Effective microorganisms composite scupper drain (EM-CSD) as a new revolution in drainage system: A preliminary study

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Abstract. Effective microorganisms composite scupper drain (EM-CSD) system, which is designed using eco-composite in porous concrete with the concrete mixture and a cement replacement, consists of the waste material elements that being recycled, such as wood waste ash, egg shells, rice husk ash (RHA), and many more, for the purpose of managing stormwater quantity and quality, and also for ecologically sustainable development. The numerous eco-composite materials researches have been conducted, specifically for the building materials. In addition, several impermeable surfaces including sidewalks, secondary roads, and also parking lots in several countries have used the porous concrete materials, as it is good quality in terms of the concrete strength, the porosity, the workability, and also the maintenance cost reduction. Besides, previous researches related to effective microorganisms (EM) as an admixture in concrete have been done, as a part of construction materials. However, the previous researches of eco-composite, specifically using RHA and EM did not focus on the drainage systems. Therefore, this paper presents a preliminary study of EM-CSD system using RHA and EM as a cement replacement, as a green technology and sustainable development in urban drainage systems. This kind of technology is a new revolution to replace the existing drainage systems, with high cost effective consideration, high concrete mixture strength and workability, and low temperature. For the part of the research, Shah Alam, Selangor as the main study area to implement this kind of the new drainage system technology for the purpose to reduce the flash flood phenomenon, to overcome the dengue fever issues due to stagnant water in the drainage system, and also vandalism of the drainage cover, which cause a safety issue for public. This preliminary study using EM-CSD as a new revolution in the drainage system indicates the eco-composite porous concrete mixtures are expected able to overcome the drainage system problems with low cost maintenance and high on concrete strength and workability.

1. Introduction
Nowadays, there is an increasing of impervious surface due to the rapidly increasing on urbanization. This kind of condition has influenced to cities and also public. Besides, it gives several impacts to urban stormwater management, including the drainage systems, where some issues on flash flood due to the excessive stormwater runoff, water pollution and many other issues related to this urbanization and urban stormwater management. In order to overcome this issues, several researches related to the urban stormwater management using pervious concrete either for drainage system or in parking areas have been conducted in many countries around the world with variety of purposes, such as to recognize the utilisation of pervious concrete in order to decrease the excessive stormwater runoff and to overcome water pollution, to develop a new techniques in using pervious concrete for paving roads,
or any non-structural components, to apply and enhance the sustainable ways to recharging groundwater.

The drainage system, especially in urban areas that design with porous concrete materials as a cement replacement using waste material such as wood waste ash, egg shells, rice husk ash (RHA), and many more, for the main purpose to reduce the flash flood phenomenon. Specifically, for RHA, there are some benefits using this material as a cement replacement, such as, the improvement of the concrete mixture strength, the high on material cost savings due to reduction on cement usage, high concrete mixture strength and workability, environmental benefits to the removal of RHA waste where the wastes have been identified to use in concrete mixture.

Other than that, the effective microorganisms (EM) that was founded in the early 1980s by Dr. Teruo Higa, a Horticultural Professor from Japan are added as admixtures in EM-CSD system as the EM have many benefits, for example, the improvement on the concrete mixture strength and the workability, as investigated by several researchers [1–4]. EM is a set of co-existing microorganisms in a culture solution, where it is naturally available, not genetically modified, environmentally friendly, and display as co-existence and co-prosperity.

However, there is lack of significant research using eco-composite (RHA) and EM in porous concrete for drainage system, mainly for scupper drain system. This type of waste materials are being used as construction and building materials such as RHA usage by [5–7], egg shells by [7–9], sawdust ash (SDA) [10], and many more.

This paper presents the preliminary study on eco-composite using RHA and EM in porous concrete for drainage system, focusing on EM-CSD as a new revolution potentially replace the existing drainage systems for urban flood management systems.

2. Problem Statement

Generally, this research is focusing in Shah Alam, Selangor as the main study area because of the common issues related to the flash flood because of the numerous of the impermeable areas including roads, parking lots, the pedestrian areas, and also drainage systems (Figure 1). In addition, improper drainage conditions due to clogging with garbage, sedimentation, and also issues on drainage systems maintenance and cleaning services, also cause flash flood to get worse. In order to overcome the issues on flash flood and the poor drainage systems, the eco-composite using RHA and EM can be implemented as the porous media in the concrete drainage system. This new technology in the drainage system as a part of urban stormwater flood mitigation measures, which is expected able to reduce the flash flood in Shah Alam, and also to improve the drainage system with green technology in the drainage concrete mixture.

Recently, flash flood phenomenon in Shah Alam are very common not only during the monsoon season, but also during normal days with heavy rain occur. As Shah Alam is called the capital city of Selangor state, it has become an image problem for Majlis Bandaraya Shah Alam (MBSA) to public. Because of that, MBSA need to take this issue seriously. Therefore, this research using EM-CSD is expected can reduce the flash flood issues in Shah Alam.

Figure 1. Shah Alam, Selangor is one of the example of flash flood area.
In addition, other issues related to the poor drainage system is dengue fever, where Shah Alam, Selangor also being affected by this vector-borne disease (Figure 2). Since the issue of dengue fever due to Aedes mosquito should not be underestimated, MBSA as the main public authority in Shah Alam need to overcome this issue. Due to that, the poor drainage system is a part of it to be improved.

![Figure 2. The clogged drainage system cause the Aedes fertilization increase.](image)

In order to overcome the flash flood issues specifically in urban area, one of the important elements is to improve the drainage system with proper maintenance. Besides, in term of cost optimization, sustainability, and materials workability, it is recommended to implement the porous concrete drainage system. Thus, this research implement EM-CSD as a new drainage technology using eco-composite materials, which is more environmental, low cost in term of drainage maintenance, and high concrete mixture strength and workability.

3. Effective microorganism composite scupper drain (EM-CSD) system

Several areas in Shah Alam, Selangor have been installed with the eco-composite drainage systems using EM (Figure 3) as the main purpose to reduce flash flood and also the improvement on drainage systems problems that affect to public safety and health issues. This kind of technology are being implemented for one of the drainage types, which is scupper drain system. The implementation including the new design of scupper drain, and also the usage of RHA and EM in concrete mixture affect to drain maintenance and cleaning work become easier.

The EM-CSD system is selected as the new revolution in drainage systems, by considering several factors with the current conditions and ecosystem, such as high material and installation costs, high maintenance costs, long duration for cleaning work, long construction period, drain clogged with garbage, low design strength, the bed rough surface causes resistance to water flow, public safety and health, and also traffic conditions. Table 1 shows 4 different designs with several criteria, i.e. cost, creativity, capability and also laboratory testing being conducted for material strength testing. From this evaluation, Design 4 is selected as the best option for EM-CSD (Figure 4).

![Figure 3. (a) Before and, (b) After the implementation of EM-CSD in Shah Alam, Selangor.](image)
Table 1. Composite porous concrete (CPC) slab design selection evaluation.

| Evaluation criteria | Design 1 | Design 2 | Design 3 | Design 4 |
|---------------------|----------|----------|----------|----------|
| Design              | ![Image]  | ![Image]  | ![Image]  | ![Image]  |
| Cost                | 3        | 2        | 1        | 4        |
| Creativity          | 2        | 2        | 3        | 5        |
| Capability          | 2        | 3        | 3        | 5        |
| Mark                | 7        | 7        | 7        | 14       |

*(Scale: 1 for unsatisfactory – 5 for very satisfying)*

Figure 4. EM-CSD based on Design 4.

Besides, the installation and implementation of EM-CSD give positive impact on cost saving as compared to the existing drain design systems. Table 2 indicates the cost comparison between the existing drainage systems and the EM-CSD.

Table 2. Cost comparison between the existing drainage systems and the EM-CSD.

| Type of drain              | Cost of Labour | Cost of Machinery |
|----------------------------|----------------|------------------|
| Existing Drainage System   | 4 persons x RM80.00/day x 2/month = RM 640.00 | 1 x RM550.00/day x 2/month = RM 1,100.00 |
| EM-CSD                    | 1 person x RM80.00/day x 2/month = RM 160.00 | 0 x RM80.00/day x 2/month = RM 0.00 |
| Cost Saving using EM-CSD  | RM 480.00      | RM 1,100.00      |

Other than that, EM-CSD also has some special features in terms of concrete mixed design strength, and also the temperature is lower and cold as compared to the existing materials used in the conventional drainage systems. It is shown in Figure 5 and Figure 6 where several laboratory testings have been done in order to determine the EM-CSD design concrete mixture strength and workability, and comparing with the existing drainage systems materials. While Figure 7 shows the lower temperature have been identified when using EM-CSD design concrete mixture.
4. Conclusion
The new revolution using EM-CSD system to replace the conventional drainage design system will definitely give benefits to public in reducing flash flood and maximize water filtration. Besides, the specialty of EM-CSD including the cost savings, the high strength on the design mixture with lower temperature as compared to the existing drainage systems have been approved by this preliminary study.
Finally, this research is expected to be a part of urban stormwater flood mitigation measures in order to overcome related drainage system issues like flash flood, cover slab vandalism, and also Aedes fertilization due to stagnant water in the drain due to the clogged drainage system.

5. References

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