Record Keeping and Archiving of Materials' Sample for Sustainable Floor Tiles Maintenance

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Abstract-**The use of ceramic tiles as floor finish is associated with some problems. One of these problems is the lack of proper record of the tiles used. Samples used are also not kept for future references. This has resulted into the occurrence of uncoordinated maintenance activities with the resultant effect showing in the existence of tiles of different colours and sizes within the same space after the initial life span of the tiles. This paper investigates some of the reasons behind the use of tiles of different colours and sizes as replacement for faulty ones during maintenance and advocates for proper record keeping and archiving of materials used for building construction. It employed the use of physical measurement of affected portions within the same floor of different buildings in institutional buildings that are exposed to strong human traffic. Findings show that lack of proper record and archiving of previously used tiles for future references can lead to the use of any available tiles for replacement. This is also found to alter the aesthetic outlook and the rhythm of the respective floors thus resulting into very ugly and unsightly building finish.**

Keywords: ceramic tiles, record, archive, maintenance, colour, size,

I. Introduction

The frequency or otherwise of maintenance activities in buildings depend to a large extent on the quality and the type of materials used in the process of construction. Ascertaining the performance of materials under peculiar conditions according to Barriera and de Freitas (2007) are germane to determining their durability. Maintenance also depends among other factors on the method of construction and the expertise of the workmen involved in fixing the materials (Zhao and Zhang, 1997). The design, methods of construction, materials' colour, texture, detailing and finish categorically determine the behavior of building skin - building fabric or wall materials (Aosmohor, 2010). The decision on specification of a particular material goes a long way to determining the future cost of maintenance, quality, life-span and value of the building as identified by Yiu (2007). One of the most important functions of floor finishes is to protect the main structure and enhance aesthetics elements (Zhano and Zhang, 1997; Brock, 2005). Utmost care must be given to its design and selection (Low et al, 2008; Carmody et al, 2007; Chua and Chou, 2010)

Most often, records of the materials used which should comprise of their quality, life span, manufacturer's guarantee, coating or consolidated protection, possible time for replacement, source of the material, chemical properties, physical properties and the mechanical properties among others are not kept. Whereas the adoption of appropriate maintenance strategies in the findings of Flores-Colen and de Brito (2010) such as record keeping and archiving of samples of materials used are essential to control the first stages of degradation. The method of construction that will increase the moisture permeation resistance of building materials especially on the surface treatment of finishes will enhance the longevity of the material and reduce the frequency of maintenance (Chunxiang et al, 2009). It is pertinent to mention that provisions either legally or procedural are not made for the keeping of such records within the ambit of the building procurement process in most countries.

Issues relating to archiving of materials - a system whereby samples of the materials used are kept for reference purposes and for the sourcing of such materials for maintenance works in due dates are rarely mentioned within the construction industry. This was identified as a source of major criticism of the construction industry by other sectors of the economy (Dulaimi, 2005). Some building materials such as sandcrete blocks, concrete, wooden roof trusses, sand and steel reinforcement components may not need to be archived because they are already regimented and consistent in properties, although there are minor differences in the composition of sand and granite in different climates. However, Demian and Frutcher (2005) observed that access to appropriate information

from archive will reduce the confusion that may confront a maintenance contractor who is working on a particular building for the first time.

Building materials that are used especially for finishes are dynamic in purpose and manufacturing. Some of these materials such as ceramic tiles, vitrified tiles, marble tiles, plastic and steel tiles are always changing. The dynamic nature of these products is evident in the consistent change in colour, shape and thickness as opined by Silvestre and de Brito (2011). Even though the chemical composition may remain the same, the physical and mechanical compositions are consistently subjected to current aesthetic drive. Torres and Alarcon (2003) opined that there is an increase demand for new ceramic tiles, this ever increasing demand is responsible for more production that takes attention away from record keeping and archiving of old productions.

Records have shown that ceramic tiles that is the most commonly used among these family of tiles due to many factors such as its cost advantage, availability, ease of production compared with others and ease of handling by local workmen will only last for between 20-30years when used as floor finish and for about 100years when used as wall finish (ASTM, 2005). However, Wetzel et al (2012) suggest the use of porcelain tiles as better alternative due to their higher resistance to moisture penetration. Since replace of ceramic tiles that are used for floor finish are expected to be carried out within 20-30years after application, it is therefore necessary and essential that the record of the type used are kept while samples are also archived so that whoever is saddled with the responsibility of carrying out or overseeing the maintenance works at due date will have adequate information to act upon.

Various factors that are responsible for the failure of ceramic tiles used as floor and wall finish have been investigated (Zhao and Zhang, 1997; Chew, 1999; Nicoletti et al, 2002; Torres and Alarcon, 2003; Mahaboonpachai et al, 2010; Bovea et al, 2010; Silvestre and de Brito, 2011). This paper examines the challenges that are faced when replacing faulty portions and the end product of the activities. It also identified the problems that are associated with improper record keeping in the construction industry in terms of materials used for floor finish in institutional buildings and the resultant outcome on the replacement of floor tiles on due dates for maintenance. It focuses on how this affects the aesthetic outlook of the floors of the buildings in the Faculty of Built Environment of the Universiti Teknologi Malaysia that is used as a case study. This serves as a test case for all the buildings within the campus that are subjected to heavy pedestrian traffic due to students' population.

II. Study Location

The Faculty of Built Environment of the Universiti Teknologi Malaysia as shown in figure 1 is located at the middle of the university's campus and it's popularly referred to as the centre point. The Faculty has four departments which are Architecture, Quantity Surveying, Landscape Architecture and Urban and Regional Planning with 455 postgraduate students and 891 undergraduate students. The population of academic staff is 100 while 47 others are supporting staff. These are constant users of the building apart from several others that use the corridors as passage way. The Universiti Teknologi Malaysia is located in Skudai near Johor Bahru the capital of Johor State of Malaysia. It is the South most state in Peninsular Malaysia. It shares boundaries with Singapore, Indonesia and the South China Sea. It lies between latitude $1^{0}2^{l}$ and $2^{0}35^{l}$ of the equator. The average rainfall is 1778mm with 82-86% humidity.

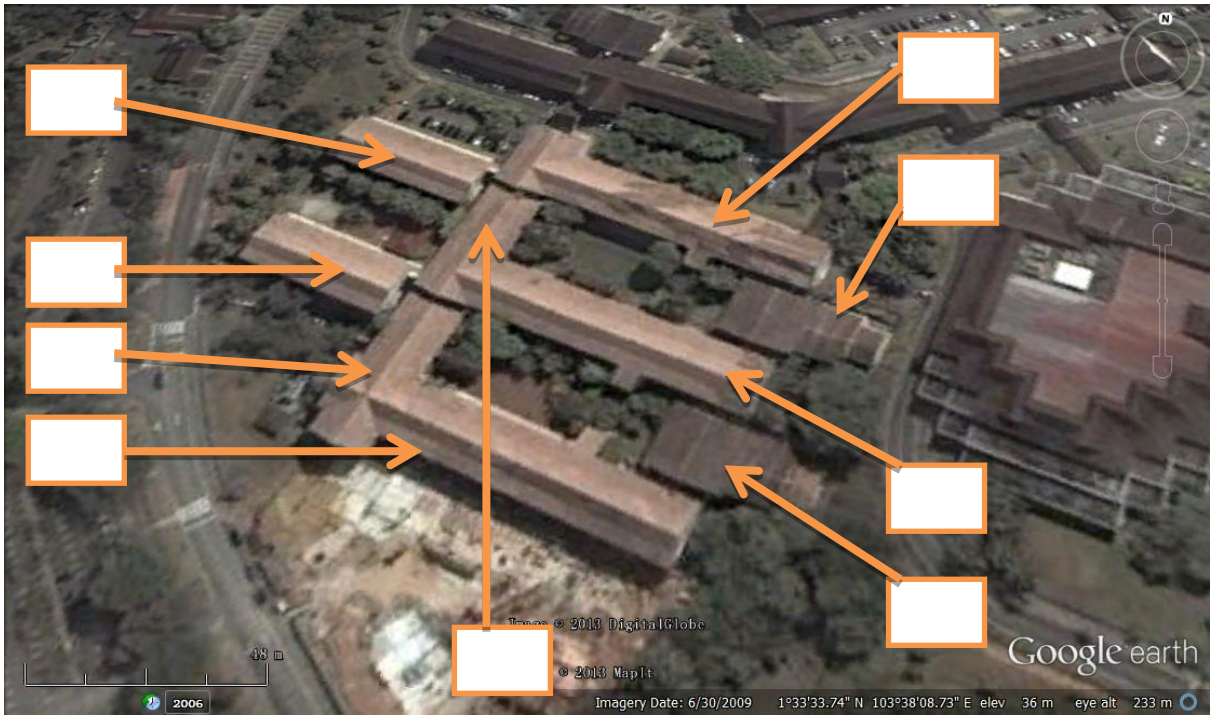

Figure 1: Faculty of Built Environment of UTM

The climate of the area is tropical with monsoon rainfall between November and February. The temperature of the area also ranges from 25.5^0C to 27.8^0C. This supports the evergreen tropical rain forest of the area. The weather is constantly warm and humid. The prevailing climatic condition has the tendency of exerting pressure on building finishes due to heat and moisture transfer (Solin et al, 2010; Qin et al 2009; Koniorczyk and Gawin, 2008). The long corridors and balconies are further shown in the later part of the article.

III. Methodology

The Faculty has twelve (12) buildings that are coded B01 to B12. B01 serves as power house for B02-B10 and B12. B02 to B10 have four levels each and are as shown in figure 1, B11 and B12 are relatively new buildings with five floors and are not shown in figure 1 because they are not due for maintenance yet. All the floors of all the corridors, balconies and passages of the buildings are finished with ceramic tiles except B11. B01-B10 was built in 1985, B11 was completed in 2005 and B12 was completed and handed over for use in 2012. Nine of the buildings that are B02-B10 which comprise of 36floors were investigated for this research because B01 is just a power house.

The method adopted in obtaining data for analysis was primarily observation and physical measurement of affected areas of all the corridors, balconies and passages. The field measurements were carried out with the metric tape between 10^{th}- 15^{th} of June, 2013 with the support of a field assistant. These nine (9) buildings serve as a case study for the entire buildings on the campus. Simple descriptive statistics was used to analyse the data obtained.

IV. Data Analysis and Interpretation

The data obtained during the physical measurement of the floor areas of each building and affected portions are presented in Table 1. The results show that level1 of B02 has a total floor area of 147.78m^2. 93.6m^2 which constitute 63.77% had been replaced after more than 20years of usage. The tiles used in replacing the faulty ones are of different colours and sizes. Observation shows that 3 different colours of tiles were used as replacement. This makes the total number of colours on this particular floor to be equal to 4. The sizes of the new fixing are also different from the old tiles, 2 different sizes were used. This also shows that tiles of 3 different sizes are laid haphazardly on the same stretch of floor. Level2 of B02 has a total floor area of 163.2m^2 out of which 44m^2 is affected. Despite only 26.99% of the floor is affected, 6 different colours of tiles and 2 different sizes are laid as replacement for faulty tiles. This shows that there are 7 different colours and 3 different sizes of tiles on the same floor.

The total area of floor that is tiled in level3 of B02 is 253.1m^2. 76m^2 (30.03%) had been replaced. It was observed that 5 different colours of tiles are laid on the floor because 4 different colours of tiles were used during the replacement of faulty ones. These tiles are also of 3 different sizes, thus indicating that 4 different sizes of tiles are on the same floor. Only a small portion of- 1.7m^2 (5.56%) of the total of 30.6m^2 of tiled floor in leve4 of B02 had been replaced. This

however was done with tiles of different colour and size as shown in Table 1

The results also show that no maintenance works had been carried out in level1 of B03. However, 44.2m^2 (27.08%) of the total floor area of 163.2m^2 in level2 of B03 had been replaced. This was done with tiles of 4 different colours and with a size that is different from the size of the tiles that was used originally. The tiles laid on level3 and level4 of this block are still in good condition. All the levels in B04 have witnessed maintenance. In level1, 43.28m^2 (33.61%) out of the total of 128.78m^2 had been replaced with tiles of 4 different colours and with a size that is different from the size that was used originally. Over half (60.64%) of the 79.9m^2 of the floor area of level2 had been replaced with tiles of 2 different colours and of 2 different sizes, thus indicating that the floor has 3 different colours of tiles and 3 different sizes juxtaposed together. Only a very small portion of 3.4m^2 (4.26%) of the total floor area that is tiled in level3 (79.9m^2) had been replaced. However, this was done with tiles of 2 different colours even though they are of the same sizes. 7.65m^2 (17.31%) of the 44.2m^2 tiled floor in leve4 of B04 had been replaced over the years with tiles of different colour and size.

Despite only a quarter of the floor area of 325.81m^2 of level1 in B05 (79.45m^2=24.39%) had been replaced; as many as 9 different colours of 3 different sizes were used as replacement. This indicates that 10 different colours and 4 different sizes co-exist without any pattern or rhythm on the same floor. 11.5m^2 (7.35%) of the total floor area of 156.4m^2 in level 2 of B05 had been replaced. This was done with tiles of 2 different colours and sizes. Level3 with 156.4m^2 floor area of tiles had witnessed 14.28m^2 (9.13%) repair with 3 different colours and 2 different sizes of tiles. 11.96% (18.7m^2) of the 156.4m^2 of the total floor area in level4 of B05 had been replaced with 4 different colours and 2 different sizes of tiles. This indicates that there are 5 different colours and 3 different sizes of tiles that are mixed together on the same floor.

The results shows that only level1 of B06 had witnessed maintenance in the whole block. 60.08m^2 (47.79%) of the total floor area of 140.4m^2 had been replaced with tiles of different colour and size. All the floors in B07 had witnessed maintenance. Although only a little area of 3m^2(2.12%) of the total floor area of 141.58m^2 had been replaced in level1 of B07, this was done with tiles of different colour and size. Level2 had 38.59% (39.5m^2) of replacement out of the total floor area of 102.88m^2. Tiles of 5 different colours and 2 different sizes were used. This indicates that there are tiles of 6 different colours and 3 different sizes on the floor of level2 in B07. 31.26m^2(30.38%) of the total floor area of 102.88m^2 in level3 of B07 had been replaced with tiles of different colour and size. More half (53.51%) of the total floor are in level4 of B07 had been replaced with tiles of different colour and size.

Level1 of B08 has the largest floor area that is tiled. It also has the largest area that had witnessed maintenance. 133.8m^2 which constitutes a third portion of the total floor area of 391.9m^2 had been replaced with tiles of 3 different colours and 2 different sizes. Only 16.44m^2 (7.75%) of the total floor area of 212.1m^2 in level2 of B08 had been replaced, but this was done with tiles of 4 different colours and 2 different sizes. Also, 31.68m^2 (14.93%) of the total floor area of 212.1m^2 in level3 of B08 were replaced with tiles of 4 different colours and 2 different sizes. The tiles laid in level4 of this block are still in good condition. All the tiles on the floors of B09 are still in good condition. This also apply to B10 except for level1 of the block that had witnessed a replacement of 2m^2 (1.14%) out of the total floor area of 176m^2

Table 1: Details of Floor Tiles Condition

Building	level	Area of floor	Area affected	%	Replacement	
					Nos. of colour diff. from original	Nos. of size diff. from original
B02	1	146.78	93.6	63.77	3	2
	2	163.2	44	26.96	6	2
	3	253.1	76	30.03	4	3
	4	30.6	1.7	5.56	1	1
B03	1	40.2	0	0	0	0
	2	163.2	44.2	27.08	4	1
	3	253.1	0	0	0	0
	4	103.5	0	0	0	0
B04	1	128.78	43.28	33.61	4	1
	2	79.9	48.45	60.64	2	2

	3	79.9	3.4	4.26	2	0
	4	44.2	7.65	17.31	1	1
B05	1	325.81	79.46	24.39	9	3
	2	156.4	11.5	7.35	2	2
	3	156.4	14.28	9.13	3	2
	4	156.4	18.7	11.96	4	2
B06	1	140.4	60.08	42.79	1	1
	2	93.2	0	0	0	0
	3	93.2	0	0	0	0
	4	93.2	0	0	0	0
B07	1	141.58	3	2.12	1	1
	2	102.88	39.5	38.39	5	2
	3	102.88	31.26	30.38	1	1
	4	38.48	20.59	53.51	1	1
B08	1	391.9	133.8	34.14	3	2
	2	212.1	16.44	7.75	4	2
	3	212.1	31.68	14.93	4	2
	4	212.1	0	0	0	0
B09	1	243.7	0	0	0	0
	2	164.5	0	0	0	0
	3	164.5	0	0	0	0
	4	143.5	0	0	0	0
B10	1	176	2	1.14	1	0
	2	176	0	0	0	0
	3	176	0	0	0	0
	4	176	0	0	0	0

V. Findings and Discussions

The maintenance of the floor vis-à-vis the replacement of tiles in several portions of the floor area in almost all the buildings after 20years of installation buttressed the submission of ASTM (2005) and Nicoletti et al (2002) that stipulated 20-30years as the period that tiles used as floor finish in buildings will begin to require maintenance. Tiles of different colours and sizes were used to replace faulty ones. This is predicated on the fact that the exact type of tiles that was used at the inception of the building is no longer available in the market. The possibility of sourcing for the same tiles that was used at inception is very remote because samples were not kept anywhere either by the contactor or by the school authority for reference purpose. Although the tiles could be produced in the same size, to achieve the same colour is practically impossible because the paint formulation for the colours are not kept by the various stakeholders. The source of purchase may also not be accessible while the manufacturer could also have been submerged under the influence of economic recession. The use of multiple colours and sizes also suggest that current maintenance officers do not have the record of what transpired in the past in order to deal with the future.

The patches of different colours and sizes of tiles used as replacement for faulty ones during maintenance works as shown in figure 2a and b, figure3a and figure4a and b exemplify the outcome of lack of records and archived samples that can be used to order for exact product for replacement on maintenance due date. It shows the disadvantages of not using the same type of tiles. From these figures that show the current situation in all the blocks of the Faculty and the School in general, it is obvious that the tilling no longer complies with any pattern or rhythm and consequently constitutes an ugly sight. The aesthetics have been compromised. Silvestre and de Brito (2011) identified this as aesthetic anomalies in the works of Goldberg (1998) even though it may not affect some other functions that the tiles are meant to perform such as protecting the floor structure against environmental aggression as stated by Zhao and Zhang (1997)

Figure 2a and b: Different patches, sizes and colours in balconies and passages

Figure 3a and b: Different patches and colour along a single corridor and a typical block

Figure 4a and b: No pattern or rhythm

VI. Conclusion

Numerous problems that are associated with the use of ceramic tiles as floor finish in buildings were dicovered in this study. This paper also exposed the place and importance of record keeping and archiving of samples of materials used during the construction of a building. In the application of ceramic tiles as floor finish in buildings, the high tendency of not getting the exact type, colour and size used initially for replacement at maintenance due date is one of the major disadvantages of using the material. Apart from its role as protection to the building structure as stated by Zhao and Zhang (1997), it is also meant to sustain the aesthetic outlook of the building. However, this intended function cannot be sustained unless provision is made for making replacement of faulty portions with the same type of tiles used originally possible. The continuation of this trend will eventually lead to the use of several colours and sizes of tiles except the whole floor tiles are removed and replaced with current product. Although the replacement of an entire area is more expensive in term of cost of purchace and installation than replacing faulty portions, it will mitigate against the occurrence of different colours and sizes that pervade the entire faculty.

Singhaputtangkull, et al (2011) submitted that consideration must be given to the issues of sustainability while using materials for building construction. This should include sustainning the aesthetic value of the building. In order to archieve this however, Ofori (2007) opined that public clients such as institutions of higher leaning should provide leading examples for others to emulate. Public institutions should take the lead in setting the standard for proper record keeping and archiving of samples of materials used for the construction of their buildings. Many of this innovative ideas that can help in solving the challenges of building maintenance especially for tilling works in the construction industry remain under utilized (de Ligny and Erkelens, 2008).

VII. Limitations and Suggestion for further studies

The study does not consider the posibility of the machines becoming obsolate after some year of production. With increase in technology, new machines that are developed may not be fashioned to produce the same type or types of ceramic tiles. This paper suggests that the trend of tile production should be investigated to assertain continuity and production of such tiles in distant future.

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