Effect of Effective Micro-Organism on Temperature Variation in Concrete

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***Abstract*: To promote sustainability in concrete, Effective Micro-Organism (EM) has been used in the construction industry for the last few years. The point of the investigation is to distinguish the impact of EM on the properties of cement, for example fresh, hardened, durability and screen the temperature variety in concrete. The research is based upon the addition of 5%, 10%, 15%, 20%, 25% and 30% of EM by replacing water during the mixture of concrete. Concrete cube samples with the size of 100mm x 100mm x 100mm were prepared and tested for 3, 7, 14 and 28 days. The curing method was followed by water curing method. Lab tests had done which was temperature variety test, density test, Ultrasonic Pulse Velocity test, Initial Surface Absorption Test (ISAT) and compressive load test to distinguish the effects of effective micro-organisms in this research. The outcome of experimental results depicts that the control sample test EM test offered better quality in term of all test. Utilizing 10% of EM in the sample indicated the most noteworthy compressive quality and furthermore the least water entrance. It additionally builds the early strength of concrete that is extremely impressive. In contrast, containing 15% of EM in the sample shows the most minimal temperature during the hardening of the cement. To conclude, with the addition of EM in concrete, positive effects has been noted on the concrete properties, particularly in temperature and durability.**

***Keywords*: Durability, Effective micro-organisms, Water absorption, Hydration process, Temperature, Ultrasonic pulse velocity.**

I. INTRODUCTION

Concrete has been the most well-known material in the advancement business for quite a while. Exactly when cement is sufficient to be used at run of the mill improvement condition, its execution advances toward turning out to be crumbled when used in a tolerably unfavorable condition (A.M. Neville 1971). Concrete has been utilized for a long time due to its quality, sturdiness and moderate cost. Without a doubt, it is the most fundamental component of common and development building works beforehand a few issues, for example, workability, toughness, compressive quality and temperature increment were raised during the hydration procedure. So as to conquer such issues, a great deal of research works have been done and various assessments did to explore new materials which can be used as the admixtures for concrete.

As the admixture of concrete, the development industry has been investigating utilizing natural material, for example, micro-organisms. For the purpose of agriculture, effective micro-organisms (EM) was first introduced in japan by Professor Teruo Higa. EM is made in fluid form and it contains different types of effective, beneficial and non-pathogenic microorganisms of both aerobic and anaerobic types co-existing, by the process of natural fermentation and not chemically synthesized or genetically engineered EM produced (Higa and Wood, 1998). There are eighty-three different types of microorganism contain lactic acid bacteria, yeasts, photosynthetic bacteria, and actinomycetes, among other types of microorganisms such as fungi in EM (Trivedi, 2017) (Jamaludin et al.2012). The development of construction has been researching the use of natural material, for example, microorganisms as the admixture for concrete. As feasible microorganisms (EM) was first exhibited in Japan with the ultimate objective of cultivating, it is as of now being commonly used in various endeavors the world over (R.A Herbert1986). some examinations have been finished to research the most extreme limit of using EM its ramifications for the execution of concrete and the results showed that compressive quality of concrete increased containing EM (P. Howsam 1990). Moreover, the addition of EM in concrete at optimum level results in the improvement of workability of the fresh concrete, increase of early strength and maintaining the low temperature of concrete.

II. MATERIALS & METHODS

A. Cement

Ordinary Portland cement has been used for this research.

B. Aggregates

For coarse aggregate crushed stone with the size of 10mm was used in this research. The locally available sand in the laboratory was used as fine aggregate

C. Water

Potable water was used for casting. The mix design was prepared with a ratio of 0.53.

D. Effective Micro-organism (EM)

EM obtained from the market. The EM was used as different percentages to carry out the research work.

E. Concrete Mix Design

To determine the impact of EM in concrete, the mix design had done in two different ways. To obtain an ultimate compressive strength of 30 MPa, these mixes were designed based on the department of the environment's design method (DOE). Concrete sample with EM and without EM (control sample). The fresh property of concrete was tasted to measure the workability of concrete by slump test.

Table 1: Proportions of cement, water, fine aggregates and coarse aggregates for the design mix

	Kg/m3				% of W/C
Quantity	Cement	water	Fine Aggregate	Coarse aggregate	0.53
1m3	465	250	875	800	

Table 2: Proportions of cement, water, fine aggregates, coarse aggregates and EM required for 0.013m3 of concrete (13 samples was cast in each time 0.001x13=0.013)

			Kg/m3			
Quantity	Cement	Fine Aggregate	Coarse aggregate	water	EM %	EM
0.013m3	6 kg	11.37 kg	10.4 kg	3.25	0	0
				3.08	5	0.16
				2.92	10	0.32
				2.76	15	0.48
				2.60	20	0.65
				2.43	25	0.81
				2.27	30	0.97

F. Preparation of Material

In this study, a total of ninety-one cube specimen with a size of (100mm x 100mm x 100mm) was cast. Seven number of the specimen with different percentage of EM was cast and a thermometer was placed in the cube to observe the temperature variation.

III. RESULTS

A. Properties of Fresh Concrete Containing EM

To determine the workability of fresh concrete, slump test was conducted. The test is carried out in accordance with testing fresh concrete: slump test. London: British Standards (EN, B. (2000). 12350-2). Institution, testing fresh concrete. The result of the slump test was shown in fig1. By Adding EM in concrete the workability of concrete gradually increased. Although it replaced the amount of water from the concrete mix the workability of concrete keeps on increasing by the higher amount of EM used. Previous research also proved that concrete containing EM increases the workability of fresh concrete (Isa, Garba, & Usman, 2015) (Idris & Yusof, 2018).

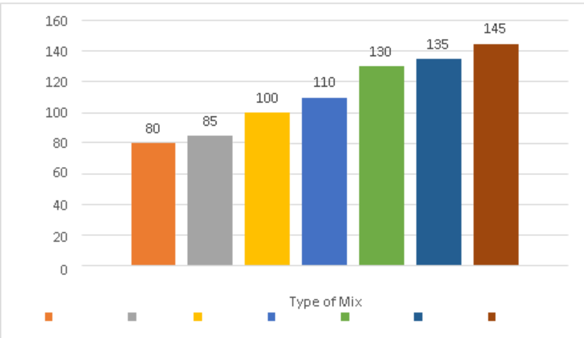

Fig. 1: Relationship of Slump and Different % of EM mix

From Figure, it is clear that the control mix has lowest workability compare to EM mix. Control mix had 80 mm slump while concrete mix with EM shows maximum 145mm slump value. When EM used in 30% the slump value was highest and it indicates the highest workability of fresh concrete.

Fig. 2: Slump

B. Ultrasonic Pulse Velocity (UPV)

In order to get information about uniformity, cavities, presence of voids or other kinds of discontinuities Ultrasonic pulse velocity (UPC) testing is performed. UPS of material depends on the density and elastic properties which the quality and compressive strength of concrete. UPV test has been conducted on concrete samples during this experiment.

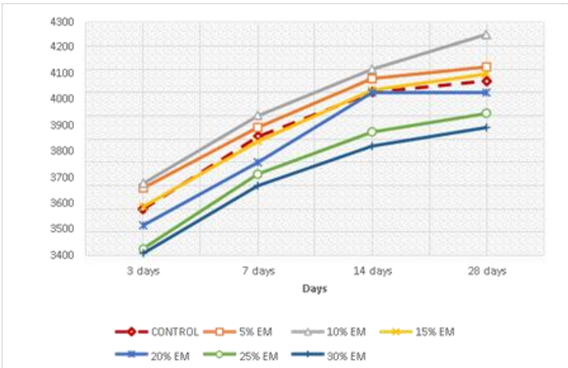

Fig. 3: UPV with different percentage of concrete mix

From figure 2, the value of ultrasonic pulse velocity (upv) shows that the velocity of the control sample is moderately lower than EM 10% and EM 5%.mix. It indicates that using EM 0f 10% the sample becomes denser and shows higher compressive strength.

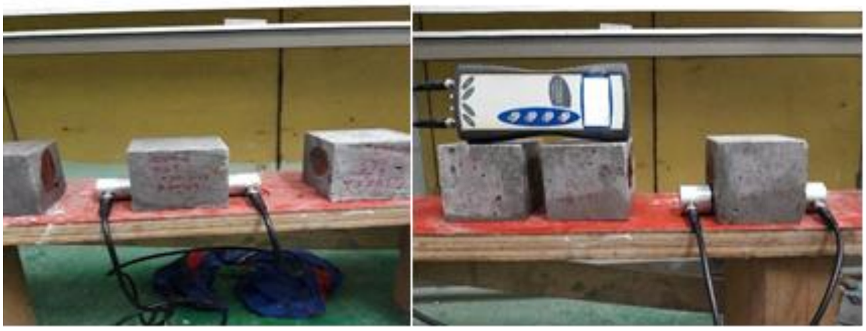

Fig. 4: UPV

C. Density of concrete

The mechanical properties of concrete are highly influenced by its density. A denser concrete generally provides higher strength and fewer amount of voids and porosity. After 3, 7, 14 and 28 days of maturity of the concrete sample density test was performed.

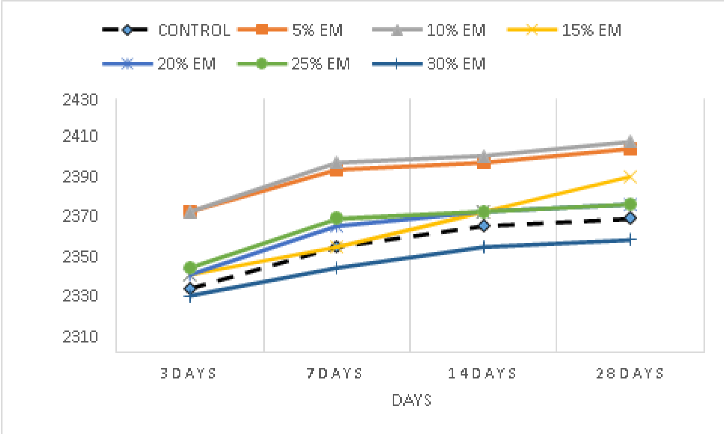

Fig. 5: Density with different percentage of concrete mix

From the graph, the density of the control sample is less than EM samples. EM in concrete increase the density of concrete in early-stage and also at the age of 28 days. But only 30%EM with concrete shows less density. EM is acidic and the concrete is alkaline (Siong Andrew, Syahrizal, & Jamaluddin, 2012) so the hydration process gets disturbed due to the acidic condition by adding EM up to 30%. As a result lower density is observed in the sample. But overall it can be said that using EM in concrete at an optimum quantity, the quality of concrete can be improved.

D. Compressive Strength

The compressive strength test for samples was done at the ages of 3, 7, 14 and 28 days. The uniaxial compressive testing machine was used for the compression test. Until failure, the specimens were placed on the machine under load control.

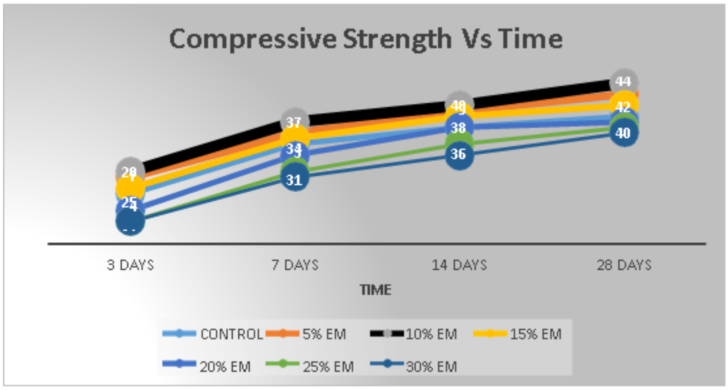

Fig. 6: Relationship between concrete compressive strength with days

E. Development of Early compressive strength (3days)

From fig 4 it is clearly shown that concrete with 10% EM has the highest compressive strength compared to all samples. The development of compressive strength is also higher compared to others. Concrete with 20% or more with EM shows Less compressive strength compared to the control sample. Also, the development of compressive strength was retarded.

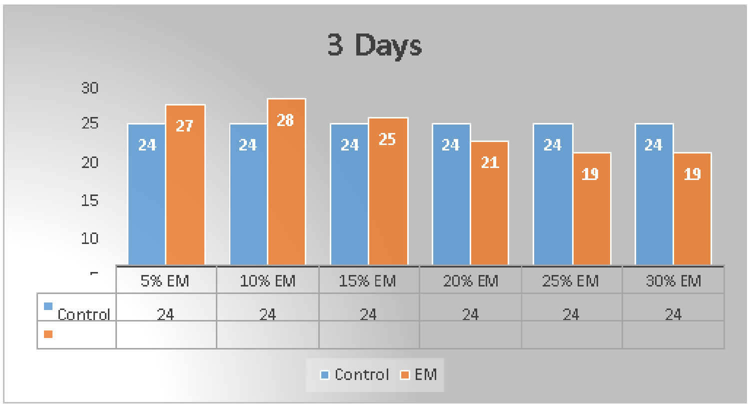

Fig. 7: Early Compressive Strength at 3 Days

The development of the early strength of concrete is higher compared to control samples. In fig:7 Concrete with 5%, 10%, and 15% EM shows a better result in term of early strength. While the control sample has compressive strength 24 N/mm2 at the day of 3, the sample with EM is 27, 28 and 25 N/mm2. On the other hand, by adding EM in concrete it increases the amount of lactic acid in samples. Lactic acid at 2% wt or below increase the early strength of concrete (Kastiukas, Zhou, Castro-Gomes, Huang, & Saafi, 2015). But when the EM quantity reaches 20% or more concrete takes more time to achieve strength and refer to lower early strength compare to control. It can be proved that concrete beyond 15% results in the hydration process and hence causes lower compressive strength. The slower rate of hardening of concrete is occurred due to the presence of molasses in EM which is a type of retarder. This retarder delays the setting and hardening time of concrete (Mohd Yatim, Wan Abdul Rahman, & Mohd Sam, 2009). Also, EM contains potassium chloride (KCL). The presence of KCL in EM influence the setting time and delay the hardening of concrete (Ismail, Mohd Saman, Mohd Jaafar, & Abdullah, 2017).

F. Development of compressive strength (28days)

All the samples achieved the design compressive strength which is 30N/mm2. EM 10% shows the maximum compressive strength in term of all ratio. So 10% of EM is the optimum quantity to be used to achieve the maximum compressive strength.

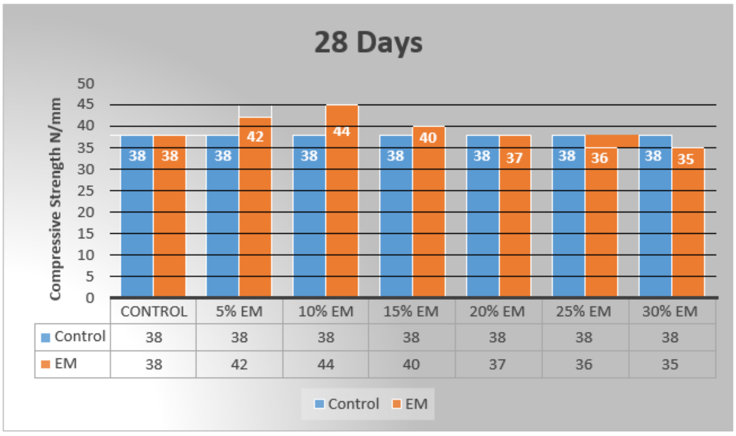

Fig. 8: Compressive Strength at 28 Days

From the result, it is clearly proved that EM increases the compressive strength of concrete. The compressive strength containing 10% of EM is 44 N/mm2 which is 146% higher than design strength 30 N/mm2. The expected reason for increasing compressive strength could be the biochemical reaction in acidic EM and alkaline concrete to create new substances. That new substance may have pozzolanic behavior that will fill up the voids and increase internal bonding (Jamaludin, Ismail, Rahman, & Yaw, 2009). Using EM more than 20% decrease the compressive strength. It may be the lactic acid concentration increase which does not benefit the strength and it no longer enhances the precipitation of hydrates but instead block it.

G. Initial surface absorption test (ISAT)

The durability of concrete is defined as the ability of concrete to resist the weathering action, chemical action while maintaining its desirable engineering properties. Concrete is a pours material and the reinforcement inside it easily corroded by water by penetration. Reduced sustainability or durability is normally caused by corrosion of reinforcing steel within concrete structure after an abundant amount of water gets absorbed into it hysterically. In order to mitigate this problem, the focus has been placed on EM concrete which is believed to have improved waterproof quality. Addition of liquid EM is added directly during the mixing of concrete by replacing some part of water. Presence of EM in the mix would fill up the pores in a specimen due to its miniature size and further enhance the water absorption capability. EM used in the samples decreases the rate of water absorption (Idris & Yusof, 2018).

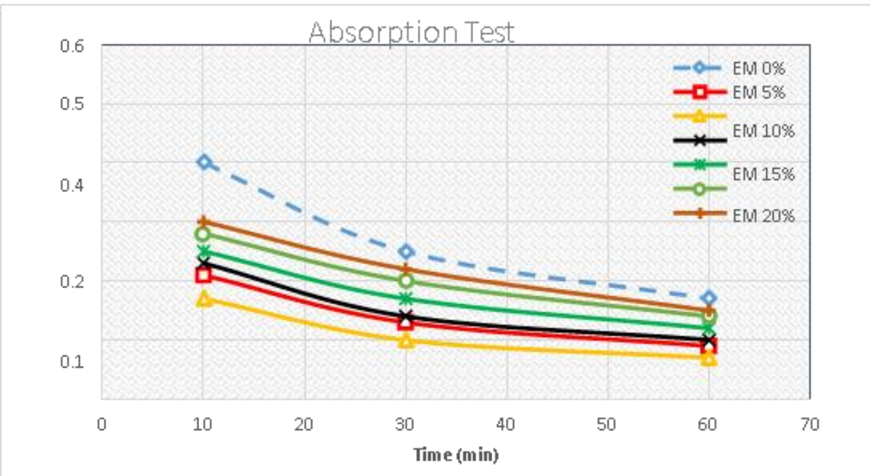

Fig. 9: Initial surface absorption vs time

EM%	Compressive Strength	ISAT Value (ml/ m2/s)

		10min	30min	60min
EM 0%	30/38	0.4	0.25	0.17
EM 5%	30/42	0.21	0.13	0.09
EM 10%	30/44	0.17	0.1	0.07
EM 15%	30/40	0.23	0.14	0.1
EM 20%	30/37	0.25	0.17	0.12
EM 25%	30/36	0.28	0.2	0.14
EM 30%	30/35	0.3	0.22	0.15

From the fig: 9 the water absorption of the control sample is 0.4 ml/m2/s at the beginning. After 30min and 1 hour, the amount of absorption gradually decrease. On the other hand, by using EM in concrete the water absorption ratio is less compared to the control sample. It indicates that the amount of pour inside the EM concrete is much less than normal concrete.

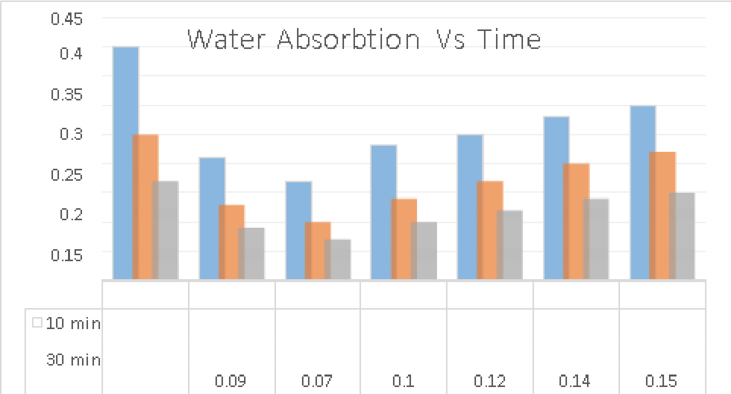

Fig. 10: Comparison between EM and control sample by absorption

After 10 min of water absorption, the reading has been taken. It is shown that the control sample has higher water absorption. The sample contains 10% of EM has the lowest water absorption. The reading has been taken at the time of 10 min, 30 min, and a 1-hour interval. After 1 hour the water absorption rate is slower by filling the pour by water. But the EM samples shows great result against water absorption. The relationship between compressive strength and water absorption is higher compressive strength with lower water absorption (less pour). Although the Sample Contain EM 20% and higher have lower compressive strength compared to the control sample they show a good result in an absorption test. It may result because the internal air is used by the EM living inside the concrete, the total volume of air in concrete reduces and hence concrete becomes denser (Mohd Yatim et al., 2009). On the other hand in addition to EM in concrete decrease the porosity (Ismail et al., 2017).

Fig. 11: ISAT

H. Temperature Variation Test

When cement is blended with water, heat is generated. This heat is the product of the exothermic chemical reaction between cement and water. For the process of cement hydration, the heat produced raises the temperature of concrete. Adding EM in concrete can be a better solution to control temperature rise. EM has low thermal properties. EM concrete contains molasses and it has low thermal property compare to water. So adding EM in concrete reduce the temperature and also make the concrete cooler then control sample.

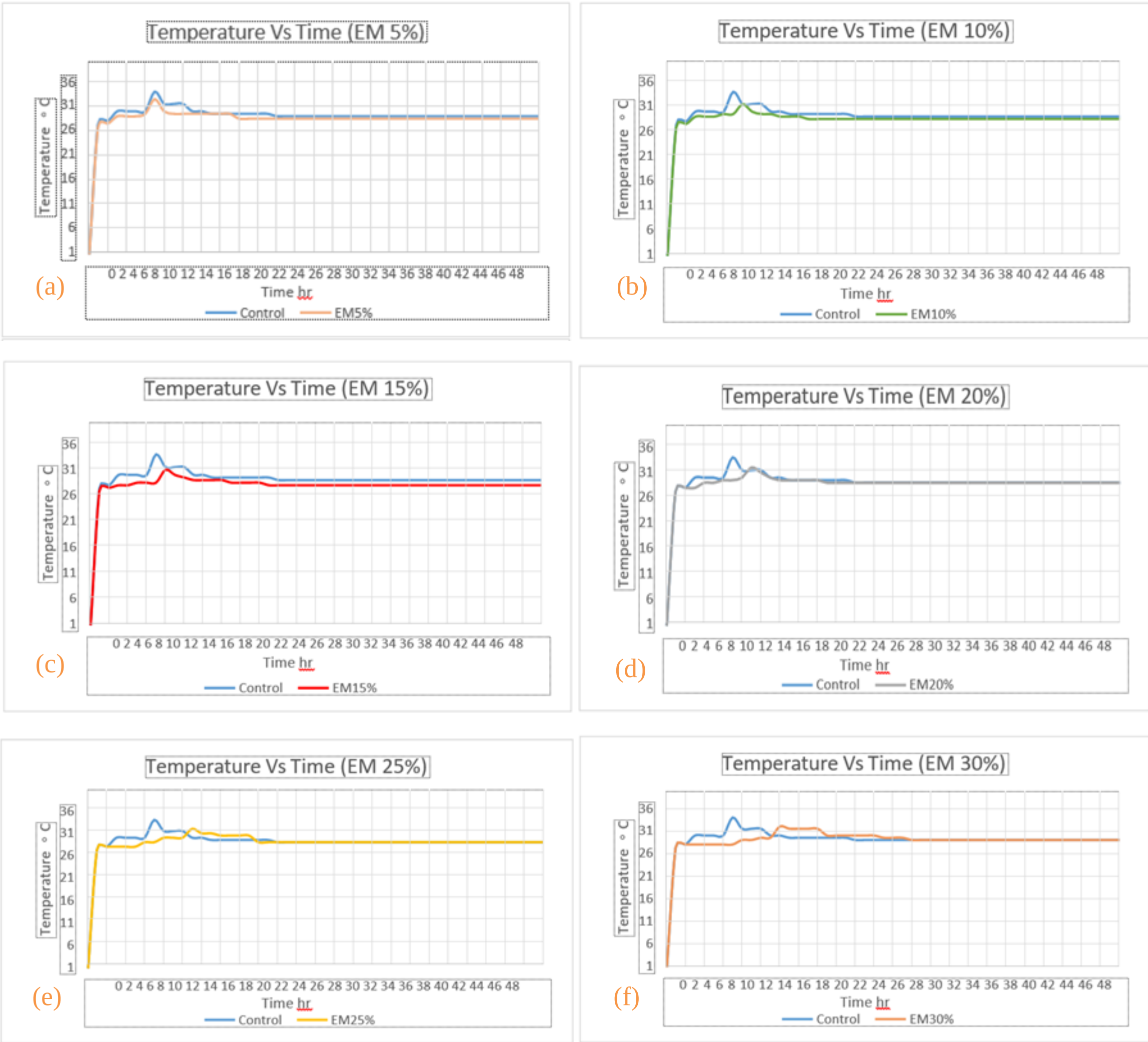

Fig.12. Graph shows temperature Vs time (a) for EM 5% (b) for EM 10% (c) for EM 15% (d) for EM 20% (e) EM for 25% (f) for 30%

The temperature variation of the concrete samples with different volume of EM is compared graphically with that of the control samples. From the graph, it is clear that EM reduces the temperature of concrete. The maximum temperature in concrete without EM reaches up to 34 degree Celsius. Although concrete temperature reduces for all the samples, the sample with 15% of EM has the lowest temperature. There is a difference of 1 degree Celsius between the sample with 15% EM and control sample after 48-hour observation and remain maintained.

It can also be seen from the graph that adding more than 15% of EM in concrete slows down the hydration process. This may be because of molasses in EM act as a retarder and slower hydration process.

IV. CONCLUSIONS

The conclusion that could be drawn from the study are as follows:

1. By adding EM in concrete, the workability of fresh concrete increases.
2. The optimum percentage of EM for the highest compressive strength is 10%. By using this amount of EM, it increases the early strength of the concrete also. So the construction work becomes faster.
3. By using 15% of EM in concrete, the temperature difference between the control sample and the EM sample is 1 degree. It can be concluded that using EM with concrete can be used as a thermal conductor and maintain the structure cool.
4. EM also acts as a retarder so that by using EM the setting time of concrete can be controlled.
5. Concrete containing EM reduces the water absorption so that it can make the concrete durable and protect from the adverse effect of the environment

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