental conditions and for strengthening of existing structural elements. Grancrete has excellent adhesive strength characteristics which lead to this study. Strengthening of reinforced concrete structures with externally bonded composites has become very popular due to its well-known advantages in comparison to conventional construction materials. This paper is extended to study the effectiveness of the proposed strengthening system. It is to determine the optimum W/G ratio to be used for the mix design of Grancrete matrix using cubes subjected to pure compression stresses. Different logical models are compared to test results. Grancrete is a tough, lightweight, fast-curing ceramic material that was developed to provide fast, adequate and low-cost housing in developing nations throughout the world. It is a relatively new product that is looking to expand its market share. Cement block made of grancrete, waste sludge and expansive agents were fabricated to produce the light weight material. It is an eco-friendly mix of locally available chemicals which is prepared from nuclear wastes also acts as a substitute for concrete. It is the tough reinforcement free ceramic building material used as a replacement of concrete. Provides good insulation in both hot and cold climates and which is efficient and cheapest building material for the poor.*

***Key Words**: Grancrete, Compressive stress, Split tensile strength*

1. INTRODUCTION

An ingenious new building technology from scientists at Argonne National Laboratory and Casa Grande LLC could help alleviate and perhaps even solve that major humanitarian problem by providing affordable housing for the world's poorest. A tough new ceramic material that is almost twice as strong as concrete may be the key to providing high-quality, low-cost housing throughout developing nations. The ceramic is called Grancrete, which, when sprayed onto a rudimentary Styrofoam frame, dries to form a lightweight but durable surface.

The resulting house is a major upgrade to the fragile structures in which millions of the world's poorest currently live. Using conventional techniques, it takes 20 men two weeks to build a house. A five person crew can construct two grancrete homes in one day. There's also plenty of commercial upside in developed nations, making low-cost buildings viable for a variety of purposes – we can see inflatable technology marrying with Grancrete construction to evolve an entirely new way of building lavishly complex structures that would be impossible any other way. It's hard to imagine it from the armchairs of most of those who will be reading this, but most of the world's population live in low income shelter.

1.1 General

The United Nations estimates World's developing nations need more than 740 million homes if we built 100,000 homes a day for 20 years, we would be 20 years behind, so clearly we need to do something different if we are to ensure that all human beings can live with pride. We need a low-cost building material and smarter construction process, so we can construct large numbers of houses to make the goal even remotely achievable. The Grancrete structural spray-on cement might be what we need.

Grancrete was developed by the Virginia firm Casa Grande in conjunction with Argonne. It is based on an Argonne-developed material called Ceramic rete, which was developed in 1996 to encase nuclear waste. The resilient Ceramic rete permanently prevents hazardous and radioactive contaminants from leaching into the environment.

Originally, Casa Grande was looking for a concrete substitute for American industry, because concrete erodes in acidic conditions, says Casa Grande president Jim Paul. But as I travelled in Venezuela, I recognized the demand for cheap housing, and I thought about how to use our material. According to experiments, Grancrete is stronger than concrete, is fire resistant and can withstand both tropical and sub-freezing temperatures, making it ideal for a broad range of geographic locations. It insulates so well that it keeps dwellings in arid regions cool and those in frigid regions warm.

Currently, Grancrete is sprayed onto Styrofoam walls, to which it adheres and dries. The Styrofoam remains in place as an effective insulator, although Wagh suggests simpler walls, such as woven fibre mats, also would work well and further reduce the raw materials required. Using Grancrete in developing countries also allows for two important criteria.

1.2 Existing system

In the existing system the mortar material is used for plastering which will be consisting only the cement, water content and the fine aggregate. There is no substitute for the wall plastering. To know the strength of the mortar the compressive strength has been carried for the normal cement mortar.

1.3 Proposed system

In the proposed system the grancrete is introduced instead of normal plastering. In this the material consists of binding material like potassium phosphate and magnesium oxide and sand is added to the grancrete. By this the strength will be increased when compared with the normal mortar.

2. LITERATURE REVIEW

2.1 Fiber Reinforced Grancrete Strengthening System

This paper reviews the research undertaken to investigate and assess the effectiveness of a new proposed strengthening system called "Fibre Reinforced Grancrete (FRG)". Grancrete is an innovative cementitious material that resists fire; it can be used as a spray able coating for safeguard of structures from severe environmental conditions and for strengthening of existing structural elements. Grancrete has superb adhesive strength characteristics which lead to this study. This paper is comprehensive to study the effectiveness of the proposed strengthening system. The experimental program consisted of three phases. The first phase was aimed to determine the optimum W/G ratio to be used for the mix design of Grancrete matrix using cubes subjected to pure compression stresses. The second phase was designed to estimate the bond strength of Grancrete reinforced with different FRP materials including Basalt Grid Sheets, Steel Reinforced Polymers, and Carbon Strands. The third phase focused on applications of various FRG systems for flexural members. A total of 32 T-section beams were constructed and tested at the Structural Laboratory at Ain Shams University.

2.2 Use of Grancrete as Adhesive for Strengthening Reinforced Concrete Structures

This paper presents an assessment of the use of a new innovative cementitious material, commercially known as Grancrete, as an alternative to epoxy for FRP strengthening systems used for reinforced concrete (RC) structures. Grancrete is an environmentally friendly material that develops high early bond strength and holds an excellent resistance to fire. The study includes an experimental program to assess the behaviour of seventeen RC slabs strengthened by using different types of fibers. The load carrying capacity, ductility, and mode of failure of the strengthened specimens were calculated and the results were compared to control specimens. Results of the experimental program showed that Grancrete paste could be used as another bonding material.

2.3 Behaviour & Flexural Prediction of Special Bonding Material for Fiber Reinforced Strengthening System

The Strengthening of RC structures with externally bonded FRP (fiber reinforced polymers) has grown into an important challenge in civil engineering. Epoxy is the main bonding agent used so far, but in the case of a fire, it is subjected to complete loss of his bonding abilities. Mineral based mixtures strengthening systems consist of FRPs and a cementitious bonding agent which form a repair or strengthening system that is more compatible with the concrete bedrocks, and rambled its efficiency. The current research introduces the use of a special cementitious material "Grancrete" as a bonding agent. Test results of 32 T-section RC beams strengthened with various FRG (fibre reinforced Grancrete) strengthening systems are offered. The results proved that most of the specimens were likely to fail by debonding of the FRP from the concrete either at the ends or at intermediate flexural cracks. This paper presents a detailed study aimed at the development of a better thoughtful of debonding failures in RC beams strengthened with externally bonded FRP systems. Different analytical models, available in the literature for plate end debonding, are reviewed and compared to test results. The results also established that when using U-wraps, the specimens were likely to fail by FRP sheet rupture.

2.4 Grancrete for Flexural Strengthening of Concrete Structures

The study includes an experimental program to evaluate the behavior of seventeen RC slabs strengthened by using different types of fibers. The load carrying capacity, ductility, and mode of failure of the strengthened specimens were evaluated and the results were compared to control specimens. All of the specimens that use Grancrete PCW paste experience a drop in load before failure. It is due to slip of the fibers with respect to the Grancrete paste or intermediate cracking (IC) induced debonding.

3. GRANCRETE

3.1 Mortar

Mortar is a workable paste used to fix building blocks such as stones, bricks, and concrete masonry units organized, fill and seal the irregular gaps between them, and sometimes add attractive colours or patterns in masonry walls. In its broadest sense mortar includes pitch, asphalt, and soft mud or clay, such as used between mud bricks.

Cement Mortar becomes hard when it cures, resulting in a inelastic aggregate structure however the mortar is proposed to be weaker than the building blocks and the sacrificial element in the masonry, because the mortar is easier and cheap to repair than the building blocks. Mortars are usually made from a mixture of sand, a binder, and water. The most common binder is Portland cement but the ancient binder lime mortar is still used in some new construction. Lime and gypsum in the form of plaster of Paris are used particularly in the repair and repointing of buildings and structures because it is important the repair materials are similar to the original materials.

3.2 Types of mortar

a. Ancient Mortar
b. Ordinary Portland Cement Mortar
c. Lime Mortar
d. Pozzolanic Mortar

3.2.1 Ancient Mortar

Ancient mortar were made of mud and clay. Because of an absence of stone and an abundance of clay, Babylonian constructions were of baked brick, using lime or terrain for mortar. The ancient sites of Harappan civilization of third millennium BCE are built with kiln-fired bricks and a gypsum mortar. Gypsum mortar, also called plaster of Paris, was used in the construction of the Egyptian pyramids and many other ancient buildings. It is made from gypsum, which requires a lower fire temperature. It is therefore easier to make than lime mortar and sets up much faster which may be a reason it was used as the classic mortar in ancient, brick arch and vault construction. Gypsum mortar is not as tough as other mortars in damp conditions.

3.2.2 Ordinary Portland Cement Mortar

Ordinary portland cement mortar commonly known as OPC mortar or cement mortar, which is created by mixing powdered Ordinary Portland Cement, fine aggregate and water. It was invented in 1794 by Joseph Aspdin and patented on 18 December 1824, largely as a result of struggles to develop stronger mortars. It was made popular during the late nineteenth century, and had by 1930 became more popular than lime mortar as construction material. The rewards of Portland cement is that it sets hard and quickly, allowing a faster pace of construction. Additionally, fewer skilled workers are necessary in building a structure with Portland cement.

3.2.3 Lime Mortar

Lime mortar having the setting speed can be increased by using infected limestone in the kiln, to form a hydraulic lime that will set on contact with water. Such a lime must be kept as a dry powder. Otherwise, a pozzolanic material such as calcined clay or brick dust may be added to the mortar mix. Adding of a pozzolanic material will make the mortar set reasonably quickly by reaction with the water. It is mainly aimed for repairing concrete structures.

3.2.4 Pozzolanic Mortar

Pozzolanic mortar is a fine, sandy volcanic ash. It was first discovered and dug at Pozzuoli, nearby Mount Vesuvius in Italy, and was subsequently mined at other sites, too. The Romans learned that pozzolana added to lime mortar allowed the lime to set relatively quickly and even under water. Vitruvius, the Roman architect, spoke of four types of pozzolana. It is found in all the volcanic parts of Italy in various colours: black, white, grey and red. Pozzolana has since become a generic term for any siliceous and aluminous stabilizer to slaked lime to produce hydraulic cement.

3.3 Grancrete

Grancrete, developed by Dr. Arun Wagh at Argonne National Laboratory, is a sprayable ceramic that is stronger than concrete, fire resistant and provides good insulation in both hot and cold climates. Dr.Wagh, the developer, is originally from India, and wants to see Grancrete used as a cheap and efficient building material for the poor. He believes that anyone will be able to erect an efficient house in a matter of hours, simply by creating a house frame out of Styrofoam (or natural materials) and then coating the outside with Grancete. Dr. Wagh hopes the United Nations and other international organizations will subsidize mass-scale production around the world. Once this product goes to market, one can only imagine the other less socially responsible uses people will think up with for Grancrete.

Virtually all steel is now made in integrated steel plants using a version of the basic oxygen process or in specialty steel plants (mini-mills) using an electric arc furnace process. The open hearth furnace process is no longer used.

In the basic oxygen process, hot liquid blast furnace metal, scrap, and fluxes, which consist of lime (CaO) and dolomitic lime (CaO.MgO or "dolime"), are charged to a converter (furnace). A lance is lowered into the converter and high-pressure oxygen is injected. The oxygen combines with and removes the impurities in the charge. These impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus and some iron as liquid oxides, which combine with lime and do lime to form the steel slag. At the end of the refining operation, the liquid steel is tapped (poured) into a ladle while the steel slag is retained in the vessel and subsequently tapped into a separate slag pot.

For a ton of conventional concrete, 1 ton of green house gases are obtained but with grancrete only 1/10th of green house gases are obtained. Two people can build a house in two days. Grancrete prevents leaching of hazardous contaminants and no reinforcement is required.

Grancrete's materials are strong @ 6000-12000psi, fire-proof, water-resistant and tolerant (no effect by exposure in pH range of 3-11). Most effective is that the materials harden in less than 30 minutes at temperatures between 0 degrees F and 110 degrees F, do not shrink or expand, can be constituted with ordinary beach sand and salt water and bond extremely well to themselve and all porous surfaces.

Production of Grancrete materials has essentially a zero carbon footprint and an effect green product. That is because the materials are comprised of all safe, inorganic compounds. The materials are not harmful to the environment in multiple ways. Validation of these benefits of using Grancrete is reflected in its selection as one of Popular Science magazine's Top 100 Innovations for 2005.

3.4 Types of Grancrete

- **a.** Grancrete A
- **b.** Grancrete B
- **c.** Grancrete HRF (High Fire Resistant)

All of these materials have very similar basic characteristics such as high compressive strength, high flexural strength, strong bonding strength, long durability, fire resistance, water/salt/acid resistance, etc. Each product also has some differences that make them valuable for certain situations and applications.

Grancrete A has the fastest setting time, usually less than 10 minutes while Grancrete B and Grancrete HFR set within 15 to 20 minutes. Grancrete A and B both have good fire and heat tolerances while Grancrete HFR can withstand significantly higher heat which makes it a better product for high heat and fire applications.The chemical composition of Grancrete is usually expressed in terms of its quick setting time. The setting time of Mortar for this concept is varied from 30 minutes to 1hour.

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Fig -1: Grancrete

Fig -2: Spraying of grancrete mortar

Fig -3: Finished grancrete building

3.4 Material properties

a. Physical Properties
Grancrete is having certain physical properties like Heat resistant, Fire resistant, water resistant etc.

b. Chemical Properties
The chemical composition of Grancrete is usually expressed in terms of its quick setting time. The setting time of Mortar for this concept is varied from 30 minutes to 1hour.

c. Thermal Properties
Grancrete is having certain physical properties like Heat resistant which can resist the weathering problems. It is also having cold resistant which can be usefull in semi-arid region.

4. METHODOLOGY

Methodology of this project is to represent the clear procedure to be carried out. The flow chart is given below.

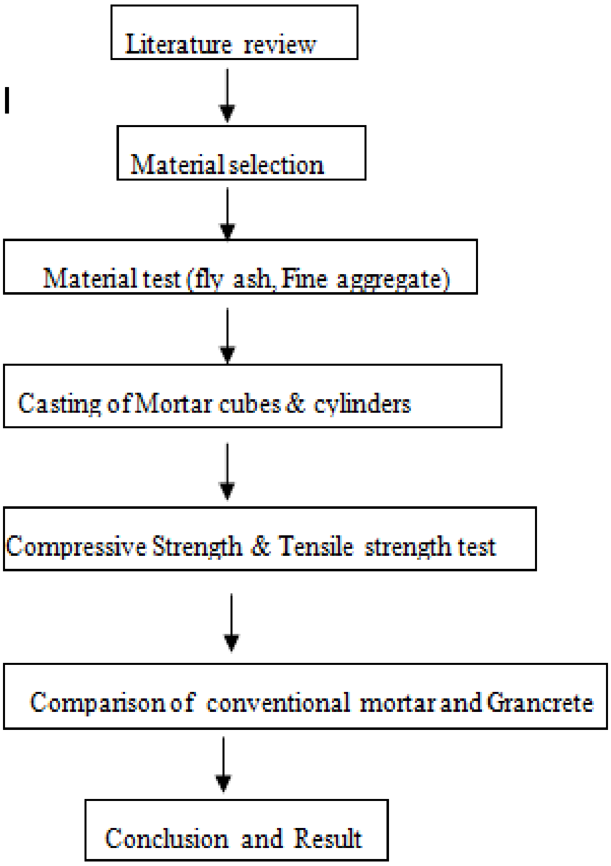

Fig 4. Methodology

4.1 Material Selection

Depending upon the requirements the materials proceeding the project was analysed and decided based on its properties.

i. Fine aggregate

Fig-5: Sand

The fine aggregate the material which passed through I.S. Sieve No. 480 (4.75mm) is termed as fine aggregates. Function of fine aggregates is to make concrete dense, by filling voids of coarse aggregates, reduces the shrinkage of cement and makes an economical mix. Natural sand or crushed stone dust is used as a fine aggregate in concrete mix. Sand may be obtained from sea, river, lake or pit, but when used in a concrete mix, it should be properly washed and tested to ascertain that total percentage of clay, silt, salts and other organic matter does not exceed specified Limit.

a. Properties of fine aggregate

TABLE- 1: PROPERTIES OF FINE AGGREGATE

S.No	Property	Values
1	Fineness modulus	2.76
2	Specific gravity	2.7
3	Moisture content (%)	2.4
4	Water absorption (%)	1

b. Origin and occurrence of fine aggregate

Sand is a naturally occurring granular material composed of outstandingly divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type.

The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example, aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. For example, it is the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.

c. Nature of sand

The composition of mineral sand is highly variable, depending on the local rock causes and conditions. The bright white sands found in tropical and subtropical coastal settings are wrinkled limestone and may contain coral and shell fragments in addition to other organic or organically resultant fragmental material, suggesting sand formation depends on living organisms, too. The gypsum sand dunes of the White Sands National Monument in New Mexico are famous for their bright, white color.

Arkose is a sand or sandstone with extensive feldspar content, derived from weathering and erosion of a (usually nearby) granitic rock outcrop. Some sands contain magnetite, chlorite, glauconite or gypsum. Sands rich in magnetite are dark to black in color, as are sands derived from volcanic basalts and obsidian. Chlorite bearing sands are typically green in color, as are sands derived from basaltic (lava) with a high olivine content. Many sands, especially those found extensively in Southern Europe, have iron impurities within the quartz crystals of the sand, giving a deep yellow color. Sand deposits in some areas contain garnets and other resistant minerals, including some small gemstones.

ii. Origin and occurrence of fly ash

Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is a coal combustion product that is composed of the particulates (fine particles of fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash.

Fig 6- Fly ash

In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

a. Nature of fly ash

The constituents of fly ash depend upon the specific coal bed makeup but may include one or more of the following elements or substances found in trace concentrations like arsenic, beryllium, boron, cadmium, chromium, hexavalent chromium, cobalt, lead, manganese, mercury, molybdenum, s elenium, strontium, thallium, and vanadium, along with very small concentrations of dioxins and PAH compounds.

In the past, fly ash was generally released into the atmosphere, but air pollution control standards now require that it be captured prior to release by fitting pollution control equipment. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used as a pozzolan to produce hydraulic cement or hydraulic plaster and a replacement or partial replacement for Portland cement in concrete production. Pozzolans ensure the setting of concrete and plaster and provide concrete with more protection from wet conditions and chemical attack.

iii. Origin and occurrence of magnesium oxide

Magnesium Oxide (or) Magnesia is a white hygroscopic solid mineral that occurs naturally as periclase and is a source of magnesium (see also oxide). It has an empirical formula of MgO and consists of a lattice of $Mg2+$ ions and $O2-$ ions held together by ionic bonding. Magnesium hydroxide forms in the presence of water ($MgO + H2O \rightarrow Mg(OH)2$), but it can be reversed by heating it to separate moisture.

While "magnesium oxide" normally refers to MgO, magnesium peroxide MgO2 is also known as a compound. Agreeing to evolutionary crystal structure prediction, MgO2 is thermodynamically stable at pressures above 116 GPa (gigapascals), and a semiconducting suboxide Mg3O2 is thermodynamically stable above 500 GPa. Because of its stability, MgO is used as a model system for investigating vibrational properties of crystals.

Fig 7.-Magnesium oxide

a. Nature of magnesium oxide

Magnesium oxide is produced by the calcination of magnesium carbonate or magnesium hydroxide. The latter is obtained by the treatment of magnesium chloride solutions, typically seawater, with lime.

Calcining at different temperatures produces magnesium oxide of different reactivity. High temperatures 1500 – 2000 °C reduce the available surface area and produces dead-burned (often called dead burnt) magnesia, an unreactive form used as a refractory. Calcining temperatures 1000 – 1500 °C produce hard-burned magnesia, which has limited reactivity and calcining at lower temperature, (700–1000 °C) produces light-burned magnesia, a reactive form, also known as caustic calcined magnesia. Although some decomposition of the carbonate to oxide occurs at temperatures below 700 °C, the resulting materials appears to reabsorb carbon dioxide from the air.

iv. Origin and occurrence of potassium phosphate

Fig 8-Potassium phosphate

Potassium phosphate is a generic term for the salts of potassium & Phosphate ions including,

- Monopotassium phosphate
- Dipotassium phosphate

Tripotassium phosphate

a. Monopotassium phosphate

Monopotassium phosphate, MKP, (also potassium dihydrogen phosphate, KDP, or monobasic potassium phosphate), KH2PO4, is a soluble salt of potassium and the dihydrogen phosphate ion which is used as a fertilizer, a food additive and a fungicide. It is a source of phosphorus and potassium. It is also a buffering agent. When used in fertilizer mixtures with urea and ammonium phosphates, it minimizes escape of ammonia by keeping the pH at a relatively low level.

b. Dipotassium phosphate

Dipotassium phosphate (K2HPO4) (also dipotassium hydrogen orthophosphate potassium phosphate dibasic) is a highly water-soluble salt which is often used as a fertilizer, food additive and buffering agent. It is a common source of phosphorus and potassium. A dipotassium phosphate solution is formed by the stoichiometric reaction of phosphoric acid with two equivalents of potassium hydroxide.

c. Tripotassium phosphate

Potassium phosphate is a water-soluble ionic salt which has the chemical formula K3PO4. It is used as a food additive for its properties as an emulsifier, foaming agent, and whipping agent. In combination with fatty acids, it is a potential antimicrobial agent in poultry processing.

5. LABORATORY TEST METHOD

5.1 General

To investigate the properties of material fine aggregate used for casting the specimen various laboratory tests were performed & the test results were obtained were compared with the Indian standard values the test results are tabulated below.

5.2 Determining sieve analysis of sand

To determine the Sieve analysis, we need standard sieves, mechanical sieve shaker (optional), dry oven and digital weight scale.

i. Sample preparation

Take a sample of fine aggregate [near about 2 kg] in pan and placed it in dry oven at a temperature of 100 – 110 C. After drying take the 1000gm sample and note down it.

ii. Test procedure

Take the sieves and arrange them in descending order with the largest size sieve on top. If mechanical shaker is used then put the ordered sieves in position and pour the sample in the top sieve and then close it with sieve plate. Then switch on the machine and shaking of sieves should be done at least 5 minutes. If shaking is done by the hands then pour the sample in the top sieve and close it then hold the top two sieves and shake it inwards and outwards, vertically and horizontally. After some time shake the 3rd and 4th sieves and finally last sieves. After sieving, record the sample weights retained on each sieve. Then find the cumulative weight retained. Finally determine the cumulative passing percentage retained on each sieves.

iii. Specific gravity of fine aggregate

1. Objective

This test covers the procedures for determining the specific gravity, apparent specific gravity and water absorption of aggregates.

2. Apparatus

- Balance
- Oven
- Pycnometer

3. Test procedure

A sample of about 1 kg for 10 mm to 4-75 mm or 500 g if finer than 4.75 mm, shall be placed in the tray and covered with distilled water at a temperature of 22 to 32°C. Soon after immersion, air entrapped in or bubbles on the surface of the aggregate shall be removed by gentle agitation with a rod. The sample shall remain immersed for 24 +/- 0.5 hours. The water shall then be carefully drained from the sample, by decantation through a filter paper, any material retained being return to the sample. The aggregate including any solid matter retained on the filter paper shall be exposed to a gentle current of warm air to evaporate surface moisture and shall be stirred at frequent intervals to ensure uniform drying until no free surface moisture can be seen and the material just attains a 'free-running' condition. Care shall be taken to ensure that this stage is not passed. The saturated and surface-dry sample shall be weighed. The aggregate shall then be placed in the pycnometer which shall be filled with distilled water. Any trapped air shall be eliminated by rotating the pycnometer on its side, the hole in the apex of the cone being covered with a finger. The pycnometer shall be topped up with distilled water to remove any froth from the surface and so that the surface of the water in the hole is flat.

The contents of the pycnometer shall be emptied into the tray, care being taken to ensure that all the aggregate is transferred. The pycnometer shall be refilled with distilled water to the same level as before, dried on the outside. The difference in the temperature of the water in the pycnometer during the first and second weighing shall not exceed 2°C. The water shall then be carefully drained from the sample by decantation through a filter paper and any material retained returned to the sample. The sample shall be placed in the oven in the tray at a temperature of 100 to 110°C for 24 +/- 0.5 hours, during which period it shall be stirred occasionally to facilitate drying. It shall be cooled in the air-tight container and weighed.

iv. Water absorption of fine aggregate

This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000g should be used. The apparatus used for this test are :- Wire basket – perforated, electroplated or plastic coated with wire hangers for suspending it from the balance, Water-tight container for suspending the basket, Dry soft absorbent cloth – 75cm x 45cm (2 nos.), Shallow tray of minimum 650 sq.cm area, Air-tight container of a capacity similar to the basket and Oven.

1. Procedure

- The sample should be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 and 32oC.

- After immersion, the entrapped air should be removed by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample should remain immersed for a period of 24 + ½ hrs afterwards.
- The basket and aggregates should then be removed from the water, allowed to drain for a few minutes, after which the aggregates should be gently emptied from the basket on to one of the dry clothes and gently surface-dried with the cloth, transferring it to a second dry cloth when the first would remove no further moisture. The aggregates should be spread on the second cloth and exposed to the atmosphere away from direct sunlight till it appears to be completely surface-dry. The aggregates should be weighed (Weight 'A').
- The aggregates should then be placed in an oven at a temperature of 100 to 110oC for 24hrs. It should then be removed from the oven, cooled and weighed (Weight 'B').

Formula used is Water absorption = [(A – B)/B] x 100%

6. OBSERVATION AND CALCULATION

6.1 General

To investigate the properties of material such as Cement, Fine aggregate, Coarse aggregate & Glass powder used for casting the specimen various laboratory tests were performed & the test results were obtained were compared with the Indian standard values the test results are tabulated below.

6.2 Test for cement

The following experiments were conducted to find the properties of cement as per IS 4031 part4 1988:

i. Standard consistency test

Standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10 mm dia and 50 mm length to penetrate to a depth of 33-35 mm from top of the mould. This test helps to determine water content for other tests like initial and final setting time, soundness & compressive strength. Some of the values are tabulated in the table that the values which gives the value consistency of cement.

TABLE -2: CONSISTENCY OF CEMENT

Weight of the cement(gm)	Percentage of water added(interms of weight of cement)	Volume of water added(ml)	Reading on gauge(mm)
400	23	92	35
400	28	112	17
400	29	116	16
400	31	124	11
400	32	128	7

Calculation:

Standard consistency (%) = (Volume of water added/ Weight of cement) x 100

= (92/400) x 100 = 23%

ii. Initial setting time

Initial setting is the time elapsed between the moment water is added to the cement to the time at which paste starts losing its plasticity. The initial setting time of cement is taken is zero.

TABLE -3: INITIAL SETTING TIME OF CEMENT

Time is at when the water is added to the cement(min)(t1)	Time at which the needle fails to pierce the test block by 5.0±0.5mm(min)(t2)	Initial setting time(min)
0	31	31

Calculation:

Initial setting time of cement= t2-t1

=31 -0 =31 min

iii. Final setting time

The time elapsed since the addition of water to the cement up to the time at which the needle with annular collar can only make a mark on the hard cement surface.

TABLE-4: FINAL SETTING TIME OF CEMENT

Time at when the water is added to cement(min)(t1)	Time at which the needle makes an impression on surface of blocks(min)(t3)	Final setting time(min)
0	605	605

Calculation:

Final setting time of concrete = t3 – t1

= 605 – 0 = 605 min

iv. 4. Specific gravity of cement

To determine the specific gravity normally it is defined as the ratio between the weight of a given volume of material and weight of an equal volume of water.

TABLE -5: SPECIFIC GRAVITY OF CEMENT

S.No	Description(mg)	Trial 1	Trial 2	Trial 3	Mean
1	Weight of empty bottle(W1)	14	14	14	3.2
2	Weight of bottle + cement (W2)	114	115	114	
3	Weight of bottle + kerosene(W3)	309	307	308	
4	Weight of bottle + Kerosene+ Water (W4)	240	238	239	
5	Specific gravity of cement	3.22	3.15	3.22	

Calculation:

Specific gravity of cement = (W2–W1)/((W2-W1)- (W3 - W4))

= (114-14) / ((114-14)-(309-240))

= 3.22

6.3 Test for fine aggregate

The following experiments were conducted to find out the properties of fine aggregate as per IS-2386 (part III)-1963:

i. Sieve analysis of fine aggregate

A sieve is an apparatus round in shape. It is identified either by size of the opening number. The standard sieve for fine aggregate no's are tabulated.

TABLE -6: SIEVE ANALYSIS

S. No	Sieve opening size	Weight of F.A retained (gm)	Cumulative weight of retained F.A(gm)	Cumulative percentage of F.A retained(%)	Cumulative percentage of F.A passed(gm)
1	10 mm	0	0	0	100
2	4.75 mm	11	11	1.1	98.9
3	2.36 mm	35	46	4.6	95.4
4	1.18 mm	234	280	28	72
5	600 µ	300	580	58	42
6	300 µ	296	876	87.6	12.4
7	150 µ	96	972	97.2	2.8
8	<150 µ	18	990	-	-
		990		Total=276.5	

Calculation: Fineness modules= total cumulative % weight retained/100 = 276.5/100= 2.76.

ii. Specific gravity of fine aggregate

The specific gravity of a fine aggregate sample is determined by the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water.

TABLE-7: SPECIFIC GRAVITY TEST

Sl. No	Description	Trial 1	Trial 2	Trial 3	Mean
1	Weight of empty pycnometer(W1)	66.3	66.3	66.3	
2	Weight of pycnometer + fine aggregate (W2)	86.3	85.6	86.2	
3	Weight of pycnometer + fine aggregate + water (W3)	167.1	167	167	
4	Weight of pycnometer + water (W4)	154.4	154.5	154.6	2.67
5	Specific gravity of fine aggregate	2.7	2.66	2.65	

Calculation:

Specific gravity of cement= (W2– W1)/((W2-W1)-(W3-W4))

= (86.3-66.3)/((86.3-66.3) – (167.1-154.4))

= 2.7.

iii. 3. Water absorption of fine aggregate

Absorption values are used to calculate the change in the weight absorbed in the pore spaces. They are also used to calculate the amount of water that is absorbed by aggregate during Portland concrete mix preparation.

TABLE-8: WATER ABSORPTION TEST

S. No	Description(gm)	Trial
1	Weight of saturated surface dry sample (W1)	867.6
2	Weight of oven dry sample (W2)	858.8
3	Water absorption	1.00%

Calculation:

Water absorption = (W2-W1)/W1 X 100

= (867.6-858.8)/867.6 X 100

= 1.0%

iv. Casting of specimen

Cube moulds of size 50x50x50mm & cylinder moulds of size 50x100mm to be used are cleaned properly with dry cloth and oil was applied before casting. The amount of cement, fine aggregate were measured based on their weight and then they were mixed on water tight platform under standard condition. Water was added gradually till all the materials has been adequately mixed together to form a uniform mix. Mortar was then filled in moulds and compacted using standard tamping rod. The mixing of materials are shown.

Fig -9: Mixing of mortar

Fig -10: Casting of mortar(1)

Fig-11: Casting of mortar(2)

v. E. Testing procedure

For each mixture, cubes of (50x50x50) mm & Cylinders of (50x100) mm were prepared. Totally 54 specimen was finished and allowed for curing. The compressive strength test of mortar cube was done.

The specimens have been tested to check the compressive and split tensile strength of the concrete after curing period of 7, 14 & 28 days. The maximum compressive and split tensile strength have been achieved after 28 days of curing.

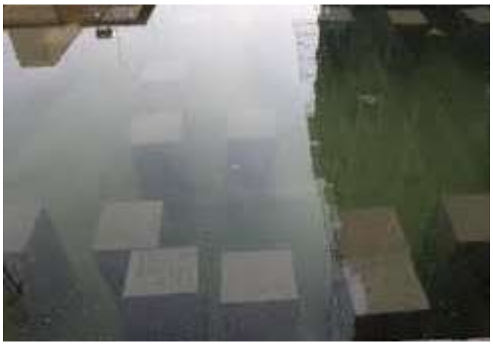

Fig- 12: Curing of mortar

7. TEST RESULT AND DISCUSSIONS

7.1 General

An easy way to comply with the conference paper forma In this chapter the compressive strength result of Mortar & Grancrete cubes after 7, 14 & 28 days curing are tested in the laboratory. Results are tabulated and charts are presented.

7.2 Compressive Strength Test

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a compression testing machine causing the sample to flatten.

A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test. The compression test have been conducted for the cube having dimension of 50 x 50 x 50 mm. The compression test is tested using the compression testing machine. The compressive strength of the mortar cube can be determined using the formula given below.

Compressive strength = Compressive load (N) / Cross sectional area of cube (mm^2)

i. Conventional mortar

The conventional mortar is made with Cement & fine aggregate.

TABLE -9: COMPRESSIVE TEST ON CONVENTIONAL MORTAR

TRIAL	LOAD (KN)	AREA (mm^2)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE (N/mm^2)
1	9.75	50 x 50	3.9	4.1
2	10.25	50 x 50	4.1	
3	10.75	50x 50	4.3	

Compressive strength = (load / area) N/mm^2

= (9.75x 103) / (50 x 50) = 3.9 N/mm^2

ii. 7th Day testing on grancrete

The Grancrete mortar is made with fine aggregate, fly ash, Magnesium oxide & Potassium phosphate.

TABLE-10: 7TH DAY COMPRESSIVE TEST ON GRANCRETE

PROPORTION	PERCENTAGE (%)				CONVENTIONAL CONCRETE (N/mm2)	AVERAGE (N/mm2)
	CEMENT	FLYASH	FA	BINDING AGENTS		
PROPORTION 1	-	25	50	25	5.01	5.33
PROPORTION 2	50	25	25	-		4.89

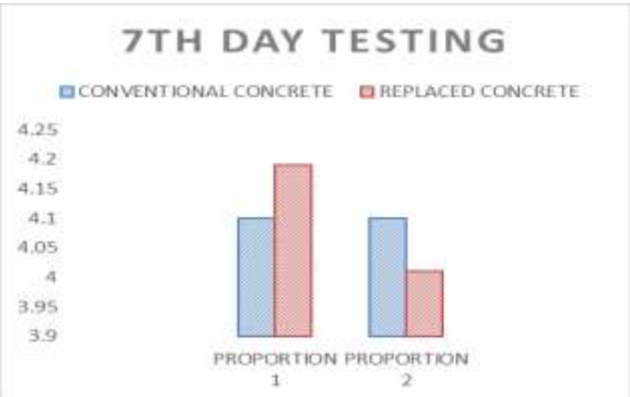

Chart -1: 7th Day Compressive test on Grancrete

iii. 14th Day testing on grancrete

TABLE-11: 14TH DAY COMPRESSIVE TEST ON GRANCRETE

PROPORTION	PERCENTAGE (%)				CONVENTIONAL CONCRETE (N/mm2)	AVERAGE (N/mm2)
	CEMENT	FLYASH	FA	BINDING AGENTS		
PROPORTION 1	-	25	50	25	4.1	4.19
PROPORTION 2	50	25	25	-		4.01

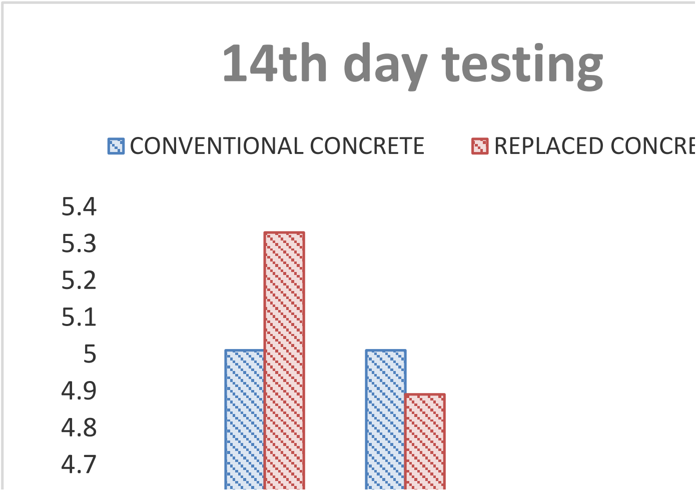

Chart- 2.:14th Day Compressive test on Grancrete

iv. 28th Day testing on grancrete

TABLE-12: 28TH DAY COMPRESSIVE TEST ON GRANCRETE

PROPORTION	PERCENTAGE (%)				CONVENTIONAL CONCRETE (N/mm2)	AVERAGE (N/mm2)
	CEMENT	FLYASH	FA	BINDING AGENTS		
PROPORTION 1	-	25	50	25	5.51	5.86
PROPORTION 2	50	25	25	-		5.40

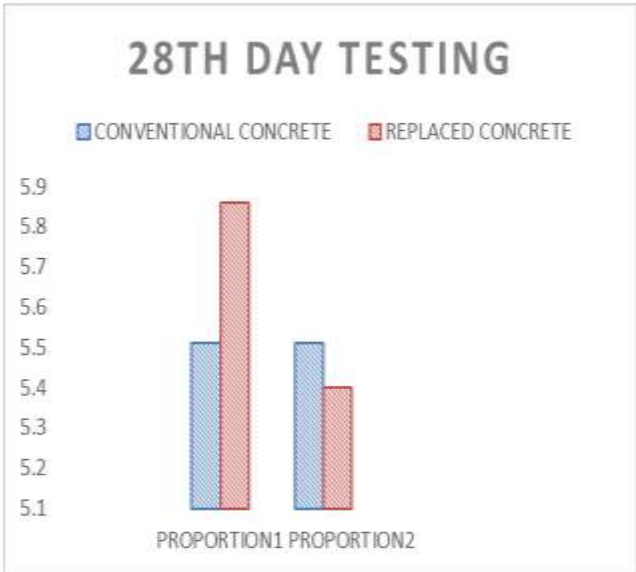

Chart -3:28th Day Compressive test on Grancrete

7.3 Split tensile test

Split tensile testing is a measure of the ability of material to resist a force that tends to pull it apart. It is expressed as the minimum tensile stress (force per unit area) needed to split the material apart.

The Split tensile test have been conducted for the cylinder having the dimension of 300 x 150 mm. The Split tensile strength of the mortar cylinder can be determined using the formula given below.

Split tensile strength = (2P) / (3.14 DL) N/mm^2

i. Conventional mortar

The conventional mortar is made with Cement & fine aggregate.

TABLE -13: TENSILE STRENGTH OF CONVENTIONAL MORTAR

TRIAL	LOAD (KN)	AREA (mm^2)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE (N/mm^2)
1	6.2	50 x 100	0.78	0.71
2	2.38	50 x 100	0.30	
3	8.15	50x 100	1.04	

Split tensile strength = (2P) / (3.14 DL) N/mm^2

= (2 x 6.2 x 1000) / (3.14 x 50 x 100)

= 0.78 N/mm^2

ii. 7th Day testing on grancrete

The Grancrete mortar is made with fine aggregate, fly ash, Magnesium oxide & Potassium phosphate.

TABLE-14: 7TH DAY TENSILE STRENGTH TEST ON GRANCRETE

PROPORTION	PERCENTAGE (%)				CONVENTIONAL CONCRETE (N/mm2)	AVERAGE (N/mm2)
	CEMENT	FLYASH	FA	BINDING AGENTS		
PROPORTION 1	-	25	50	25	0.71	0.82
PROPORTION 2	50	25	25	-		0.67

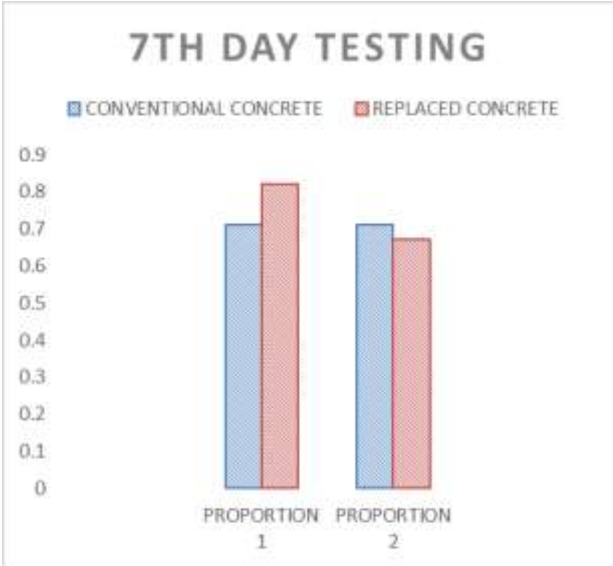

Chart- 4: 7th Day Tensile strength test on Grancrete

iii. 14th Day testing on grancrete

TABLE-15: 14TH DAY TENSILE STRENGTH TEST ON GRANCRETE

PROPORTION	PERCENTAGE (%)				CONVENTIONAL CONCRETE (N/mm2)	AVERAGE (N/mm2)
	CEMENT	FLYASH	FA	BINDING AGENTS		
PROPORTION 1	-	25	50	25	1.18	1.37
PROPORTION 2	50	25	25	-		1.12

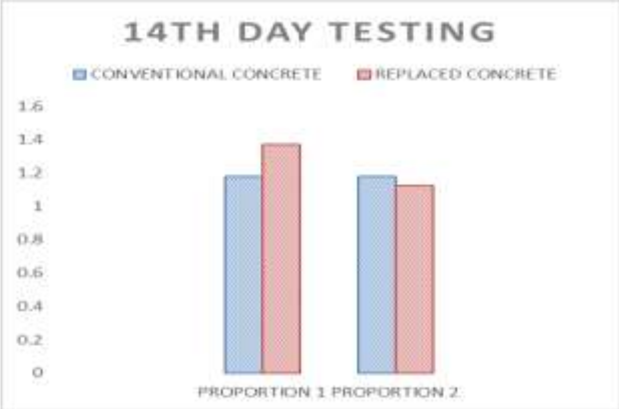

Chart-5: 14th Day Tensile strength test on Grancrete

iv. 28th Day testing on grancrete

TABLE-16: 28TH DAY TENSILE STRENGTH TEST ON GRANCRETE

PROPORTION	PERCENTAGE (%)				CONVENTIONAL CONCRETE (N/mm2)	AVERAGE (N/mm2)
	CEMENT	FLYASH	FA	BINDING AGENTS		
PROPORTION 1	-	25	50	25	1.53	1.78
PROPORTION 2	50	25	25	-		1.46

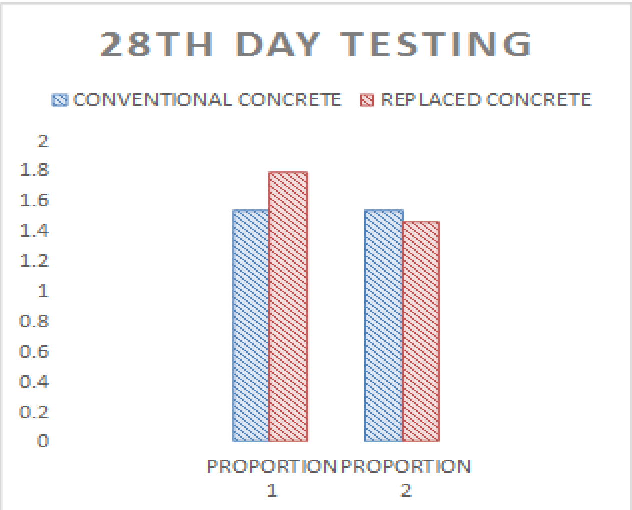

Chart-6:28th Day Tensile strength test on Grancrete

8. CONCLUSION

In this project, the Compression & Split tensile strength of cement mortar, Grancrete mortar & replaced mortar has been compared.

It is to be noted that the compressive strength of the conventional mortar cube (i.e)5.51N/mm^2 which is lesser than the Grancrete mortar (i.e) 5.86N/mm^2 but greater than the replaced mortar (i.e)5.40N/mm^2. Also, the split tensile strength of the conventional mortar cube (i.e)1.53N/mm^2 which is lesser than the Grancrete mortar (i.e) 1.78N/mm^2 but greater than the replaced mortar (i.e)1.46N/mm^2.

It can be seen that grancrete can be used as an alternative to conventional concrete and it is also low cost housing material. It is seen that grancrete is fire resistant and eco friendly material. As grancrete takes less time for setting so the time of construction is less.

Grancrete have to be repaired regularly during rainfall times and skilled labour is required during construction to handle the machinery.

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