

## Full Length Research Paper

# Basics of Light Transmitting Concrete

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**Energy saving and nice view are two key issues for infrastructure. In this paper, the development of a light transmitting concrete using plastic optical fiber (POF) is discussed and producing a new alternative to entrench the concept of sustainability in Gaza Strip, which will help to reduce the consumption of electric energy in closed environments based on the traditional means of lighting, which can manufacture some parts of the exterior walls of the molds are made of concrete, transparent and that allow the entry of the nature lighting from outside to the inside. The experimental results show that an optical fiber can be easily combined with concrete and that the POF could provide a steady light transmitting ratio. This paper also discusses the mechanical effects of introducing POF into concrete specimens. Because the smart transparent concrete can be regarded as a “green” energy saving construction material it is a promising technology for field applications in civil infrastructure.**

**Keywords:** Light Transmitting, Concrete Mix, Fibers

## INTRODUCTION

With the economic growth and science technology development, more and more large scale civil engineering structures such as tall buildings, underground buildings and landmark buildings and so on are built around the world. While the economic growth is a kind of extensive growth: high input, high consumption and high pollution, for that the energy saving technology is low, especially in developing countries. The brightness of indoor environment is entirely maintained by artificial lighting, which has consumed a large number of resources. Moreover civil engineering structures always suffer from external environmental effects, economic loss and casualties are serious once damaged. And now, building energy saving and building safety have been attracted much attention. The main problems to be

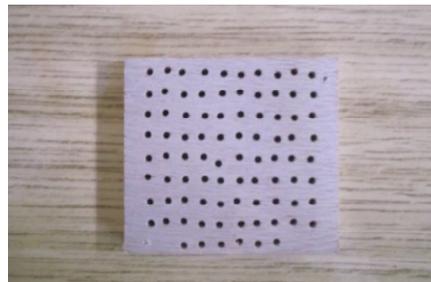
discussed are the dark and non airy concrete walls especially at morning hours, and why don't depend on sun lighting instead of energy consumption, the inner rooms that need great lighting and Electricity, that suffered by the Palestinian people in general and the Gaza Strip in particular, because of the blockade caused by the wa

## Basics of Light Transmitting Concrete

Light transmitting concrete, is a combination of optical fibers and cement paste. Due to the small pieces of aggregate. In this manner, the result is not only two materials – fiber optics in concrete - mixed, but a third, new material, which is homogeneous in its inner structure and on its main surfaces as well. The new material will transform the interior appearance of concrete buildings by making them feel light and shining rather than dark and heavy. (Losonczi A.2011)

**Table 1.1** weight of each component in the mix

Materials	Weight per six cubes (5*5*5cm) g
cement	500
water	250
Fine aggregate "sand"	1350



**Figure 1.1** a sample of wooden plates



**Figure 1.2** wooden compressive moulds



**Figure 1.3** metal compressive moulds

### **Constituent Material of Light Transmitting Concrete**

The light transmitting concrete produced consists of ordinary cement with specific contents of optical fiber.

#### **Cement**

In the most general sense of the word, cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The cement was

used in this research was ordinary Portland cement available in IUG laboratories.

#### **Water**

Is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water needs to be pure in order to prevent side reactions from occurring which may weaken the concrete, the role of water is important because the water to cement ratio is



Figure 1.4 wooden flexure moulds



Figure 1.5 metal flexure moulds

Table 1.2: No. of compressive POF needle with varying diameter and POF%

<b>POF with diameter 1.5mm</b>	
Percentage	No. of needle
2%	30
4%	57
6%	85
<b>POF with diameter 2mm</b>	
Percentage	No. of needle
2%	16
4%	32
6%	48
<b>POF with diameter 2.5mm</b>	
Percentage	No. of needle
2%	11
4%	21
6%	31
<b>POF with diameter 3mm</b>	
Percentage	No. of needle
2%	8
4%	15
6%	22

the most critical factor in the production of "perfect" concrete. The current work uses tap water available in IUG labs.

### Sand

Is a naturally occurring granular material composed of finely divided rock and mineral particles. The Composition of sand is highly variable, usually in the form of quartz. Sand particles range in diameter from 4 mm to 2 mm. The sand used is the normal sand available in Gaza strip.

### Plastic Optical Fibers (POF)

Plastic optical fiber is flexible and transparent fibers made of a pure glass (silica), It functions as a waveguide, or "light pipe", to transmit light between the two ends of the fiber.

### Experimental Program

The experimental program will show how to prepare the concrete mix, POF preparation and molds preparation.

**Table 1.3:** No. of flexure POF needle with varying diameter and POF%

<b>POF with diameter 1.5mm</b>	
percentage	No. of needle
2%	73
4%	145
6%	218
<b>POF with diameter 2mm</b>	
percentage	No. of needle
2%	41
4%	82
6%	123
<b>POF with diameter 2.5mm</b>	
percentage	No. of needle
2%	27
4%	53
6%	79
<b>POF with diameter 3mm</b>	
percentage	No. of needle
2%	19
4%	37
6%	55

**Figure 1.6:** concrete after fully handmade mixing**Figure 1.7.** concrete cubes during curing process

### Mix proportion

The main objectives are to determine the most economical and practical combination of readily available materials to produce a concrete that will satisfy the performance requirements under particular conditions of use. Also, to determine the proportion of ingredients that would produce a workable concrete mix that is durable and meets required strength. In this research work, we use ASTM 2011 for the weight of the three constituent materials that we use as shown in table

### Preparation of wooden and metal cubes

#### Compressive cubes test

In this research, several wooden moulds that are made in a certain form. These wooden moulds contain three cubes of 5\*5\*5 cm, each cube separated by perforated plates, these perforated plates were provided with the maximum number of holes to allow all fibers for the maximum fiber content applied to pass through in this study (6%) figure 1.1 shows a sample of these plates.



Figure 1.8: Cubes during compression test



Figure 1.9 concrete cube during flexural test

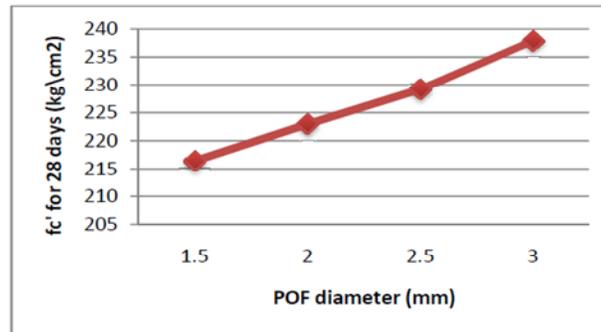


Figure 1.10 7- day compressive strength compressive strength versus fiber diameters at fiber content of 4%

Before filling these moulds, they are coated with oil to avoid the adherence of the concrete cube and wood. As shown in figure 1.2

### Flexure cubes test

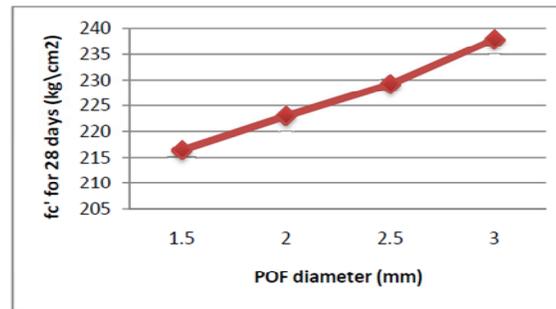
In this research, some wooden moulds that are made in a certain form similar to what have been done compressive mould tests, but with dimensions of 4\*4\*16 cm. Also before filling these moulds, they coated with oil to avoid the adherence of concrete cube and wood, as shown in figure 1.4. The same procedures were applied to metal moulds, see figure 1.5

### Preparation of POF

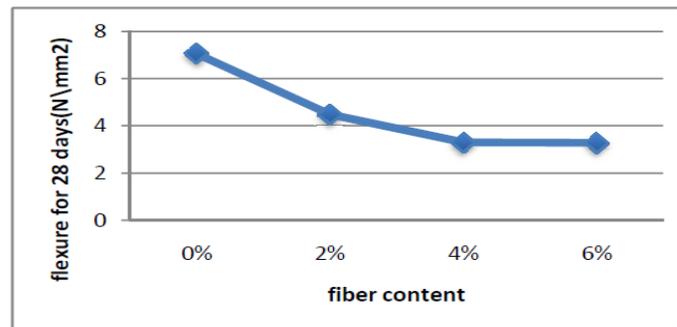
Plastic optical fibers (POF) were used in three different percentages and four different diameters, so the number of POF needle used would vary according to the diameter of POF and the percentage of POF by the volume of the cube.

### Compressive POF test

Number of POF needles calculated according to the volume percentage and the POF diameter, so the number of POF needles used would vary according to the



**Figure 1.11.** 28- day compressive strength results versus fiber diameter at fiber content of 4%



**Figure 1.12.** flexure strength results at fiber diameter of 1.5mm

diameter of POF and the percentage of POF of the volume (5\*5\*5cm).

### Flexure POF test

Plastic optical fibers were used in three different percentages and four different diameters too, so the number of POF needles used would vary according to the diameter of POF and the percentage of POF of the volume (4\*4\*16cm).

### Preparation of concrete mix

In this research work a fully handmade concrete mixing was followed according to the properties that was shown before.

Mix procedure was done as discussed:

- i. The weighted sand and cement are added in a mixing container.
- ii. The water is uniformly added throughout the whole process.

See figure 1.6

### Testing Program

In order to achieve the objective of that word an

experimental testing program was developed, the experimental program comprise investigation the effect of POF on the compression strength and flexural strength as shown below:

- 1) Compression tests: these tests are divided into two groups in order to study the effect of fiber diameter on compressive strength and also the effect of percentage of fiber content on compressive strength .
- 2) Flexural tests: which was grouped as previous test according to changing POF diameter and percentage in order to study its effect on flexural strength .

### Equipment and testing procedure

#### Curing procedure

All specimens were placed in a curing basin after it have been removed from steel cubes after 24 hours of casting , the curing process was done at Soil and Material Laboratory on IUG according to ASTM C 192 .See figure 1.7

#### Compression test

It is the most important test for concrete, tests was done according to ASTM C 109. The compression strength was obtained based on average of four cubes which were prepared for each POF diameter and content , two of

them for 7 days strength tests and the other two for 28 days strength test . The samples are (5cm×5cm×5cm) cubes which are recommended by ASTM for tests on mortar. The compressive strength machine available at soil and material laboratory in IUG . Figure 1.8 shows cubes during compression test

### Flexural Test

For this purpose just two samples were prepared for each POF diameter and content , those samples were tested after 28 days of casting and the average value is used. samples for this test were (4cm×4cm×16cm) according to ASTM recommendation for flexural test on mortar. Figure 1.9 below shows concrete cubes during flexural test.

## ANALYSIS AND RESULTS

### Results of 7- day compressive strength test

The results of 7- day compressive strength indicated that that compressive strength increases as fiber content increases reaching about 4%, then compressive strength decreases at 6% fiber content for all fiber diameters. Therefore, the concrete have the maximum 7- day compressive strength at 4% fiber content. This can be explained as fiber content increases the bond between the fibers and the concrete particles and the concrete particles themselves is improved. This behavior is not endless, after certain fiber content (4 % fiber content) the fibers start to decrease the bonds between concrete. In the same context, Figure 1.10 shows that the fiber diameter 2.5 mm have the highest compressive strength at the 4% fiber content.

### Results of 28- day compressive strength test

From the compressive strength results of 28 days, it can be seen that compressive strength decreases as fiber content increases. This can be attributed to the fact that as fiber content increases the density of the samples decreased. On the other hand, the results showed that as fiber diameter increases from 1.5 mm to 3.0 mm (with fixed fiber content of 4%) the compressive strength increases.

### Results of 28- day flexure strength test

Flexure tests were carried out on samples with fiber contents of 0%, 2%, 4% and 6% at several fiber diameters namely; 1.5 mm, 2.00 mm, 2.5 mm and 3.00 mm. the following sections presents the 28- day flexural strength obtained for each case. Taking 1.5mm diameter

results as an example as shown in figure 1.12. figure 1.12 show that flexure strength decreased at fiber content of 2% to about 36%. when fiber content increased from 2% to 4% there was another important decrease in flexural strength to 26%. However, when fiber content increases from 4 % to 6% there is a slight decrease of 6% in the flexural strength.

## CONCLUSIONS

Conclusions presented in this chapter are based on this particular research works and are to be divided into two subsections discussed briefly in the next sections.

### Compressive strength for 7 days

It's noticed that Compressive Strength increase when fiber content increase until reach 4%, then Compressive Strength decrease at 6% fiber content for all diameter. But the concrete have maximum compressive strength after 7 days at 4% fiber content, because the larger fiber content decrease the bonds between concrete. But 7 days results still not the indication for research work and 28 days result have to be taken in consideration.

### Compressive strength for 28 days

From the results of 28 days, it's noticed that Compressive Strength decrease until fiber content increase, that return to decrease weight for concrete with fiber. On the other hand, the results shown that the larger diameter have high Compressive Strength for the same fiber content. The 28 days results is the best indication for research work so conclude that the best diameter is 3mm and the more fiber content the weaker compressive strength.

### Flexural strength for 28 days

Flexure strength is slightly decreased with fiber content 2% to 20%- 55% with several diameters also at fiber content from 2% to 6% is observably decrease .

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