Effect On Thermal Properties Of Concrete Containing Micro Steel Fiber (CMSF)

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Abstract. Nowadays, the improvement of construction materials towards sustainable construction materials had become important. Due to the hot and sunny climate in Malaysia, the consumption on electricity increases. This causes a decrease of comfort in residence. The objectives of this research was to evaluate the thermal properties of concrete containing micro steel fibres (MSF). In this study, a series of concrete cubes that consists of different percentage of MSF (0%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%) was made in order to carry out compression test. Then, a Hot Guarded Box was used to obtain the optimum percentage of MSF in the concrete for thermal conductivity. As a result, the optimum percentage of MSF obtained from the compression test was 0.8% with a reading of 25.7Mpa. While, the optimum percentage of MSF obtained for thermal conductivity 0% with a reading of 0.34 W/mk. As a conclusion, it was proven that the inclusion of MSF in a concrete matrix will increase the thermal conductivity.

1. Introduction
A bunch of research has been done in recent years to enhance the concrete’s properties. As a common knowledge, concrete is relatively good in compression strength but weak in tensile strength. From the previous studies, the researchers had proven that the properties of concrete improved in term of strength and workability with the addition of material in concrete, such as fibres and superplasticizers. Fibre is known as reinforcement, it is a small piece of reinforcing material that have particular characteristic on enhancing the flexural and tensile strength. Moreover, fibres are classified to natural fibres, synthetic fibres, and steel fibres.

The application of natural fibre may decrease the temperature in the building. For an instant, palm date fibre is suitable to use as the thermal resistance material in building at the same time it may pose as a reinforcement in the concrete element [1]. As the temperature in Malaysia is keep on increasing due to the climate change. According to [2] the temperature of sea and land obtain from 1880 until 2012, reveals that the temperature increased 0.85 Celsius. This might affect the comfort level in a building.

Therefore, this study is conducted to determine optimum thermal for concrete consist different percentage of micro fibre steel (MSF). Apart from that, the improvement of concrete properties consists of MSF was observed by conducting compressive test. The percentage of MSF involve in this study are 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1.0%.
2. Literature Review

2.1. Concrete
It is known that concrete is an essential building material in construction industries. Concrete was made of water, cement and aggregates [3]. The addition of water to Portland cement and aggregates will form paste of fresh concrete. After a hydration process, the paste become hard and it follow the type and shape of the mold of concrete. If the concrete was poorly constructed, it will contribute to a high cost in maintenance of structure. Thus it will affect the characteristics of concrete to become weak [4]. In general, the concrete is important to a building, because concrete is high resistance to water and fire, and offer good thermal insulation to reduce the energy cost for heating and cooling [5]. From previous study done by [6] using metallic and synthetic fiber shows a positive result on toughness of concrete. While the study conducted by [7] on concrete with aluminum fiber, have proven that both splitting tensile and compressive strength increases as fiber increases.

2.2. Steel Fiber
Steel fiber is a metal reinforcement, it is short with discrete length and different cross-section. Steel fiber's primary role in concrete has always been to mitigate cracking and crack propagation on concrete structure [8]. Concrete with the steel fiber can view as conducting elements. [9]. On the other hand, it makes the joint stronger and reduce the costs and maintenance for repair. Suitable and use in the long term in the structure [10]. From the study conducted by [11] are using polypropylene fibre and steel fibre, have an outcome of high compressive strength and spalling concrete are delay. Besides, according [12] the crack was reduce by adding steel fibre in the concrete tunnel study.

2.3. Micro Steel Fiber (MSF)
MSF is finer and has a length longer than 10mm, and its diameter is in a range 25-40μm [13]. The properties of MSF are excellent in tensile, flexural, impact and fatigue protection, and crack confinement [14]. From previous study [15] using MSF in the range of 1% to 4% shows an optimum compressive strength at the 3% of MSF content. Furthermore, according to [16] using a combination of macro and micro steel fibre in concrete to test the pull out and tensile of concrete, the result of the test are improve.

2.4. Thermal
The ability of component’s properties to transfer heat is referred to as thermal. Thermal changes depend on component’s ages and environmental conditions change. Time of heat flow (W) through any unit of area is thermal conductivity. K-value, is W/mk. Thermal conductivity is one measure of the transfer of heat to the other surface. Conduction is the conversion of the heat kinetic energy into a solid mass. The heat transfer depends on area, thickness and material type. From the previous study of [17] porosity of concrete can affect and reduce thermal conductivity of concrete. Meantime, according to [18] the mixing carbon nanotube fiber and steel fiber can reduce the thermal conductivity. Furthermore natural fiber is the good in reduce thermal conductivity like jute and coconut fiber according [19].

3. Methodology

3.1. Material Preparation
The material used for the research is Ordinary Portland Cement (OPC) chosen in this research according to BS EN 197-1:2000 [20] suitable for most concrete work, course and fine aggregate 5mm and coarse aggregate 10mm sieve size, superplasticizers, micro steel fibre for 0.2%, 0.4%, 0.6%, 0.8% and 1.0% based on the volume of concrete and curing for 7 days, mix design by DOE and divide with compression and thermal (Table 1 and 2).
Table 1. Number of specimens for concrete

| Micro steel fiber percentages | No of specimens |
|------------------------------|-----------------|
|                              | Compression 7days | Thermal 7days |
| 0                            | 3               | 3             |
| 0.2                          | 3               | 3             |
| 0.4                          | 3               | 3             |
| 0.6                          | 3               | 3             |
| 0.8                          | 3               | 3             |
| 1.0                          | 3               | 3             |
| Total                        | 18              | 18            |

Table 2. The material mix design

| Material                        | 6 specimens for 0% | 6 specimens for 0.2% | 6 specimens for 0.4% | 6 specimens for 0.6% | 6 specimens for 0.8% | 6 specimens for 1.0% |
|--------------------------------|--------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Cement (kg)                    | 1.89               | 1.89                 | 1.89                 | 1.89                 | 1.89                 | 1.89                 |
| Coarse Aggregate (kg)          | 5.28               | 5.28                 | 5.28                 | 5.28                 | 5.28                 | 5.28                 |
| Sand (kg)                      | 6.69               | 6.69                 | 6.69                 | 6.69                 | 6.69                 | 6.69                 |
| Water (l)                      | 0.9                | 0.9                  | 0.9                  | 0.9                  | 0.9                  | 0.9                  |
| Micro Steel Fiber (g)          | -                  | 12                   | 24                   | 36                   | 48                   | 60                   |
| Superplasticizer (ml)          | -                  | 90                   | 90                   | 90                   | 90                   | 90                   |

3.2. Laboratory Testing

A slump test was performed to assess the fresh concrete's workability. These experiments were carried out in accordance with BS EN 12350-2 [21] standard. Next, a compression experiments were done to obtain optimum compressive strength of concrete matrix consists of MSF. These experiments were done correspondingly to BS EN 196-1:2005[22] standard. Finally, a Hot Guarded Box test was used to conducted the thermal conductivity.

4. Results and Discussion

4.1. Slump Test

The slump test portrayed in Figure 1 were achieve from normal concrete to 1.0% of micro steel fiber. Based on Figure 1, the minimum height decreasing was on the control concrete with 129 mm for 0% MSF at the same time the maximum height was 167 mm. the figure shows slump decrease slightly when the MSF percentage increases. 0.6% MSF increase to 175mm higher than 0.4% MSF this is happen mixing of MSF are not uniform distribute to each cube. furthermore, the decrease of slump effect by the superplasticizer where added the workability of the slump. The range of the slump target for the mixture was 60mm to 180mm set as the slump value. All the slump test is fill in the range.
4.2. Compression Test
Figure 2 show the concrete strength after the compression for 7 days based on the different percentages of micro steel fiber. Control concrete were achieved in 7 days is 23.4Mpa. Figure 2 also show the increasing strength of concrete after admixture of micro steel fiber than the normal concrete. 0.2 and 0.4 % of micro steel fiber increase slightly were given 24.6 and 25.5Mpa. At the same time 0.6% micro steel fiber strength decreased to 24.9Mpa lower than 0.4% micro steel fiber. That happen because of distribution of micro steel fiber not uniformly for each of cube that makes the result decrease. 0.8% micro steel fiber result increased to 25.7 Mpa and drop to 25.4 Mpa at 1% micro steel fiber. The expected strength is supposed increasing due to the increase of the steel fiber in the concrete according [23]. The strength is related to the admixture of the material. The increasing happens because the increment in the volume fraction of steel fiber in concrete improve energy absorption capacity of the concrete matrix. According [24], The additional steel fiber into the fresh concrete prevents steel fiber in a bunch if mixing well and fill the void in concrete. besides the steel fiber gives highest compressive strength.

4.3. Thermal Conductivity test
From graph in Figure 3 the thermal conductivity test for 7 days, the result for normal concrete at 0% of micro steel fiber is the lowest it is for 0.36W/mk compare with all admixture micro steel fiber in concrete. 0.2% of micro steel fiber were higher than normal concrete with 0.39W/mk. The result from Figure 3 keeps increasing slightly as the inclusion of MSF increases. 0.4% micro steel fiber show the graph increase to the 0.47 W/mk. From all result, the highest thermal conductivity is 0.4 % micro steel fiber. This is because the material was micro steel fiber is a conductor of the heat transfer where micro steel fiber is from the copper properties good in heat transfer and coated with steel fiber. Steel fiber in reinforced concrete improves the effectiveness of thermal conductivity. [18].

Figure 1. Slump test.

Figure 2. Graph result for compression
5. Conclusion

Based on the outcome from the slump test, compression test, thermal test and critical review, it can be concluded that concrete containing micro steel fiber drawn are as follows: i) MSF has been added into the concrete by the percentages based on volume concrete 0.2%, 0.4%, 0.6%, 0.8% and 1.0% as admixture. ii) The higher the MSF volume the greater the strength. The highest strength obtained at the presence of 0.8% MSF, that is 25.7Mpa.

6. References

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Acknowledgments
This study was supported by Universiti Tun Hussein Onn Malaysia and Ministry of Higher Education Malaysia under grant Malaysian Technical University (MTUN) Fund number K122, Industry Grant PLUS (M007) and Postgraduate Research Grant (GPPS) H657.