International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-5, January 2020

Potential Effects of Microorganism to Reduce Building Defects in Malaysia

Monirul Islam, Sarajul Fikri Mohamed, Shogo Musbau Adeniyi, Alghamdi Khalid Ahmed M, Karban Abdullah Saeed

Abstract*: Over the last few years, building defects is major concern in Malaysian construction industry. Design mistake or building flaw define as a defect which reduces building value and make a hazardous situation. A Building defect arises due to various reason, such as low handiwork or the use of adherent components, climatic construction, and faulty design. Building defects never emerge to have been minimized in contempt of new improvement in building technology. Defective building construction contributes both final cost of the product and cost of maintenance, which can be generous. By using effective microorganism (EM) in concrete building defects such as surface cracks, fatigue cracks and thermal contraction can be reduced significantly. Previous works in Japan and Malaysia found that effective in agriculture microorganism makes it possible increasing crop yields to twice or three times what they are at present to do so without the agricultural chemicals or artificial fertilizers, 5% of EM mixed into the concrete the tensile, compressive and flexural strength were 25.23%, 143.90% and 19.17% that are compared to design compressive strength that signify improve the concrete strength and durability. By using 25% EM in concrete the tensile strength was higher than the lower dosage. From the previous study, fermentation is the main notion in EMC in which the process will not produce detrimental texture. The research was carried out to investigate the potential usage of effective microorganism and its application in concrete that can help to reduce the building defects and improve building strength and durability. It was observed that most cost-effective and maximum percentage of EM mixed into the concrete is 5% in which enhancing its compressive, tensile and flexural strength.

Keywords: Effective Microorganism of Concrete (EMC), Crack, Defects, Cost, Effectiveness.

Manuscript published on January 30, 2020.
* Correspondence Author
Monirul Islam*, Department of Quantity Surveying, Faculty of Built Environment, University Teknologi Malaysia, Johor Bahru, Malaysia, monir176@gmail.com
Sarajul Fikri Mohamed, Department of Quantity Surveying, Faculty of Built Environment, University Teknologi Malaysia, Johor Bahru, Malaysia, sarajul@utm.my
Shogo Musbau Adeniyi, Department of Quantity Surveying, Faculty of Built Environment, University Teknologi Malaysia, Johor Bahru, Malaysia, sogo4qs@gmail.com
Alghamdi Khalid Ahmed M, Umm Alqura University, College of Engineering and Islamic Architecture
oraijart@gmail.com
Karban Abdullah Saeed, Umm Alqura University, College of Engineering and Islamic Architecture
Arch-ask@hotmail.com

I. INTRODUCTION

Currently, concrete application is constantly growing around the world due to its availability of basic ingredients. Cement is the main element of concrete that has a greater impact on global warming on the environment. Making sustainable concrete is therefore one of the instantaneous environmental justification requirements. Concrete admixtures with filling capacity can be implemented and their characteristics improved. There are some herbal waste materials that have extra capacity to produce less brittle concrete as a partial substitution for ordinary Portland cement. Construction issues and combining the difficulty of construction using waste materials are reasonable evidence of any other form of concrete. Bacterial concrete is a unique area of study and can be used for cemented materials that use the bio-mineralization mechanism to cure it automatically. The aim to introduce microorganism into concrete is to precipitate calcite through pores and small areas of the cavity. The presence of pores and micro-cracks in the hydrated cement paste can have a great effect on the concrete properties and could provide a route through which humidity, chlorides, carbon dioxide and other hostile retailers could penetrate. Mostly the microcracks will intensify without sufficient and immediate consideration, causing the concrete strength to deteriorate and collapse. According to Wang *et al.* 2012 [1], the concentrations of microorganism or variety of colonies are not cited as the factor and bacteria are typically bought from the lifestyle collection centers. Distinct mobile concentrations of microorganism had been introduced in concrete to achieve most efficient attention of bacteria that may increase its electricity notably. Bacteria became directly isolated from the tropical surroundings and its extraordinary concentrations had been extracted primarily based on the correct serial dilution factor. Bacillus is a sort of microorganism that may produce as a binding filler cloth to decrease concrete capillary pores to improve its energy and sturdiness. According to De Muynck *et al.* 2008 [2], there are some species of Bacillus that produce urease enzyme to precipitate calcite associated with biomineralization. According to Rao *et al.* 2013 [3], The process of bio-mineralization will not interfere with concrete laying time. It is therefore appropriate to use any concrete mix design standards for bacterial concrete.

Based on the mechanism for bio-mineralization (precipitation of CaCO3), this new approach can significantly reduce the protection fee required for bacterial concrete due to its longer life span boom, a good way to reduce atmospheric CO2 emissions, thus helping to reduce the demand for cement. Based on the mechanism for bio-mineralization (precipitation of CaCO3), this new approach can significantly reduce the protection fee required for bacterial concrete due to its longer life span boom, a good way to reduce atmospheric CO2 emissions, thus helping to reduce the demand for cement. According to Wu et al. 2012 [4], the equations show a sequence of biochemical response occurring with the help of ureolytic bacteria to form calcium carbonate in cemented fabric. The present work shows that the mechanism of bio-mineralization in cemented materials can be the appropriate method for improving the characteristics of structural concrete. Hence, to gain extra potential to recognize the outcomes of microorganism in concrete, more investigation should be carried out to observe the importance. Costs are without a doubt the most vital concern in any business try, not slightest in the development business.[5]

II. BUILDING DEFECTS IN MALAYSIA

Defect is defined as [6] a aspect which has a shortcoming and no longer fulfils its intended feature". However, constructing illness is "a failure or shortcoming within the characteristic, performance, statutory or person necessities of the structure, cloth, offerings or different facilities". According to Buys and Roux, 2013 [7] building defects can categories into two which are: a) patent and b) latent defects. Patent defects can be diagnosed at some point of production's inspection and all through. According to Isa 2011 [8], Defect Liability Period (DLP) evaluate to latent illness which normally occurs after the building is occupied. Normally, constructing defects will occur via wear and tear [9]. There are various kind of building defects which causes by using moisture problems inclusive of staining, discoloration paint, peeling paint, blistering of wallpaper, corrosion and mold. The staining troubles in rendered wall are because of one-of-a-kind moisture contents with numerous origins inclusive of ground, rainfall etc. [10]. Rainwater is considered as one of the prime causes for staining problems on façade.[11]. For the discoloration of paint, peeling paint and blistering of wallpaper are because of water seepage and leakages ([12];[11]). The corrosion disorder at steel sheeting and AI sheet is due to (1) materials together with incompatible substances and presence of micro-organism, (2) environmental elements inclusive of pollution, direct exposure and moisture infiltration, (three) chemical effects [13]. For mould to grow, it needs 4 elements along with viable spores, a nutrient source as timber, carpet or and so forth, moisture, and heat. Kubba, 2008 [14] observed that the increase of microbes inclusive of mold, fungi, microorganism are cause by excess moisture at the building elements with a view to pollute indoor air best that could an negative impact on fitness risk. Most mould troubles befell at ceiling, floor and wall. For medical institution study was carried out by Othman *et al.* 2015 [15], in which moisture troubles have prompted building defects consisting of peeling paint, discolored paint, blistering of wallpaper, staining, sweating on wall and water marks or fungus. According to Of and Mosque 2018 [16], there are usually diverse causes and kinds of defects (layout and creation deficiencies) that affect the overall performance of a construction. Home defects also include dust, honeycomb, roof defects, mortar joint deterioration, reinforced steel corrosion, base failure, peeling paint, faulty plater rendering, and wood rot. A disorder is typically defined as deterioration, damages, default or deficiency [9] Besides, there are few levels of defects which patent degree can be, latent stage, progression degree and habitual degree. The patent stage and latent degree defects regularly can be seen in buildings and the defects occur at some stage in the building life cycle [9] On the opposite hand, the styles of defects that have an effect on the building is terrible workmanship, production cloth, loss of supervision and protection, confined time and cost, faulty design, climatic situation, and external surroundings [16]. The reason why disorder takes place within the buildings may be due to non-compliance with the Building Code and does not follow the same old technique when constructing the paintings. Therefore, maintenances are needed to be able to save you those types of defects which might be take place.

III. CRACKS IN BUILDING STRUCTURES

Of and Mosque 2018 [16] studied about Cracks that can be categorized according to the extent of the crack, such as a classic crack and balance crack; the shape of the crack, such as a horizontal, vertical, diagonal or random crack, and the width of the crack, ranging from a delicate crack to a large crack. Cracking usually can arise in numerous elements inside the buildings. In addition, cracking is also an indication of corroded strengthening. It is possible to use precautionary steps to reduce the cracking that appears in buildings. Structural and non-structural cracks can be categorized as cracks. Samples with standardized defects had been best handled at the facet containing the illness. Structural cracks normally may be located in wall, columns or the beams and its miles purpose by using lifeless masses or different forces that carried out on it. Other than that, terrible soil bearing, terrible production web page and overloading may additionally motive structural cracks to be formed as nicely defined by [16]. According to Of and Mosque 2018 [16] expressed as non-structural cracks will occur in the building substances due to internal stresses. Usually, tensile, compressive and shear cracks are the structural cracks that can be seen. If any of the imposed tensile loads are not preserved by the structural factors, then cracking will occur within the tensile. There are usually few gaps in slab and beams. In addition, shear cracks were also subjected to the causes. If the fabric's compressive electricity is less than the hundreds levied, then it will manifest the compressive cracks. Columns usually have problems of this kind. Furthermore, many varieties of cracks can occur within the concrete surface including transverse and longitudinal cracks, surface and map crazing, long-length shrinkage drying, plastic cracks and early thermal contraction.

IV. BIOLOGICAL CRACKS REPAIR TECHNIQUE

According to Van Tittelboom *et. al.* 2016 [17], two traditional restoration methods were used to determine the precipitation form of bacterial CaCO3. A2-factor epoxy resin (Sikadur52) and a 2-issue cement-sure mortar (Sika Top 111) were used to repair cracks. The specimens are rendered dust-unfastened and clean by using a soft brush before the remedy. Close the crack, a tape changed into applied at a range of about zero.5 cm, so a small sector around the crack could be impacted by the repair cloth in the handiest way. The epoxy resin and the mortar are arranged in accordance with the consumer indicators. The 2-thing epoxy resin was injected inside the crack by

Table 1: Scholars studies on characteristic of several cracks

No	Type of Crack	Characteristic	Author(s)
1	Transverse	Transverse cracks are the most common and dangerous cracks, as they can reduce the cross section of a structure and thus reduce its structural strength. Transverse cracks are perpendicular to the beam structure's longitudinal axis.	[18]
2	Longitudinal	Longitudinal cracks can affect the torsional ability of a structure. Longitudinal cracks are parallel to the beam structure's longitudinal axis.	[18]
3	Shear	Shear cracks have an angle around the beam structure's longitudinal axis.	[18]
4	Surface Crack	Research has shown that surface cracks are more important than subsurface cracks in the dynamic behavior of structures.	[19]
5	Plastic Shrinkage	Hard concrete shrinkage can be divided into three main categories: drying shrinkage, plastic shrinkage, and ending genous shrinkage. Drying shrinkage strongly depends on the environment's humidity and the concrete's water – cement ratio. The evaporation of water produces suction in the pore fluid as wet concrete dries, which causes the concrete to contract. Plastic shrinkage in early age occurs when the level of water evaporation from the concrete surface reaches its bleeding rate, resulting in high capillary pressure near the surface.	[20]
6	Fatigue	While the tiredness mechanism in concrete is not clearly understood due to the heterogeneous composition of the material, studies have shown that tired concrete loading initiates the growth of microcracks at internal flaws locations. Fatigue crack propagation in concrete relies on the relationship between the growth of the microcrack which facilitates further cracking and the aggregate crack bridging which prevents further cracking. Concrete structures can take more than one million cycles to collapse, depending on the degree and direction of pressure. Fatigue cracks, however, can cause excessive deformations, large crack widths, and debonding reinforcement all of which can result in severe structural failures.	[21]
7	Map Crack	Also known as pattern crack, this type of crack. It is common in any of the concrete structures to be seen. The main cause of this crack is due to expansion due to alkali-silica reaction (ASR) and concrete layer drying and shrinking. It can be avoided by stopping liquid from being added or finished while bleeding still occurs	[18]

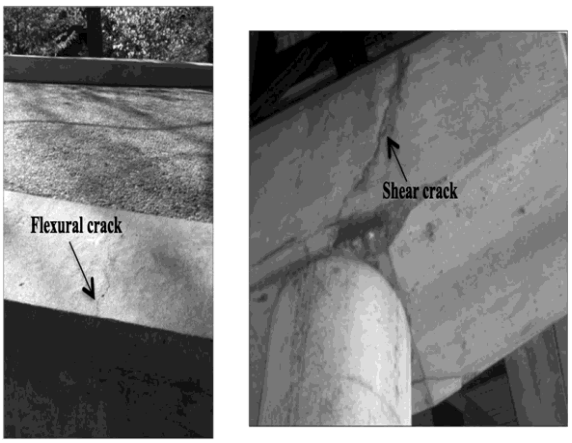

Figure 1. Left: a flexural (transverse) crack in concrete; right: a shear (slant) crack in a concrete beam [22]

the use of an injection needle. The cement-certain mortar (grout) became implemented the use of a spatula. The samples with sensible cracks, received from the splitting check, were treated on both facets. Samples with standardized cracks had been simplest dealt at the aspect containing the crack. Cracks had been also repaired via the use of $CaCO_3$ precipitating bacteria. Within the preceding research, B. Sphaericus (BS) strains are isolated by a biocatalytic ureolytic calcification reactor from calcareous sludge. Six unique traces are outstanding from their morphology. The distilled strains were deposited with the serial numbers LMG 222 55 till LMG 222 60 on the BCCM tradition series in Ghent. Because of its most desirable CaCO3 precipitation ability, the strain LMG 222 fifty-seven was selected for the treatment of the samples [23]

A. Epoxy-Injection Method

The tensile, compressive and binding strength of epoxy compounds is very strong. But, when used as bonding or binding materials for cement, they can be used to repair mortars.

The cost of epoxy concrete is forbidden and cracks as slim as 0.05 mm can be bonded by epoxy injections. It is an impressive towel to patch cracks because they have outstanding residences that are resistant This approach has been efficiently used within the restore of cracks in constructing, bridges, and other styles of concrete structures (Doshi, 2018). Epoxy compounds have compressive, tensile and bond strength in their entirety. But, when used as bonding / binding agents for concrete such as epoxy cement, they can be used to repair mortars, the price is forbidden and cracks as slim as 0.05 mm can be confined by epoxy injections. It is notable material for servicing cracks because they have superb homes inclusive of resistant towards water percipience, immune to fracture formation and their superb gluey houses. This technique has been used efficiently inside the restoration of cracks in bridges, building, and other forms of concrete constructions. By using the restore technique to clean the cracks, the first real step is to smooth the fracture that have pollutants along with oil, first-class particles, dirt or grease and such pollutants prevent the epoxy percipience into the cracks to be rectified. surface cracks must be sealed by using sealing of surface. It is used to avert leakage of the epoxy earlier than it is gelled. This can be done by adding an epoxy, polyester or other suitable fastening substantial to the crack floor and permitting it to be hardened. By installing the venting and entry ports, when the v-grooved cracks form drill holes are made within the 20 mm diameter groove apex of the v-grooved phase is below. Furnishings including pipe nipples are added into the holes. If cracks are not v-grooved, the concrete face over the crack to be bonded. By epoxy mixing, it is carried out either via non-stop strategies or batch. The adhesive additives are premixed in batch mixing in compliance with manufacturer's orders, typically the use of mechanical stirrer, such as paint mixing paddle. The liquid adhesive components bypass through metering and driving pumps before passing through an automatic mixing head in the continuous method. Crack repair can achieve with the following strategies that are epoxy-injection routing, grouting and sealing bendy sealing by stitching, , drilling, offering additional reinforcement and plugging, grouting, prestressing steel, dry packing overlays autogenously recovery surface coatings.

Figure 2: Repair of cracks by Epoxy-injection method [24]

B. Grouting Method

By filling the Portland cement grout in the affected areas, cracks in thick concrete wall and gravity dams can be repaired. This approach has been shown to be advantageous in stopping water leakage, but It will no longer structurally bind broken sections. The very first step in this approach is to use air jetting or water jetting to clean the concrete alongside the crack, install grout nipples at suitable intervals, seal with sealant between the seats, flush the crack to smooth it and test the seal and grout the whole area. Additionally, plastic agreement cracks can be used to enhance the grout's homes. Silicates, urethanes and acrylomides are chemicals used for grouting. In contrast to concrete grouts consisting of solid particle suspensions in a liquid, two or more chemical substances are combined to form a gel, foam, or stable precipitate. In moist conditions and in very first-rate fractures, chemical grouts can be used. But with some drawbacks for gel time control. (Doshi, 2018). By using two techniques of grouting cement from Portland to repair cracks in any chosen area. Liquid solution or Slurry is called grouting injection into a form of rock or soil. The substance injected is called the grout. The Ordinary Portland Cement use for grouting is as per IS: 269 and as per IRS Concrete Bridge Code, sand and water should be. Admixtures can be applied with the Divisional Engineer's approval to offer non-shrinkable homes and improve grout float capacity. The weight ratio of water-cement for the grout is 0.4 to 0.5, the decrease ratio should be used if the crack width exceeds 0.5 mm. Pressure grouting gear is used in the cracks to pump grout. Air Compressor is used with three to four cum per minute capacity. The pressure of grouting will be two to four kg per square of Healing for fourteen days has to be done after grouting centimeter. All the grouting gear which involves the slurry and mixing drums, tubes, nozzles, etc. must wash completely to prevent equipment damage. After the completion of the work, it must be completely checked in cost by the Engineer and stored under observation after grouting for a duration of six months or more for its conduct. Its time eating method, though, but it's widely used as it gives higher results. The product of the grouting technique will restore the cracked part and increase its strength.

V. POTENTIAL USE OF EM IN CONCRETE REPAIR

The thinking of Effective Microorganisms (EM) used to be developed by using Professor Teruo Higa, University of the Ryukyus, Okinawa, Japan. EM consists of combined cultures of really useful and plausible microorganisms that can be utilized in concrete as an admixture to expand physical, mechanical and chemical homes of the concrete which limit building defects. EM carries selected species of microorganisms including predominant populations of lactic acid microorganism and yeasts, and smaller numbers of photosynthetic bacteria, actinomycetes and other sorts of organisms.

These are compatible with one another and can coexist in liquid culture. Cycling and produce bio energetic compounds such as vitamins, hormones and enzymes that stimulate concrete strength. Harmful microorganisms are those that can induce diseases, stimulate no longer proper concrete and produce poisonous and putrescent materials that adversely have an effect on concrete strength. An extra unique classification of really helpful microorganisms has been cautioned by Higa which he refers to as "Effective Microorganisms"or EM. EM is now not a substitute for other management practices. EMC is a product from Effective Microorganisms (EM). EM had broad functions such as in agriculture, environmental treatment, household usage, medicine healthcare, disaster treatment and construction industry. In agriculture, EM technological is how makes it possible to increase crop yields to twice or three instances what they are at present, and to do so except the use of agricultural chemical compounds or artificial fertilizers. Thus, Higa stated “I trust I have identified a way of tackling and solving the essential hassle of the food supply and second it lies in making use of the tiny creatures I called it as nice microorganisms”. The attainable of EM to aid in resolving issues of environmental air pollution is structured upon the action of two types of microorganisms: zymogenic EMs, wonderful microorganisms which produce the anti-oxidizing agents known as antioxidants, and sure synthesizing lines of anaerobic microorganisms. Apart from that, EM is additionally in a position to stop the “Sick House Syndrome” especially for the newly constructed building. Adding EM in concrete has already been practiced in Japan. This research has shown that plausible wonderful microorganism can minimize building defects and extend concrete strength. This lookup additionally suggests what kinds of building cracks, crack restore technique and software of viable high-quality microorganism in concrete. Costs contribute to major percentage of total construction costs[25].

In the preceding lookup [13] confirmed that concrete with 5% EMC admixture indicates a more suitable strength compared to the control set. The 1-day compressive power for 5% EMC admixture is able to obtain 53.07% of the attribute power (30MPa) compared to the manipulated set which is only done 36.53% of the characteristic energy (30MPa) in 1 day. These effects are charming to the construction enterprise at which the formwork elimination procedure can be shortened, and this subsequently expedites the complete development period. In pre-cast industry, high early electricity is crucial. This is mostly due to the tight schedule and the restricted framework in the casting yard. High strength of concrete enables the contractors to eliminate the formwork early and proceed to the next casting. In tradition, in order to gain high early strength, the contractors will add chemical admixture to the concrete which is fantastically highly-priced compared to EMC. Moreover, the uses of chemical admixtures are no longer environmentally-friendly. The low 1-day compressive strength for the instances with 25% EMC and beyond are frequently due to the hydration processes which used to be interrupted via EMC as concrete is in alkaline whereas EMC is in acidic state. The 28-day compressive energy of concrete with 5% EMC (43.17MPa) is capable to beautify the Grade C30 concrete by 43.90% compared to the designed characteristic strength. The contractors will normally add chemical admixtures into concrete in order to obtain higher compressive power which is now not environmentally-friendly and cost-effective. Leakage of chemical admixtures may motive pollution or hazards to the environment, but leakage of EMC will not having troubles due to the fact Effective Microorganisms (EM) science was once firstly formulated to decorate the boom of vegetation in the agricultural enterprise and catastrophe treatment. Hence, even although EMC leaks to the environment, it will now not possess any hazard to the surroundings however in contrasts, it will benefit to our surroundings as advisable microbes observed in the food industries are used in EM and the cloth is made locally. The oblique tensile electricity of the concrete and the addition of EMC had a positive relationship generally. The tensile strength develops more rapidly than the compressive strength and is typically about 10 to 15 percentage of the compressive electricity at a while of up to about 14 days, falling to about 5 percentages at later. By adding EMC, the tensile power is in a position to achieve 10.27MPa in 50% EMC which is 34.23% of sketch compressive strength. 50% of EMC is capable to enlarge the oblique tensile strength by means of 68.09% when compared to the control set are numbered with Roman numerals. Include a note with your final paper indicating that you request color printing.

VI. RESULT AND DISCUSSION

The major objective of the potential effective microorganism is to reduce the cost of construction and at the same time ensure safety or serviceability of the building over the life cycle. Paudel 2008 [26] revealed that the cost of construction is increasing by 50 per cent over the normal inflation due to hike in the cost of conventional building materials and labor. There is an imperative need to utilize potential effective microorganism technology options leading to cost-effective results. The market survey was carried out on the cost implications of building component without EM and cost implication of introducing a mixing culture with EM. Two major building components such as concrete and paint were compared and contrast with EM and without EM in table I & II respectively. Table 1 shows the cost implication of building component without the EM while 2 presents the cost implication of introducing a mixing culture with EM only.
The study involved five selected projects. From the results presented in the table it could be deduced that the cost per meter square of adding EM to achieve the objective of self-healing of crack not more than 3mm is achieved. From the result it can be deduce that the cost adding to achieve the desired objective is very minimal. The results are further shown the following graph.

Table 2: The cost implications of using concrete and skim coat without EM Building Components

A. COST OF BUILDING COMPONENTS					
Project	Area (M^2)	Concrete (RM)	Cost/M^2	Skim Coat (RM)	Cost/M^2
A	21,007.65	2,179,494.24	103.75	-	-
B	33,473.04	4,112,316.00	122.85	880,792.00	26.31
C	39,010.00	5,732,031.40	146.94	104,212.81	2.67
D	31,919.42	4,403,449.40	137.96	827,277.80	25.92
E	6,295.04	1,392,173.44	221.15	21,888.00	3.48
Average cost per m2			146.53		14.59

Table 3: : Cost implication of introducing EM

B. *COST OF MIX CULTURE IN BUILDING COMPONENTS*					
Project	*Area (M^2)*	*MC in Concrete*	*Cost/M^2*	*MC in Skim Coat*	*Cost/M^2*
A	*21,007.65*	*102,593.61*	*4.88*	-	-
B	*33,473.04*	*180,280.00*	*5.39*	*6,384.85*	*0.19*
C	*39,010.00*	*217,189.84*	*5.57*	*561.31*	*0.01*
D	*31,919.42*	*219,333.27*	*6.87*	*9,431.54*	*0.30*
E	*6,295.04*	*64,774.98*	*10.29*	*300.96*	*0.05*
C. Average cost per m2			*6.60*		*0.14*

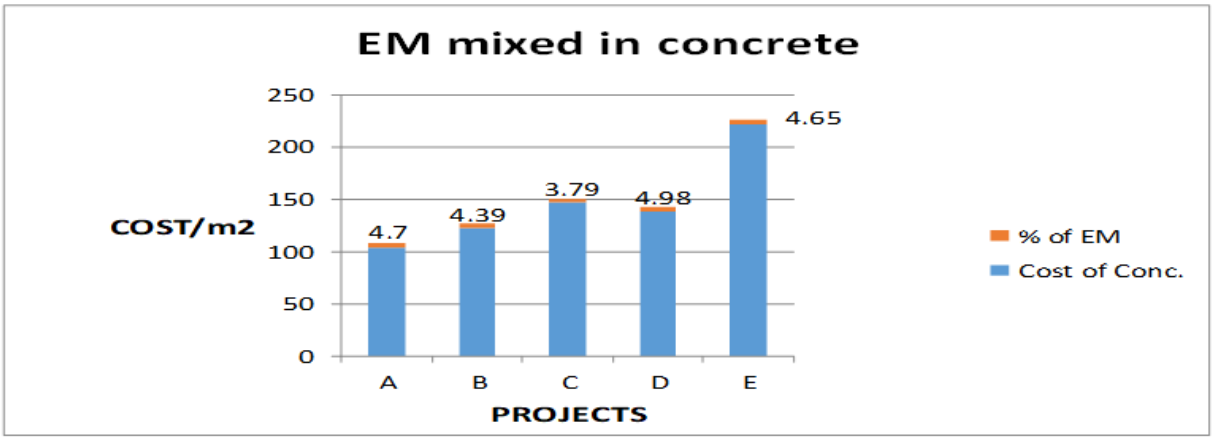

Figure 3: Assessment of introducing EM to concrete

The outcome of the analysis from the survey carried out on the five projects as shown in table 1 and 2 which indicates that the cost implication of using EM as remedies for cracks in building component is very minimal and affordable. The results indicate that the average cost of concrete work and EM is 146.53 and 6.6 respectively. This implies that EM is only 4.50% of the overall mixture in concrete. In the same veins the average cost of skin coat and EM is RM14.59 and RM 0.14 which means the EM in the remedies component is only 0.96%. Figure 3 shows the details of the concrete and EM in graphical illustration for all the five projects. The prices of inclusion of EM are shown as a percentage of the concrete component with an average figure of 4.5% and 0.96% for the concrete and skin coats elements respectively. The cost of EM at various projects is low and at the same time provides significant benefits in terms of strength, green material and minimizes cracks on plastering.

VII. CONCLUSION

The research was carried out to investigate the potential effective microorganism and its application in concrete that can help to reduce the building defects and improve building strength and durability. Potential Effective Microorganism generally enhances the mechanical properties of concrete.

If this mixing culture apply to structural component of the building the compressive, tensile and flexural strength of potential effective microorganism concrete is greater than the normal concrete respectively. The potential effective microorganism also provides high tensile strength. A lot of cracks such as flexural, transverse, surface, map, shear, longitudinal, plastic shrinkage crack also reduced by potential effective microorganism. Potential effective microorganism not only reduces building defects but also increases building strength and minimizes the construction cost. The admixture of potential effective microorganism in concrete is environmentally friendly and offers a relatively cheaper and better concrete admixture. Previous study shows fermentation is the main concept in EMC in which the process will not produce harmful substances. It can be concluded that it is more economical to add less than 5% of EM to building component in order to enhance compressive, tensile and flexural strength as well as provide the self-healing quality in case of cracks that is within 3mm. It is also used by popular traditional technique which is epoxy-injection method and grouting for crack repair.

ACKNOWLEDGMENT

The author would like to thank the Ministry of Education (MOE) Malaysia through Research University Grant (RUG) No 1501 UTM funding project title Development of Biocement Using Ex Situ Mixing Technique for Construction Materials, for financial assistances while conducting this research project.

REFERENCES

1. J. Wang, K. Van Tittelboom, N. De Belie, and W. Verstraete, “Use of silica gel or polyurethane immobilized bacteria for self-healing concrete,” *Constr. Build. Mater.*, vol. 26, no. 1, pp. 532–540, 2012.
2. W. De Muynck, D. Debrouwer, N. De Belie, and W. Verstraete, “Bacterial carbonate precipitation improves the durability of cementitious materials,” *Cem. Concr. Res.*, vol. 38, no. 7, pp. 1005–1014, 2008.
3. M. V. S. Rao, V. S. Reddy, M. Hafsa, P. Veena, and P. Anusha, “Bioengineered concrete - A sustainable self-healing construction material,” *Res. J. Eng. Sci.*, vol. 2, no. 6, pp. 45–51, 2013.
4. M. Wu, B. Johannesson, and M. Geiker, “A review: Self-healing in cementitious materials and engineered cementitious composite as a self-healing material,” *Constr. Build. Mater.*, vol. 28, no. 1, pp. 571–583, 2012.
5. K. Y. Siti Mazzuana Shamsuddina*, Rozana Zakariaa, Sarajul Fikri Mohamedb, Abd. Latif Salehc, Christiono Utomod, Muhd Zaimi Abd Majide and AFaculty, “Jurnal Teknologi D EVELOPING METHODOLOGY FOR CRADLE TO GRAVE,” *J. Teknol. Full*, vol. 16, no. 0, pp. 37–42, 2015.
6. L. S. Pheng and D. Wee, “Impact of iso 9000 on the reduction of building defects,” *Archit. Sci. Rev.*, vol. 44, no. 4, pp. 367–377, 2001.
7. F. Buys and M. Roux, “Causes of defects in the South African housing construction industry : perceptions of built-environment stakeholders : review articles,” *Acta Structilia J. Phys. Dev. Sci.*, vol. 20, no. 2, pp. 78–99, 2013.
8. H. M. Isa, “Learning from Defects in Design and Build Hospital Projects in Malaysia Haryati,” in *International Conference on Social Science and Humanity*, 2011, vol. 5, pp. 238–242.
9. O. A. L. a, M. F. Khamidi, and A. Idrus, “Sustainability in the Context of Maintenance : Building Defects in the Malaysian University Campuses,” *J. Retail Leis. Prop.*, vol. 9, no. 2, 2010.
10. I. Flores-Colen, J. de Brito, and V. P. de Freitas, “Stains in facades’ rendering - Diagnosis and maintenance techniques’ classification,” *Constr. Build. Mater.*, vol. 22, no. 3, pp. 211–221, 2008.
11. M. A. Hassanain, A. M. Al-Hammad, and F. Fatayer, “Assessment of architectural defects attributed to lack of maintenance feedback to the design team,” *Archit. Sci. Rev.*, vol. 57, no. 2, pp. 132–138, 2014.
12. P. S. Kian, “A REVIEW OF FACTORS AFFECTING BUILDING DEFECTS IN SINGAPORE,” *Dimens. Tek. Sipil*, vol. 3, no. 2, pp. 64–68, 2001.
13. T. A. N. C. Siong Andrew, I. I. Syahrizal, and M. Y. Jamaluddin, “Effective Microorganisms for Concrete (EMC) Admixture – Its Effects to the Mechanical Properties of Concrete,” *Casp. J. Appl. Sci. Res.*, vol. AICCE’12, no. AWAM International Conference on Civil Engineering & Geohazard Information Zonation, pp. 419–426, 2013.
14. S. A. A. Kubba, *Architectural Forensics*. 2008.
15. N. L. Othman, M. Jaafar, W. M. W. Harun, and F. Ibrahim, “A Case Study on Moisture Problems and Building Defects,” *Procedia - Soc. Behav. Sci.*, vol. 170, pp. 27–36, 2015.
16. M. Of and B. Mosque, “World Journal of Engineering WJERT MANAGEMENT OF BUILDING MOSQUE IN MALAYSIA,” vol. 4, no. 3, pp. 48–56, 2018.
17. K. Van Tittelboom, N. De Belie, W. De Muynck, and W. Verstraete, “Use of bacteria to repair cracks in concrete,” *Cem. Concr. Res.*, vol. 40, no. 1, pp. 157–166, 2010.
18. Y. Yao, S. E. Tung, and B. Glisic, “Crack detection and characterization techniques — An overview,” *Struct. Control Heal. Monit.*, vol. 21, pp. 1387–1413, 2014.
19. G. Sabnavis, R. G. Kirk, M. Kasarda, and D. Quinn, *Cracked shaft detection and diagnostics: A literature review*, vol. 36, no. 4. 2004.
20. R. I. Gilbert *et al.*, *Time-Dependent Behaviour of Concrete Structures*. 2010.
21. S. G. Shah and J. M. Chandra Kishen, “Use of acoustic emissions in flexural fatigue crack growth studies on concrete,” *Eng. Fract. Mech.*, vol. 87, pp. 36–47, 2012.
22. Y. Yao, S. T. E. Tung, and B. Glisic, “Crack detection and characterization techniques - An overview,” *Structural Control and Health Monitoring*. 2014.
23. J. Dick *et al.*, “Bio-deposition of a calcium carbonate layer on degraded limestone by Bacillus species,” *Biodegradation*, vol. 17, no. 4, pp. 357–367, 2006.
24. Mishra, “Epoxy injection for Concrete Crack Repair in foundations, basements, beams, columns, slabs, walls and other concrete structures,” *The Constructor Civil Engineering Home*, 2019. [Online]. Available: https://theconstructor.org/videos/epoxy-injection-for-concrete-crack-repair/5842/. [Accessed: 12-Oct-2019].
25. N. A. Khiyon and S. F. Mohamed, “Life cycle costing of mechanical and electrical services for private finance initiatives projects in Malaysia,” *Int. J. Tomogr. Simul.*, vol. 28, no. 3, pp. 96–103, Sep. 2015.
26. S. K. Paudel, “Engineered bamboo as a building material,” *Proc. 1st Int. Conf. Mod. Bamboo Struct. ICBS-2007*, vol. 5, no. 3, pp. 33–40, 2008.

AUTHORS PROFILE

Monirul Islam is currently a graduate research assistant at the Department of Quantity Surveying, Universiti Teknologi Malaysia, Johor Baharu, Johor. The author obtained his first degree in civil engineering in 2011 at the Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh. He has been working as an assistant engineer at Local Government Engineering Department (LGED). The research area is on Development of Operation and Maintenance Cost Model for Highway Projects. He is register Civil Engineer certified by the Institution of Engineers, Bangladesh. Now he attends a MPhil program in Quantity Surveying at the Universiti Teknologi Malaysia. He has more than 8 years of working experiences in field works in the consultancy firm, government and semi-government projects.

Associate Professor Sr Dr. Sarajul Fikri Mohamed is an academic staff at the Department of Quantity Surveying, Universiti Teknologi Malaysia, Johor Baharu, Johor where he specializes in Construction Management, Project Estimating and Construction Innovation.

He obtained B.Sc. in Quantity Surveying from Universiti Teknologi Malaysia (UTM). In the year 2002, he completed his Master of Science in Construction Innovation and PhD in Construction Management in 2006 from Loughborough University, United Kingdom. His research areas include construction procurement, construction innovation and commercial management in construction. Prior to this, he worked as property and construction consultant at MDA Consulting UK. The examples of projects he was involved in are Stratford Western Relief Road (Warwickshire County Council), William Baker Building (University of De Montfort), Airfield Business Park Market Harborough (William Davis), and Sport Complex Building (Leicestershire County Council). He has more than 17 years working experiences in related field.

Shogo **Musbau Adeniyi** is currently an assistant chief lecturer at the Federal Polytechnic, Offa, Kwara State, Nigeria. The author obtained his first degree in quantity surveying in 1997 at the Federal University of Technology Minna, Niger State Nigeria, and master's degree in construction management at the prestigious University of Lagos, Nigeria, in 2011. The research area is on Public-Private Partnership (PPP) and Green Materials for construction of affordable buildings. He is a registered member of Nigeria Institute of Quantity Surveyors (NIQS) and register quantity surveyor certified by the Quantity Surveyors Registration Board of Nigeria (QSRBN). Presently at the final laps of his Ph.D. in Quantity Surveying program at the Universiti Teknologi Malaysia. He has about 20 years of working environment in academic and practical works in the construction industry.

My name is **Khalid Alghamdi** I am from Makkah, Saudi Arabia. I studied Design and earned a bachelor's degree in Graphic Design from Umm Al-Qura University in 2007. Since then, I have been working as a teacher assistant at the Graphic Design department at the same university. While working as a teacher assistant, I participated in several researches, studies, and design projects at Excellence in Haj and Umra Research (CEHOR) and other centers in Saudi Arabia. In 2010, based on excellence in work and effort he received a full scholarship at the University of New South Wales in Sydney. Then in 2012, he earned a Master's degree in Design from the University of New South Wales college of Fine Arts in 2012, also I work as a contemporary artist and I have a lot of art projects acquired from the Saudi Contemporary Museum in Riyadh and Ather gallery and Hafez Gallery in Jeddah. Now I attend a Ph.D. program in urban and regional planning at University Technology Malaysia.

My name is **Abdullah Karban** I am from Makkah, Saudi Arabia. I studied Architecture and earned a bachelor's degree in Architecture from Umm Al-Qura University in 2008. Since then, I have been working as a teacher assistant at Islamic Architecture department at the same university. While working as a teacher assistant, I participated in several researches, studies and design projects at Excellence in Haj and Umra Research (CEHOR) and other centers in Saudi Arabia. In 2013, I worked as a Graduate Research Assistant at the Center for Urban and Regional Planning Research, at The University of Texas at San Antonio. Then in 2014, I earned a master's degree in Urban and Regional Planning from The University of Texas at San Antonio. In 2015, I worked at prince Khaled Al-Faisal Chair for developing informal areas in Makkah region. Now I attend a Ph.D. program in urban and regional planning at University Technology Malaysia.

.