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Synthesis of multiwall carbon nanotube with fly ash in the production of desired green concrete

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Abstract. Green concrete was introduced in concrete production in order to reduce the usage of natural resources. In this research, fly ash and MWCNTs were used in the production of green concrete since industrial waste material such as fly ash becomes a major concern during waste disposal. MWCNTs was used in this experiment to strengthen this green concrete. In this paper, effect of heat during curing process was studied and it was found that the compressive strength was increase when introducing the heat during curing process of this green concrete. The 3 days of water curing at room temperature and 3 days of heat curing at 100°C produces compressive strength at 27.2 MPa which is higher than normal curing process at 28 days, which is 14.63 MPa. Therefore, this research shows that green concrete can be produced using fly ash and MWCNTs and produce high compressive strength when heat was presence during curing process.

1. Introduction

Concrete is the most commonly used material in construction areas since it has good properties such as high strength and durability. In the production of concrete, cement was used as a binder to provide good properties for the concrete. However, the production of cement is not environmental friendly. Cement production has been found as one of the major causes of CO_2 emissions in the air due to the releases of CO_2 during the crashes of limestone and clay at a high temperature (±15000°C) [1]. Therefore, Green concrete was introduced in the production of concrete to reduce the emissions of CO_2.

Green concrete was cheap to produce because it is prepared by waste materials which has lower energy consumption, and low cost in the production. Fly ash (FA) is industrial solid waste material that produced by coal power plant. The waste disposal of the fly ash was disposed in landfills and pollution becomes a major concern [14]. Many researchers were investigating of using FA in a production of concrete since it can reduce the usage of natural resources like limestone [2]. The FA is one of the normal supplementary of cementitious materials utilized as a part of cement since it can hardened the concrete [3]. Golewski et al. [4] found that addition of FA can increase the compressive strength and fracture toughness in a production of concrete. Yu et al. [15] reported that lowering the water/binder ration to 0.2 can increase the strength of the structural concrete even though 80% of cement was replaced with fly ash. The fly ash replacement ratio is not significantly affect the cementing efficiency when less than 80% of cement was replaced by fly ash. Therefore, the introduction of fly ash in the production of concrete causes changes in the phase composition and the microstructure of cement phase.

Since the compressive strength of Green concrete is lower than the conventional concrete, therefore, Nano-size particle was introduced to increase the strength of Green concrete. Multi-wall Carbon nanotubes (MWCNTs) was found to has good properties such as high tensile strength and modulus of durability and enhanced electrical conductivity of materials that appear to be greatly fundamental in concrete production [5]. Naqi et al. stated that MWCNTs can increase the compressive strength of the concrete [6]. However, dispersion of MWCNTs can affect the properties of material. The dispersion of MWCNTs using ultrasonication process can improved the dispersion of MWCNTs hence improve the mix materials [7].

This research is to study the mechanical properties especially in compressive strength and elastic modulus of the fly ashes with the help of the MWCNTs as the reinforced materials in the production of green concrete using oven during the curing process. In concrete production, hydration process or curing period can affect the strength of the concrete. During this process, the hardened concrete is kept moist so that hydration process can occur in order to strengthen the strength of concrete. Noushini et al. [8] studied the effect of heat curing in a curing process of the concrete. From the study, it was found that heat curing can increase the compressive strength and elastic modulus of concrete. Few studies was found using oven during the curing process. Therefore, this research is to study the effect of curing process when using MWCNTs and the fly ashes in the production of concrete. This prompted a new development of high innovation utilizations in manufacturing of concrete.

2. Methodology

In this research, multi-walled carbon nanotubes (MWCNTs) from USAINS Group was used together with fly ash from power plant. First, sulfuric acid (H_2SO_4) and nitric acid (HNO_3) acid solution was prepared prior to functionalize the MWCNTs for 6 hours at 70°C. This mixture was sonicated for 30 minutes using ultrasonic bath (ElmaSonic S30H) in order to disperse the MWCNT's. Then, MWCNTs was dried inside a furnace for 8 hours at 200°C. The dried MWCNTs was mixed with fly ashes. After that, this mixture was mixed with water, clay, cement, and rocks and was dried at room temperature for one (1) day using a mould. Then the hardened samples were taken out from the mould and were cured for water curing, and water curing and heat curing. Normally, the water curing was done for 7, 14 and 28 days [13]. Therefore, in this research, water curing at 1 day, 7 days, 14 days and 28 days were analysed where the samples were kept inside the water bath at a room temperature. Then, the combination of water curing and heat curing at temperature 100°C was done in order to investigate the effect of heat curing for this green concrete. The samples was cured by 3 days of water curing and 1 day of heat curing, 3 days of water curing and 2 days of heat curing, 3 days of water curing and 3 days of heat curing, 7 days water curing and 1 day heat curing, and 7 days water curing and 2 day heat curing. The 3 days of water curing was used in order to reduce the time taken for normal curing process. Furthermore, all these samples were tested using the cube testing machine for the tensile strength and compressive strength result. Morphology of the samples was tested using Scanning Electron Microscopy (SEM) in order to identify the porosity that presence on the surface of the sample.

3. Results and Discussions

Figure 1 shows morphology of green concrete of fly ash and MWCNTs at (a) 7 days water curing (b) 7 days water curing and one (1) day heat curing, and 3 days water curing and 3 days heat curing. Figure 1 (a) exhibited different microscopic shapes such as needle shape and dense paste. However, Figure 1 (b) shows more dense paste, irregular hexagonal panel crystals which can reduce the porosity structure hence increase the hardness of the sample [11]. Therefore, introduce the heat in the production of concrete can reduce the porosity structure.

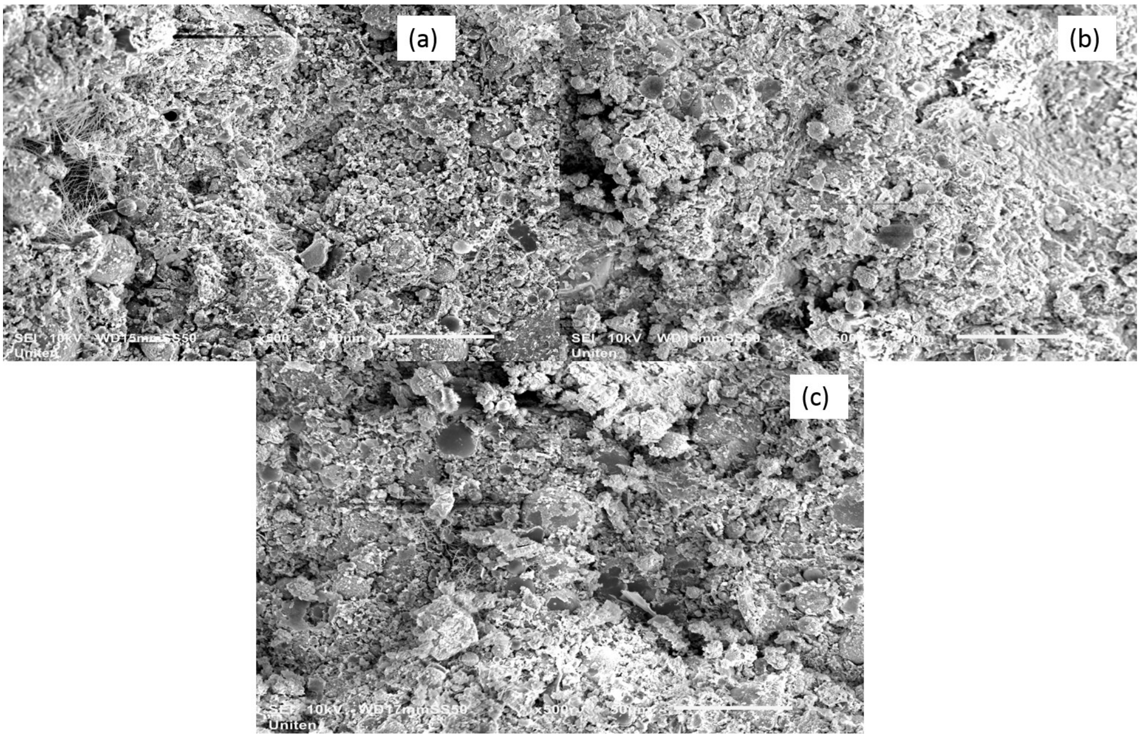

Figure 1. Morphology of green concrete of fly ash and MWCNTs at (a) seven (7) days water curing (b) seven (7) days water curing and one (1) day heat curing (c) three (3) days water curing and 3 days heat curing.

For Figure 1(b), 3 days water curing and 3 days of heat curing was done in order to reduce the curing time process. The morphology was dense paste and has irregular hexagonal panel crystals. Henry et al. [12] stated that heat curing can increase the amount of pores in the concrete. However, Sedaghatdoost et al. [9] proved that the presence of MWCNTs in concrete can reduce the amount of cracks since the porosity structure of the concrete is reduced hence improve the compressive strength of the concrete. Moreover, it was reported that initial cracks start to initiate when temperature at 200°C. So, in this research, temperature of 100°C during heat curing process were used in order to produce the green concrete using fly ash at high compressive strength.

Table 1 shows the compressive strength for 7 days, 14 days, 28 days of water curing and 7 days of water curing together with 1 day of heat curing. From the result, 7 days of water curing together with 1 day of heat curing has the highest compressive strength which is 18.61 MPa. This result is in agreement with Sedaghatdoost et al. [9] that heat curing can intensify the hydration process since additional heat can increase the hydration rate process hence increase the compressive strength of the concrete. Moreover, presence of MWCNTs at high temperature can increase the performance and residual strength than concrete without MWCNTs since the MWCNTs act as a catalyzed in a production of concrete.

Furthermore, it clearly can be seen that the presence of heat during curing process can decrease the water curing process time with the improvement of the compressive strength of the concrete. Furthermore, the presence of heat for this green concrete production can increase the elastic modulus hence increase the hardness of concrete. Therefore, the combination of MWCNTs with fly ash with the presence of heat can increase the compressive strength and elastic modulus of green concrete.

Table 1. Compressive strength and elastic modulus for 7 days, 14 days, 28 days of water curing and 7 days of water curing together with 1 day of heat curing.

Curing Process	Compressive Strength (MPa)	Elastic Modulus (MPa)
7 days (Water curing)	9.63	277.6
14 days (Water curing)	12.00	463.32
28 days (Water curing)	14.63	502.51
7 days (Water curing) and 1 day (Heat curing)	18.61	626.04

Table 2 shows compressive strength and tensile strength for 3 days water curing at different day of heat curing which are 1 day, 2 days and 3 days, respectively, and 7 days of water curing at 1 day and 2 days of heat curing. Increases the heat curing period of time for 3 days can increase the compressive strength from 19.02 MPa for 1 days to 27.20 MPa for 3 days. The 7 days of water curing with 2 days of heat curing produce lesser compressive strength when compare to 3 days of water curing with 3 days of heat curing. This result shown that the curing time can be reduced when increases the amount of heat curing. However, the water curing is still needed in this curing process since it can maintain the moisture inside the concrete prior to develop the desired properties in terms of strength and durability [13].

Table 2. Compressive strength for 3 days water curing and 1 day heat curing, 3 days water curing and 2 days heat curing, 3 days water curing and 3 days heat curing, 7 days water curing and 1 day heat curing, 7 days water curing and 2 days heat curing.

Curing Process	Compressive Strength (MPa)	Tensile strength (MPa)
3 days (Water curing) and 1 day (Heat curing)	19.02	1639.25
3 days (Water curing) and 2 days (Heat curing)	24.83	2205.95
3 days (Water curing) and 3 days (Heat curing)	27.20	2230.6
7 days (Water curing) and 1 days (Heat curing)	18.61	1650.59
7 days (Water curing) and 2 days (Heat curing)	24.59	1821.24

Tensile strength for the 3 days water curing and heat curing is higher compare to 7 days water curing and heat curing. This probably due to the 3 days has enough time to maintain the moisture inside the concrete prior to develop the desired properties in terms of strength and durability [13]. Increase the time of heat curing can increase the tensile strength due to the reduction of porous structure. For 3 days water curing and 3 days heat curing produce highest tensile strength which is 2230.60 MPa. Therefore, green concrete can be produced by using fly ash and MWCNTs as binder material using oven in order to increase the compressive strength and tensile strength of the material and reduce the curing time.

4. Conclusions

In this research, effect of heat curing was investigated when using fly ash and MWCNTs in the production of green concrete. From this research, introducing heat curing during water curing process can increase the compressive strength and tensile strength of the concrete. For 3 days of water curing and 3 days of heat curing produces better compressive strength compare to 28 days of water curing, and 7 days water curing and 1 heat curing. Water curing is needed during curing process needed in curing process since it can maintain the moisture inside the concrete prior to develop the desired properties in terms of strength and durability. Therefore, the curing process time can be reduce when using both water curing and heat curing at temperature 100°C in the production of green concrete using fly ash and MWCNTs.

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