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AN EFFECTIVE UTILIZATION OF NANO GRAPHENE OXIDE IN STANDARD CONCRETE

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ABSTRACT
Concrete plays a vital role in the construction field due to its versatile nature. It is a combination of cement, water, fine aggregate and coarse aggregate. The application of nanomaterial's in construction is a new alternative to enhance the mechanical properties of concrete. One of the most interesting nanomaterial's which still require detailed investigation is nano Graphene Oxide (nGO). One of the advantages of the nGO is its easy dispersibility in water and other organic solvents. This remains as a very important property when mixing the material with concrete to improve their properties. On the other hand, in terms of electrical conductivity, nGO is often described as an electrical insulator. Our project shows how nGO can effectively utilized in ordinary concrete and compares the strength between standard concrete with and without nGO. The present experimental investigation was carried out on mechanical properties like compressive strength and tensile strength after 7, 14, 21 and 28 days of curing. The mechanical properties are evaluated and get a conclusion that number of curing days increases, the strength of the nGO concrete is also increases. The durability of nGO is more when compared to standard concrete.

Key words: ***Standard concrete, nano Graphene Oxide, mechanical properties, compressive strength, tensile strength.***

1. INTRODUCTION

Concrete is world most widely used construction material. The utilization of concrete is increasing day by day at a higher rate due to development in infrastructure and construction activities all over the world. Concrete is relatively brittle, and its tensile strength is typically only about one tenth of its compressive strength.
However, there are some negative impacts of more production of concrete like continuous extensive extraction of aggregate from natural resources will lead to its depletion and ecological imbalance. Regular concrete is therefore standardly reinforced with steel reinforcing bars.
The application of nanomaterial's in construction is a new alternative to enhance the mechanical properties of concrete. One of the most interesting nanomaterial's which still require detailed investigation is nano Graphene Oxide. Concrete containing hydraulic cement, fine aggregate, coarse aggregate and water with Nano Graphene Oxide is called Nano Graphene Oxide Concrete.
Adding nano Graphene Oxide to sand filters to remove ability of sand filters to remove pollutants from water. The main advantage of nano Graphene Oxide is it fails after the deformation of concrete or there will be no sudden failure.
Dr. Shiva Kumar B, et.al: He has proposed that Floating Concrete is a special type of innovative concrete whose density is less than 1000Kg/m^3. An attempt has been made to develop a Floating Concrete with considerable compressive strength. [1]
S. Nandhini and I Padmanabam, et.al: They explained that the application of nano materials in construction is a new alternative to enhance the mechanical properties of the concrete. Adding Graphene Oxide to the concrete increases the strength of the concrete. [2]
Rayees Ahmad Ganie, et.al: He proposed that the aggregate size and proportion influences the unit weight and compressive strength of concrete. It is possible to produce a floating and satisfies strength concrete. [3]
F Perrozzi, S Prezioso, et.al: They explained that Graphene Oxide is really a versatile material. Toxicity is the crucial issue that must be addressed to exploit the use of Graphene Oxide in any interaction with living matter. [4]
Aman Mulla, Amol Shelake, et.al: They proposed that the EPS concrete gives good workability and could easily be compacted and finished. Workability increases with increase in EPS content. [5]
Rajendra Prabhu, Katta Venkataramana,et.al: They suggested that increase in EPS beads content in the concrete mixes reduces the compressive and tensile strength of the concrete. The replacement of the material shows a positive application as an alternative material in building non-structural members. [6]
Abhijit Mandlik, Tarun Sarthak Sood, et.al: The authors have proposed that the cost of EPS concrete is less when compared to that of the standard concrete. They suggest that the expanded polystyrene concrete has scope for non-structural applications like wall panels, partition walls, etc. [7]

Nano Graphene Oxide is a single-layer sheet of graphite oxide, which was proposed one and a half century ago. In recent years, nano Graphene Oxidehas attracted great concern mainly because it is a potential starting material for the mass production of graphene. Chemistry of nano Graphene Oxide has been reviewed.

Nano Graphene Oxide can be a semiconductor or insulator, depending on the degree of oxidation, and their electronic and optical properties can be tuned in large scope. The controllable optical and electronic properties enable nano Graphene Oxide to be used in many fields. The major concern about nano Graphene Oxide is mainly focused on its chemical structure, electronic properties, reduction reaction and chemical functionalization.

The structure of nano Graphene Oxide is still unclear due to its complicated non-stoichiometric nature. There are different kinds of oxygen species and bonding to carbon in graphene layer, such as epoxy, hydroxyl, carbonyl, carboxylic groups. Refer Fig 1 for the proposed structure of the Nano-Graphene Oxide.

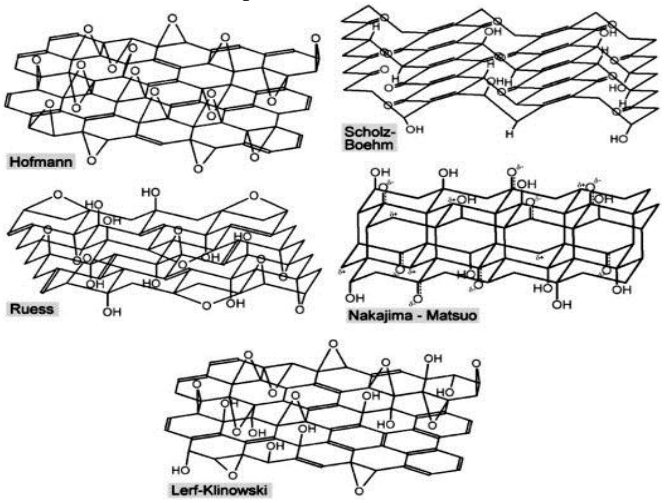


Fig 1: - Proposed structure of Nano Graphene Oxide

The electronic properties of nano Graphene Oxide mainly depend on the oxidation level and chemical composition; it can be tailored by removal or addition of certain oxygen groups to adjust the proportion of sp^2 and sp^3 carbon. Nano Graphene Oxide is easily converted into graphene, as explained above. The application fields of nano Graphene Oxide are mainly focused on sensor and drug delivery. With a large number of functional groups, nano Graphene Oxide can react with many chemical groups and can be easily modified to improve its functionalities and create new functionalities.

2. EXPERIMENTAL STUDY

MATERIALS

CEMENT

The most commonly available Portland cement is 53-grade. Ordinary Portland (Sagar Cement) was chosen so that the influence of Nano Graphene Oxidecouldn't affect the properties of cement and can be studied without any other intervention. The 53-grade ordinary Portland cement was chosen because of its greater fineness which would have effective hydration and also secondary hydration. The raw material used in the manufacture of Portland cement consists of lime, silica, alumina and iron oxide. These compounds interact with one another in the kiln to form a series of more complex products. The proportions of these compounds are responsible for influencing the various properties of cement.

COARSE AGGREGATE

Coarse aggregate is produced by disintegration of rocks and by crushing rocks. These are available in different sizes. Coarse aggregate are usually those particles which are restrained on IS 4.75 mm sieve. We used coarse aggregate which is IS 16 mm passed and 12.5 mm retained. The coarser the aggregate, the more economical the mix.

Usually the aggregates occupy 70% to 80% of the volumes of concrete and have an important influence on its properties. In current study, the high-performance concrete mixes were prepared using locally available aggregates. Coarse aggregate was proportioned to get a mixture of maximum density.

FINE AGGREGATE

Fine aggregate is usually sand or crushed stone that are less than 9.55mm in diameter. Typically, the most common size of aggregate used in construction is 20mm. Here we used 4.75mm passed material of sand as fine aggregate.

Granular material of mineral composition such as sand, gravel, shale, slag or crushed stone. The material which completely passes through 9.5mm sieve is termed as fine aggregate. Fine aggregate is an inert material mixed with a binding material like cement or lime in the preparation of mortar or concrete.Based on the size of the particles, fine aggregates are divided into zones. Here we used, fine aggregate of zone 2.

NANO GRAPHENE OXIDE

Nano Graphene Oxide is effectively a by-product during the oxidation of graphite with strong oxidizers.It is a single atomic layer sheet of graphite oxide. Nano Graphene Oxide is a chemically modified graphene containing oxygen functional groups such as epoxides, alcohols and carboxylic acids and chemical analysis shows the carbon to oxygen ratio to be approximately 3 to 1. Nano Graphene Oxide is not a good conductor.

Nano Graphene Oxide and reduced nano Graphene Oxide lend themselves to covalent functionalization due to the presence of defects in the graphene lattice that act as sites for reactivity. We shall concentrate on covalent functionalization of pristine graphene based around the disruption of sp^2 bonds.

INITIAL TESTS ON MATERIALS

TESTS ON CEMENT

The fineness of a given sample of cement = 5%

Standard consistency value of cement (P) = 28%
Initial setting time of cement = 35 minutes
Final setting time of cement =420 minutes
Specific gravity of cement = 2.75

TESTS ON FINE AGGREGATE

Specific gravity of fine aggregate = 2.63
Zone of sand= Zone II

TESTS ON COARSE AGGREGATE

Flakiness Index = 14.2%
Elongation Index = 12.5%
Specific Gravity of Coarse Aggregate = 2.68

TESTS ON CONCRETE

Slump Cone Test; The Slump of concrete = 42 ± 10
Compaction Factor Test; Compaction Factor= 0.955 (Good)

MIX DESIGN

- ⇨ Grade of concrete = M30
- ⇨ Type of cement = OPC (53 grade, IS 12269)
- ⇨ Type of aggregate = angular aggregate
- ⇨ Max. standard size of aggregate = 20 mm.
- ⇨ Min. cement content = 320 Kg/m^3 (IS 456:2000)
- ⇨ Water cement ratio = 0.45 (table 5, IS 456:2000)
- ⇨ Workability = 40 mm slump.
- ⇨ Specific gravity of coarse aggregate= 2.68.
- ⇨ Specific gravity of fine aggregate = 2.63.
- ⇨ Degree of control / supervision = Good.
- ⇨ Mineral = Nano-Graphene Oxide.
- ⇨ Fine aggregate sieve = 4.75 mm pass.
- ⇨ Coarse aggregate sieve = 20 mm – 16 mm.

Table 1: Mix proportions

Cement	413.33 Kg/m^3
Water	186 l/m^3
Fine aggregate	662.76 Kg/m^3
Coarse aggregate	1152.4 Kg/m^3
Water / cement	0.45

CASTING OF STANDARD CONCRETE

In standard concrete cubes, we generally use cement, fine aggregate, coarse aggregate and water. We made 10 such type of cubes with the use of above mix design i.e., M30 grade of concrete.

The size of cube mould is 150mm x 150mm x 150mm. Mix the sample of concrete required to fill the 10 moulds. After mixing the concrete uniformly, now pour the concrete in the cubes in 3 layers. Compact each layer with 25 number of strokes with the tampering rod. Finish the top surface by a trowel after compaction of the last layer.
After 24 hours, remove the specimen from the mould. While removing, take care to avoid the breaking of the edges. Code the cube with paint or marker. Submerge the specimen in clean, fresh water until the time of testing.

Fig 2: Mixing of Concrete

nGO CONCRETE

nGO stands for Nano Graphene Oxide and this is a mineral which has the capacity to increase the strength and durability. So, we added Nano Graphene Oxide to the standard concrete to increase the properties.
Same procedure is was used as that of standard concrete casting cubes. The specimens are of 150mm x 150mm x 150mm. The concrete was mixed as per the mix design. And we added 10 grams ofNano Graphene Oxide in the wet mix only. As soon as we mixed Nano Graphene Oxide in the concrete, we started pouring it into the moulds in 3 layers. Each layer was given 25 number of strokes with the tampering rod. Finish the top surface by a trowel after compaction of the last layer.
After 24 hours, remove the specimen from the mould. While removing, take care to avoid the breaking of the edges. Code the cube with paint or marker. Submerge the specimen in clean, fresh water until the time of testing.

Fig 3: Casting of cubes

CASTING OF STANDARD CYLINDERS

We have made 4 cylinders of standard concrete mix to check the split tensile strength. The cylinders were of 150 mm diameter and 300 mm height. After the sample has been mixed, the concrete was poured into the cylinder in 3 layers. Each layer was tampered 25 strokes with the tampering rod. After filling the cylinder, the top layer of the mould was finished with the trowel by removing the extra concrete.
After 24 hours, remove the specimen from the mould. While removing, take care to avoid the breaking of the edges. Code the cube with paint or marker. Submerge the specimen in clean, fresh water until the time of testing.

Fig 4: Casting of cylinders

CASTING OF nGO CYLINDERS

As discussed in the making of nGO concrete cubes, the same procedure was followed in the casting of cylinders. The dimensions of the cylinder were 150mm x 300mm. According to the mix design, the concrete was mixed. When the sample was ready, we mixed 10 grams ofNano Graphene Oxide in it and mixed thoroughly. As soon as the mixing was over, the concrete was poured in the cylinder in 3 layers. Each layer was compacted with 25 number of strokes with the tampering rod. And finishing touch was given by a trowel on the top layer.

After 24 hours, remove the specimen from the mould. While removing, take care to avoid the breaking of the edges. Code the cube with paint or marker. Submerge the specimen in clean, fresh water until the time of testing.

3. RESULTS AND DISCUSSION

COMPRESSION TEST

The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. The load shall be applied without shock and increased continuously at a rate of approximately 140 Kg/sq cm/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 shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Compressive strength of concrete= Load/Area.

The units of strength= N/mm^2.

COMPRESSION TEST FOR STANDARD CONCRETE BLOCKS

Table No 2: - Compressive strength of Concrete for 7 days

S. No	Name of the specimen	nGO used in grams	Blocks	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	Block 1	540	24.11
			Block 2	520	23.76
2.	Sample 2	10 grams	Block 1	480	21.33
			Block 2	455	20.22

Table No 3: - Compressive strength of concrete for 14 days

S. No	Name of the specimen	nGO used in grams	Blocks	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	Block 1	630	28.00
			Block 2	660	29.33
2.	Sample 2	10 grams	Block 1	720	32.20
			Block 2	730	32.44

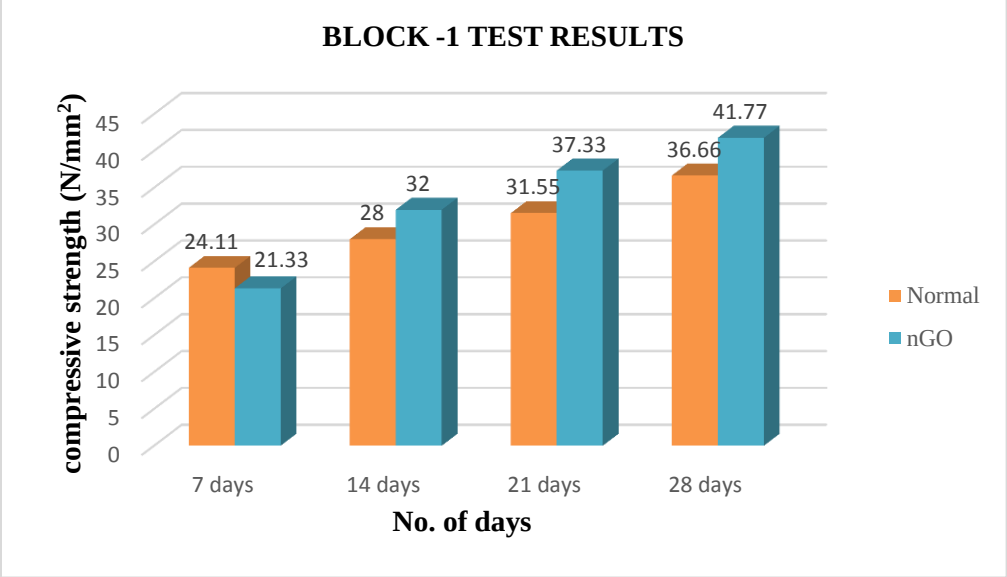
Table No 4: - Compressive strength of concrete for 21 days

S. No	Name of the specimen	nGO used in grams	Blocks	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	Block 1	710	31.55
			Block 2	730	32.44
2.	Sample 2	10 grams	Block 1	840	37.33
			Block 2	870	38.66

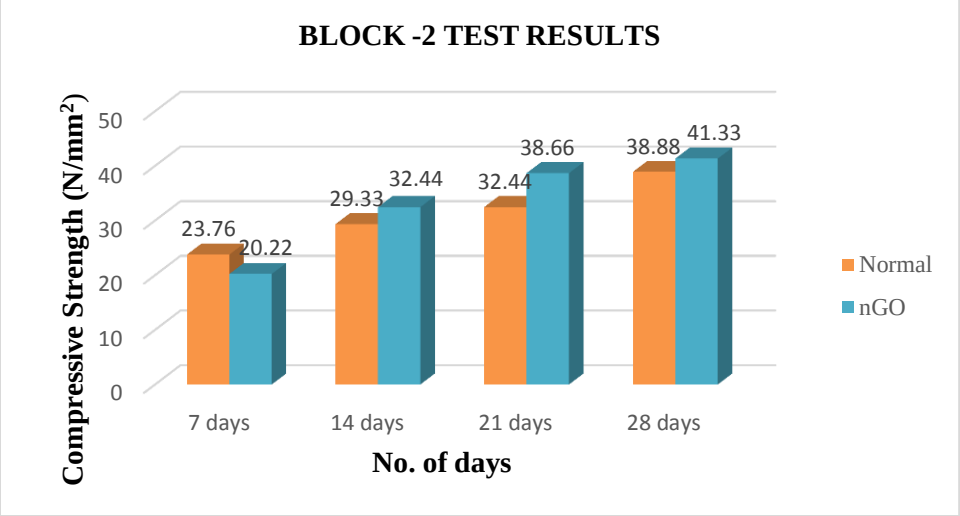
Table No 5: - Compressive strength of concrete for 28 days

S. No	Name of the specimen	nGO used in grams	Blocks	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	Block 1	825	36.66
			Block 2	875	38.88
2.	Sample 2	10 grams	Block 1	940	41.77
			Block 2	930	41.33

Fig 5: - Compression Test for nGO concrete block



Graph 1: - Comparison of compressive strength for Block 1 concrete



Graph 2: - Comparison of compressive strength for Block 2 concrete

COMPARISON BETWEEN STANDARD AND nGO CONCRETE

To compare the compressive strength between Standard Concrete and Nano Graphene Oxide concrete, we have made 10 Standard cubes and 10 Nano Graphene Oxide cubes. We tested them for 7, 14,21 and 28 days and we observed the difference between the strengths of Standard concrete and Nano Graphene Oxide concrete.
When we compared the compression test values of both Standard and Nano Graphene Oxide concrete, we observed that Nano Graphene Oxide concrete gave more strength when compared to Standard concrete. Strength of Nano Graphene Oxide concrete increased with the time of curing. And finally, with this experiment, of mixing Nano Graphene Oxide in standard concrete, we have showed that Nano Graphene Oxide concrete gave us more strength than Standard concrete. The major advantage of mixing the Nano Graphene Oxide in the standard concrete is, it shows the deformation before failure or there will be no sudden failure whereas, the standard concrete doesn't have this property.

SPLIT-TENSIE STRENGTH

The bearing surfaces of the supporting and loading rollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.
Draw diametric lines each end of the specimen using a suitable device that will ensure that they are in the same axial plane. Centre one of the plywood strips along the center of the lower bearing block.Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip. Place a second plywood strip lengthwise on the cylinder, centered on the lines marked on the ends of the cylinder. Apply the load continuously and without shock, at a constant rate within, the range of 689 to 1380 KPa/min splitting tensile stress until failure of the specimen. Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture.

Tensile strength of concrete= $\frac{2P}{\pi D L}$

The units of strength= N/mm^2

SPLIT-TENSILE STRENGTH FOR STANDARD CYLINDERS

Table No 6: - Split-tensile strength of concrete for 7 days

S. No	Name of the specimen	nGO used in grams	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	140	1.98
2.	Sample 2	10 grams	160	2.26

Table No 7: - Split-tensile strength of concrete for 14 days

`	Name of the specimen	nGO used in grams	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	170	2.40
2.	Sample 2	10 grams	200	2.82

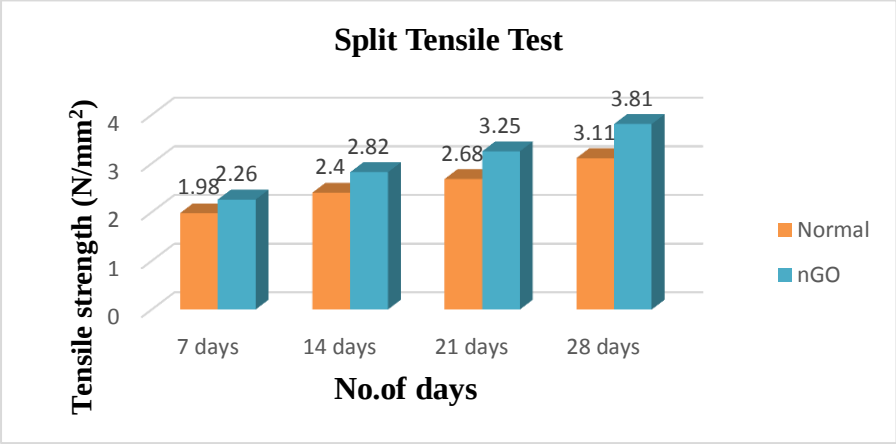
Table No 8: - Split-tensile strength of concrete for 21 day

S. No	Name of the specimen	nGO used in grams	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	190	2.68
2.	Sample 2	10 grams	230	3.25

Table No 9: - Split-tensile strength of concrete for 28 days

S. No	Name of the specimen	nGO used in grams	Load (KN)	Strength (N/mm^2)
1.	Sample 1	0 grams	220	3.11
2.	Sample 2	10 grams	270	3.81

Fig 6: - Split-Tensile strength for cylinder



Graph 3: - Comparison of Split-tensile strength for concrete cylinders

COMPARISON BETWEEN STANDARD AND nGO CYLINDERS

To compare the strengths between the standard cylinders and nano Graphene Oxide cylinders, we have made 4 cylinders of standard concrete and 4 cylinders of Nano Graphene Oxideconcrete. Both the specimens were tested with split tensile strength for 7, 14,21 and 28 days and we observed the strength between Standard cylinders and Nano Graphene Oxide cylinders.

When we compared the split tensile test values of both Standard and Nano Graphene Oxide concrete, we observed that Nano Graphene Oxide concrete gave more strength when compared to Standard concrete. Strength of Nano Graphene Oxide concrete increased with the time of curing. And finally, with this experiment, of mixing Nano Graphene Oxide in standard concrete, we have showed that Nano Graphene Oxide concrete gave us more strength than Standard concrete. The major advantage of mixing the Nano Graphene Oxide in the standard concrete is, it shows the deformation before failure or there will be no sudden failure whereas, the standard concrete doesn't have this property.

4. CONCLUSION

Based on the results of this experimental investigation, the following conclusion can be obtained

- The main advantage of nano Graphene Oxide is it fails after the deformation of concrete (or) there will be no sudden failure.
- The durability of nano Graphene Oxide concrete is more when compared to standard concrete.
- As the number of curing days increases, the strength of the nano Graphene Oxide concrete is also increases.
- Adding nano Graphene Oxide to the concrete mix increases the compressive strength and split-tensile strength of the concrete.
- In an effective utilization of 1gm of nGO to 3Kg cement shown a good strength in both compressive and tensile strength.

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