Effect of temperature on the compressive strength and sustainability of expanded clay lightweight basalt fiber reinforced concrete

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Abstract. Concrete exposure to high temperature is a threat to the concrete which leads to loss of strength and degradation of the concrete. Based on this, it was necessary that the behavior on compression of lightweight expanded clay basalt fiber reinforced concrete (BFRC) be investigated when exposed to high temperature. The parameters and dosages of basalt fiber in lightweight expanded clay concrete have effects on the strength of the concrete. The sustainability of a structure in any environment is of high importance therefore, the types of material used as an aggregate and reinforcement must be durable, trustworthy and with the necessary properties suitable for the structure. The main aim of this paper is focused on the ability of lightweight expanded clay basalt fiber reinforced concrete when exposed to high temperature and tested for compressive strength, not to lose its total strength whereby, creating opportunity for the reuse of the concrete. The method of this research is based on laboratory test and practical review analysis. From the compressive strength, a view on the sustainability of this type of concrete is discussed. In this paper, the two sets of specimens were placed on three temperature ranges in a specific time interval. After, they were tested for compression. From the result, it was seen that expanded clay lightweight basalt fiber reinforced concrete didn’t lose much strength under compressive test after it was exposed to high temperature thereby making the concrete sustainable to high temperature.

Keywords: lightweight compressive strength, sustainability of expanded clay lightweight BFRC

1. Introduction
Concrete is generally known as a building material mostly used in structural construction. Concrete is mostly preferred for some reasons. Example of such reasons is the fire resistance ability of concrete [1]. Though concrete cannot be classified as a combustible material, it has the ability to behave differently when exposed to thermal. In concrete, aggregates make up the most important part of concrete volume. Differences in aggregate properties significantly affect the performance of the concrete during heating. Differences in aggregate properties cause cracks, weight loss and gain, and breakages.
Lightweight expanded clay basalt fiber reinforced concrete has fire resistance properties. Comprising of this type of concrete are expanded clay which has the ability to withstand the high temperature of upto 1200°C and basalt fiber of upto 1400°C. Lightweight concrete has recognizable benefits like its good thermal insulation, dead load reduction [2], satisfactory durability, etc. Lightweight concrete has been utilized for structural purposes for a long time now due to its excellent properties [3-6].

Sustainability of construction materials is highly important because the potentials posed by the material. Lightweight expanded clay basalt fiber reinforced concrete is a sustainable material that is highly recommendable for its strength, cost-effective, durability [7], ductile, fire resistance ability etc. Addition of fibers in the proportion of 1.0–1.5% increases the unit weight of concrete by 8.5% and compressive strength by 21.1% [8].

When the appropriate basalt fiber is mixed in concrete, basalt fiber reinforced concrete (BFRC) compressive strength is reduced to varying degrees and breaking strength is improved significantly [9, 10].

This research is placed with the task to assess the behavior of lightweight expanded clay concrete when reinforced with basalt fiber and without basalt fiber exposed to thermal. The compressive strength of the concrete after exposure to thermal will be analyzed through a laboratory experimental process. Due to the type of environment being considered for the implementation of this concrete, it is necessary that the sustainability of lightweight expanded clay concrete is will be discussed.

2. Materials And Methods

In this research, the materials and admixtures for this experiment, analysis and design are Cement, Aggregate (Expanded clay or Gravel), Quartz flour, modifier MB10-50C, Quartz Sand, Modifier Silica fume MK-85, Superplasticizer, Water, and basalt fiber.

An analysis on the sustainability of lightweight expanded clay concrete and the effect of crude oil on the concrete will be reviewed.

2.1 Compressive tests on lightweight basalt fiber reinforced concrete (BFRC) at room temperature

The compressive test will be made on a total number of 18 cube specimens: 9 cube specimens from the 18 are with basalt fiber and 9 without basalt fiber. The basalt fiber has parameters of 20mm length and 1.5µm diameter and as reinforcement. 1.2% portion of basalt fiber will be added to the concrete. The compressive strength of the concrete will be checked on the 7th, 14th and 28th day with specific cube sample specimens at room temperature. The dimensions of the cube specimens used are Length 100mm x Width 100mm x Height 100mm.

2.2 Compressive tests on lightweight basalt fiber reinforced concrete (BFRC) exposed to high temperature

On the 28 day curing period of both concrete samples (lightweight concrete without basalt fiber and lightweight bfrc), 9 cube specimens for each concrete specimen on the ratio of 3 specimens from each concrete will be placed in an oven and heated at temperature ranging of 150°C , 300°C, 600°C for a period of 1 hour. After the thermal procedure, the concretes are will be left to cool off at room temperature of 20°C for 30 minutes then, the compressive test will be conducted on the specimens.

3. Results and discussion

3.1 Compressive test specimens result at normal room temperature

There is a slight decrease in the compressive strength of the cube specimens with basalt fiber. Figure 1 shows a good result as the concrete cube specimens without basalt fiber showed high visual cracks and breaks when if compared to specimens with 1.2% basalt fiber which shows little cracks. Table 1 shows the test result for the concrete cube specimens after the average strength result from each of the curing days bearing 3 specimens have been calculated.
Table 1. Compressive test result of concrete cube specimens test at room temperature.

| Basalt fiber content (%) | Basalt Fiber parameters: length = 20mm, Diameter 1.5µm |
|-------------------------|--------------------------------------------------------|
|                         | Compressive strength MPa on:                           |
|                         | 7 day | 14 day | 28 day       |
| 0                      | 17.86 | 26.72  | 86.62        |
| 1.2                    | 10.19 | 18.57  | 82.31        |

Figure 1. Compressive strength concrete cube result at normal room temperature

3.2 Compressive test concrete cube specimens result exposure to thermal

Table 2 results show a decrease in the compressive strength of the specimens both with basalt fiber and without basalt fiber. With the increase in temperature, it is seen that the compressive strength of the concrete decreases. Figure 2 gives a good illustration of the results as the specimens without basalt fiber showed high visual cracks when compared to specimens with 1.2% basalt fiber.

Table 2. Compressive test result of concrete cube specimens exposed to thermal.

| Basalt fiber content (%) | Basalt Fiber length = 20mm, Diameter 1.5µm |
|-------------------------|------------------------------------------------|
|                         | Flexural strength MPa on:                     |
|                         | 150°C | 300°C | 600°C       |
| 0                      | 83.22 | 76.14 | 52.17       |
| 1.2                    | 81.52 | 78.21 | 62.57       |
4. Sustainability of lightweight expanded clay basalt fiber reinforced concrete

The two main materials in consideration are materials that are of great value to the world of construction. The properties of expanded clay and basalt fiber give the lightweight expanded clay basalt fiber reinforced concrete higher advantages to the normal concrete. As one of the challenges of structures is the poor resistance of most construction to high temperature. When a structure or structural elements are exposed to thermal, they begin to show the after effect of the high temperature they are being exposed to. Some of these effects are the degradation of the structure which leads to cracks and eventually collapses of the structure.

A good example of the type of environment to use lightweight expanded basalt fiber reinforced concrete is crude mining environment where oil spill and possible fire outbreak is experienced. The high thermal resistance of basalt fiber and expanded clay is a good property that makes this type of concrete reliable. Another property is the ability to resist the acidic effect. Every contractor or user of structures need a good and reliable environment and structure to work effectively.

5. Conclusion
i. The test result shows that adding some percentages of chopped basalt fiber to lightweight expanded clay concrete caused a slight reduction in the compressive strength of the concrete.
ii. Though there was strength lost in the concrete with 1.2% basalt fiber, there was more strength growth with the increase in the curing period of the concrete.
iii. After thermal exposure, it is seen that lightweight expanded clay concrete reinforced with 1.2% basalt fiber has little and slower degradation of strength when compared to concrete with 0% basalt fiber which shows faster and more strength lost in the temperature ranges.
iv. Lightweight expanded clay basalt fiber reinforced concrete shows its sustainable ability under high temperature.

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