CONVENTIONAL CONCRETE Vs FLY-ASH BASED FIRE-RESISTANT GEOPOLYMER CONCRETE

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ABSTRACT

A large amount of waste generated by enterprises has provided an amazing challenge in terms of disposal and environmental impact. Disposal of waste from initiatives is a method of exchange. As a result, geopolymer is the hub for debunking natural contamination. Geopolymer is a family of aluminosilicate restricting materials made by combining strong aluminosilicate base materials, such as flyash, metakaolin, GGBS, and so on, with a soluble base metal hydroxide and silicate arrangement using heated actuation. Sodium hydroxide, sodium silicate, and temperature were used to activate the geopolymer. The blends were created with 14M NaOH in mind. The soluble arrangement used in the current study was a mixture of sodium silicate and sodium hydroxide with a variable proportion of 2.50.

150x150x150 mm 3D objects were heat-relieved at 80°C in a broiler as test samples. @ comprehensive restorative circumstances, high-quality geopolymer cements of 65 and 80 MPa with geopolymer fasteners Several scientific approaches, such as XRD, FTIR, and FE-SEM, were used to depict the crude material and the fly ash-based geopolymer produced. Geopolymer cements have a high early quality and are resistant to harsh weather. The qualities of geopolymer concrete under various situations, as well as fire-resistant properties, have been highlighted.

Keywords: *Disposal of Waste, Geopolymer, Fly Ash, Sodium Hydroxide, Sodium Silicate*

1. INTRODUCTION

The extraordinary global market and its possibility progressions are driving the development of new materials with clean innovation to reduce the considerable cost of handling and wear of regular assets, as well as environmental contamination. In a plausible global situation and directly tied to development, the production of pollution control (PC) over the planet creates alarming figures in terms of its pollution, with explicit CO2 emissions estimated to be approximately 2.5 billion tonnes per year throughout the world.

As a result, there is a need to consider this type of new material to use on the other hand the PC and on the other hand to check with the fundamental demands of the current populace and the rules overseeing them, as well as to be environmentally friendly (Joseph 2005, Hardjito et al. 2005, Bakharev, 2005). Because of its great functionality, fly ash appears to be the most encouraging antecedent for large-scale mechanical manufacture of geopolymer products (Deventer et al. 2007).

Geopolymer is a family of inorganic polymers framed by reacting silica-rich and alumina-rich solids with a high basic organisation that consolidates polymer, pottery, and concrete capabilities (Joseph. 2015, Letizia, et al. 2008). Geopolymer studies are gaining a lot of attention these days because they can be used as a more cost-effective alternative to natural polymers and inorganic concretes in a variety of applications, such as innovative earthenware production, warm-protecting froths (Les, et al 2015), flame-resistant structure materials (Alehyen et al. 2017), and cross-breed inorganic-natural composites (Shuzheng et al 2004).

J. Davidovits invented the first fire-resistant geopolymer, and until many more fire-resistant geopolymer, composite geopolymer, and geopolymer cement have been developed and examined, the ash product has been an excellent research and perfect fire-resistant material (Komnitsas et al. 2011). Metakaolin (MK) and fly ash (FA) are two commonly used aluminium silicate raw materials for geopolymer assembly. Metakaolin-based geopolymers have been shown to have excellent mechanical characteristics at elevated temperatures. It is known that the properties of salt activators, their focus, restoring temperature, the type of crude materials and their surface regions, superplasticizer silica rage, calcium silicate hydrate, and other factors influence various properties of geopolymer mortar and cement, including fireproof properties (Rashad et al. 2011, Brown et al. 2007).

The soluble base arrangement activator, which plays an important role in geopolymer concrete qualities is one of the advantages of building soluble base started material. (Jaarsveld et al. 2003) Geopolymer concrete made with pure metakaolin has a lesser environmental impact than geopolymer concrete made of fly ash. In terms of green materials, geopolymer covers have the ability to ensure a higher rating than OPC. Green development materials should, on the whole, be climate friendly, tough, bio-based, and reused, with low harmfulness and outflows (Habert et al. 2011).

2. MATERIALS AND METHODOLOGY

2.1 MATERIAL

2.1.1 FLY ASH

A couple of collected fly ashes from two different places of Bhadrak district, from that two fly ashes during which the share of silicon and aluminum is more, utilized in this experiment. The chemical composition of every ash was monitored by X-Ray fluorescence spectrometry (XRF) at the mechanical department of the centurion university and is shown in table-1

Compound	Fly ash 1	Fly ash 2	GGBFS
SiO_2	56.733 %	59.320%	29.580%
Al_2O_3	25.873%	27.235%	18.928%
TiO_2	3.041 %	2.296%	1.356%
Fe_2O_3	8.169 %	5.805%	0.974%
MnO	466.3 ppm	380.2ppm	0.281%
CaO	1.996 %	1.576%	45.714%
K_2O	2.123%	2.239%	0.913%
P_2O_5	1.150 %	0.938%	-
Cr_2O_3	437.1 ppm	307.4 ppm	29.9 ppm
NiO	179.9 ppm	126.4 ppm	
V_2O_5	658.6 ppm	478.1 ppm	92.1 ppm
ZrO_2	837.7 ppm	756.1 ppm	971.0 ppm
SO_3	0.331 %	0.121%	1.716%
SrO	358.2 ppm	345.7 ppm	0.106 %
LOI	1.561	1.667	2.689

Table 1. Chemical composition of fly ash and GGBFS by XRF (mass %)

By this table, fly ash and GGBFS is considered.

2.1.2 GGBFS (Ground granulated blast furnace slag)

Composition of GGBFS is obtained from XRF analysis and specific gravity. In GGBFS the specific gravity is 2.8. Composition of GGBFS is shown in Table 1.

2.1.3 AGGREGATES

The aggregate used in this project collected from CUTM Ground. For the preparation of all the test specimen,good quality and well-graded aggregates in surface dry condition were used.Natural available fine sand and coarse aggregate with maximum size 20 mm are used .Properties of the aggregate are given in Table 2

Property	Fine Aggregates	Coarse Aggregates
Specific gravity	2.60	2.66
Fineness Modulus	2.92	7.10
Water Absorption	1.50%	0.80

Table 2: (Aggregate Properties)

2.1.3 META KAOLIN:
The clay used in this project is metakaolin collected from. It was first dried under ambient atmosphere at room temperature for a period of 24 hours to facilitate its grinding. It was crushed in a mortar with a pestle and finally sieved to obtain particles smaller than 106 µm. The chemical composition of the metakaolin is shown in

Table 3:

SiO_2	Al_2O_3	CaO	Fe_2O_3	SO_3	MgO	TiO_2	LOI	Density
42.7	54.2	0.8	0.3	-	-	1.2	0.8	2.6

Table 3 : (chemical composition of metakaolin)

2.1.4 Alkaline Activators-Sodium hydroxide and sodium silicate were used in this study as an alkaline activator which play a vital role in the geopolymerization process. Sodium hydroxide solutions of required molarity were prepared from pellets with 98% purity and sodium silicate solution (Na_2SiO_3) with SiO_2/Na_2O between 1.90 and 2.5 were procured commercially. The specification of the sodium silicate is as shown in

Table 4 :

Item	Specification
Colour	Colour less
Density	1.49

Table 4 : (Sodium silicate specification)

2.1.5 Superplasticizer
Sodium silicate and sodium hydroxide solutions are more viscous than water, hence their use makes the geopolymer concrete more cohesive and stickier than conventional concrete. So, order to improve the workability of the fresh geopolymer mix, a naphthalene Sulfonate based water reducing superplasticizer is used.

Normal potable tap water was used for every purpose of this study. Water is used mainly for preparing NaOH solutions.

2.2 Manufacture of geopolymer concrete
Design mix procedure is taken into account for the GPC manufacturing where the alkali activated solution is ready and used only after 24 hours of blending for best results. the answer is taken in molarity. for instance, if 1M is taken into account, we all know the relative molecular mass of NaOH is 40 gm. So, for 1 M the quantity of NaOH is 40×1=40 gm, similarly for 14M solution the load of NaOH required is 40×14=560gm.And because the ratio of NaOH to Na2SiO3 is taken into account as 2.5, the quantity of Na2SiO3 is 560×2.5=1400 ml. First of all, the dry ingredients FA, GGBFS, Fine aggregates, Coarse aggregates and meta kaolin are mixed well similarly as within the case of ordinary cement concrete. the bulk of additional water calculated is added thereto and mixed. After the blending get moist the specified alkali activated solution is added with half the remaining water and mixed thoroughly following which superplasticizer alongside the remaining a part of the additional water is added thereto forming a homogeneous workable GPC mixture able to cast.150 mm × 150 mm × 150 mm moulds were taken for the casting of GPC. The moulds is fielded with GPC in three layers with 25 blows of tamping rod in each layer. the highest surface of the cube is labelled well by using the remaining GPC mortar and left to the set well.

After the GPC cube sets it's demoulding to 2 halves. The samples were kept at temperature for ambient curing. The cubes need to be examined for compressive strength after curing the ratio of alkali activated to the binder is taken as 0.25 and therefore the extra water is taken into account because the 0.2 of total binder. to form GPC mixture, the quantity of superplasticizer i.e. 5% of total alkali activated solution is added. Design mix proportions of various ratios of binder are given below in Table 5 and Table 6.

Table 5:

Materials	Mass (Kg/m^3) G1	G2	G3	G4	G5	G6
Fly Ash	414	372.6	331.2	289.8	248.4	207
Ggbfs		41.4	82.8	124.2	165.6	207

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Fine Aggregate	555	555	555	555	555	555
Coarse Aggregate	1293	1293	1293	1293	1293	1293
Alkali Activator	138	138	138	138	138	138
Sodium Hydroxide Solution	39	39	39	39	39	39
Sodium Silicate Solution	99	99	99	99	99	99
Super Plasticizer	5.52	5.52	5.52	5.52	5.52	5.52
Extra Water In Aggregate	82.8	82.8	82.8	82.8	82.8	82.8
Molar	14M	14M	14M	14M	14M	14M
Curing	Ambient	Ambient	Ambient	Ambient	Ambient	Ambient

Table 5 : (Mix proportion of FA-GGBFS GPC)

Here G1: FA 100%, G2: FA+GGBFS 90+10, G3 : FA+GGBFS 80+20, G4: FA+GGBFS 70+30, G5 :FA+GGBFS 60+40, G6: FA GGBFS 50+50

Table 6 :

Materials	Mass (Kg/m^3) G1	G2	G3	G4	G5	G6
Fly Ash	414	363.92	322.51	279.45	237.22	194.58
Ggbfs	-	41.4	82.8	124.2	165.6	207
Metakaolin		8.28	8.28	8.28	8.28	8.28
Fine Aggregate	555	555	555	555	555	555
Coarse Aggregate	1293	1293	1293	1293	1293	1293
Alkali Activator	138	138	138	138	138	138
Sodium Hydroxide Solution	39	39	39	39	39	39
Sodium Silicate Solution	99	99	99	99	99	99
Super Plasticizer	5.52	5.52	5.52	5.52	5.52	5.52
Extra Water In Aggregate	82.8	82.8	82.8	82.8	82.8	82.8
Molar	14M	14M	14M	14M	14M	14M
Curing	Ambient	Ambient	Ambient	Ambient	Ambient	Ambient

Table 6 : (Mix proportion of FA-GGBFS-MK GPC)

Here : G1 100% FA, G2, G3, G4, G5, G6 FA + GGBFS + Metakaolin

Now the cubes were wont to measure the compressive strength at 80°C.

Geopolymers synthesized at heat or high exhibit much enhanced compressive strength. Geopolymers utilized in this study were produced under ambient condition (i.e. temperature and atmospheric pressure) to make sure cost effectiveness and simple production in application. It is reported that the reaction in geopolymer may be a rapid polymerization process and geopolymer can gain high strength at an early curing age. Therefore, the geopolymer concrete specimens are cured for 7 days, 28 days.The universal material testing machine was used for bending tests at ambient temperature. The central distance between two supporting ends of a specimen was adjusted to 100 mm. The load was applied at the mid span of the specimen and increased at a rate of fifty N/s. Until the specimen splits into two part. This was following for compressive strength. This test was administered on each of the 2 broken parts separately.

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Figure :1

Fig .1 A : fly ash, GGBFS, meta kaolin **B:** Cubes of GPC without meta kaolin
C: Fig 2.5 cubes of GPC with meta kaolin **D:** Fig 2.6 ambient curing cube

3. RESULTS AND DISCUSSION

3.1 Compressive Strength

It is the most commonly studied mechanical property of the concrete which is correlated with other properties too.

Table 7 :

Compressive strength	G1	G2	G3	G4	G5	G6
7 days Mpa	11.3	15.7	21.4	26.8	37.3	42.3
28 days Mpa	18.2	24.4	27.3	35.1	45.0	51.5

Table 7 : (7days and 28 days Compressive strength of Fly ash-GGBFS GPC)

Table 8:

Compressive strength	G1	G2	G3	G4	G5	G6
7 days Mpa	11.3	17.1	23.9	28.4	39.2	45.9
28 days Mpa	18.2	26.2	30.3	37.9	48.3	54.1

Table 8: (7 days and 28 days Compressive strength of Fly ash-GGBFS-MK GPC)

Figure :2

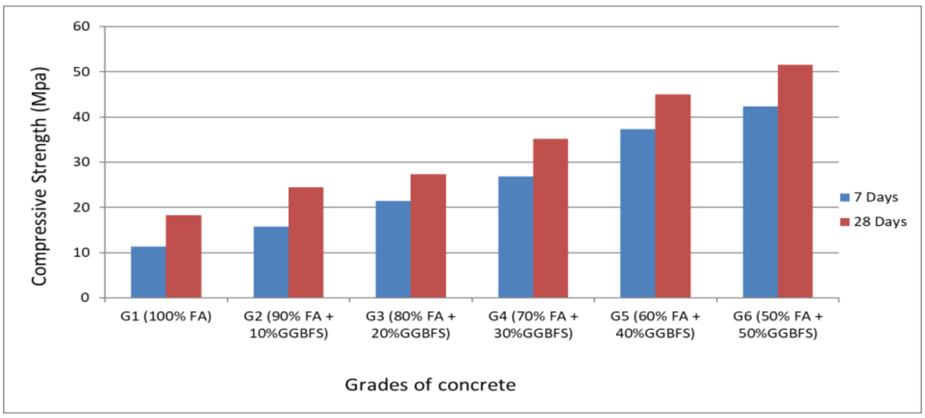

Fig 2 : Compressive Strength of FA-GGBFS GPC

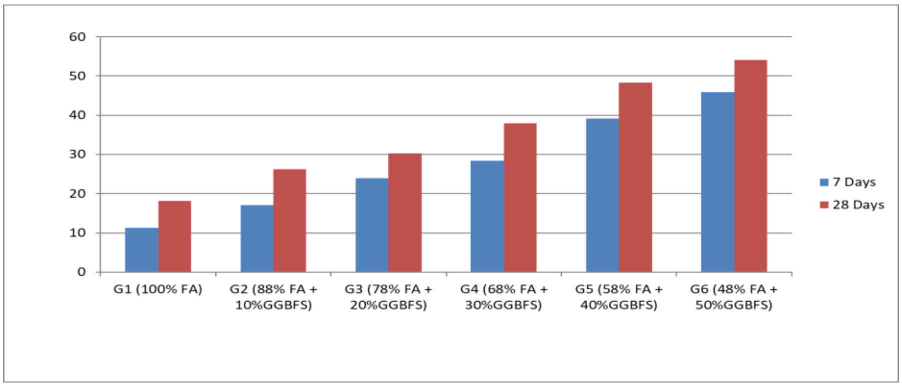

Fig 3 : Compressive strength of FA-GGBFS-MK GPC

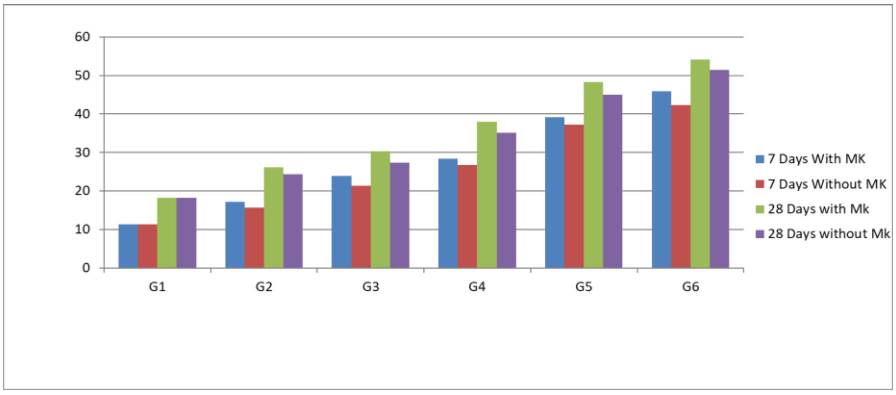

Fig 4: Comparison of compressive strength of with MK and without MK

From the above figures it is observed that for constant molarity (14M) of alkaline activator and GGBFS to fly ash ratio the 7- and 28-days compressive strength increases respectively. Also, in constant molarity of alkaline activator and GGBFS-MK to fly ash ratio compressive strength increases. In comparing both the cases compressive strength is better in fly ash-GGBFS-MK GPC.

3.2 Characterization and microstructure of the GPC

3.2.1 FTIR

FTIR has been one among the foremost common spectroscopic techniques that were used for the identification of various chemical functional groups present in geopolymers. The grafting of geopolymer and meta kaolin was confirmed by the FTIR spectral study as shown in Fig. 5. From Fig.5 , A stands for geopolymer and B stands for metakaolin. In fig A the formed peaks are 3474 cm^{-1},1446 cm^{-1}, 1054 cm^{-1}, 540 cm^{-1}. While in fig B the peaks are 3472 cm^{-1}, 1445 cm^{-1}, 1195 cm^{-1}, 1054 cm^{-1}, 543 cm^{-1}. the height 3474 cm-1 is thanks to -OH bonding (oxygen intercalated bonding). 540 cm^{-1} and 543 cm^{-1} shows a bending region of metal oxide geopolymer consisting of intercalated character. In B extra addition bonding in 1195 cm^{-1} of Si-O binds with the geo-polymerization process. consistent with A and B, some different bonding nature in big peaks clarify the geo-polymerization process without filler A and with filler B. In with filler B polymerization takes place during a composite manner and perfectly bonded in geo-polymerization.

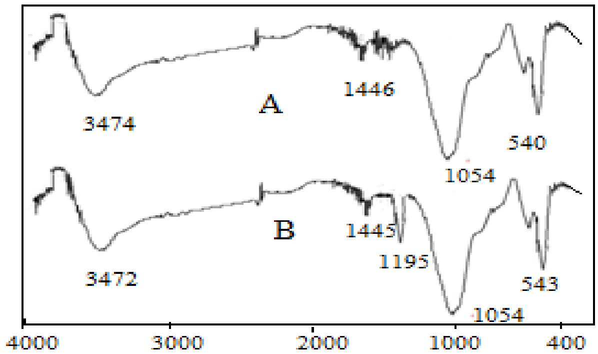

Fig. 5 : FTIR peaks of geopolymer and metakaolin

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3.2.2 X-ray diffraction (XRD)

The crystallinity of samples like fly ash and geopolymer were investigated by Fig. 6. Fig A indicates that fly ash generally consists of some compound sort of metal. The compound sort of metal is usually crystalline structure. thanks to crystalline form it indicates sharpness of peak. Number of sharpness peaks observed for the crystallinity of the compound. Fig B indicates the geopolymer process. within the case of geopolymer processes, individual compounds form a polymeric compound. That polymeric compound consists of various individual compounds of fly ash. Where polymerization processes indicate the amorphous nature of the compound. and therefore, the amorphous nature means less sharpness peak observed within the figure. So, A and B are different thanks to different crystallinity nature.

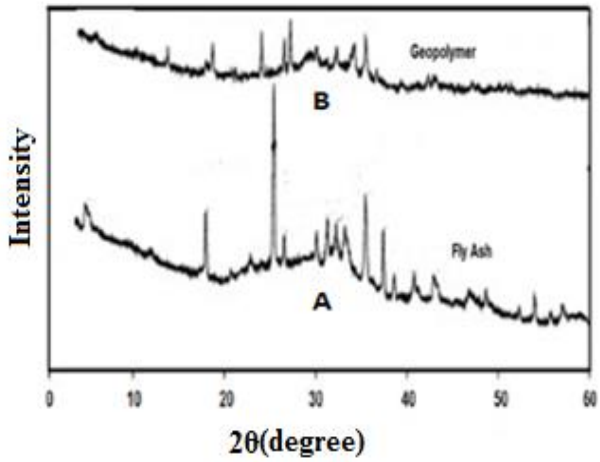

Fig 6: XRD pattern for fly ash and geopolymer

3.2.3 Scanning Electron Microscopy (SEM)

The SEM micrographs of the geopolymers are shown in Fig. 7. Fig. A for fly ash, Fig. B for GGBFS, fig.C for microstructure arrangement. Fig 7 , at different magnifications like 1000 kx, 5000 kx and 10,000 kx, A and B are shown finely by surface morphology. These two figures indicate a completely pure sort of ash and GGBFS individually perfect spectrum line. From Fig. C some spherical structure in regular arrangement and regular arrangements indicate that geopolymer matrices of various compounds are arranged during a proper manner. That proper manner means perfectly bind with one another in binding geo-polymerization and surface morphology indicate that geo-polymerization process will happen in Fig C.

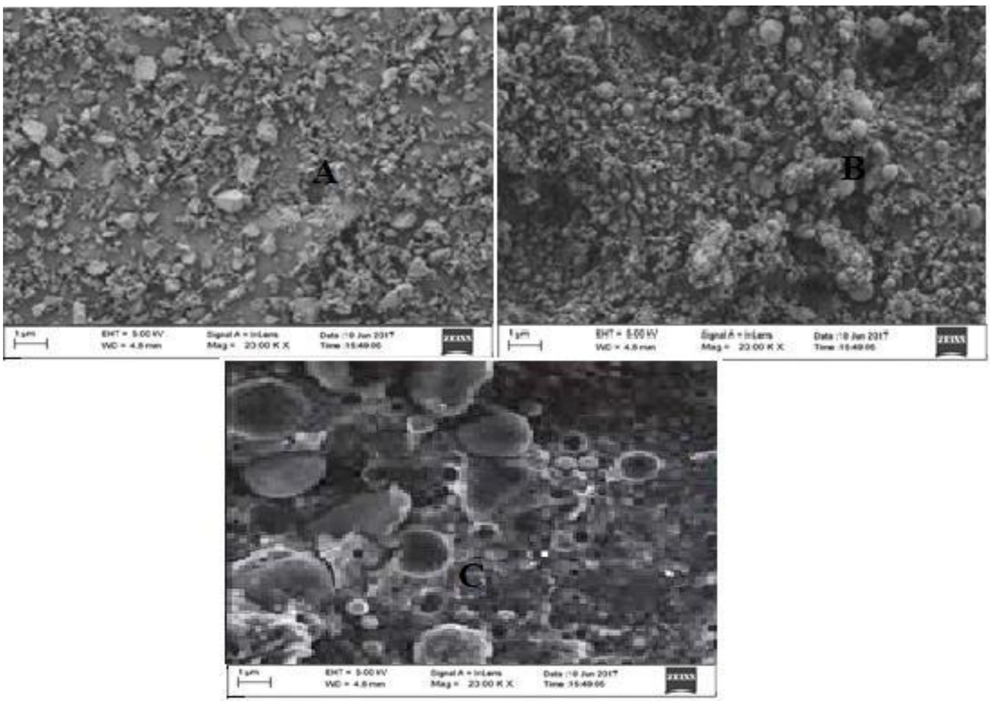

Fig 7: A for fly ash, B for GGBFS, C for microstructure arrangement

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4. CONCLUSION

The point of this proposition is usage of high-volume debris in development material like cement. This proposal is focusing on soluble base actuated fly debris. this kind of cover doesn't contain pressure driven concrete and it could likewise lessen the get together of CO_2 outflow when contrasted with water powered concrete emanation. By then usage of debris adds to the development and economy of the nation. It helps for preservation of normal assets and improvement of natural highlights geopolymer concrete with great physical and mechanical properties was taken 14 M NaOH concentration gives most outcome result. The geopolymer characterization study by X-ray diffraction, FE-SEM microscopy and FT-IR and the physical and mechanical properties of the solidified example were portrayed by compressive strength..

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