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Critical Study on Transparent Concrete.

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Abstract*: Construction of high rise buildings and sky scrapers leads to the obstruction of natural light in buildings. Due to this problem, use of artificial light has increased in large amount. Thus, it becomes necessary to reduce artificial light consumption in structure. This leads to the introduction of innovative concrete, Transparent concrete. Transparent concrete is fiber reinforced concrete which is used for aesthetical application by inserting the optical fibers in concrete. Both natural as well as artificial light passes through the transparent concrete due to optical fibers. The study is not only constrained with the decorative purpose but the effect of fiber application in strength aspect is also discussed. Load carrying capacity of transparent concrete increases when fibers are arranged in different layers and also various pattern can be created to make the concrete decorative. This concrete can be used in interiors of hall, lobby and ceiling to glow in dark by external lighting source and in day time it glows by the light transmission from natural resources. This paper presents the study on addition of waste glass with optical fiber in transparent concrete.*

Key words: Transparent concrete, Optical fiber, Waste glass.

INTRODUCTION

Concrete plays a very vital role in construction and has been used since roman times for development of infrastructure and housing. Basic components of concrete have not yet changed. Composition of dry mix consists mainly of three ingredients i.e., coarse aggregates, which consists of larger pieces of material like stones or gravel, fine aggregates, consisting of smaller particles such as sand, cement, a very fine material powder that holds the mix together when water is added.

Due to rapid urbanization in 1960, concrete was often misconceived and disfavored. But since that time, considerable progress has been made in concrete, not only in scientific terms but also in aesthetic terms.

It is no more bulky, cold and grey material of the past; it has changed to attractive and lively. By research and innovation, newly established concrete has been designed which is more immune, light-weight, white or colored, etc. Concrete adapt almost all new challenges that appears. In 2001, the Hungarian architect Aron Losonzi invented the concept of transparent concrete at the Technical University of Budapest, and the first transparent concrete block was favorably produced by adding large amount of glass fiber into concrete in 2003, named as LiTraCon.

Table 1: Properties of Transparent concrete blocks by Litracon company:

Product	Litracon-Light Transmitting Concrete
Ingredients	96% concrete, 4% optical fibre
Density	2100-2400 kg/m^2
Block size	600mm*300mm
Thickness	25-500mm
Compressive strength	50 N/mm^2
Tensile strength	7 N/mm^2

The transparent concrete mainly concentrates on transparency and its aim is to attain the artistic finish and to generate the green technology. Transparent concrete is mainly "the mixture of optical fibers and fine concrete". Nowadays, green building mainly focus on saving energy with indoor thermal systems. Therefore, it is important to introduce a new working material to serve the purpose of the structure in terms of safety (such as damage detection, fire warning), protection of environment, energy saving and artistic modeling.

Nowadays, the space between buildings is reduced due to globalization and the construction of high-rise buildings, this leads to increase in the use of non- renewable energy sources, thus, there is a requirement of new construction technique like green building and indoor thermal system.

Translucent concrete (Transparent concrete) is an innovative concrete which is dissimilar from normal concrete. Transparent concrete permits light to pass through it and are light-weight as compared to normal concrete. The main aim of transparent concrete is to use sunlight as source of light in spite of using electrical energy in order to minimize the use of non-renewable sources. This technique results in to energy saving. Optical fibers are a detecting or transmission element, to reduce the use of non-natural light, the normal concrete is swapped by translucent concrete, which has natural lighting and art design. By introducing the concrete with optical glass fibers, light travels from outside in or inside out. Transparent concrete has the same strength as regular concrete and will continue to transmit light through walls up to twenty meters (twenty-two feet) thick. The expectation is that the new material will remodel the interior of concrete buildings by sensing them feel light and airy rather than dark and heavy.

LITERATURE REVIEW

Satish Kumar V and Suresh T (2015)[1] produce the concrete specimen by reinforcing optical fibers with different proportion based on the volume of the cube by 0.15%,0.25%,0.35% to compare the strength and intensity of light passing through it. The cube and cylinder mould used in the project is of standard size 150mm*150mm and 150mm*300mm respectively. Different test was carried out on the specimen like Compressive strength test, Split-Tensile strength, Intensity of light passing through it, etc. They have observed that the reinforcing of optical fiber will transmit light and also eventually increases the strength of the concrete as compared to conventional concrete. Compressive strength of the concrete is increased by 22.99% of the normal concrete for 0.25% of optical fiber. The tensile strength of the concrete is increased by 83.95% for 0.25% of optical fiber, which clearly indicates that transparent concrete transmits light without affecting the strength of concrete.

Soumyajit Paul and Avik Dutta (2013)[2] casted a special type of concrete with light transmitting properties, to study their characteristics and to develop a functioning material which is not only energy saving but gives out artistic finish. For obtaining transparent concrete, material comprises of mixture of polycarbonate and epoxy matrices as well as glass fibers, optical fibers, colloidal silica, silica and diethylenetriamine (DETA) and Portland cement. The content of the component is: epoxy matrix from 0% to 90%, and the polycarbonate matrix from 0% to 10%, colloidal silica sol from 0.5% to 5%, fiberglass from 0% to 10%, silica from 0.5% to 10%, diethylenetriamine (DETA). The ratio of the polymer matrices and the mortar is at least 1.5:1, and the mixing is done manually or mechanically. Maximum water absorption range is within 0.35%. This invention has greater mechanical strength properties as compared to the standard concrete, with lower density and mechanical characteristics that enable same to be used in both structural and architectural manner. This paper concluded that the transparent concrete has good light guiding properties and the ratio of optical fiber volume to concrete is proportion to transmission. This concrete does not lose the strength parameter when compared to regular concrete and also it has very vital property for the aesthetical point of view.

Salmabanu Luhar and Urvashi Khandelwal (2015)[3] investigated the compressive strength of transparent concrete and compared with the conventional concrete, in order to find the potential of using transparent concrete for construction of green buildings. Three cubes of size 7cm*7cm*7cm were casted out of these two were of control concrete and one was of transparent concrete. The plastic optical fiber of diameter 1mm were embedded in it and were distributed in horizontal direction equally at distance of 8mm. they constituted 1% volume of concrete cube. Each cube was separated by perforated plates. The optical fibers were passed through the holes of these perforated plates. Before filling these cubes with concrete, they were coated with oil, so that the cubes would not adhere to the moulds. The compressive strength of these cubes was found out using compressive testing machine. The compressive strength of control concrete was observed to be 38.77N/mm^2 and 40.23N/mm^2 whereas that of transparent concrete was 36.70N/mm^2. It can be concluded that the compressive strength of transparent concrete is similar to that of control concrete. The investigation showed that the transparent. The investigation shows that the transparent concrete can reduce the electricity bills without compromising the strength of the building. It will reduce the energy consumption of both residential and industrial buildings.

P. M. Shanmugavadivu et al (2014)[4] investigated to check whether the introduction of fiber wire in to concrete will help or influence to change the engineering properties of the member. Mix proportion for experiment purpose are as follows: Cement – 360kg, Sand – 560kg, Fiber – 4.5kg, Water – 190lit. Initially fibers are arranged in the required pattern in the formwork before casting of concrete. After installation of fiber, one end is connected to the lighting source and other end is left free. Then the wet mix is applied on the slab mould prepared. The concrete is allowed to cure for 7-15 days. After curing, these slabs will transmit light on its surface. Fibers are glowing at free end by giving light source on another end. Workability of the concrete is determined by conducting the slump cone test and observed slump is 92mm. Compressive strength and flexural strength test is performed. The results evidently show that the decorative concrete also performance based on strength aspect is also considerably high. This paper concludes that the efficiency of the application of optical fiber is studied by comparing the strength with normal M20 grade concrete and the test results proved that the efficiency is more in all aspects. The fibers can be used in concrete for decorative purpose. Hence the application of optical fiber will make the concrete decorative as well as can make the concrete structural efficient.

Jadhav G S et al (2016)[5] replaced fine aggregate by waste toughen glass as 5%, 15%, 25% and 35% by weight for M30 mix design. As glass is a major component of solid waste stream, it is cheaper and can be found in many forms including container glass, glass door, vertical window, furniture, bathroom, etc. the concrete specimen was tested for compressive strength and the results obtained were compared with those of normal concrete. The partial replacement of fine sand by waste toughen glass gives best result at 25% replacement of fine sand by waste toughen glass. The strength of glass concrete has increased by 7% at 25% partially replacement of fine sand by waste toughen glass as compare to conventional concrete. It has observed that the crack width goes on increasing over the 25% replacement of the waste toughen glass in concrete. It also reduces the total cost of the project.

T. Bhagyasri et al (2016)[6] reduced the quantity of manufacturing of cement by partially replacing with glass powder and avoided the disposal problem of waste glass material. The specimens are cubes, prisms and cylinders were casted by partially replacing cement by glass powder with 10%, 20%, 30% and 40%. They used finely ground glass material to increase the strength without using the strength increasing admixtures. They even studied the role of glass powder in mechanical properties of concrete. Initial and final setting time of cement, specific gravity test, workability test, UPV test, compressive strength test, flexural strength test has been performed. The study concludes that the setting time of

concrete increases as there is increase in the percentage of glass powder. Workability of concrete decreases with increase in the glass powder content. From UPV test it is concluded that the quality of concrete increases with increase in the cement replacement with glass powder. Both at the ages of 7 and 28 days maximum compressive strength occurs at 20% of glass powder. Water absorption of concrete reduces by increasing the glass powder content. There is increased in the flexural strength as the glass powder content increases.

Mohd Vasique Hussain and Rajiv Chandak (2015)[7] studied the behavior of M30 grade concrete to determine the compressive strength and split tensile strength by partially replacement of cement by waste glass powder. Cement was partially replaced by waste glass powder in 10%, 20%, 30% by weight. The results obtained were compared and examined with respect to the control specimen. Experiments were conducted on cubes and circular specimen of dimension 150*150*150mm and cylindrical specimen of height 300mm and 150mm dia. A design mix of M30 grade was used to prepare the specimen. The specimens were held for curing at 28, 56 and 90 days. The results show there is a gradual increase in the strength of concrete with the addition of glass powder. At the replacement of 10% of cement by glass powder meets maximum strength as compare to that of normal concrete and other percentage of replacement of cement. It is concluded that waste glass powder can be used to increase the strength up to certain extent.

S. No.	Cube Specimen Designation (sets)	No. of cube specimens	Avg. compressive strength (N/mm²) 28 days	Avg. compressive strength (N/mm²) 56 days	Avg. compressive strength (N/mm²) 90 days
1	GP-0	3	40.25	42.14	42.99
2	GP-10	3	41.99	43.74	44.32
3	GP-20	3	35.31	36.47	37.20
4	GP-30	3	33.71	34.73	35.45

Fig 1: Average compressive strength of specimen [taken by (6)]

Prachi Sharma et al (2013)[8] suggested that fiber optics is a chief building block in the telecommunication infrastructure. Its high bandwidth capabilities and low attenuation characteristics that makes it ideal for gigabit transmission and beyond. The various types of fiber and their applications, light sources and detectors, splitters, couplers, wavelength division multiplexers, and state-of-the-art devices used in the latest high-bandwidth communication systems have been hand over. Fiber-optic biosensors will play a vital role in the growth of biosensors because they can be simply miniaturized and integrated for the purpose of various target compounds in an extensive variety of application fields, such as industrial process and ecological monitoring, food processing, and clinical applications. Newly developed various application of fiber optic has been debated. The progress of the fiber optics industry over the past five years has been explosive. Analysts expect that this industry will endure to grow at a tremendous rate well into the following decade and beyond.

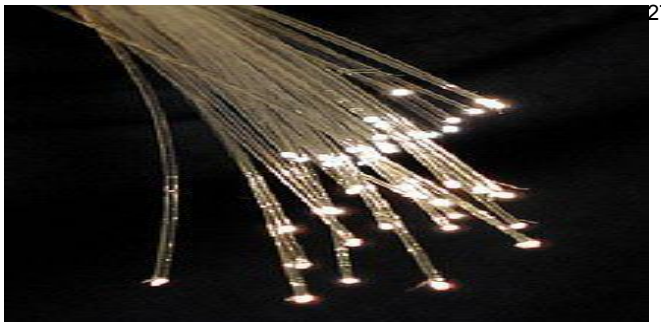

Fig 2: Optical fibers

P.S Mane Deshmukh and R.Y Mane Deshmukh (2014)[9] investigated the use of waste glass as cement replacement in concrete construction sector in order to decrease the production cost of concrete and industry would become more environmental friendly. The main purpose of this investigation is to find out the strength of concrete containing waste glass powder as pozzolana. Cement replacement by glass powder is done in the range 5% to 20% in increments of 5 percentage (5%, 10%, 15%, 20%). M53 grade cement is used. Mix design are mixed in dry state and then the desired water quantity is added and the concrete is poured in the cube of 150*150*150mm size and cylinders of 150*300mm size. These moulds are tested for compressive strength and split tensile strength and results are compared with conventional concrete. The maximum compressive strength when 20% cement was replaced by glass powder in concrete. The density of concrete reduces with the increase in percentage of replacement of cement by glass powder. The workability decreases as the glass content increases. Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio. According to strength criteria, replacement of cement by glass powder is feasible. It is concluded that the utilization of waste glass powder in concrete as cement replacement is possible.

Dr. M. Vijaya Sekhar Reddy et al (2015)[10] investigated the issues of environmental and economic concern by the use of waste glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by waste glass powder as 10%, 20% and 30% by weight for M20 mix. The concrete specimens were tested for compressive strength at 7 and 28 days of age and the results obtained were compared with those of normal concrete. Waste glass when grounded to a very fine powder shows some pozzolanic properties as it contains high siO_2 and therefore to some extent it replaces the cement and contributes for strength development. Glass is an ideal material for recycling and the use of recycled glass helps in energy saving. The result shows 35% increase in compressive strength at 7 days and 30% increase in compressive strength at 28 days with 20% replacement of fine aggregates. Fine aggregates can be replaced by waste glass up to 30% by weight showing 8.5% increase in compressive strength at 28 days. Water absorption decreases with increase in waste glass content, average weight decreases by 5% for mixture with 30% waste glass content thus making waste glass concrete light weight. Workability of concrete mix increases with increase in waste glass content.

M. Sangeetha et al (2015)[11] studied light weight light transparent concrete in which coir pith is used partially instead of fine aggregates to reduce its self-weight. Coconut is used as an additional material. Optical fibers are one which helps for transmission of light through fiber. Coarse aggregates are not used in light transmitting concrete. The aim of the study is to make the concrete decorative by laminating on the surface, to reduce the dead weight of the structure and to check whether the introduction of fiber wire in to the concrete will help or influence to change in the engineering properties of the member. Fine aggregates were partially replaced with coir pith by 10%, 15%, 20% and size of cube is 100*100*100mm. compressive strength test and flexural strength test and weight comparison are performed. The results evidently show that the decorative concrete also performance based on the strength aspect is also considerably high. The efficiency of the application of optical fiber is studied by comparing the strength with normal M20 grade concrete and the test results proved that the efficiency is more in all aspect. The fibers can be used in concrete for decorative purpose also light weight is applicable for site. The main advantage of light weight is reducing the self-weight of the structure. This decorative concrete can be used in place of windows and in interior design of buildings as panels in slabs, walls, etc.

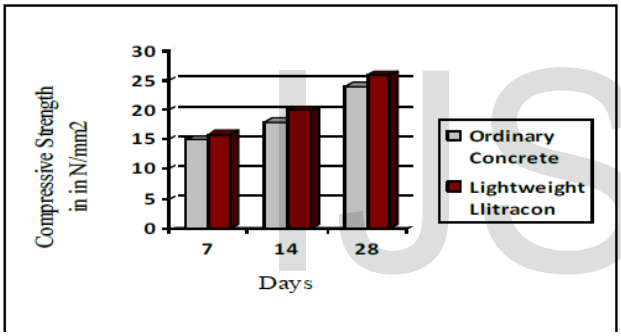

Fig 3: Compressive strength of the concrete [taken by (11)]

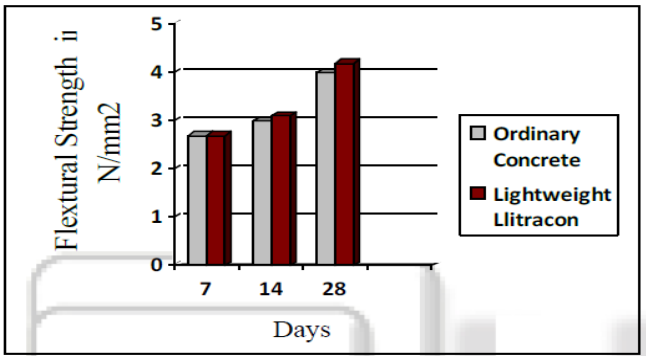

Fig 4: Flexural strength of the concrete [taken by (11)]

M.N.V. Padma Bhushan et al (2013)[12] studied the modelling of transparent concrete blocks and their usage and also the advantages it brings in the field of smart construction. Holes are punched on opposite walls of cuboid. The optical fibers have to run through these holes from one end to the other and then concrete is made to set in it with the fibers inside. The light falling on one side of the block get transferred to the other side through these many optical fibers running from one end to the other. The concrete then undergoes a curing process. The excess fibers running out of the block are cut off and slightly polished. The modelling of transparent concrete block is complete. It is concluded that transparent concrete blocks can be used in many ways and implemented into many forms and be highly advantageous. Yet, the only drawback would be its high cost. That doesn't stop high class architects from using it. It's a great sign of attraction and artistic evolution. Any structure with a small hint of translucent concrete is bound to make heads turn and make them stand in awe. Apart from the beauty aspects, there's also this security and supervision. Large houses, with big security walls are often low on security. That's why they are mostly fitted with electrocuted fencing. If those outer walls were fitted with translucent concrete blocks, the owner would know right away if there was anybody trying to climb the wall as he/she can visibly see it. Prison guards would know very easily if any of the inmates were trying to escape or if any of them are fighting. The same can be case for schools and colleges too as well as museums and other places. Green buildings would get an easy accreditation under daylight savings with this. Large and tall office buildings can share the lighting when the ceilings are translucent. Energy savings as well as heat insulation simple adds to the list of its amazing properties. Translucent concrete is the future. It is the smart way of optimizing and utilizing light, a smart way of living.

Sameer Shaikh et al (2015)[13] studied utilization of waste glass powder (GLP) in concrete as partial replacement of cement as well as the use of crushed glass particles (CGP) retained on 1.18mm and 2.36mm IS sieve as a partial replacement of sand, which is beneficial from environmental as well as strength point of view. Recycling of mixed colour waste glass possesses major problems for municipalities and this problem can be greatly eliminated by re-using waste glass as sand/cement replacement in concrete. In this study, the attempts have been made to partially replace the cement as well as sand by waste glass powder and crushed glass particles with equal combination by 5 intervals up to 20% replacement and observe its effect on the strength of concrete after 7 days and 28 days of curing. Cubes of dimensions 150*150*150mm, cylinders of diameter 150mm and length 300mm and beams of 100*100*500mm was casted and tested for compressive strength, split tensile strength and flexural strength respectively. It is concluded that the concrete with using waste glass powder and crushed glass particles has a very high workability from control sample. This result achieved from the slump test that use of waste glass powder will increase the workability of concrete. In term of strength, concrete with using waste glass powder averagely have higher strength at 28 days. Conventional concrete shows at 7 days compressive strength as 14.51 N/mm2, split tensile strength of 1.55N/mm2 and flexural strength of 1.97N/mm2.Conventional concrete shows at 28 days compressive strength as 19.25 N/mm2, split tensile strength of 1.88 N/mm2 and flexural strength of 2.72N/mm2. Replacement of glass powder in cement as well as crushed glass particles in sand by 5%, 10%,15% and 20% increases the compressive strength after 28 days by 9.25%, 38.50%, 70.80%, and 33.09% respectively. Replacement of glass powder in cement and crushed glass particles in sand by 15% increases the split tensile strength after 28 days by 4.25%. Replacement of glass powder in cement by 5%,10%,15% and 20% increases the flexural strength after 28 days by 5.88%, 30% and 44.85%, and 13.97% respectively. Glass powder

concrete increases the compressive, tensile and flexural strength effectively at 15% combine replacement when compared with conventional concrete. Very finely ground glass has been shown to be excellent filler and may have sufficient

APPLICATIONS

Transparent concrete offers advanced technical solutions, semi-natural and ecological concrete. This concrete has a wide range of utilization in construction, architecture, decoration and even furniture. Some of the feasible applications for the creative concrete are as follows:

1. Transparent concrete blocks are best suited for floors, pavements and load-bearing walls.
2. Interior wall cladding, dividing walls and facades based on thin panels.
3. It can be used as partitions wall where the sunlight does not reach satisfactorily.
4. Transparent concrete can also be used in furniture for the fancy and creative purpose.
5. Light hanging from ceiling.
6. Used to glow sidewalks at night.
7. Increasing range of vision in dark subway stations.
8. To light indoor fire exit in case of power failure.
9. Highlighting speed bumps on freeways, highways and expressways at night.

CONCLUSION

An innovative material called transparent concrete can be established by introducing optical fiber or large diameter glass fiber in the concrete mix. Addition of waste glass in transparent concrete can even make the concrete sustainable and can reduce the overall cost of the project to some extent. The transparent concrete has good light guiding property and the ratio of optical fiber volume to concrete is proportional to transmission. The strength parameter of transparent concrete is observed to be same as the conventional concrete and it is also important from aesthetical point of view. Transparent concrete can be used in temples, furniture, walls, ceiling, panels for the best architectural appearance of the building. It can also be used in the field, where the sunlight cannot reach with suitable intensity. This innovative kind of building material can merge the idea of green energy saving with the usage of self - sensing properties of working material.

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