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Assessment of the Use of Solid Concrete and Interlocking Stones in the Construction of Walkways in a Tertiary Institution

Aghimien, Emmanuel Imuetinyan[1] Aghimien, Douglas Omoregie[2*] Awodele, Imoleayo Abraham[3]
1. Department of Architecture, Federal University of Technology, P.M.B. 704, Akure, Nigeria
2. Department of Quantity Surveying, Federal University of Technology, P.M.B. 704, Akure, Nigeria
3. Department of Building, University of Lagos, Akoka, Yaba, Lagos State, Nigeria

Abstract
Over the years solid concrete and interlocking stones have gained popularity in the construction of walkways due to their immense benefits. This study therefore assessed their usage in the construction of walkways in a tertiary institution, using the Federal University of Technology, Akure as a case study. The study, through the review of documentary evidence, personal observation and interview, assessed the level of usage of these materials within the institution, the present condition of these walkways, factors influencing the usage of these materials and the factors affecting their present conditions. The study revealed that the use of solid concrete for walkway construction is gradually fading away as most of the walkways newly constructed are done with the use of interlocking stones. This is as a result of the need for beautification and the need to meet up with present trend. The major defects associated with solid concrete walkways within the institution are cracks and breakages while that of interlocking stones are presence of vegetative growth in between voids, removal of interlocking stones and undulating walkways. The major factors responsible for these defects include; adverse weather condition, poor construction, poor usage and poor maintenance. The study therefore recommend adequate maintenance, use of underground drains beneath sub soil to allow proper draining of absorbed water, shading of concrete walkways through use of light weight covering and proper filling and compaction of sub-base to avoid underground settlement.
Keywords: Construction, Interlocking stone, Pavers, Solid concrete, Walkways.

1. Introduction

The need for movement is paramount in the lives of every living organism and as such science has identified it as one of the characteristics of every living thing. The act of locomotion allows every living being to move and as such the main pattern of locomotion among animals which is slower than running and any other type of movement is called walking (Biewner, 2003). Christine (2012) opined that walking is currently the most popular form of physical activity in the world, with studies from the United Kingdom and United States demonstrating that the prevalence of walking is two to three times higher than those of the next most frequently reported activities. The need for movement makes every living organism walk and this has overtime led to the creation of footpaths and walkways.

The primary use of a walkway is to allow for pedestrian movement. According to Rangamuwa (2014) walkways can be describe as a passage or path for walking, especially a path connecting parts of the built environment. In the past, traditional materials such as stone blocks, bricks, cobbles, and composite wood and tar units have been used to construct the surfaces of walkways and roads, however, as human taste increases the need for better walkway materials arose. This is as a result of the need to reduce construction cost, achieve surface smoothness and the availability of other more economical alternatives that are less labour intensive (Knapton, Imai and Tsukada, 2003).

In Nigeria today, the most common types of walkways are those constructed with the use of solid concrete and interlocking stones. Both walkways are produced from the same construction materials; that is concrete as observed by Ajamu, Jimoh and Oluremi (2012), nevertheless, they differ in appearance, method of application and cost incurred in production and installation. Interlocking concrete floor paver is believed to have inherent strength and its aesthetic nature accompanied with its lightness and form makes it a highly competitive material when compared to the traditional poured concrete (solid concrete) and black asphalt used for walkways and road construction (Abdulsalam, Naiya, Getso and Gidado, 2014; ICPI, 2004; Mark, 1994). However, Ajamu *et al.,* (2012) and Concrete network (2016), opined that solid concrete floors due to its uniqueness, acts as an effective means to address important environmental issues and sustainable growth, and it has great resistance to compression hence making it highly resistant to high foot traffic and increasing its life cycle. Thus it can be said that both materials have their benefits when used for walkway construction.

Gibbons (1999) opined that the major function performed by a walkway is to bear the weight of pedestrian and sometimes vehicles. For this reason the type of walkway material used should be able to perform the intended function for which the walkway is designed. It is based on this knowing that this study was carried out to assess the use of solid concrete and interlocking stones for the construction of walkways in an educational environment with a view to improving their usage and performance.

2. Literature Review

2.1 Walkways

A walkway is a composite term for all formal surfaces which support the act of walking. This includes sidewalks and paths. According to Grand Concourse Authority (2016) walkways can be defined as the passage or path for walking along a raised passageway connecting different sections of a building or a wide path in a park or garden. In architecture, walkways are part of the hard landscape of the built environment and they are usually covered with hard surfaces called pavement. Federation of Canadian Municipalities and National Research Council (2004) explains that walkways are an integral component of the municipal landscape that should be safe and universally accessible. They should be capable of accommodating all users, including mobility and visually impaired users. Valeria (2011) explains that a large range of materials are available for pavement projects and these materials range from natural stone, concrete pavers, paving slabs, landscape stones and blocks as well as gravel. In Nigeria however, the use of cement concrete tiles and interlocking paving blocks is common and it finds its applications in construction of pavements, footpaths, gardens, passenger waiting sheds, bus-stops, industry and other public places.

2.2 Solid Concrete Walkway

Solid concrete for walkway has been extensively used worldwide for construction of pavements by the industry for some time now. Prabhakar, Ashwinand Arjun (2015) explains that unlike the fixed form paving, this form of paver usually performs screeding, consolidation and finishing. NYCDOT (2011) stated that the concrete paving is usually composed of a mixture which comprises of cement, aggregate, water, and other chemical admixtures, smoothed and then allowed to harden, forming a solid sidewalk surface. In order words, it is a type of walkway made out of mass concrete poured to fit into a framed site. According to Mary (2010) these solid concrete can also be made of pervious concrete which is also known as the no-fines, porous, gap-graded, permeable concrete or enhance porosity concrete which has been found to be a reliable storm water management tool.

According to Radhikesh, Nanda, Amiya and Moharana (2010) a concrete mix of 1:2:4 (cement: sand: stone chips) by volume may be used for solid concrete walkways. The concrete mix should not be richer than 1:6 by volume of cement to combined aggregates before mixing. Fineness modules of combined aggregates should be in the range of 3.6 to 4.0. All the raw materials are placed in a concrete mixer and rotated. Quality parameters like actual proportion of the individual raw materials, ratio of coarse aggregates to fine aggregates, water to cement ratio, good finish, and accuracy in size is necessary for good construction.

2.2.1 Merits and Demerits of Solid Concrete

Ajamu *et al.,* (2012), asserted that solid concrete floors due to its uniqueness acts as an effective means to address important environmental issues and sustainable growth. This is because when it rains, they automatically acts as a drainage system, thereby channeling water to appropriate places. Solid concrete floors usually have great resistance to compression hence making it highly resistant to high foot traffic and increasing its life cycle (Concrete Network, 2016). They are resistant to moisture transmission and require little maintenance after construction. NYCDOT (2011) outlined the possible benefits of solid concrete floors as: providing a durable and frictionally excellent sidewalk surface; availability of materials for construction; it is cost effective; the exposed aggregate creates a texture and more natural appearance; they increase slip resistance of surface. Thus, it can be concluded that they can also be regarded as been advantageous due to durability, stiffness, quick speed of construction, damp resistance and easy cost of maintenance.

Despite these identified merits of the solid concrete for walkway construction, several demerits can still be observed from its usage. Suryanka (2015) explains that solid concrete are difficult to patch in sections where utility cuts or defects occur. They cannot be easily repaired by patch work, as this causes defacing of the surface. Also, according to The Constructor (2015), solid concrete walkways are prone to structural failure due to shrinkage and absorption of moisture directly from the ground underneath it. This causes cracks to appear on the surface of their surface after long period of usage.

2.3 Interlocking Stones Walkways

Interlocking concrete pavement consists of solid concrete paving units with joints that create openings in the pavement surface when assembled into a pattern (TechBrief, 2015). They are usually paving stones of precast or in-situ solid products made out of cement concrete and they are ideal for footpaths because they allow easy laying, better look and finish (Radhikesh *et al.,* 2010).

Nataraja and Lelin (2006) stated that interlocking stones has been extensively used in many countries for quite some time as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints. This extensive usage can also be attributed to its ability to allow seepage of underground water without losing its property of strength and durability, which is as a result of its interlocking arrangement as observed by Bean, Hunt, and Bidelspach (2007). Thus, this makes it a good paving material especially in areas susceptible to

flooding.

According to Enohuean and Omo-Irabo (2015) interlocking floor stones are molded with a mix of cement and sand 1:3 that is, one head pan of cement to the ratio of three head pan of stone dust or cement and sand 1:6 that is, one bag of cement to the ratio of six (6) head pan of stone dust. After this is carried out, the interlocking stones are allowed to cure so as to control the extent and rate of moisture loss when drying the stones. The process of curing helps in giving the interlocking stones the maximum strength required to resist the compression forces as a result of movement. The production of interlocking tiles becomes effective when inspected and this deals with testing of the compression strength along with resistance to water, frost and de-icing chemicals. The compression strength of these tiles are determined after 28 days of production (Brožovský, Matějka and Martinec, 2005).

Interlocking stones comes in different patterns and are produced in different shapes and sizes and the edges of each paving stone are shaped to accommodate the next one for proper bonding (Imai, Tsukada and Takahashi, 2003; Radhikesh *et al.,* 2010). The method of application of interlocking stones and type of bonding system used are different and are sometimes base on manufacturer's description in special cases and are designed to offer end users various options (Ojuri, 2012). When selecting a bond pattern for the interlocking stones, the designer should consider the traffic that will use the pavement as the integrity of the paving relies primarily upon adhesion to the base and the interlock between pavers. Thus the performance of interlocking stones, to a large extent depends on the interlocking of the individual units than on the shape and the thickness of the units. It is also influenced by the laying pattern and the thickness of the bedding sand (Brick Industry Association, 2010; BSI, 2005; Interpave, 2003)

2.3.1 Merits and Demerits of Interlocking Stones

Enohuean and Omo-Irabo (2015) asserted that interlocking paving stones provide a weather seal, which have immaculate finesse, designs and strength. They also provide the benefit of being made of fine quality stone and can withstand toughest daily grind. Collins, Hunt and Hathaway (2008) outlined the benefits of interlocking paving stones as: shorter time of construction; reduces or eliminates unsightly retention ponds and related liability; reduced downstream flows and stream bank erosion due to decreased peak flows and volumes; reduced overall project costs due to reduction or elimination storm sewers and drainage appurtenances; high solar reflectance index as surface helps reduce micro-climatic temperatures and contributes to urban heat reduction; easy removal and reinstallation of interlocking paving units and base materials.

Despite these identified merits of the interlocking stones for walkway construction, several demerits can still be observed from its usage. TechBrief (2015) explains that interlocking paving stones is not recommended in areas subject to loading/unloading or storage of hazardous materials. It is also not suitable in areas with high depth to seasonal water tables and extremely dirty sites where there is uncontrolled water borne sediment or wind borne dust that can rapidly clog the surface, thus reducing the compressive strength of the tiles. According to NYCDOT (2011) interlocking paving tiles are not appropriate for use due to the following reasons: they are not effective at slopes greater than 5%; only certain soil types are appropriate as sub bases for infiltration; due to their permeability, they can convey harmful chemicals into the soil; unit pavers can become loose over time and will require regular maintenance; vegetative growth in voids are likely to occur.

3. Research Methodology

The study employed a case study approach which is a qualitative approach and according to Yin (2003) it is best suited for determining the "how" and "why" questions of a research problem, or when the investigator has little control over events. A case study of walkways in the Federal University of Technology Akure (FUTA) was carried out. Data were gotten through personal observations, review of documentary evidence and interview of selected construction professionals in the Physical Planning Unit (PPU) of the institution. PPU has a total of 15 construction professionals out which 6 were interviewed base on their participation in the construction of some identified walkways within the institution and their availability as at the time of carrying out this study. Data gathered from the interview were analyzed using content analysis.

The institution is located in Akure, the capital city of Ondo State, Nigeria and it has two campuses; Obakekere and Obanla campuses. The campuses are planned using the university master plan which gives vivid information that includes urban design, landscaping, infrastructure, service position, circulation, present and past future land use and built form of the institution. The FUTA campus master plan was designed to follow a radial zoning about the senate area from the round-about on the Obanla wing of the campus. There is the student Hostels to a quadrant, the school sport center to another quadrant and the lecture area also to another. All these were designed with need for pedestrian movement and interaction in view and as such walkways were designed to link buildings around these areas together. These walkway design were also implemented in the planning of the Obakekere campus as well.

4. Findings and Discussions

4.1 Use of Solid Concrete

The use of solid concrete has been the major walkway material along roads in the university campus right from its inception. Findings from past records revealed that these were used along Oduduwa way, part of Oduduwa road, Middle belt road and Niger Delta road located within the institution, before they were changed to interlocking stones. In recent times, the use of solid concrete as a paving material has gained less dominance as the modernity associated with the use of interlocks has reduced its usage. Nevertheless, the use of this material is still evident in walkways connecting School of Engineering and Engineering Technology and School of Agriculture and Agricultural Technology, Student Affairs, male and female hostels, School of Environmental Technology and the School of Science all located in the Obanla campus of the institution. It is imperative to note that these walkways are not major walkways within the campus. They are short distance walkways connecting two or more buildings. Longer distance coverage of this material for walkway construction is evident in the Obakekere campus of the university. This is used along Oduduwa road which links the campus and the university's south gate, walkways around the male hostel and the university's health centre. Reason for this can be attributed to the fact that the Obakekere campus is the old area of concentration of the institution before most activities were moved to the Obanla campus.

4.1.1 Existing Condition

Observation shows that most of the solid concrete walkways in the Obakekere campus are still in good condition however some have experienced some measure of degradation due to several external factors. Some of these solid concrete walkways have worn out with several visible forms of repairs carried out on them. Some of the major existing problems are:

Cracking of walkways which is basically as a result of absorbed heat from the sun leading to gradual disintegration of the particles making up the solid concrete. Nevertheless, some can be attributed to poor usage and maintenance.

Breaking of walkways which is the aftermath of cracking of such walkways. This is majorly found along student affairs walkway, School of Environmental Technology, and the two male hostels in both campuses. The breakage in these walkways has however led to the presence of vegetative growths in such areas of breakage

as seen in plate 2.

Plate 1 and 2: Showing cracks, breakage and vegetative growth in solid concrete walkways within the institution.

Source: Researchers field survey, 2016

4.2 Use of Interlocking Stones

The use of interlocking stones has been predominantly adopted in the Obanla campus of the university while in the Obakekere campus, its use has been confined to the postgraduate hostel only. Reason for this can be attributed to the fact that the Obanla campus is presently the area of concentration of the institution with more construction development springing forth. Some of the interlocking walkways include; the walkway from the university's north gate that runs into most core areas of the institution, the walkway around the 2 in 1 lecture theatre, the School of Environmental Technology, School of Agriculture and Agricultural Technology, central research laboratory, post graduate laboratory linking the 3 in 1 lecture theatre, post graduate hostel and the new undergraduate hostel. It is noteworthy to add that these walkways are major walkways connecting several

faculties and buildings within the institution.

4.2.1 Existing Conditions

Just like the solid concrete, some of the interlocking stone walkways have also experience some form of degradation. The major challenges defining the existing conditions of these walkways in the university campus are explained as follows:

Presence of vegetative growth in between voids and spirogyra on interlock surface which is as a result of seepage of water in between voids of interlocks leading to continuous watering of the subsoil underneath them and this in turn as promoted the growth of plants as seen in plate 3 and 4. Also, the effect of spirogyra on surfaces of interlocks has become another issue worth discussing. This is sometimes due to poor drainage leading to stagnancy of water and this creates an avenue for development of spirogyras. The issue of vegetative growth is evident on walkways along post graduate laboratory linking the 3 in 1 lecture theatre and the walkway around the 2 in 1 lecture theatre.

Breakage and removal of interlocks which although is not a major challenge but is visible in some walkways within the institution. This can be as a result of poor usage and poor workmanship.

Undulating nature of existing walkways which can be as a result of continuous downward pressure exerted on them by the feet during usage or as a result of improper ramming of the subsoil before installation of the interlocks. This is evident along middle belt road, 2 in 1 lecture theatre, research laboratory road, post graduate laboratory walkway linking the 3 in 1 lecture theatre and new undergraduate boys' hostel. This undulating nature sometimes leads to stagnancy of water and in turn leading to presence of spirogyra on surfaces of interlocks.

Plate 3 and 4: Showing the vegetative growth and undulating nature of an interlocking stone walkway within the institution.

Source: Researchers field survey, 2016

4.3 Interview Findings

In order to gather information on the factors influencing the choice of material to be used for walkway construction and the factors responsible for the present state of the assessed walkways, interview of selected construction professionals in the PPU of the institution was carried out. A total of 6 construction professionals were interviewed and this comprises of 1 Architect (16.67%), 2 Quantity Surveyors (33.33%), 2 Civil Engineer (33.33%) and 1 Builder (16.67%).The average years of working experience within the institution is put at 11 years, which make them adequate enough to give reasonable answers to the questions of this research.

4.3.1 Factors Influencing the Choice of Material for Walkway Construction

Majority of the interviewee (83.33%) asserted that the need for beautification and the need to conform to present trend are the two major factors that influences the choice of material to be used for walkways within the institution. Also 66.66% were of the opinion that the client's desire is a major yardstick for choosing the type of walkway to be constructed, while 50% stated that durability is equally an important factor that is considered for all construction works within the institution. In terms of frequency of maintenance, 33.33% believe this factor also influences the choice of the type of walkway to be constructed, as a material with low maintenance frequency tends to be favoured more.

Result also showed that the rate of expected traffic for a proposed walkway is not a major factor considered when choosing walkway materials. This is evident in the fact that only 16.67% believe it is being

considered, with 83.33% stating that it is not considered in most cases. Reason for this was attributed to the fact that it is difficult to ascertain the number of students that will be admitted into the institution each session, coupled with the number of staffs and expected visitors within the campus. Hence the Architect is left with the option of designing what he seems fit for the walkway, as long as it is in line with the present standards and client's desire.

Interestingly, the cost of construction is among the least factors that influences choice of material for walkway construction when choosing between the interlocking stone and solid concrete. This is evident in that fact that 83.33% stated that cost does not affect the choice of using either interlocking stone or solid concrete for walkway construction, rather the cost of construction only arises when choosing the particular type of interlocking stone to be used, as the cost of these interlocking stones differs. This is understandable as despite the fact that the interlocking stone seem to be more expensive in terms of construction, its usage within the institution is still very visible compared to the solid concrete walkway which is cheaper.

4.3.2 Factors Responsible for the Present Condition of Walkways within the Institution

Analysis of interview data showed that the weather condition has a major effect for the present state of the walkways within the institutions. All the interviewee were of the opinion that excess rainfall leads to vegetative growth on the walkways, most especially the interlocking walkways, while intense heat is said to be responsible for cracks on solid concrete walkway. One of the respondents stated that "*Ondo State is called the sunshine state, we should expect the heat intensity to adversely affect concrete works not to mention the constant rainfall every now and then*".

Coupled with these weather conditions, 83.33% were of the opinion that poor construction is also responsible for the present poor condition of some of the walkways within the institution. It was suggested that poor technical know-how was responsible for the removal and undulating nature of some of the interlocking stone walkways, while failure to use the right mix by contractors was stated as being a major factor responsible for the disintegration and subsequent vegetative growth on solid concrete walkways.

Poor usage leading to breakage of walkways was also held responsible for the poor state of some of the walkways. This reason was given by 50% of the interviewee. However, 33.33% holds poor maintenance and poor drainage responsible. This poor drainage leads to stagnant water, which weakens the interlocking stones or solid concrete and also lead to the vegetative growth, while poor maintenance culture was said to have led to the vegetative growths within the walkways as constant spraying of herbicides would have taken care of such occurrence. It was also suggested that if maintenance was constant, then most of the damaged interlocking stones and cracked solid concrete walkways would have been repaired/replaced. One of the interviewee however stated that "*it is rather difficult to maintain what was not properly constructed from the beginning*". This implies that it is not an issue of maintenance for some of these walkways but rather poor construction from the onset which need to be rectified before effective maintenance can be carried out.

4.4 Discussion of Findings

Base on the findings of this study, it is evident that the use of interlocking stones is more common for walkway construction within the institution as against the use of solid concrete. The use of solid concrete is gradually becoming a thing of the past as even some of the walkways designed using solid concrete are being changed to interlocking stones. This recent changes is majorly attributed to the need to conform to present trends and provide a more aesthetic environment conducive for learning. However the use of interlocking stones is not without its own problem as vegetative growth, removal of interlocking stones and undulating nature of walkways were evident in some of the walkways assessed. This further affirms NYCDOT (2011) and Ojuri (2012) that interlocking paving stones may not be too appropriate for walkway construction because they allow for vegetative growth and unit pavers may get loosed overtime. It is also in line with Abdusalam *et al.,* (2014) findings that differential settlements, algae growth and cracks are some of the more common defects of walkways constructed with the use of interlocking stones in Zaria urban area, Nigeria.

The presence of cracks and breakages on solid concrete walkways furthers affirms Gajda (2016) assertion that under high temperature solid concrete cracks due to its inability to handle intense heat from the sun. The Constructor (2015) identifies the cracking of solid concrete as one of the disadvantage of using it as a paving materials. Basically, the issue of cracking of solid concrete has become the major barriers to its usage as this leads to breakage and sometimes vegetative growth, hence, increasing cost of maintenance.

The issue of weather condition is a major factor responsible for the poor state of some of the walkways within the institution as observed from the interview carried out. Due to the university's location around the tropics, the issue of heavy rainfall and high solar intensity has contributed immensely to the reduction in the level of performance of these walkway materials. The issue of hydrology and rainfall has led to the weakening of interlocking stones as well as causing the growth of vegetative matter around its void. This further confirms Gibbons (1999) assertion that moisture and temperature are the environmental factors affecting the use of concrete paving materials and Xiaoshan and Lihua (2015) assertion that the use of concrete paving are usually

affected by solar radiation. It also confirms Peter Mosoud, Lev, and John (2015) view that the issue of hydrology has a role to play in the performance of interlocking stones and solid concrete.

5. Conclusion and Recommendation

This study sets out to assess the use of solid concrete and interlocking stones for walkway construction in a tertiary institution with a view to increasing their usage and performance. Using a case study of walkways in the Federal University of Technology, Akure, the study was able to ascertain the level of usage of both materials within the institution, the factors responsible for the choice of materials for walkway construction and the factors responsible for the poor condition of some of the walkways within the institution.

The study concludes that the use of solid concrete for walkway construction is gradually becoming something of the past as most of the walkways newly constructed are done with the use of interlocking stones and even the old ones constructed with solid concrete stones are being replaced with interlocking stones. The choice of the use of interlocking stone is affected by; the need for beautification and the need to meet up with present trend, client's desire, and its durability. The study also revealed that the major defects associated with solid concrete walkways with in the institution are cracks and breakages while that of interlocking stones are presence of vegetative growth in between voids and spirogyra on interlock surface, breakage and removal of interlocking stones, and undulating walkways. The major factors responsible for these defects include; adverse weather condition, poor construction, poor usage and poor maintenance.

The study therefore recommends that performance of solid concrete walkways and interlocking stones can be improved if adequate maintenance can be done. This involves continuous weeding of plants that grows around voids through the use of herbicides and scrubbing of interlock surfaces decaying as a result of presence of spirogyra plants. The use of vacuum pumps can be adopted for better result. Also, the use of under drains beneath sub soils can be used to allow proper draining of absorbed water and this prevents weakening and loosening of interlocks. Shading of concrete walkways through use of light weight covering where applicable should be encouraged to reduce cracks, while proper filling, compaction and slope be taken during construction in under to avoid underground settlement which can lead to undulating nature of walkway and even removal of walkway materials.

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