A

DISSERTATION REPORT

ON

IMPACT OF USE OF MARBLE WASTE ON THE PROPERTIES OF LIGHT TRANSMITTING CONCRETE

Submitted in partial fulfillment of the requirements for the award of degree of

Master of Technology

In

STRUCTURAL ENGINEERING

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DECLARATION

I hereby certify that the work which is being presented in the seminar report entitled "**Impact of use of marble waste on properties of light transmitting concrete** ", in partial fulfillment of the requirements for the award of the Degree of Master of Technology and submitted in the Department of Civil Engineering of the Malaviya National Institute of Technology Jaipur is an authentic record of my own work carried out during a period from August 2015 to JUNE 2016 under the supervision of **Dr.A.K.VYAS**, Professor, Department of Civil Engineering, Malaviya National Institute of Technology Jaipur, India.

The matter presented in the thesis has not been submitted by me for the award of any degree of this or any other Institute.

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(**ANJALI CHAWLA**)

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ABSTRACT

The extraction of marble and its processing as marble blocks is most common in several states of India. But its extensive growth has put adverse impact on the environment because of the production of huge amount of marble sludge in processing industries. This experimental study highlights the impact of use of marble waste on the properties of light transmitting concrete (LTCM) . The basic objective of this experimental program is to replace river sand in concrete by an optimum combination of quarry dust and marble powder and to determine improvement in light transmittance in concrete by use of marble waste as aggregate. Six proportions of mix (by varying the percentage replacement of fine aggregate with marble waste from 0-100% by weight) were prepared to investigate the compressive strength, flexural strength ,permeability and ultrasonic pulse velocity. The result shows all these properties were improved for complete substitution of fine aggregate with marble powder. The study was further carried out with 75% and 100% substitution of fine aggregates to determine improvement in the light transmittance of LTCM. It was observed that light transmittance increased to 44% for 100%marble powder compared to control mix prepared with 100% quarry dust and 0% marble powder.

CHAPTER – 1

INTRODUCTION

CHAPTER - 1

INTRODUCTION

1.1 GENERAL

Advanced growth in the infrastructure globally has made concrete the most widely and ordinarily utilized construction material all through the world. Growing demand of infrastructure has created huge pressure on the concrete industry to produce large quantum of concrete. The cost of concrete production primarily depends on the cost of its constituent raw materials namely, cement, aggregates (coarse and fine) and water. Among the raw materials of concrete, the Natural River sand which forms around 35% of the concrete volume plays an important role in deciding the cost of concrete.

Depleting sources of Natural River sand and strict environmental guidelines on mining has gradually shifted the attention of the concrete industry towards a suitable fine aggregate alternative that can replace the presently used Natural River sand.

The reduction in the sources of natural sand and the need for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to constituent materials as aggregates in the production of concretes. Various types of materials have been studied for this purpose both in developing and developed countries and the outcome of success has been varying. The materials usually researched for this purpose are either by-product materials or even sometimes manufactured aggregates.The advantages of utilization of by-products or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load and waste management cost, reduction in concrete production cost and possible enhancement in some properties of concrete.

Quarry dust and Marble dust have surfaced as viable alternative to Natural River sand and can be possibly used as fine aggregate in concrete

1.2 INDUSTRIAL WASTE

QUARRY DUST

Quarry dust, a by-product from the crushing process during quarrying activities is one of those materials being studied, especially as substitute material to sand as fine aggregates.

Quarry dust has been used for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks.

MARBLE DUST

Among the most important mining activities the extraction of marble and its processing as marble blocks is most common in several states in India. But its tremendous growth has put adverse impact on the environment because of production of huge amount of marble sludge in processing industries. In factories or workshops marble blocks are cut into different sizes and varied thickness. To prevent the rock saw from overheating and to prevent dust, water is used during the cutting process. This process results in the mixing of dust with water, which forms marble sludge. The waste produced from the processing of material is dumped into the environment, either in its residual form or following dewatering is done in treatment plant. Approximately 30% of a quarried marble block becomes waste in the form of sludge. Storage of this waste marble sludge in the processing plants is not easy. Thus, the re-evaluation of this waste material will be financially and environmentally beneficial and acceptable for the industries.

Marble sludge after drying can be easily converted into Marble Powder (MP). Marble powder is being put to several industrial uses, including the paper, dyeing and plastic industries in addition to, animal forage production, and the lime and steel production industries. However, utilization of marble powder is not sufficient to consume all waste material stocks. Concrete, on the other hand, is an advantageous construction material, whose production exceeds billions of cubic meters annually. The incorporation of marble powder into concrete and cement-based products would make significant positive environmental and economic contributions.

1.3 NEED OF STUDY

- Rapid growth in the infrastructure has made concrete most ordinarily used construction material.
- Reduction in the sources of natural river sand resulting in its shortage.
- Extraction of natural river sand causes environmental imbalance.

- Dumping of waste material produced from industries occupy space and lead to the environmental pollution.
- Replacement of river sand by optimum ratio of these waste material and investigating mechanical properties of concrete.

1.4 OBJECTIVES OF STUDY

- To replace river sand in concrete by an optimum combination of quarry dust and marble powder.
- To determine improvement in light transmittance in concrete by use of marble waste as aggregate**.**

1.5 Organization of thesis

The work carried out in this study is presented in six relatively independent chapters. A brief idea about the organization of thesis and its included chapters is as follows:

Chapter 1 Introduction

This chapter introduces the necessity of using waste in concrete works. A brief review of study by past researchers and need of present study has been discussed. Objectives of the present study have also been outlined.

Chapter 2 Literature Review

This chapter includes the detailed review of the research work done by various researchers on the replacement of fine aggregates with marble dust and on the mechanical properties of light transmitting concrete, such as, light transmittance, compressive strength and flexural strength.

Chapter 3 Materials and Methodology

The experimental study undertaken, the details of materials used and preparation of specimens have been discussed. It also includes the overview of properties of the materials and test procedures.

Chapter 4 Results and Discussions

The results obtained from the experimental work have been discussed in this chapter. It also includes results, tables and graphs along with the discussion.

Chapter 5 Cost Analysis

Cost of light transmitting concrete has been estimated and recovery period is calculated.

Chapter 6 Conclusions

This chapter states the conclusions drawn from the experimental program. Scope for future study has been included in this chapter.

CHAPTER – 2

LITERATURE REVIEW

CHAPTER - 2

LITERATURE REVIEW

2.1 General

Several waste materials such as fly ash, zinc and blast furnace slgs, copper slags, etc. have been used by many researchers in concrete mixes partly replacing fine aggregate. It was reported that properties of concrete improve to certain extent thus limiting cost of concrete and more beneficial aspect is use of waste in infrastructure works. Studies reported by several researchers on partial replacement of fine aggregate by marble waste is described in the next paragraph.

2.2 Partial replacement of fine aggregates with marble powder

Corinaldesi et al. (2010) investigated characteristics of marble dust in mortar and concrete production. For this purpose, eight mortar series of 40x40x160mm were prepared by varying the water to cement ratio (0.4‑0.5), all specimen were prepared with the same ratio of sand to cement (ratio of 3:1). the amount of marble powder addition (10% and 20% by weight of cement or sand) and by adding a super plasticizing admixture (at a dosage of 0.5% by weight of very fine materials, i.e., cement plus marble powder). It was concluded that when either cement or sand is replaced with 10% marble powder caused about 10‑20% compressive strength decrease in later age. However, marble powder used as the replacement of sand performed better (10% decrease) than the case for the marble powder used as the replacement of cement (20% decrease).It was also noticed that for 10%replacement of sand, showed maximum compressive strength in the presence of super plasticizing admixture compared to that without admixture.

Demirel (2010) investigated the effects of using waste marble dust (WMD) as a fine material on the mechanical properties of the concrete. For this purpose four different series specimen of size 100 × 100 × 100 mm were prepared by replacing the fine sand (passing 0.25 mm sieve) with WMD at proportions of 0, 25, 50 and 100% by weight**.** Relative to the reference sample, the 28-day compressive strength and dynamic modulus of elasticity of the 100%-replacement samples were increased by 10% and 25%, respectively, and the porosity decreased by 8%.

Belachia and Hebhoub (2011) studied the use of waste marble aggregates in concrete production. They prepared mixtures in which natural sand (NS) is substituted by the recycled sand (RS) at 25%, 50%, 75% and 100%.The compressive strength was conducted on cylinder of size 16cm×32cm.The highest compressive strength was achieved at the 25% substitution ratio maintaining the ratio at 0.45 w/c, they found that the samples not containing waste marble have a compressive strength of 33MPa, whereas in samples containing 25% waste marble, the compressive strength increased to approximately 36MPa. These researchers concluded that waste marble is a suitable alternative material to natural aggregates.

Omar et al. (2012) replaced the sand in concrete with marble dust at ratios of 5, 10, and 15% and compared the strengths of the modified concretes. Marble dust at a ratio of 15% increased the modulus of elasticity by 5.1%, but decreased the concrete's workability. At any ratio, the marble dust noticeably increased the compressive strength on days 7, 28, and 90. In samples with 350 kg/m3 cement density and 5% marble dust substitution, the compressive strengths on days 7, 28, and 90 were increased by 10, 5, and 5%, respectively, relative to the reference sample with no marble dust. The corresponding increases were 17, 15, and 15% in the 10% marble dust sample, and 22, 17, and 17% in the 15% marble dust sample. Moreover, the splitting tensile strengths in all marble dust samples increased by 10%.

F.Gameiro et al. (2014) assessed the durability performance of concrete containing various percentages of fine aggregates produced from the waste generated by the marble quarrying industry (0%, 20%,50% and 100% of the total volume of fine aggregates).For each series four cubes of size 100×100×100mm were prepared. They substituted granite, basalt, and river sands with marble dust at volume ratios of 20, 50, and 100%. Regarding water absorption by immersion, it can be concluded that incorporating marble improved the permeability of the granite and basalt concrete specimens, which is beneficial for durability. The effect of marble sand on all mixes' drying shrinkage proved to be beneficial because compactness improved and drying shrinkage was more pronounced in the first 20 days.

In terms of water absorption by capillary action, addition of marble aggregates proved to be positive, especially at a replacement ratio of 20%.

Alyamaç and Aydin(2015) prepared 150mm cubes and 100 mm cubes for testing tensile strength and compressive strength respectively with varying the percentage of marble powder as MP10, MP20, MP30, MP40, MP50, MP90 where MP 10 represents 10 % marble powder. The results obtained indicates maximum compressive and splitting tensile strength for MP20. For 28days, compressive strength was 38.1MPa and for reference concrete it was 36.2MPa. Splitting tensile strength was 3.2MPa and for reference concrete it was 2.6MPa. Optimal amount of marble replacement results in increase in strength and excessive use of marble powder results in very low slump.

2.3 Partial replacement of coarse aggregate with marble

Binici et al. (2008) studied the mechanical properties of the modified concrete. Concrete mixtures were made by replacing coarse aggregate with crushed marble, granite and limestone (control specimen) and fine aggregates were replaced by granulated blast furnace slag and control specimen is prepared with river sand. 100mm×200mm concrete cylinders were made for the determination of compressive strength and splitting tensile strength. It was concluded that the compressive strength at 365 days was 62.1MPA for crushed marble used as coarse aggregate and 36.8MPA for control specimen. In addition, the splitting tensile strength at 28day was 57%, higher respectively, in the test samples than in the reference sample. These researchers clarified that crushed marble improve the mechanical properties of conventional concrete.

Belachia and Hebhoub (2011) studied the use of waste marble aggregates in concrete production. They prepared mixtures in which natural sand (NS) is substituted by the recycled sand (RS) at 25%, 50%, 75% and 100%. The compressive strength was conducted on cylinder of size 16cm×32cm.The highest compressive strength was achieved at 75% substitution .

2.4 LIGHT TRANSMITTING CONCRETE

BACKGROUND

In 2001, the concept of transparent concrete was first put forward by Hungarian architect AronLosonzi, and the first transparent concrete block was successfully produced by mixing large amount of glass fibre into concrete in 2003, named as Litracon. Joel S. and Sergio O.G. developed a transparent concrete material, which can fulfil 80% light requirement from natural sunlight. It is worth mentioning that Italian Pavilion in Shanghai Expo 2010 shows a kind of transparent concrete developed by mixing glass into concrete in 2010. While the transparent concrete mainly focuses on transparency and its objective of application pertains to green technology and artistic finish.

LIGHT TRANSMITTING CONCRETE

Concrete has a vital role in development of infrastructure and housing. Due to globalization, population growth and space utilization worldwide, there is drastic change in construction technology. Small buildings are replaced by high-rise buildings and skyscrapers. This arises one of the problem in deriving natural light in building, due to obstruction of nearby structures. Due to this problem use of artificial sources for illumination of building is increased by great amount. Complete dependence on artificial sources has adverse impacts on our environment and health of people living in these buildings. Production of these artificial sources of energy pollutes our environment. So, it is very essential to reduce the artificial light consumption in structure.

Light transmitting concrete allows natural sunlight or any light to pass through it, thus increasing the natural light content in the building to enhance optical activity. It reduces electricity consumption in the buildings and makes it easier for buildings to achieve higher

LEED (Leadership in energy and environmental design) rating. Thus reduces the dependence on artificial sources.

Transparent concrete is a concrete-based building material with light-Transmissive properties due to embedded light optical elements i.e. plastic optical fibres. Light is conducted through the concrete from one end to the other. Therefore the fibres have to go through the whole object. Transparent concrete is also known as the translucent concrete and light transmitting concrete because of its properties. It is used in fine architecture as a facade material and for cladding of interior walls.

Light transmitting concrete is made up of cement, fine aggregates , coarse aggregates and optical fibers, placed in alternate layers. It is based on the principle of total internal reflection of light in the core of the plastic optical fiber. When light falls on one end of the optical fiber, it gets totally internally reflected in the fiber and gets transmitted on other end of the fiber.

Fig.2.1 Block of light transmitting Concrete

This concrete is very important from sustainable development and green building point of view as it allows use of natural light more efficiently without compromising much on strength parameter. For green buildings, according to IGBC (Indian Green Building Council), 50% of daylight is mandatory which accounts for 3 credits in the green buildings. Light transmitting concrete allow sufficient light inside the building, thereby making it easier to achieve higher ratings for buildings.

Functional principle of Light transmitting concrete

Diffuse natural light and sunlight provide the full spectrum of colors shining through the concrete panels. Sunlight is the most inexpensive light source. If the panel is mounted free standing or in front of a window, one will not need any artificial light source. Transparent concrete or translucent concrete is work Based on “Nano-Optics”. Optical fibers passes as much light when tiny slits are placed directly on top of each other as when they are staggered. Principle can carry because optical fibers in the concrete act like the slits and carry the light across throughout the concrete.

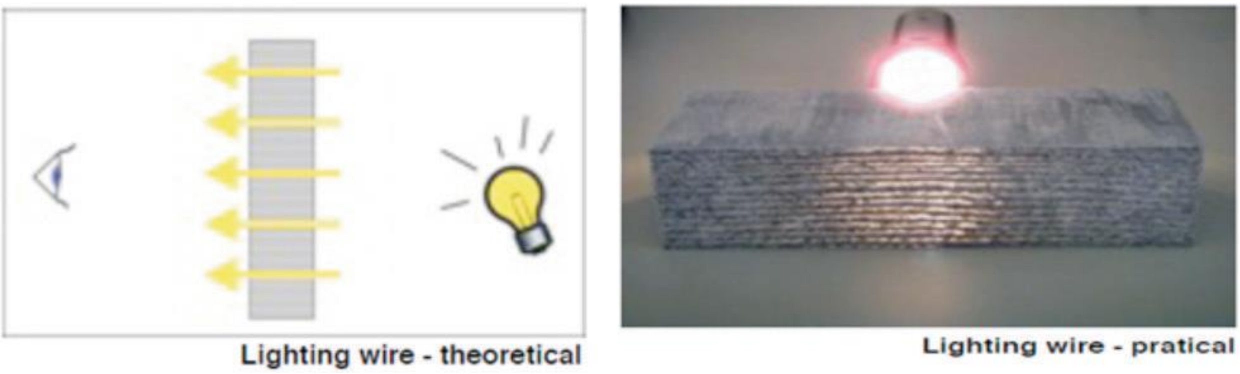

Fig.2.2 Principle of Light transmitting concrete

TOTAL INTERNAL REFLECTION

When light travels from denser to rarer medium with angle of incidence greater than critical angle leading to completely reflecting of light and the phenomenon is known as total internal reflection (TIR). This principle is used in the design of optical fiber thus guiding light from one end to another end of optical fiber when it is objected at angle greater than critical angle without major loss of light. This range of angles is called the acceptance cone of the fiber, acceptance cone depends on the refractive index difference between the fiber's core and cladding.

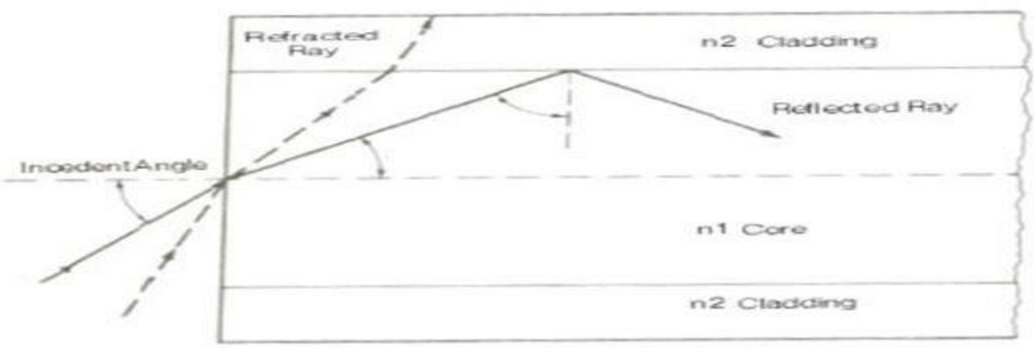

Fig.2.3Total internal reflection between two dielectric medium

Specifically, there is a angle which is maximum at which light may penetrate the fiber so that it will propagate through the core of the fiber and received at the other end. The sine of this maximum angle is the numerical aperture (NA) of the fiber. Less precision is required to work with a larger NA than fiber with a smaller NA. Single-mode fiber has a small NA.

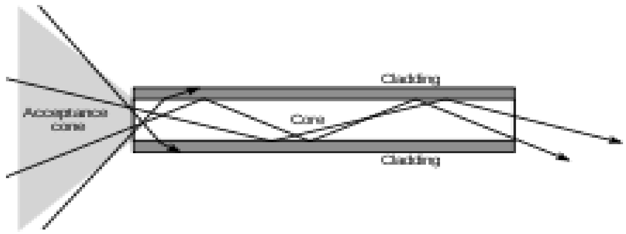

Fig.2.4 Propagation of light

Usage of Light Transmitting Concrete Blocks

- Translucent blocks can be installed as front wall of restaurant and shops to let people from outside know about inside condition, which can catch customers.
- Ceilings can be made up of this concrete, thus saving electricity cost and providing scattered light.
- It can be used to make speed breakers and road marking by providing light source beneath it and Light transmitting block over it.
- Sidewalks can also be constructed with light source beneath it which will provide scenic view as well light during night.
- In subways and airports it can be added as guiding mark as well as safety mark during time of darkness.
- It can be used for making different decorative shapes such as book shelves, outer home boundary, statues etc.
- Translucent walls should be installed in museum, prison cell, and schools thus providing way to vigilance along with safety.

Disadvantage of Light Transmitting Concrete

Light transmitting Concrete being a new construction material, have a lot of advantages but disadvantages as well:-

Cost of construction is very high as plastic optical fiber is used. Due to optical fiber its cost is increased.

It requires skilled labour for its manufacture as fibers need to be placed properly and quality control needs to be maintained throughout its manufacture process.

Experimental Properties Reviewed

2.4.1 Compressive strength of light transmitting concrete

Compressive strength is most important property for any material that is intended to be used for construction. Any material cannot be used for construction until it satisfies the requirements about sufficient strength to withstand all the loads that will be acting on it after construction during its useful life.

Various studies have been carried out to investigate the compressive strength of light transmitting concrete.

Bashbash et al(2013),prepared 50mmx50mmx50mm cubes with plastic optical fiber 4% with diameters of fiber as 1mm, 2mm, 3mm, 4mm. Weight of cube specimen Cement-500g, water-250g. fine aggregate -1350g.The compressive strength for 1mm, 2mm, 3mm, 4mm optical fiber diameter was observed as 21.5MPa, 22MPa, 23MPa, and 23.5MPa.They observed that for the same percentage of fiber, the larger diameter fiber concrete has higher strength.

Momin (2014), used glass rod cubes of sizes 150mmx150mmx150mm with spacing 1.5cm,3.0cm,4.5cm, 1:1.5:3.0 cement/sand/aggregates w/c 0.50, and for plastic optical fiber 150x100x100mm cubes with fiber spacing 0.5cm, 1cm,2cm, grade 1:2.0 cement/sand and w/c

0.45. It was observed that for concrete with glass rods, compressive strength was 24.57,25.1,25.27N/mm2 for 1.5cm,3cm,4.5cm rod spacing and for optical fiber, 22.2, 21.3, 20.7N/mm2 with 0.5cm,1cm,2cm spacing respectively.

Shanmugavadivu et al (2014),used 150mmx150mmx150mm cubes, compared the strength of the specimens with the M20 concrete and test results proved that the efficiency is more in all the aspects.Mix proportions used as follows:

Cement – 360kg, Sand – 560kg, Fibre – 4.5kg, Water – 190lt.

They observed that compressive strength for 28days without optical fibre was 22MPa and without optical fibre decreased to 20MPa.

E.jimenez (2014), used different percentage of glass fibers 0%,5%,10%, 15% and 30%, and observed that 7days compressive strength varied as 33.6, 28.9, 33.6, 29.9, 25.7 and compressive strength at 28days was 34.2, 29.5, 34,30.3, 26.9N/mm2.

2.4.2 Flexural strength of light transmitting concrete

Flexure tests were carried out by ***Bashbash et al(2013)*** on samples with fiber contents of 0%, 2%, 4% and 6% at several fibre diameters namely;1.5mm,2.00mm,2.5mm and 3.00mm.Taking 1.5mm diameter it was observed that flexure strength decreased at fibre content of 2% to about 36% and when fibre content increased from 2% to 4% there was further decrease in flexural strength to 26%

Yue Li a, Jiaqi Li , Yuhong Wanc, Zhiyuan Xu a,2014 The matrix material of LTCM was a high consistency cement mortar. The mix design of cement mortar was shown as follows: the mass ratio of sand to cementitious materials was 0.75; the mass ratio of cement to blast furnace slag was 4; the addition of water reducer was 0.2% by mass of cementitious materials; and the addition of antifoaming agent was 0.2% of the total mass.

For the flexural strength test, the distribution of optical fibres is perpendicular to the direction of the force. The strengths of specimens decrease with the increasing volume fraction of optical fibres. For the specimen whose volume fraction reaches up to 4%,the flexural strength is 83% of that of pure cement mortar.

2.4.3 Light transmittance property

The main purpose of using light transmitting concrete is to enable light to pass through it. The light transmittance property can be found out with the help of any intensity of light measuring instrument such as photometer, Newport 835 Optical Power meter, etc.

Momin et al. (2014) made light transmitting concrete samples with the help of Glass rods and optical fiber. The specimens with glass rods were fabricated as 150x150x150mm size cube with cement/sand/aggregates ratio of 1.0:1.5:3.0 and w/c ratio of 0.5. The spacing of glass rods in the specimens was kept as 1.5cm, 3.0cm, 4.5cm. The optical fiber specimen were made 150x100x100mm cuboids and cement/sand/water ratio was kept as 1.0:2.0:0.45. The spacing of optical fibers in cuboids was kept as 0.5cm, 1.0cm, 2.0cm. The light transmittance in the specimens was observed by voltage regulator, resistance box, ammeter, Light dependence resistor (LDR) panel and a plywood box. Light transmittance for optical fiber specimen with spacing of 0.5cm, 1.0cm, 2cm was found to be 9.5%, 8.39%, 7.41% respectively and for glass rod specimen with spacing of 1.5cm, 3cm, 4.5cm was 1.57%, 0.785%, 0.254% respectively. The transparency of concrete specimens with optical fibres is more as compared to the specimens with glass rods and also justifies the fact that more the transparency of the material more effective will be the light transmittance.

Zhi Zhou et al. (2009), studied the light transmittance characteristics of light transmitting concrete by making four mortar specimens of 100x100x100mm with sand/cement/water ratio of 1:2:0.44. and plastic optical fiber ratio of 3.14%, 3.80%, 4.52% and 5.3% . New port 835 optical meter was used to study the light transmittance, It was observed that light transmittance was between 1% to 2.25% of the incident light for fiber ratio between 3.14% to 5.3%.

Ahuja, Mosalam.M. Khalid and Zohdi I Tarek (2014) investigated translucent concrete. They used fibers to channel solar radiation into the building to reduce the dependence on artificial lighting requirement during the day. They presented a geometrical ray-tracing algorithm to simulate light transmission properties of a panel of translucent concrete. It was concluded from the investigation that a tilt angle of 30 degree for the panel transmitted the maximum amount of light among all the tilt angles considered. Using this tilt angle, they calculated rate at which sunlight radiation is absorbed by the translucent concrete panel and conducted a preliminary study to estimate the solar heat gain coefficient of the panel for possibility of using it instead of glazing material by the construction industry.

2.5 SUMMARY

Light transmitting concrete is a special type of construction material that allows light to pass through thereby, allowing the natural light or any form of light to pass through it. The literature reviewed demonstrates that Light transmitting concrete is very efficient for energy savings and abide with the green building concept, and makes it easy to get green building ratings. It is definitely the present and future of civil construction due to its energy saving and aesthetic beauty.

2.6 Gaps in Literature

From the above literature, it is evident that very limited research has been done on the light transmitting concrete. Various properties of light transmitting concrete have not been explored sufficiently. There is great need for further research work on light transmitting concrete. It is an eco-friendly product that reduces the dependence on artificial source of energy for optical activities. The strength parameters, light transmittance characteristics, durability aspects and other experimental properties of light transmitting concrete have not been researched sufficiently. Thus, need arises to study the experimental properties of light transmitting concrete, Such as Light transmittance properties, Compressive strength parameters, durability,etc.

Thus, the present study is carried out to study the experimental properties of light transmitting property.

CHAPTER – 3

MATERIALS AND METHODOLOGY

CHAPTER - 3

MATERIALS AND METHODOLOGY

3.1 General

To achieve the objectives of this experimental study, an extensive experimental program was planned, which included study of concrete prepared with substitution of fine aggregates with quarry dust/marble dust(varying the percentage of marble dust) and replacing coarse aggregates with marble aggregates. Out of these different ratios the best possible ratios is selected on the basis of strength, permeability, dynamic modulus of elasticity, porosity and thereafter light transmitting concrete is prepared which is further evaluated for compressive strength, durability and finding out the light transmittance characteristics of light transmitting concrete.

This chapter outlines the experimental program planned in detail. The properties of the materials used for the manufacture of light transmitting concrete, concrete mix details, casting, curing, details of tests performed on the specimens of light transmitting concrete are presented in this chapter.

3.2 Test Program

The following test program was planned to investigate the light transmittance, compressive strength and durability of the light transmitting concrete.

- To obtain the physical properties of the constituents of light transmitting concrete i.e. ordinary Portland cement (PC), fine aggregates-Quarry dust(QD) and marble dust(MD), coarse aggregates-conventional(CA) and marble aggregates(MA), plastic optical fiber(POF) and water, test carried out as per relevant Indian Standard Codes of Practice.

- Obtaining the design mix for concrete grade M10 as per 1S 456:2000.
- Casting and curing of specimens as per the requirement of the test.
- Determination of strength, permeability, dynamic modulus of elasticity and porosity.

- Selecting the best possible ratio and preparation of light transmitting concrete with optimal percentage of plastic optical fibers.
- Casting of cubes for durability and light transmittance.
- Obtaining the compressive strength and durability characteristics.
- Analyzing the observations to obtain various properties of the light transmitting concrete.

3.3 Materials used

The properties of materials used in light transmitting concrete are determined in laboratory as per relevant code of practice. Different materials used in this experimental study were cement, fine aggregates, coarse aggregates (passing 10mm IS sieve), plastic optical fiber and water. Results of the tests conducted to determine physical properties of materials are reported and discussed in this section. The materials in general conformed to the specifications laid down in the relevant Indian Standard Codes. The materials used has the following characteristics

3.3.1 CEMENT

Portland Pozzolana cement conforming to IS: 8112-1989 was used. Cement was tested according to IS: 4031-1988. The cement was of uniform color i.e. grey with light greenish shade. The properties of cement are given in table 3.1

Table 3.1: Physical properties of cement

S.NO	Physical Property	Experimental Value
1	Bulk density	1.1g/cc
2	Specific gravity	2.9

3.3.2 QUARRY DUST

Quarry dust has been sieved from IS 2.36mm sieve. It did not contain any impurities such as vegetable matters, organic matter, lumps, etc. The various properties conform to IS: 383-1960 as given in table 3.2 & table 3.3.

Weight of sample taken = 200g.

Table 3.2 Sieve analysis of quarry dust.

Sieve size (mm)	Retained weight (g)	% weight Retained	Cumulative %weight Retained
10	0	0	0
4.75	0	0	0
2.36	4	2.05	2.05
1.18	48	26.67	28.72
600µ	28	41.03	69.75
300 µ	33	57.95	127.7
150 µ	30	73.33	201.03
TOTAL		201.03	

Fineness modulus of quarry dust = 201.03/100 = 2.01

Table 3.3: Physical properties of quarry dust.

Physical tests	Values
Specific gravity (Bulk-OD)	2.26

Apparent specific gravity	2.75
Specific gravity (Bulk-SSD)	2.44
Fineness modulus	2.01
Water absorption	7.76
Air content	2.75
Bulk density(compacted) (kg/m^3)	1790
Bulk density (loose) (kg/m^3)	1530

3.3.3 MARBLE DUST

Marble dust has been sieved from IS 2.36mm sieve. It did not contain any impurities such as vegetable matters, organic matter, lumps, etc. The various properties conform to IS: 383-1960 as given in table 3.4 & table 3.5.

Weight of sample taken = 200g.

Table 3.4 Sieve analysis of marble dust

Sieve size (mm)	Weight Retained (g)	% weight Retained	Cumulative %weight Retained
10	0	0	0
4.75	0	0	0
2.36	0.5	0.25	0.25
1.18	15	7.75	8
600µ	27	21.25	29.25

300 µ	52	47.25	76.5
150 µ	43	68.75	145.25
TOTAL		145.25	

Fineness modulus of marble dust = 145.25/100 = 1.45

Table 3.5: Physical properties of marble dust.

Physical tests	Values
Specific gravity (Bulk-OD)	2.35
Apparent specific gravity	2.91
Specific gravity (Bulk-SSD)	2.54
Fineness modulus	1.45
Water absorption(% of dry weight)	8.23
Air content	2.91
Bulk density(compacted) (kg/m^3)	2010
Bulk density (loose) (kg/m^3)	1670

3.3.4 COARSE AGGREGATE

The maximum nominal size of aggregate used was 10mm.The various properties and particle size distribution are given in table 3.6 and 3.7.

Table 3.6 Particle size distribution of coarse aggregate

Sieve size	Percentage Passing of Marble Aggregate	Percentage Passing of Natural Aggregate
40	100	100
20	95.28	95
10	37.28	54.88
4.75	0.14	6.8

Table 3.7 Physical Properties of Aggregates

Aggregate Type	Specific gravity	Water Absorption (%) by weight	Grading Zone
Natural coarse aggregate	2.61	0.54	As per Table 2 of IS 383
Marble coarse Aggregate	2.70	0.05	As per Table 2 of IS 383

3.3.5 WATER

Water used for mixing and curing was clean potable and free from injurious amounts of oils, acids, alkalis, salt, sugar, organic materials or other substances which might have affected the properties of fresh and hardened concrete. The P^H value of the water was 7.6.

3.3.6 PLASTIC OPTICAL FIBRE

An optical fiber is a flexible, transparent fiber made of extruded glass (silica). It can function as a waveguide, or “light pipe”, to transmit light between the two ends of the fiber. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics.

Optical fibers are widely used in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than wire cables. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing view in confined spaces. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers.

CROSSECTION OF PLASTIC OPTICAL FIBRE

Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide.

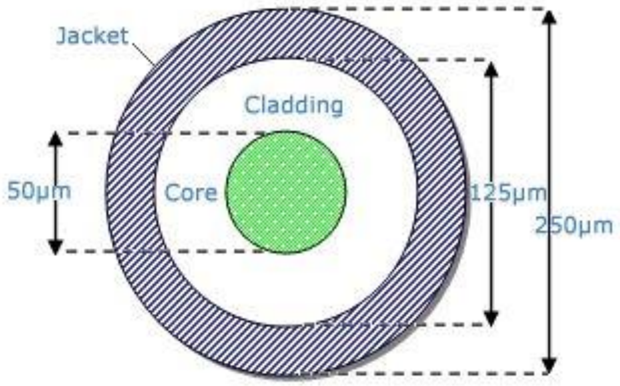

Fig.3.1 Crossection of plastic optical fiber

For plastic fibre, the core made up of polystyrene or polymethyl methacrylate and the cladding is generally silicone or Teflon and for glass fibre both the cladding and the core are made out of Silica with small amounts of dopants such as Boron, Germanium to change its Index.

Optical fibers have a wide number of applications. They are used as light guides in medical and other applications where bright light needs to be shine on a target without a clear line-of-sight path. Optical fiber lamps are used for illumination in decorative applications, including signs, art. Optical fiber is an intrinsic part of the light-transmitting concrete.

An optical fiber is a cylindrical dielectric waveguide (non-conducting waveguide) that transmits light along its axis, by the process of total internal reflection. The fiber consists of a core surrounded by a cladding layer, both of which are made of dielectric materials. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The boundary between the core and cladding may either be abrupt, in step-index fiber, or gradual, in graded-index fiber.

Fig.3.2 Bundle of Optical Fiber

These can have diameters up to 2mm. POF allows to transmit sunlight or light from any source to pass through it. When used in concrete, these fibers transmit light that falls on one face of the concrete to the other face. There is little or no signal loss in the POF when light passes through its core.

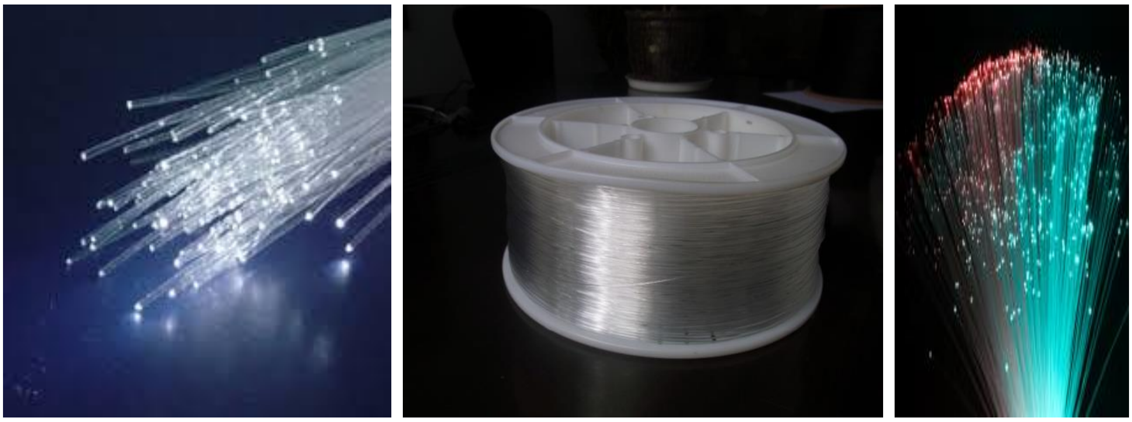

Fig.3.3 Strands of plastic optical fiber.

METHODOLOGY

3.4 DESCRIPTION

The experimental program was divided into two parts.

The first part was dedicated to examine the effect of substitution of fine aggregates with quarry dust(QD)/marble dust(MD) and coarse aggregates(CA) with marble aggregates(MA). The samples were tested for compressive strength, flexural strength, permeability and ultrasonic pulse velocity. The effects of these properties were examined by varying the percentage replacement of quarry dust with waste marble dust.

The second part of the experimental program focused on the optimization of the selected design mix. Thereafter, light transmitting concrete is prepared for the selected design mix to study the light transmittance characteristics and durability aspects.

GRADE DESIGNATION

The strength required for light transmitting concrete to be used in load bearing walls is 10MPA.In order to satisfy the above requirement M10 grade is selected for experimental study.

3.5 PROPORTIONS FOR NOMINAL MIX CONCRETE

As per IS 456:2000, the mix proportions shall be selected to attain the adequate workability of the fresh concrete and when concrete is hardened, it shall have the required strength, durability and finish.

The determination of the proportions of cement, aggregates and water to ensure the required strength shall be made as follows:-

By designing the concrete mix-DESIGN MIX CONCRETE

By adopting nominal mix-NOMINAL MIX CONCRETE

Nominal mix concrete is used for concrete of M20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with IS 456:2000 Table 9.

Table 9 of IS 456:2000

Grade of concrete	Total quantity of Dry aggregate by mass per 50kg of cement	Proportion of fine aggregate to coarse aggregate (by mass)	Quantity of Water per 50kg of cement, Max
M 5	800	Generally 1:2 but subject to an upper limit of 1:1 1/2 and a lower limit of 1:2 1/2	60
M 7.5	625		45
M 10	480		34
M 15	330		32
M 20	250		30

TABLE 3.8 PROPORTIONS OF NOMINAL MIX

DESIGNATION	SPECIFICATIONS	DETAILS	CEMENT(Kg)	QUARRY DUST(Kg)	MARBLE DUST(Kg)	COARSE AGGREGATES(Kg)	WATER(Lt)
A1	QD/CA	Control mix	50	192		288	43.6
A2	QD/MA	Control mix	50	192		288	43.6
A3	MD25/MA		50	144	48	288	41.2
A4	MD50/MA		50	96	96	288	38.8
A5	MD75/MA		50	48	144	288	36.4
A6	MD100/MA		50		192	288	34

TABLE 3.9 PROPORTIONS OF NOMINAL MIX (IN TERMS OF RATIOS)

DESIGNATION	SPECIFICATIONS	DETAILS	CEMENT	QUARRY DUST	MARBLE DUST	COARSE AGGREGATES	W/C ratio
A1	QD/CA	Control mix	1	3.84		5.76	0.872
A2	QD/MA	Control mix	1	3.84		5.76	0.872
A3	MD25/MA		1	2.88	0.96	5.76	0.824
A4	MD50/MA		1	1.92	1.92	5.76	0.776
A5	MD75/MA		1	0.96	2.88	5.76	0.728
A6	MD100/MA		1		3.84	5.76	0.68

3.6 PREPARATION OF CONCRETE SPECIMEN

For each series,12cubes of 100 x 100 x 100mm and 3cubes of 150 x 150 x 150mm and 6beams of 100 x 100 x 500mm were prepared as per above mentioned ratios. Quantity of mix are as follows.

Fig.3.4 Casting of cube and beam specimen

TABLE 3.10 Total weight of cube specimen

DESIGNATION	SPECIFICATIONS	CEMENT(Kg)	QUARRY DUST(Kg)	MARBLE DUST(Kg)	COARSE AGGREGATES (Kg)	MARBLE AGGREGATE (Kg)	WATER(Lt)
A1	QD/CA	5.69	21.84		32.77		4.96
A2	QD/MA	5.69	21.84			32.77	4.96
A3	MD25/MA	5.69	18.28	6.09		36.57	4.68
A4	MD50/MA	5.69	12.29	12.29		36.87	4.415
A5	MD75/MA	5.69	6.23	18.69		37.38	4.142
A6	MD100/MA	5.69		25.196		37.78	3.869

TABLE 3.11Total weight of beam specimen

DESIGNATION	SPECIFICATIONS	CEMENT(Kg)	QUARRY DUST(Kg)	MARBLE DUST(Kg)	COARSE AGGREGATES (Kg)	MARBLE AGGREGATE (Kg)	WATER(Lt)
A1	QD/CA	8.036	30.86		46.29		7.007
A2	QD/MA	8.036	30.86			46.29	7.007
A3	MD25/MA	8.036	25.18	8.39		50.36	6.621
A4	MD50/MA	8.036	16.92	16.92		50.77	6.235
A5	MD75/MA	8.036	8.85	25.74		51.49	5.85
A6	MD100/MA	8.036		34.69		52.04	5.464

3.7 EXPERIMENTAL PROPERTIES REVIEWED

3.7.1 Compressive strength

Three specimens of each mix proportion were prepared to determine the compressive strength at 7 and 28days The cube specimens were cast at an average temperature of 25^0 C and unmolded after 24 hours. After casting cubes, curing was done for 7 days. The cubes were tested for compressive strength on Compression testing machine. All the specimens were tested on compression testing machine at constant loading rate as per IS: 516-1959.

Surface of the machine should be clean and there should be no sand particles or any other matter over machine and sample surface which may give false results as well care should be given to alignment of cube and thrust point of machine.

Fig.3.5 Universal Testing machine (UTM)

Fig.3.6 Cube after compression failure

3.7.2 Flexural strength

Three specimen of each mix proportion were prepared to determine the flexural strength at 7 and 28days. All the specimens were tested as per procedure laid down in IS 516-1959.

Testing setup consists of two steel roller of 38 mm diameter which are placed at a distance of 60 cm and 40 cm respectively for a specimen of 15 cm and 10 cm respectively. Assembly of roller is such that dividing whole specimen in 3 equal parts and all rollers shall be mounted in such a manner that the load is applied axially without subjecting the specimen to any secondary stresses or restraints.

The Flexural Strength or modulus of rupture (F_b) calculated using

$$F_b = Pl/bd^2$$

Fig.3.7 Flexural strength testing machine

Fig.3.8 Beam after failure

3.7.3 Permeability

Water permeability test was carried using German Standard DIN 1048 apparatus for which three cubes of each series of size 150 x 150 x 150mm is prepared. This apparatus is capable of testing six specimens at a time. In this test cell assembly, cube is subjected to a constant water pressure of 0.5N/mm2 for 72 hours using water tank connected to air compressor which is applied perpendicular to cube face as shown in assembly.

After application of water pressure cube is split and depth of penetration is measured using visual method.

Fig.3.9 Splitting of cube **Fig.3.10 Depth of water penetration**

3.7.4 Ultrasonic pulse velocity test

Ultrasonic pulse velocity test used to evaluate the dynamic modulus of elasticity, to determine the homogeneity of concrete, presence of cracks, voids and assess the quality of concrete. The quality of concrete structure is assessed in terms of ultrasonic pulse velocity as per IS 13311-2(1992).

Table 3.12 Velocity criteria for concrete quality

S.NO	Pulse Velocity by cross probing (Km/sec)	Concrete Quality grading
1.	**Above 4.5**	**Excellent**
2.	**3.5 to 4.5**	**Good**
3.	**3.0 to 3.5**	**Medium**
4.	**Below 3.0**	**Doubtful**

The dynamic Young’s modulus of elasticity (E) of the concrete determined from the pulse velocity and the dynamic Poisson’s ratio using the following relationship.

$$E_d = \frac{V^2 n(1+\mu)(1-2\mu)}{1 \quad \mu}(10^{-6})$$

where E= dynamic young's modulus of elasticity

n = unit weight (kg/m3)

V=pulse velocity in m/s

On the basis of these experimental properties four series A1, A2, A5 and A6 are selected for the study of light transmitting concrete

3.8 PREPARATION OF LIGHT TRANSMITTING CONCRETE SPECIMEN

In the process of making light transmitting concrete, the first step involved is preparation of mould. The mould required for the prototype can be made with different materials which can be of either tin or wood. The standard minimum size of the cube according to ASTM is 5cmx5cmx5cm. So, any size of mould can be taken from 5cmx5cmx5cm to 15cmx15cmx15cm.

In this study, wooden moulds of size 10cmx10cmx10cm were prepared with the perforated wooden sheets. Wooden sheets which are used for electrical switchboards were used. Perforated wooden sheets with varying number of drilled holes were attached in the moulds, for preparing cubes of varying percentage of P.O.F. The diameter and spacing of the holes depended on the percentage of fiber in the cube. Purpose of sheet is to enable the placement of P.O.F properly in the concrete.

Fig.3.11 Perforated Sheet

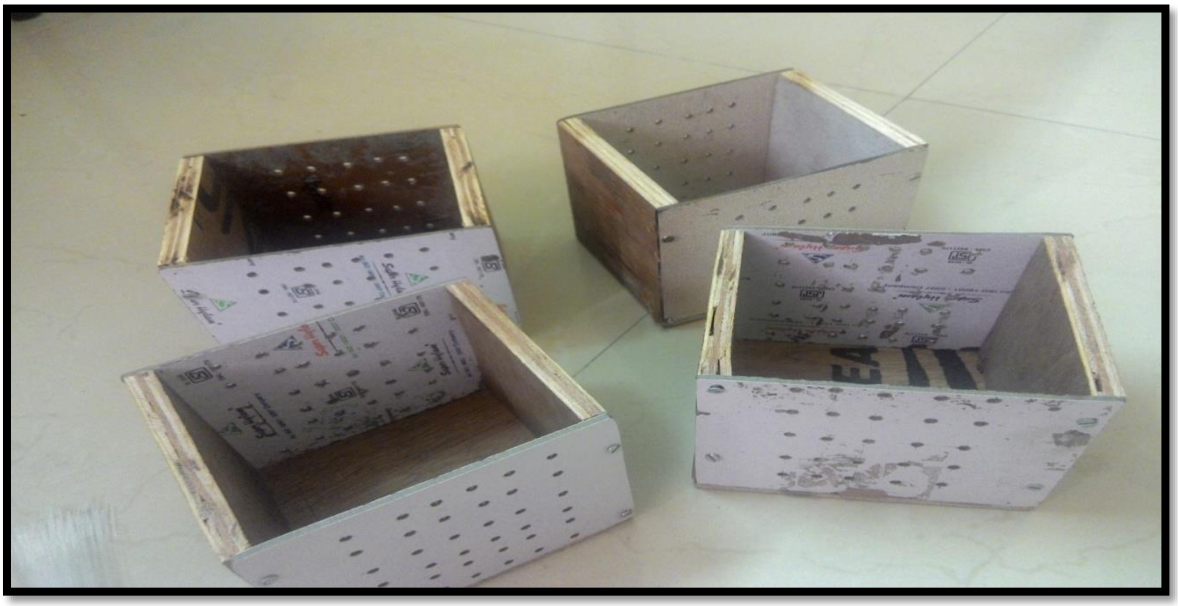

Fig.3.12 Wooden moulds

Wooden moulds were made with sheet at two parallel faces with holes to place plastic Optical Fibers (POF) in it. The mould is open at the top. Before placing concrete, the P.O.F were placed in the mould through the holes made in the sheet. After placing P.O.F concrete was poured in the mould while keeping the mould on a mechanical vibrator, so that pores are not formed in the concrete cube.

Concrete of four mix proportions i.e. A1, A2, A5, A6 were used for preparing cubes of 10cmx10cmx10cm size. Percentage of Plastic Optical Fibers used was 4.0% to study strength, durability and light transmittance characteristics of POF.

Fig.3.13 Placing of fibers in the mould

TABLE 3.13 QUANTITY OF LIGHT TRANSMITTING CUBE SPECIMEN

MIX	SPECIFICATIONS	CEMENT(Kg)	QUARRY DUST(Kg)	MARBLE DUST(Kg)	COARSE AGGREGATES(Kg)	MARBLE AGGREGATE(Kg)	WATER(Lt)
A1	QD/CA	1.459	5.56		8.34		1.272
A2	QD/MA	1.459	5.6			8.406	1.272
A5	MD75/MA	1.459	1.45	4.35		8.717	1.062
A6	MD100/MA	1.459		5.84		8.77	0.992

Concrete was poured in the moulds while placing moulds on the vibrating table. By giving vibrations concrete was completely filled in the moulds with no void left in between the fibers. The cubes were compacted properly on the vibrating table. POF of 0.5mm diameter were used in the cubes.

Fig.3.14 Casting of light transmitting cube

Fig.3.15 Cubes after unmoulding

After unmoulding of cubes, specimen are placed in the curing tank for curing process.

Fig.3.16 Curing of cubes

3.9 EXPERIMENTAL PROPERTIES STUDIED ON LIGHT TRANSMITTING CONCRETE

3.9.1. Test for light transmittance property

Light transmittance test was performed to study the light transmittance characteristics. It is most important test to be performed, as main purpose of translucent concrete is to transmit light. Transmittance ratio is found by measuring intensity of incident light and transmitted light. Intensity of light is measured with the photometer. Photometer measures intensity of light in terms of lumens.

Experimental setup for light guiding property test

For studying light guiding property of light transmitting concrete, samples of P.O.F volume of 4% for each series A1, A2, A5, A6 were cast. The transmittance was measured by Photometer (or lux meter) that measures intensity of light in lumens, having range of 0.1 to 1,00,000 lux. The incandescent lamp with light intensity of 1100lux was chosen as light source. A wooden box with light source fitted on one face, photometer was attached on other face in the box, such that all light transmitted from the sample falls in the box of photometer.

Readings of transmitted light were noted with photometer. Precaution was taken to see that the box of photometer was correctly attached and all transmitted light fall in the box.

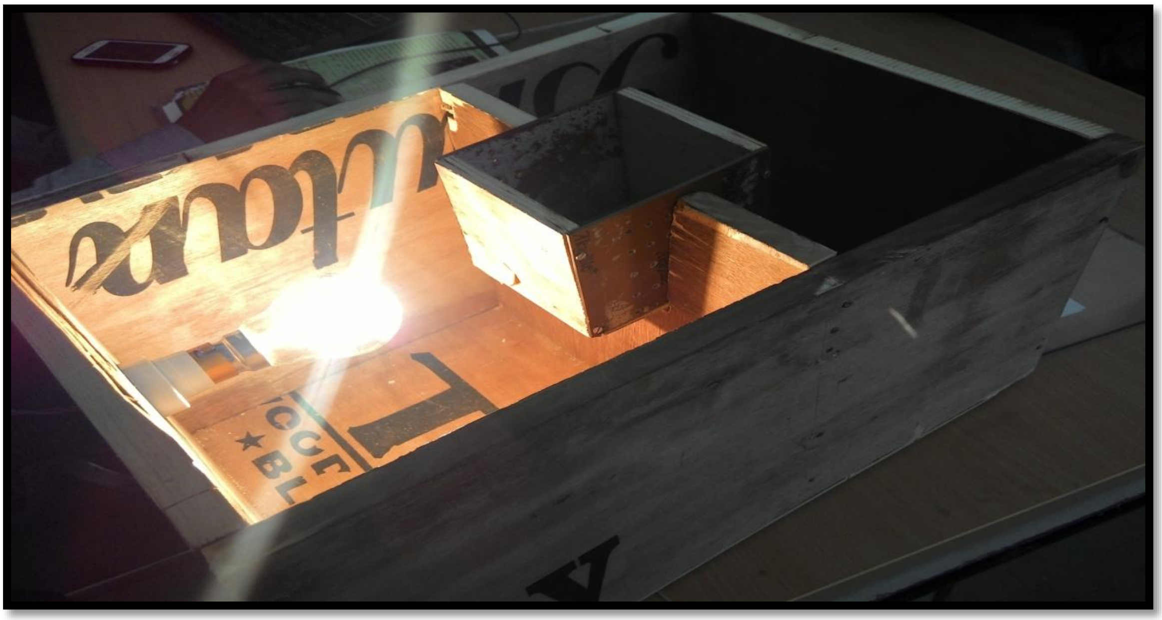

Fig.3.17 Wooden box-experimental setup

Fig.3.18 Experimental setup of light transmitting concrete

Fig.3.19 Light transmittance through cube

3.9.2. Compressive strength test on light transmitting concrete

Cubes of size 10cmx10cmx10cm of 4% plastic optical fiber ratio were prepared. Three specimens of each POF percentage and mix proportion were prepared according to procedure mentioned above. The cube specimens were cast at an average temperature of 24^0 C and unmoulded after 24 hours. After casting cubes, curing was done for 7 days. The cubes were tested for 28 day compressive strength on Compression testing machine. All the specimens were tested on compression testing machine at constant loading rate as per IS: 516-1959.

Fig.3.20 Universal testing machine

Fig.3.21 Light transmitting cubes after failure

3.9.3 Durability Test

SULPHATE ATTACK

For sulphate attack concrete cube specimen of size 100×100×100mm are prepared for four different ratios of A1,A2,A5,A6.The specimen are cast and kept in mould for 24hours.After 24hrs, cubes are unmoulded and kept in curing tank for 28days.After 28days specimen are kept in atmosphere for constant weight subsequently,the specimen are weighed and immersed in 5% sodium sulphate (Na_2SO_4) solution for 28-days.After 28days of immersing in solution specimen are washed in running water and kept in atmosphere for constant weight.Subsequently,weight is taken and loss in weight and percentage loss in weight is calculated.

ACID ATTACK

For acid attack concrete cube specimen of size 100×100×100mm are prepared for four different ratios of A1,A2,A5,A6.The specimen are cast and kept in mould for 24hours.After 24hrs, cubes are unmoulded and kept in curing tank for 28days.After 28days specimen are kept in atmosphere for constant weight subsequently,the specimen are weighed and immersed in 5% sulphuric acid (H_2SO_4) solution for 28-days.After 28days of immersing in solution specimen are washed in running water and kept in atmosphere for constant weight. Subsequently, weight is taken and loss in weight and percentage loss in weight is calculated.

Fig.3.22 Placing of cube specimen in sulphuric acid and sodium sulphate solution

TABLE 3.14 QUANTITY OF SPECIMEN FOR DURABILITY TEST

MIX	SPECIFICATIONS	CEMENT(Kg)	QUARRY DUST(Kg)	MARBLE DUST(Kg)	COARSE AGGREGATES(Kg)	MARBLE AGGREGATE(Kg)	WATER(Lt)
A1	QD/CA	9.91	38.01		57.01		8.64
A2	QD/MA	9.91	39.14			58.71	8.64
A5	MD75/MA	9.91	9.89	29.96		59.93	7.21
A6	MD100/MA	9.91		40.22		60.33	6.738

3.10 Summary

The test program as planned to achieve the objectives of the experimental study has been described in this chapter. The basic properties of the various constituents of light transmitting concrete such as cement, fine sand, coarse aggregate, plastic optical fiber and water are presented in this chapter. Preparation of moulds for specimens, and method of casting of specimens for various tests has been reported. The testing procedure for various experimental tests i.e. Light transmittance test, compressive strength test, durability test of light transmitting concrete are discussed in detail. Few images were used to enlighten the testing techniques.

CHAPTER – 4

RESULTS AND DISCUSSIONS

CHAPTER - 4

RESULTS AND DISCUSSIONS

4.1 General

In this chapter, Experimental investigations were divided into two phase. In the first phase compressive strength at 7 and 28 days, flexural strength at 7 and 28 days and Din permeability test are carried out for six(A1,A2,A3,A4,A5,A6) different ratios. On the basis of results of first phase, experimental investigations are further carried in second phase to study the light transmittance characteristics using halogen light source of 500 Watts (11,000 lumens) intensity. Compressive strength characteristics of different mix proportion and durability characteristics were determined.

The detailed analysis and discussion of test results as obtained from the test program is presented in the following sections.

4.2 COMPRESSIVE STRENGTH

Compressive strength at 7days and 28days for six different proportions are shown below:

Table 4.1 Compressive strength(Mpa) at 7days

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	5.15	4.9	5.04	5.03
A2	QD/MA	Control mix	5.3	5.04	5.2	5.18
A3	MD25/MA		5.8	5.51	5.4	5.57
A4	MD50/MA		6.21	6.29	6.4	6.3
A5	MD75/MA		8.49	8.9	9.01	8.8
A6	MD100/MA		10.12	10.3	10.48	10.3

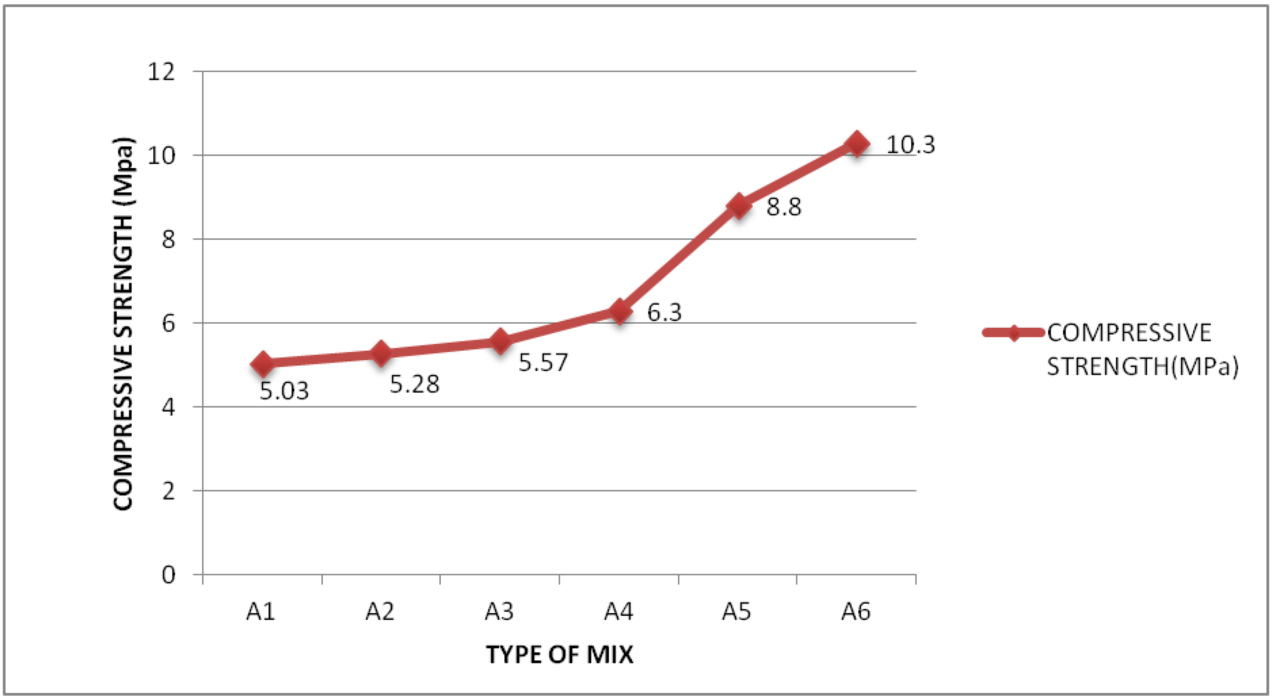

Fig.4.1 Compressive strength at 7days vs mix proportion

<u>Table 4.2 Compressive strength(MPa) at 28days</u>

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	9.5	9.2	8.5	9.06
A2	QD/MA	Control mix	9.75	9.89	9.85	9.83
A3	MD25/MA		9.8	10.6	10.2	10.2
A4	MD50/MA		11	11	11	11
A5	MD75/MA		13.5	13.8	14.1	13.8
A6	MD100/MA		17	16	17	16.67

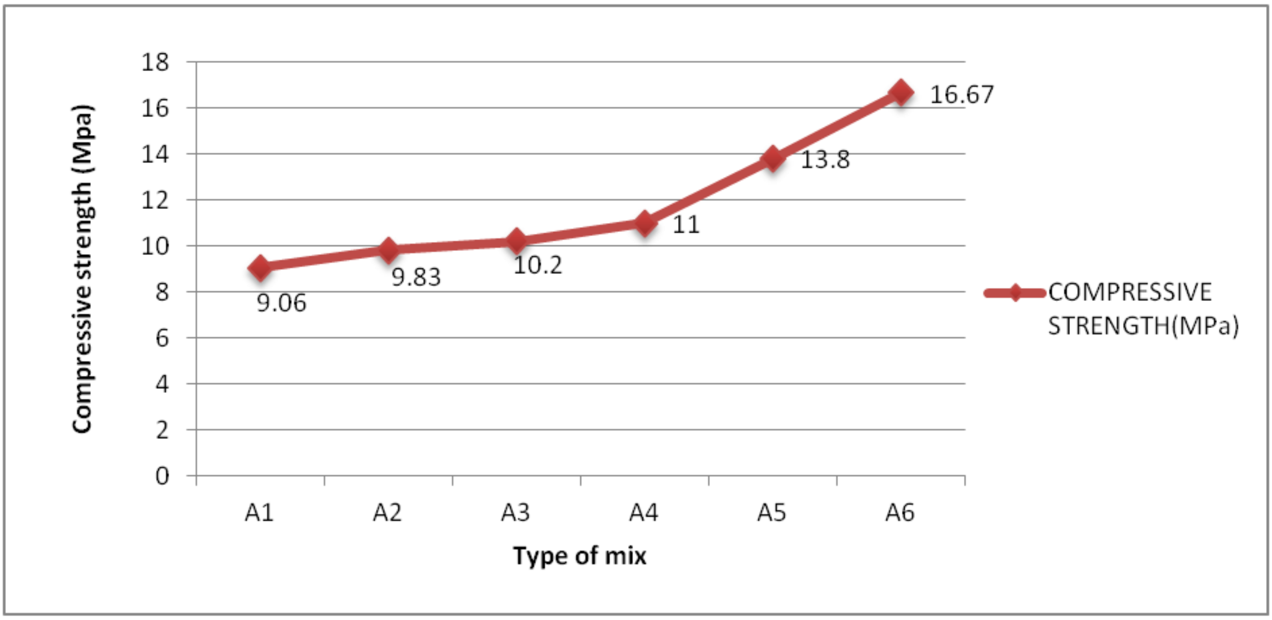

Fig.4.2 Compressive strength at 28days vs mix proportion

It can be seen that compressive strength of concrete increases with increase in percentage of marble dust.Concrete prepared with complete substitution of fine aggregate with marble dust and coarse aggregate with marble aggregate showed the maximum compressive strength. It increased from 9.06MPa(MD0) to 16.67MPa(MD100).This increase may be due to the effect of marble dust as micro fine filler. This filler effect enhances the cement matrix and transition zone properties.

4.3 FLEXURAL STRENGTH

Flexural strength at 7days and 28days for six different proportions are shown below:

Table 4.3 Average flexural strength at 7 days

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	1.38	1.32	1.5	1.4
A2	QD/MA	Control mix	1.52	1.65	1.63	1.6
A3	MD25/MA		1.65	1.74	1.8	1.73
A4	MD50/MA		1.9	2	1.89	1.93
A5	MD75/MA		2	1.99	2.04	2.01
A6	MD100/MA		2.22	2.19	2.325	2.245

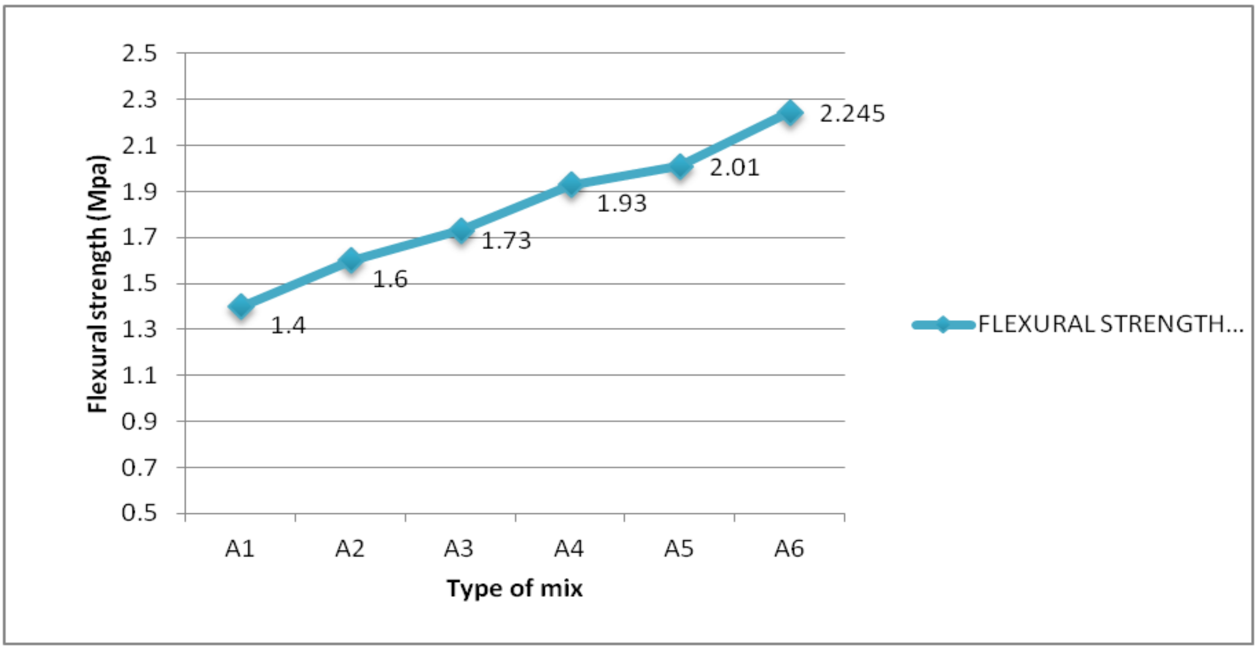

Fig.4.3 Flexural strength at 7days vs mix proportion

Table 4.4 Average flexural strength at 28 days

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	2.52	2.57	2.725	2.605
A2	QD/MA	Control mix	2.5	2.83	2.8	2.71
A3	MD25/MA		2.77	2.65	2.95	2.79
A4	MD50/MA		2.87	2.82	2.8	2.83
A5	MD75/MA		2.925	2.85	2.865	2.88
A6	MD100/MA		3.2	3.12	2.95	3.09

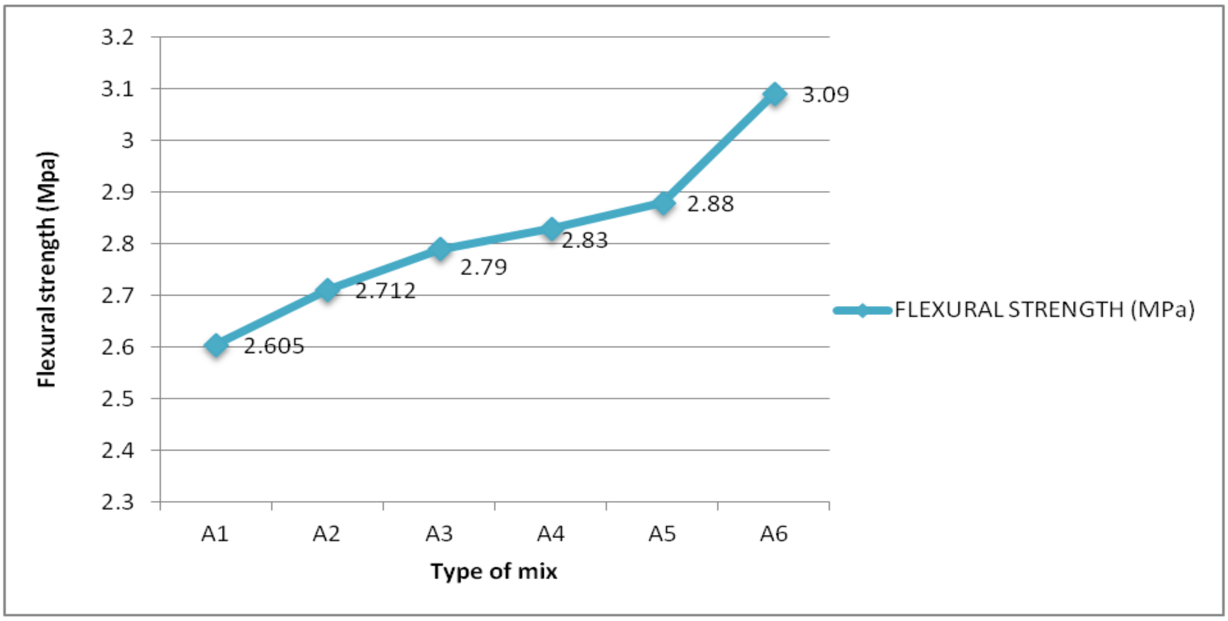

Fig.4.4 Flexural strength at 28days vs mix proportion

Flexural strength increases with increase in proportion of marble dust. It can be seen from the above tables and figures that flexural strength for specimen containing 100%marble dust is increased by 18.6% than that of control mix. Generally, this improvement in tensile strength refers to the low porosity and good strength of both cement paste matrix and the interfacial transition zone (ITZ)

4.4 ULTRASONIC PULSE VELOCITY

It is determined to access the quality of concrete.

TABLE 4.5 Time and UPV(Km/s) for each proportion

MIX DESIGNATION	TIME(µsec)	UPV(Kmps)
A1	24	4.167
A2	23.33	4.28
A3	22	4.54
A4	21.3	4.69
A5	20.4	4.90
A6	20.1	4.975124378

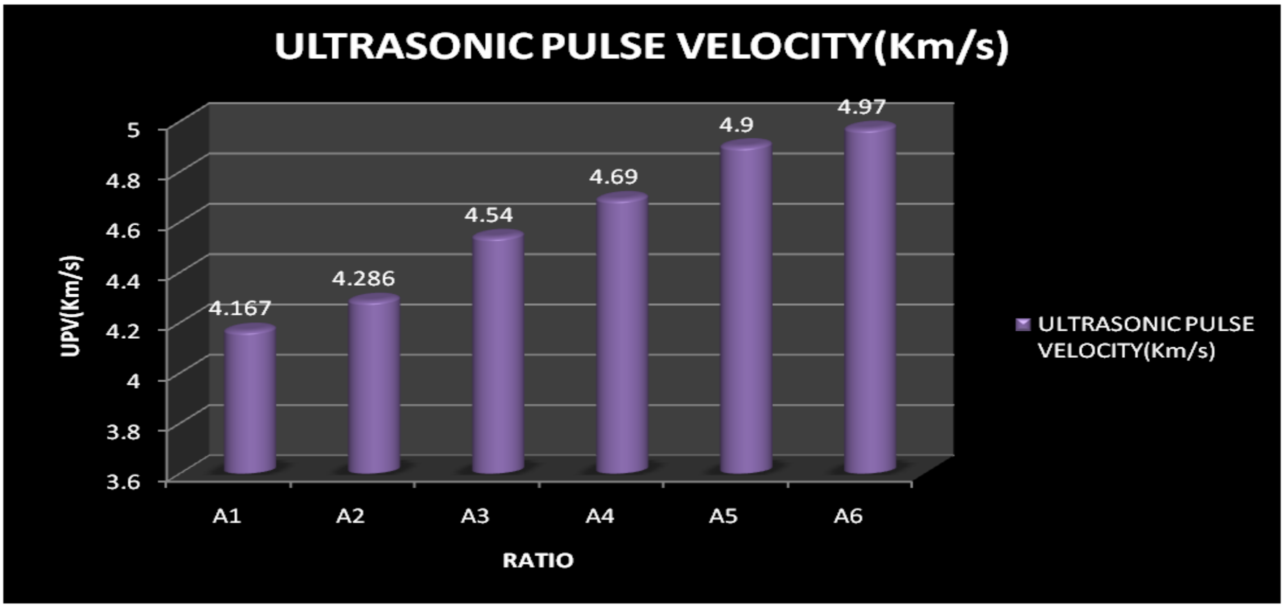

Fig.4.5 Ultrasonic pulse velocity vs mix proportion

From the above tables and graphs.it is found that the ultrasonic pulse velocity increases as substitution of marble dust increases and for 100% marble dust it is maximum.

The quality of concrete structure is assessed in terms of ultrasonic pulse velocity as per IS 13311-2(1992). The table given in code specifies that mix proportion which has ultrasonic pulse velocity above 4.5km/s is of excellent quality.Thus, the mix proportions A3,A4,A5 and

A6 are of excellent quality and A1,A2 (control mix) are of good quality.This is due to the fact as content of marble dust increases the mix will become more dense and lesser time ultrasonic wave will require to pass through the specimen.

4.5 PERMEABILITY TEST

Water permeability test was carried using German Standard DIN 1048 apparatus.It is used to determine the depth of penetration.

TABLE 4.6 Depth of penetration(cm)

RATIO	PERMEABILITY
A1	10.6
A2	9.8
A3	8.5
A4	8.2
A5	7.9
A6	7.6

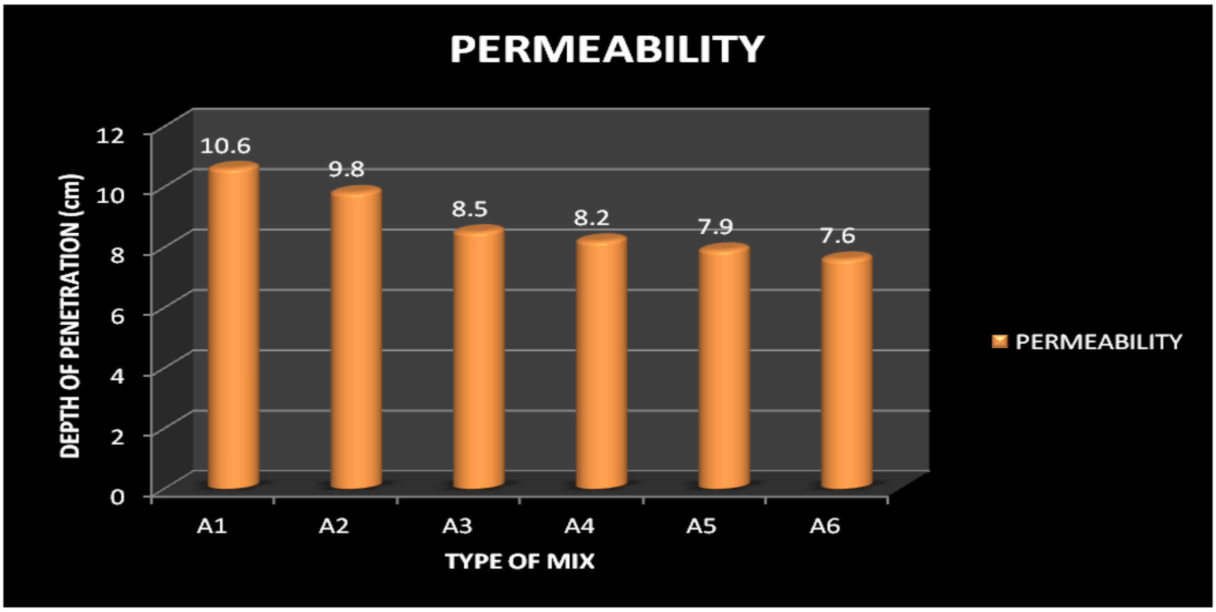

Fig 4.6 Depth of penetration vs mix proportion

It can be seen that depth of water penetration decreases as substitution of marble dust increases. It is 10.6cm when mix is prepared with quarry dust as fine aggregate and conventional coarse aggregate and decreased to 7.6cm when mix is prepared with marble dust as fine aggregate and marble as coarse aggregate.This may be an outcome of high specific gravity of waste marble dust and also the filler effect of marble dust results in decrease of permeability.

On the basis of above results A1, A2, A5 and A6 series is selected and further test of light transmittance, compressive strength and durability test is carried out.

4.6 LIGHT TRANSMITTANCE TEST

It is done to determine the light transmittance ratio i.e. amount of light that can be transmitted from one end to another end of specimen through plastic optical fiber. The halogen light source used is of 1100lux.

TABLE 4.7 LIGHT TRANSMITTANCE (LUX)

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	92	91	92	91.67
A2	QD/MA	Control mix	123	125	122	123
A5	MD75/MA		125	129	127	127
A6	MD100/MA		135	131	130	132

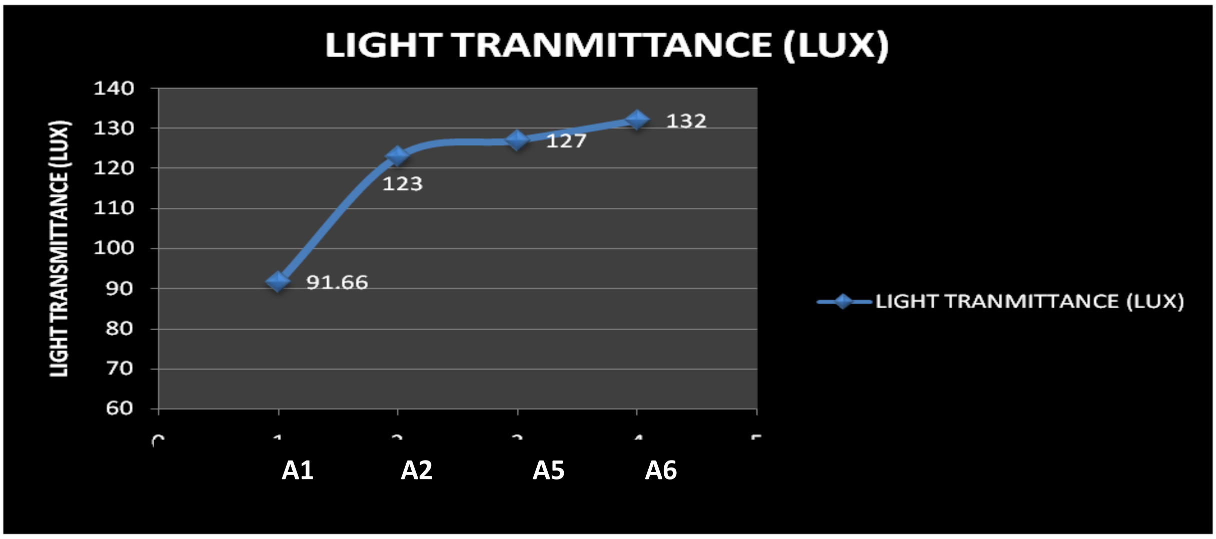

Fig.4.7 Light transmittance(lux) vs mix proportion

From the above graph and table it can be seen light transmittance increases with increase in substitution of waste marble dust.It is increased to 44% for mix prepared with marble dust and marble aggregates as compared to control mix (prepared with conventional coarse aggregate). When light is incident on the cubes (prepared with marble dust as fine aggregate and marble as coarse aggregates), it gets reflected and results in more light to pass through optical fibres and when light is incident on the cubes (prepared with quarry dust as fine aggregate and conventional coarse aggregate), it absorbs all the light and does not reflect. Thus, it can be concluded that incorportion of marble as aggregate has improved the light transmittance and improved result is the outcome from minimum absorption of light and maximum reflection of light by marble due to its white colour and the maximum absorption of light and minimum reflection by the conventional coarse aggregate in the control mix specimen.

It can also be stated light that can be transmitted is 8.33% for control mix progressively increases up to 12% as per variation in proportion of marble dust.

4.7 COMPRESSIVE STRENGTH TEST FOR LIGHT TRANSMITTING CONCRETE

The results of compressive strength for light transmitting concrete is presented as

TABLE 4.8 Average Compressive strength of light transmitting cube specimen

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	8.45	8.32	8.49	8.42
A2	QD/MA	Control mix	9.5	9.15	9.25	9.3
A5	MD75/MA		13.2	13.4	13.33	13.31
A6	MD100/MA		16.29	16.25	16.36	16.3

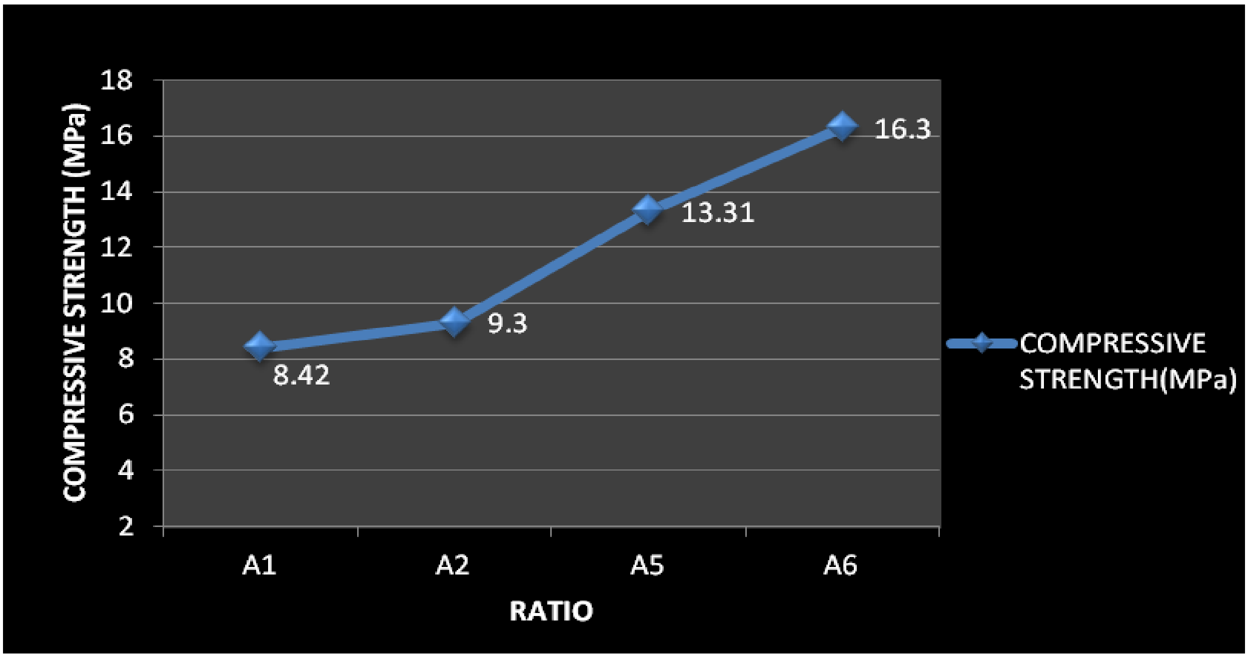

Fig.4.8 Compressive strength vs mix proportions

As the proportion of marble dust increases compressive strength increases and in case of light transmitting cube specimen it is increased from 8.42MPa to 16.3MPa.

4.8 COMPARISON OF COMPRESSIVE STRENGTH OF LIGHT TRANSMITTING CONCRETE

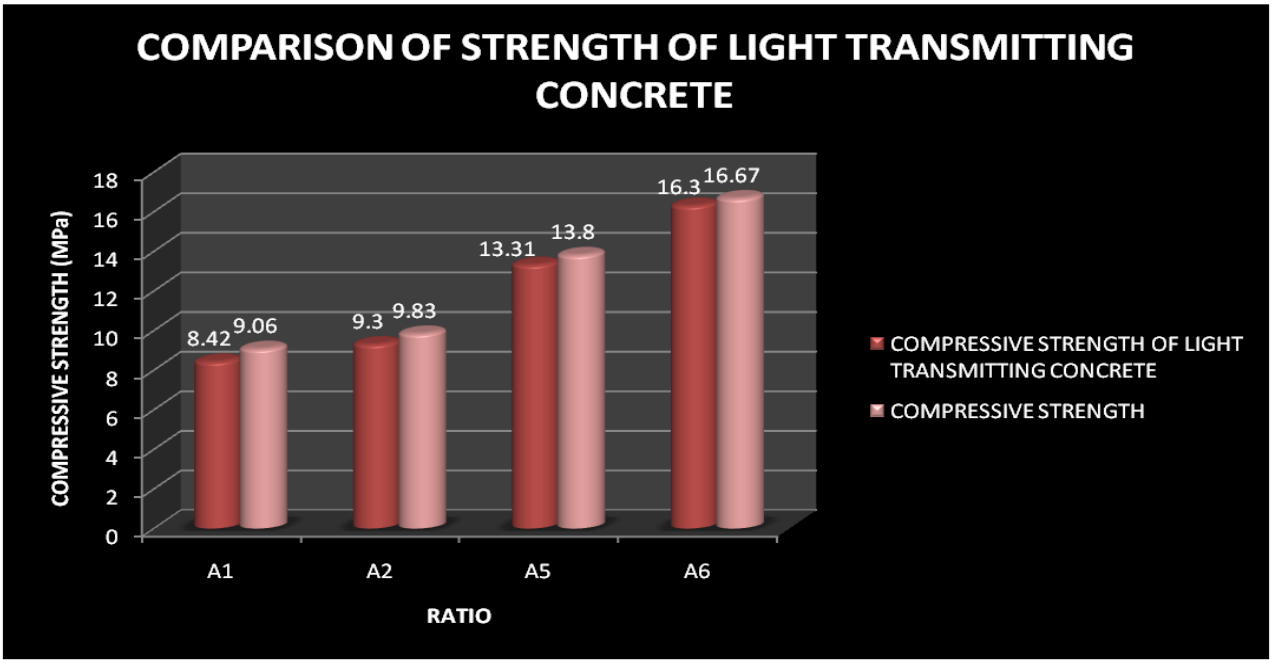

Fig.4.9 Comparison of compressive strength with optical fiber and without optical fiber

It can be seen from the above graph when optical fiber is placed in specimen,strength for control mix decreased to 7.6% and for complete substitution of fine aggregate with marble dust it decreased to 2.2%.This shows that A6 mix proportion performed better as compared to all other mix proportions.

4.9 DURABILITY TEST

4.9.1 SULPHATE ATTACK

It is done to determine the resistance against sulphate ions.Loss in weight and percentage loss in weight is calculated.Thereafter,compressive strength is determined to investigate the decrease in strength.

TABLE 4.9 Average of compressive strength after sulphate attack

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	8.5	8.01	8.21	8.24
A2	QD/MA	Control mix	9	8.9	9.04	8.98
A5	MD75/MA		12.56	12.82	12.9	12.76
A6	MD100/MA		15.8	15.3	15.79	15.63

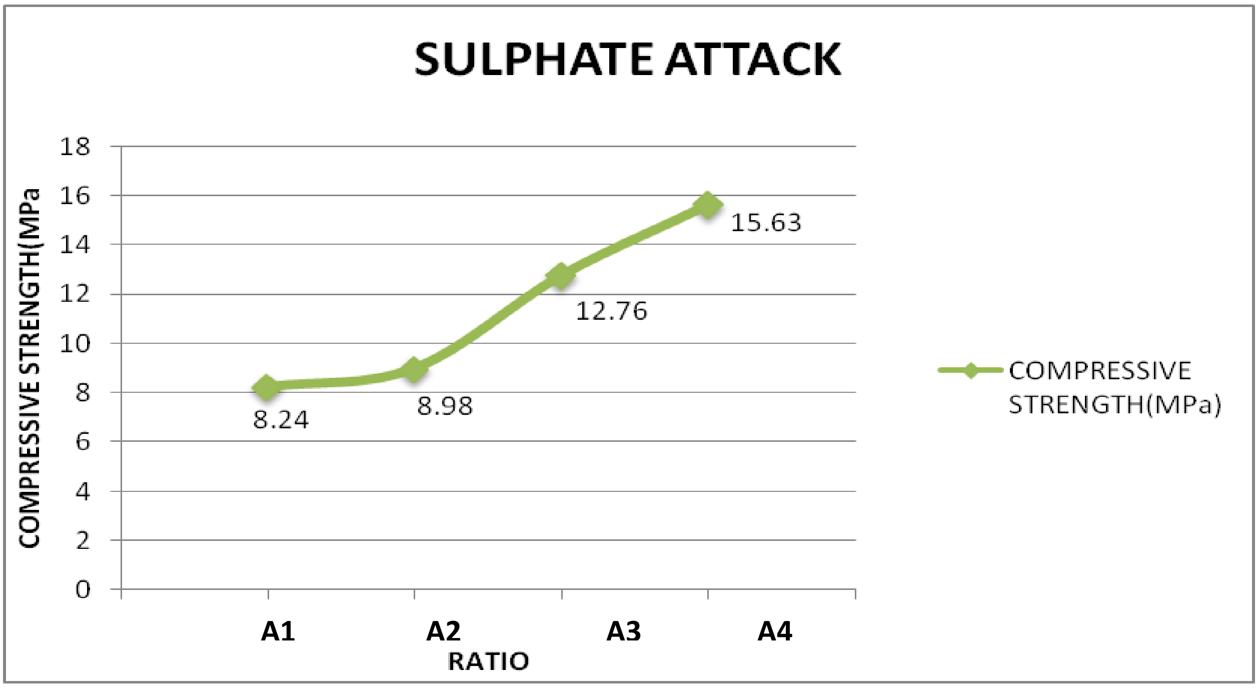

Fig.4.10 Compressive strength after sulphate attack vs mix proportion

COMPARISON OF COMPRESSIVE STRENGTH AFTER SULPHATE ATTACK

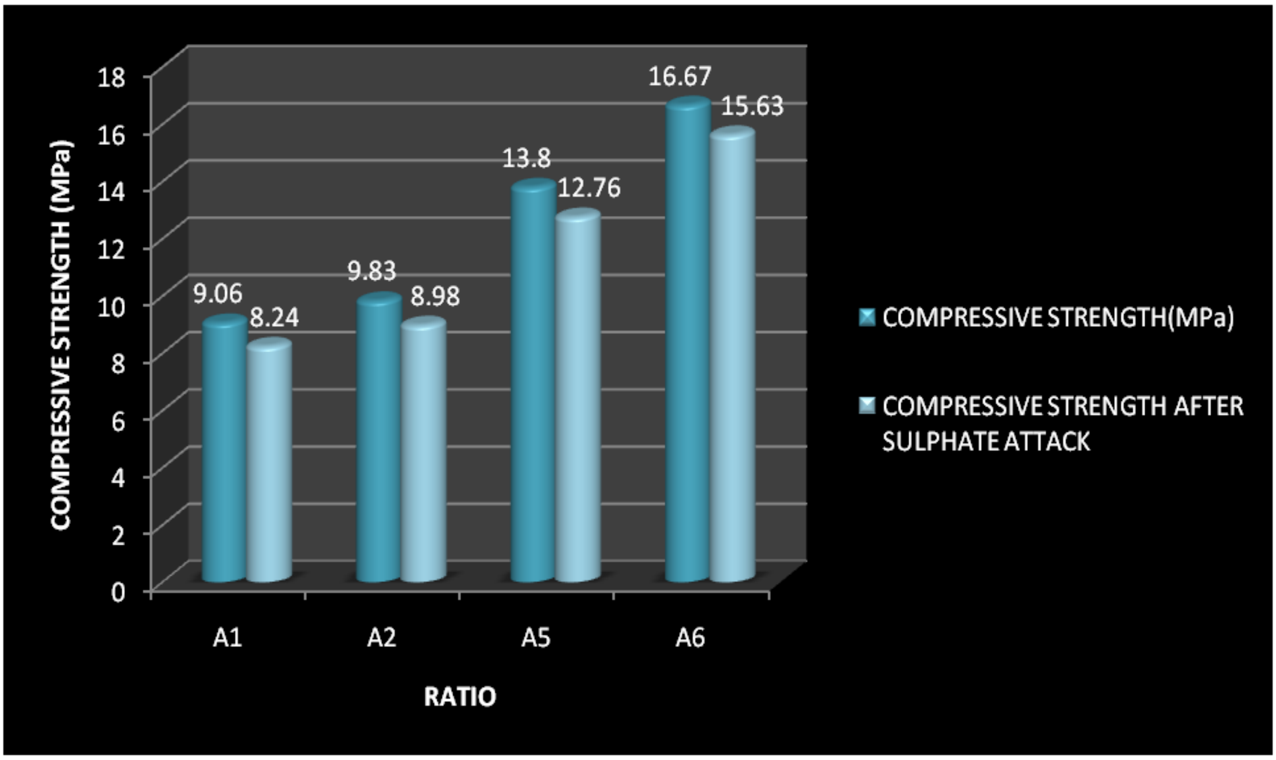

Fig.4.11 Comparison of compressive strength after sulphate attack for different mix proportions

From the above graph it is found that after 28days of sulphate attack the compressive strength for control mix decreased to 9.05% and for A6 (MD100) it is decreased to 6.23%.

WEIGHT LOSS DUE TO SULPHATE ATTACK

TABLE 4.10 Percentage weight loss due to sulphate attack

MIX DESIGNATION	SPECIFICATION	ACTUAL WEIGHT(g)	WEIGHT LOSS(g)	PERCENTAGE LOSS
A1	QD/CA	2343.34	2338.7	0.20%
A2	QD/MA	2456	2451.33	0.19%
A5	MD75/MA	2465	2461	0.16%
A6	MD100/MA	2556	2552.5	0.14%

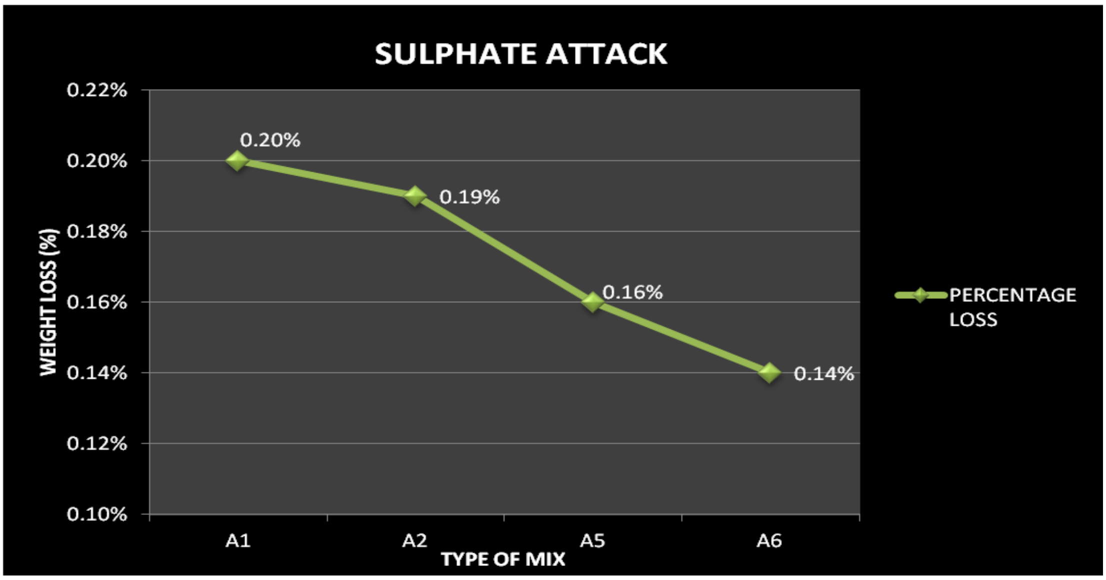

Fig.4.12 Weight loss vs type of mix

It can be seen from the above table and graph weight loss after sulphate attack for control mix(A1) is higher as compared to weight loss for 100% substituted marble powder (A6).

4.9.2 ACID ATTACK

It is done to determine the resistance against sulphuric acid .Loss in weight and percentage loss in weight is calculated.Thereafter,compressive strength is determined to investigate the decrease in strength.

TABLE 4.11 Average of compressive strength due to acid attack

DESIGNATION	SPECIFICATIONS	DETAILS	CUBE 1	CUBE 2	CUBE 3	AVERAGE
A1	QD/CA	Control mix	8.4	8.29	8	8.23
A2	QD/MA	Control mix	8.9	8.91	8.95	8.92
A5	MD75/MA		12	12.8	12.76	12.52
A6	MD100/MA		15.2	15.35	15.92	15.49

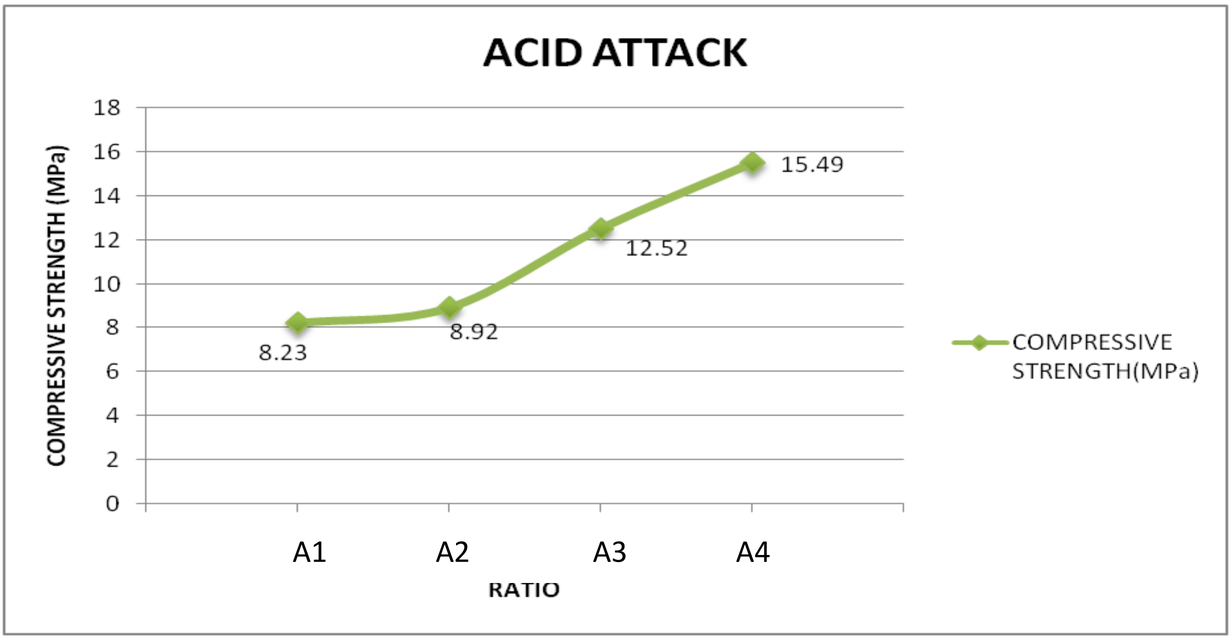

Fig.4.13 Compressive strength after acid attack vs mix proportion

COMPARISON OF COMPRESSIVE STRENGTH AFTER ACID ATTACK

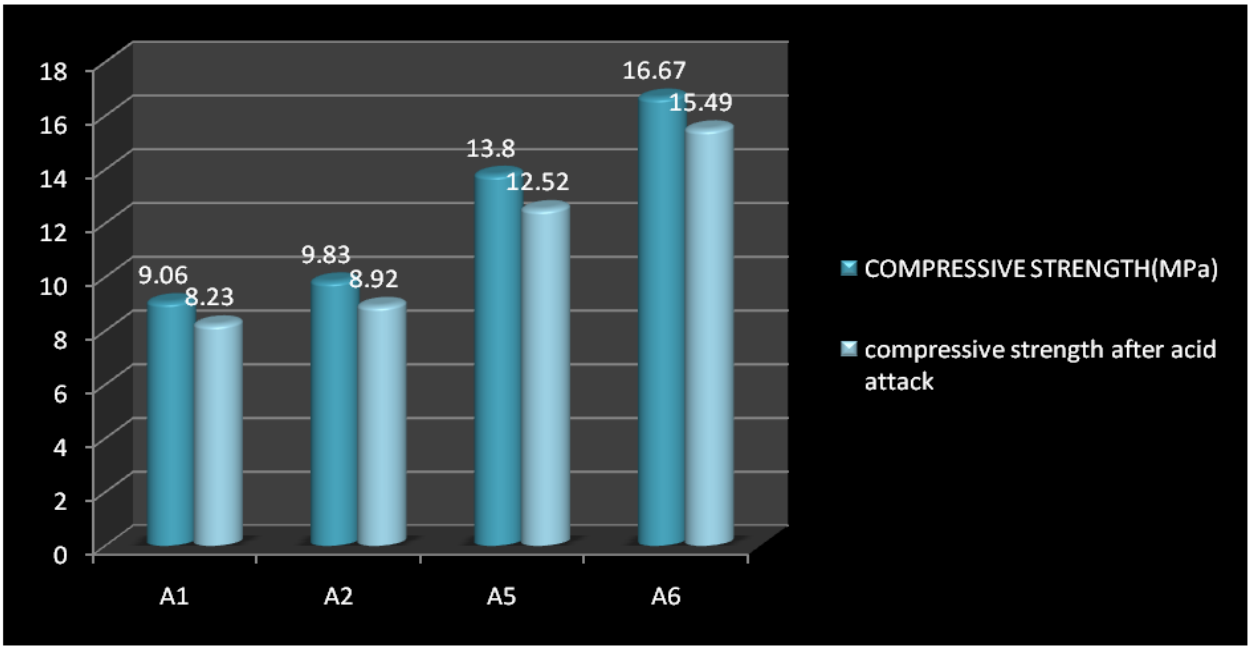

Fig.4.14 Comparison of compressive strength after acid attack for different mix proportions

From the above graph it is found that after 28days of acid attack the compressive strength for control mix decreased to 9.1% and for A6 (MD100) it is decreased to 7.07%.

WEIGHT LOSS DUE TO ACID ATTACK

TABLE 4.12 Percentage weight loss due to acid attack

MIX DESIGNATION	SPECIFICATION	ACTUAL WEIGHT(g)	WEIGHT LOSS(g)	PERCENTAGE LOSS
A1	QD/CA	2343.34	2338.65	0.20%
A2	QD/MA	2456	2451.28	0.19%
A5	MD75/MA	2465	2460.66	0.18%
A6	MD100/MA	2556	2552.11	0.15%

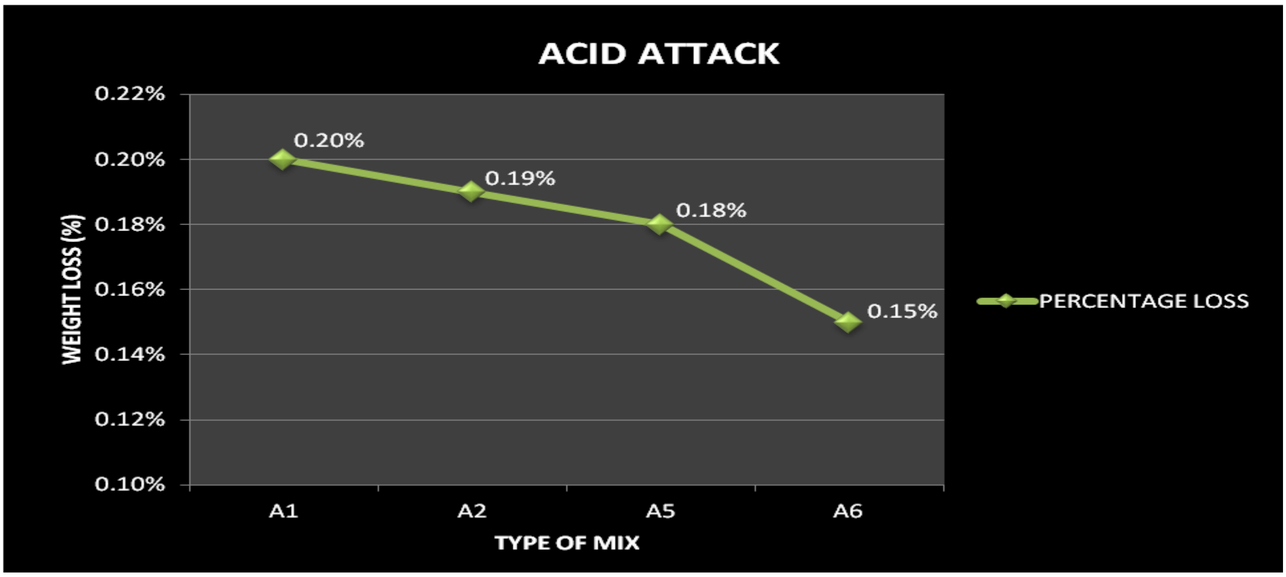

Fig.4.15 Weight loss vs type of mix

It can be seen from the above table and graph weight loss after acid attack for control mix(A1) is higher as compared to weight loss for 100% substituted marble powder (A6).

CHAPTER – 5

COST ANALYSIS

CHAPTER - 5

COST ANALYSIS

5.COST ANALYSIS

5.1 Light requirement

Normal activity = 100lux

Outside room with clear sky = 2000lux

During sunlight = 35000lux

Light passed through light transmitting concrete for 4% optical fibres by volume = 10%

Available light inside room through transparent wall = 10% of 1100lux = 110lux

5.2 Cost of conventional concrete for M10 grade

Cement = 6Rs/kg

Sand = 0.5Rs/kg

Conventional coarse aggregate = 0.43Rs/kg

Quarry dust = 0.9Rs/kg

Marble waste = 0.35Rs/kg

Marble aggregates = 0.35Rs/kg

For a block of 1000mmx1000mmx100mm

Mix prepared with sand and coarse aggregate will cost 270 Rs

Mix prepared with quarry dust and coarse aggregate will cost 240 Rs

Mix prepared with marble waste and marble aggregate will cost 250 Rs

5.3 Cost of light transmitting concrete block using optical fibre

5.3.1 Number of optical fibre

Diameter of optical fibre = 1mm

Length of optical fibre = 100mm

Volume of one fibre = 78.5mm3

For 4%by volume, Volume of optical fibre required = 4% of 1000mmx1000mmx100mm = 4x10^6mm3

No of optical fibres required = Volume of optical fibre required/volume of one fibre

= 4x10^6/78.5 = 50955.4 of 100mm length

5.3.2 Cost of optical fibre concrete block

Cost of optical fibre = 40paise/m

Total cost of optical fibre = 50955.4x0.4/10 = Rs 2038

Cost of concrete = Rs 238

Total cost of concrete = Rs 2276

Extra cost required = Rs (2276-250) = Rs 2026

5.4 Power Consumption By Artificial Lighting :

Power consumption when one 60 Watt light bulb is used for illumination for 30 days for 8 hours = 60 X 30 X 8

= 14400 = 14.4 Units

Cost of power supply = Rs 8/unit

Total cost saved per year by using transparent concrete = 14.4x8x12 = Rs 1382/year

5.5 Cost Recovery

Cost will be recovered = 2028/1383 = 1.5year

CHAPTER – 6

CONCLUSIONS

CHAPTER – 6

CONCLUSIONS

6.1 CONCLUSIONS

From this experimental study, it is concluded that light transmitting concrete is advantageous construction material. It can be used in green buildings to increase the energy efficiency of the structure. It is definitely the future of civil engineering construction material, and its use would keep on increasing in construction as the time will go on. The following conclusions can be drawn based on the results of this experimental work.

- The compressive strength increases with increase in percentage replacement of fine aggregate with marble powder. Maximum compressive strength of 16.67MPa at 28days is found when mix is employed with 100% substitution of fine aggregate with marble powder and coarse aggregate with marble.
- Flexural strength also increases with increase in percentage replacement of fine aggregate with marble powder. Maximum flexural strength of 3.09MPa at 28days is achieved at complete substitution of fine aggregate with marble powder and coarse aggregate with marble.
- According to the results of ultrasonic pulse velocity test, it is found that as the marble powder content increases, mix become dense and lesser time ultrasonic wave requires to pass through the specimen. Thus, ultrasonic pulse velocity for complete substitution with marble powder is above 4.5Kmps.Hence, the hardened concrete obtained is of excellent quality.
- The results obtained from the permeability test shows that depth of water penetration decreases as substitution of marble powder increases. It is 10.6cm when mix is prepared with quarry dust as fine aggregate and conventional coarse aggregate and decreased to 7.6cm when mix is prepared with marble powder as fine aggregate and marble as coarse aggregate.
- The light transmittance ratio up to 12% was achieved by using 4% Plastic Optical Fiber ratio. Thus, it proves that Light transmitting concrete can be very efficiently

used in Green buildings. It will ensure natural sunlight inside the buildings throughout the day. It will reduce dependence on artificial sources of energy.

- From the compressive strength results, it can be seen that strength of light transmitting concrete is not affected much as compared with control concrete. For concrete of mix proportion, with fine aggregate as quarry dust and conventional coarse aggregate, 28 day compressive strength decreased from 9.06 N/mm^2 of control concrete to 8.42 N/mm^2 for concrete with 4% of POF. For concrete of mix proportion with fine aggregate as marble powder and coarse aggregate as marble, 28day compressive strength decreased from 16.67 N/mm^2 to 16.3 N/mm^2 for concrete with 4% of POF.

- The results obtained from the durability test i.e. **sulphate attack** states that the compressive strength for control mix when conventional coarse aggregate are used decreased to 9.05% and for control mix when marble used as coarse aggregate decreased to 8.64%. For mix proportion when fine aggregate is 100% employed with marble powder compressive strength after sulphate attack decreased to 6.23%.

- The results obtained from the durability test i.e. **acid attack** states that the compressive strength for control mix when conventional coarse aggregate are used decreased to 9.1% and for control mix when marble used as coarse aggregate decreased to 9.25%. For mix proportion when fine aggregate is 100% employed with marble powder compressive strength after acid attack decreased to 7.07%.

- Due to effect of sulphate ions percentage weight loss for control mix is 0.2% and weight loss for 100% marble powder is 0.14%

- Due to effect of sulphuric acid percentage weight loss for control mix is 0.2% and weight loss for 100% marble powder is 0.15%.

- From the cost analysis it is found that the cost of light transmitting concrete can be recovered in 1.5years.

6.2 SCOPE FOR FUTURE STUDY

Very limited research has been done on light transmitting concrete so far, and there is vast scope of future research on its various aspects regarding mechanical property, light guiding characteristics, and air and water permeability of light transmitting concrete. etc.

The following proposals are made for future study

- This study was carried out to study light transmitting characteristics, compressive strength, durability of light transmitting concrete. It can be extended for investigating air and water permeability.

- Effect of super plasticizers during manufacture of light transmitting concrete can be found.

- Plastic optical fibers were used in this study, glass fibers can be used and its effect on light transmittance characteristics can be found.

- By varying the angle of incident light, its effect can be found on the transmittance characteristics.

- Effect of changing wavelength of incident light, Self sensing property, freeze thaw test can be carried out for future study.

- Effect of varying size of fibers and spacing of fibers on various properties of concrete can also be carried out for further study.

REFERENCES

[1] **Aliabdo, A.A., Abd Elmoaty, Abd Elmoaty M., Auda, E.,M., 2014.** *Re-use of waste marble dust in the production of cement and concrete. Construction Building Material 50, 28e41.*

[2] **Ahuja Aashish, Khalid M. Mosalam, M.ASCE; and Tarek I. Zohdi, 2014,** Computational Modeling of Translucent Concrete Panels, DOI:10.1061/(ASCE)AE.1943-5568.0000167. © 2014 American Society of Civil Engineers.

[3] **Alyamaç, K.E., Ince, R.A., 2009.** *Preliminary concrete mix design for SCC with marble powders. Constr. Build. Mater. 23 (3), 1201e1210.*

[4] **Andre, A., de Brito, J., Rosa, A., Pedro, D., 2014.** *Durability performance of concrete incorporating coarse aggregates from marble industry waste. J. Clean. Prod. 65, 389e396.*

[5] **Basma F. Bashbash, Hajrus Roaa. M, Doaa F. Wafi, Alqedra Mamoun A., 2013,** *Basics of Light Transmitting Concrete, Global Advanced Research Journal of Engineering, Technology and Innovation (ISSN: 2315-5124) Vol. 2(3) pp. 076-083*

[6] **Bhavin K. Kashiyani, Varsha Raina, Jayeshkumar Pitroda, Shah Bhavnaben K., 2013.** *A Study on Transparent Concrete: A Novel Architectural Material to Explore Construction Sector, International Journal of Engineering and Innovative Technology (IJEIT) Volume 2,Issue 8.*

[7] **Belachia, M., Hebhoub, H., 2011.** *Use of marble wastes in the hydraulic concrete. In: 6th International Advanced Technologies Symposium (IATS'11), 16e18 May 2011, Elazıg, Turkey.*

[8] **Belaidi, A.S.E., Azzouz, L., Kadri, E., Kenai, S., 2012.** *Effect of natural pozzolana and marble powder on the properties of self-compacting concrete. Constr. Build. Mater. 31, 251e257.*

[9] **Binici, H., Kaplan, H., Yilmaz, S., 2007.** *Influence of marble and limestone dusts as additives on some mechanical properties of concrete. Sci. Res. Essay 2 (9), 372e379. ISSN: 1992-2248.*

[10] **Corinaldesi, V., Moriconi, G., Naik, T.R., 2010.***Characterization of marble powder for its use in mortar and concrete. Constr. Build. Mater. 24 (1), 113e117.*

[11] **Demirel, B., 2010.** *The effect of the using waste marble dust as fine sand on the mechanical properties of the concrete. Int. J. Phys. Sci. ISSN: 1992-1950 5 (9), 1372e1380.*

[12] **Gameiro, F., de Brito, J., Correia da Silva, D., 2014**. *Durability performance of structural concrete containing fine aggregates from waste generated by marble quarrying industry. Eng. Struct. 59, 654e662.*

[13] **Hebhoub, H., Aoun, H., Belachia, M., Houari, H., Ghorbel, E., 2011.** *Use of waste marble aggregates in concrete. Construction Building Material 25 (3), 1167e1171.*

[14] **Hameed, M.S., Sekar, A.S.S., 2009.** *Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate. ARPN J. Eng. Appl. Sci.ISSN: 1819-6608 4 (4), 83e89.*

[15] **Juan shen and Zhou zhi,** *some progress on smart transparent concrete, Pacific Science review, vol.15, no 1, 2013.*

[16] **Jimenaz-munoz.E and Fernandez-martinez.F, 2014,** *Translucent concrete research with glass, optical fiber and glass fiber, Springer international publishing Switzerland 2014.*

[17] **Momin A.A. , Kadiranaikar R.B. , Vakeel.S. Jagirdar , Arshad Ahmed Inamdar** *Study on Light Transmittance of Concrete Using Optical Fibers and Glass Rods IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334XPP 67-72 .*

[18] **Neha R. Nagdive & Shekhar D. Bhole,** *TO EVALUATE PROPERTIES OF TRANSLUCENT CONCRETE /MORTAR & THEIR PANELS, International Journal of Research in Engineering & Technology (IMPACT: IJRET) ISSN(E): 2321-8843; ISSN(P):2347-4599 Vol. 1, Issue 7, Dec 2013, 23-30.*

[19] **Omar, O.M., Abd Elhameed, G.D., Sherif, M.A., Mohamadien, H.A., 2012.** *Influence of limestone waste as partial replacement material for sand and marble powder in concrete properties. HBRC J. 8 (3), 193e203.*

[20] **Paul Soumyajit, Dutta Avik, 2013,** *Translucent Concrete, International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013 1 ISSN 2250-3153.*

[21] **Rodrigues, R., de Brito, J., Sardinha, M., 2015.** *Mechanical properties of structural concrete containing very fine aggregates from marble cutting sludge. Construction Building Material 77, 349e356.*

[22] **Shanmugavadivu. P.M, Scinduja.V, Sarathivelan.T, Shudesamithronn.C.V,2014,***AN EXPERIMENTAL STUDY ON LIGHT TRANSMITTING CONCRETE, Volume: 03Special Issue: 11, NCAMESHE – 2014, Jun-2014, Available @ http://www.ijret.org.*

[23] **SiddarthaReddy.P1, Shaik.jabaulla2 and Dr. D. Neeraja3,2013.** *Light Transmitting Concrete Using Plastic Optical Fibers, International Journal of Applied Engineering Research, ISSN 0973-4562, Vol. 8, No. 19.*

[24] **Tennich, M., Kallel, A., Ouezdou, M.B., 2015.** *Incorporation of fillers from marble and tile wastes in the composition of self-compacting concretes. Constr. Build. Mater. 91, 65e70.*

[25] **Topcu, I.B., Canbaz, M., 2007.** *Effect of different fibers on the mechanical properties of concrete containing fly ash. Constr. Build. Mater. 21 (7), 1486e1491*

[26] **Topçu, _I.B., Bilir, T., Uygunoglu, T., 2009**. *Effect of waste marble dust content as filler on properties of self-compacting concrete. Constr. Build. Mater. 23 (5),1947e1953.*

[27] **Yue Li, Jiaqi Li, Yuhong Wan, Zhiyuan Xu, 2015.** *Experimental study of light transmitting cement-based material(LTCM), Construction and building materials 96(2015)319-325, ELSEVIER.*

[28] **Yue Li, Jiaqi Li, Yuhong Wan, Zhiyuan Xu,** *Preparation and study of light transmitting properties of sulfoaluminate cement based material, materials and design 83(2015)185-192.*

[29] **Zhi Zhou, GeOu, Ying Hang, Genda Chen, JinpingOu.,***2009,Research and Development of Plastic Optical Fiber Based Smart Transparent Concrete, published on Proc. of SPIE Vol.7293 72930F-1.*

[30] **Zhou. Z, Ou. J.P, and B. Wang,.2003,** *Smart FRP-OFGB Bars and Their Application in Reinforced Concrete Beams. Proceedings of the First International Conference on Structural Health Monitoring and Intelligent Structure, Japan: 861~866.*