Effect of Effective Microorganisms (EM) on concrete performance

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Abstract. Concrete technology is life-long research, that strives to discover the best additives or admixtures that are able to produce good concrete in terms of physical, chemical and mechanical properties in a more economical, sustainable, environmental friendly and obtainable. This study focuses the effect of different percentages of EM toward strength of concrete. The compressive strength test was carried out to analyse these properties by using the concrete cubes with size 100 mm x 100 mm x 100 mm. These concrete mixes were tested at different ages which are 7, 14 and 28 days. Effective microorganism (EM) replacement percentages are 5%, 10% and 15% and the strength of concrete with EM replacement will be compared with the control sample. All the cubes were cured by immersed in the water for curing process before the compressive strength tests were conducted. The finding shows that the workability degree of EM mixture is similar with the conventional mixture. The compressive strength increase with the increment of EM content. The results shows that 10% of EM could be the optimum value of water replacement in concrete production to improve strength and durability.

1. Introduction
Concrete has been the most cost effective material in construction industry for many decades. Concrete is preferred material to be used in construction industry due to its durability and strength which is depend on the concrete mix design, materials selection, mixing process and curing process [1]. In rapid development, the demand for better performance concrete increased [2]. To solve this problem, researchers and engineers are conducting the research and technical development for solution of the problem. Previous researches had proven that by adding admixture into concrete mixture or replacing substitute material in concrete production, the quality of concrete increase especially in strength and durability [3,4]. One of the potential admixture is Effective Microorganisms. A few studies have been carried out to explore the full potential of using EM its effects on the performance of concrete [5, 6].

Generally, EM is very useful in wide range of fields as in agriculture it has been used to enrich the soil and produce quality and healthy crops at a greater yield. In animal husbandry, the EM increase the quality of meat, dairy and eggs as decrease the animal disease insect infestations. The technology of Effective Microorganisms is growing tremendously, but the usage of EM as substitute materials in concrete is still at minimum stage as the exposure to EM in civil construction is limited. Therefore, this research was conducted to investigate the potential usage of EM in construction especially in concrete production. The aim of this research is to determine the optimum EM content to be used in concrete production.
2. Material and methods
The raw materials used in the study were cement, aggregate, water and effective microorganism (EM). All the specimens were prepared using material from the same sources to ensure the consistency of the findings.

2.1. Cement
Ordinary Portland Cement (OPC) OPC was used in this research study. The chemical composition of the cement are as followed:

| Chemical composition          | Percent (%) |
|------------------------------|-------------|
| Tricalcium Silicate (C3S)    | 55.3        |
| Dicalcium Silicate (C2S)     | 15.3        |
| Tricalcium Aluminate (C3A)   | 9.1         |
| Tetra Calcium Alumino Ferrite (C4AF) | 10.3 |

2.2. Fine aggregate
The fine aggregate used have maximum aggregate size passing 5 mm sieve and retained on 0.063 mm sieve. The fine aggregate was sieved before use. Fine aggregate used is river sand.

2.3. Coarse aggregate
Single-sized coarse aggregate with maximum size of 10mm was used to suit the size of concrete cube, which was 100 mm by 100 mm by 100 mm. The type of coarse aggregate was ground granite obtained from the sieve analysis with grading limits complying with BS 882: 1992. The coarse aggregate was air-dried for at least 24 hours before it was used in the mixing.

2.4. Effective microorganisms (EM)
EM is produced through a natural fermentation process and is not chemically synthesized nor genetically engineered. The three main ingredients that were needed are molasses, food waste and distilled water. The molasses was dissolve into liquid form, by using boiling technique, where the molasses was combine with the distilled water. Then, the molasses, distilled water and food waste was combining together in an airtight container. After the fermentation process has completed, EM should be stored in a cool dark place and used within 1 month. When the pH is reach below 4.0, the EM is then ready to be used as partially water replacement in the concrete. The percentage of EM used in this research study is in the range 5% to 15%.

2.5. Concrete mixture
The dimensions and the calibrations of the concrete samples and moulds were in accordance with BS EN 12390-1:2000[7]. Thirty six cubes were prepared to determine the compressive strength at 7 days, 14 days and 28 days. All the concrete samples were fully immersed in the curing tank until the testing day. All the curing procedures were in accordance with BS EN 12390-2:2009 [8].

3. Result and discussion

3.1. Slump test
The slump tests were conducted for assessing the workability of fresh concrete. The mixing time, mixer's ability, and the uniformity of mixing plays important role in workability of fresh concrete.

Table 2 shows the results of slump test. Twelve specimens were prepared and the average results obtained were presented in Table 1. Higher slump value will produce greater workability of fresh concrete which in other words, make the compaction process become easier. This situation leads to the easier condition to achieved the desired concrete properties due to the low porosity and permeability of the concrete. The findings show that all concrete samples were satisfied the workability requirement which is should be in the range of 60 180 mm. The slump value for control mix is 70 mm and this value...
is similar with concrete incorporating EM. The slump value are slightly different at 5% and 15% EM, which the slump value is 69 and 71 mm respectively.

Table 2. Results of slump test for control and EM mixtures samples.

| Test mix | Sample | Water/cement ratio | Slump (mm) |
|----------|--------|--------------------|------------|
| Control  | A₀     | 0.5                | 70         |
| 5% EM    | A₁     | 0.5                | 69         |
| 10% EM   | A₂     | 0.5                | 70         |
| 15% EM   | A₃     | 0.5                | 71         |

3.2. Compressive strength

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces or maximum stress a material can sustain under compressive loading. When the limit of compressive strength is reached, materials are crushed. Compressive strength is calculated by dividing the maximum load with the original cross-sectional area of a specimen in a compression test. Table 3, show the overall results of compressive strength.

Table 3. Results of compressive strength for control and EM mixtures samples.

| EM content (%) | Mixture | Compressive strength (N/mm²) |
|----------------|---------|-------------------------------|
|                |         | 7 days | 14 days | 28 days |
| 0              | A₀      | 14.056 | 18.382  | 25.017  |
| 5              | A₁      | 14.515 | 19.774  | 26.557  |
| 10             | A₂      | 16.087 | 21.143  | 27.623  |
| 15             | A₃      | 15.344 | 18.659  | 25.440  |

Figure 1 shows the compressive strength of concrete at different curing period. 36 specimens were prepared for compressive test. The results shows that concrete mixture with 10% EM as water replacement have the highest compressive strength, 27.623 N/mm² at 28 days. This is followed by 5%, 15% and control which the compressive strength were 26.557, 25.440 and 25.017 N/mm² respectively. The presented results shows that the presence of the EM had increased the compressive strength. The compressive strength increased uniformly with the increasing of EM content. However when the EM content reached 15%, the compressive strength started to decrease. The improvement in compressive
strength is due to the aerobic activities of EM. Total volume of air voids will become lesser as the internal air was used by the EM inside the concrete. This situation lead the concrete to become denser and then exhibits higher compressive strength [6].

4. Conclusion
The conclusions that could be drawn from this study are as follows:
1. The degree of the workability of concrete mixture with EM had similar result with the conventional mixture. The differences results between each samples (control, 5%, 10% and 15%) were not very significant.
2. The optimum EM content is 10%. This is because from the results obtained, 10% of EM replacement had the highest compressive strength, 27.623 N/mm² compared to other mixture.
3. The acidic and aerobic activities of EM, influence the concrete strength [6].

References
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