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PUBLIC PERCEPTIONS ON URBAN OUTDOOR CONSTUCTIONS AND THEIR MATERIALS

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Abstract

Human perceptions on their environment are an important aspect that has to be considered in the development construction works to meet the common final goal of a sustainable and satisfactory project. Of the perceptions, those on construction materials are important as it directly links to present day important concerns such as global warming, heat island effects etc. Though extensive research has been carried out on construction materials, the studies are limited on public perceptions on outdoor construction materials. This paper presents the detailed analysis of data collected through a sample of public on their perceptions on the paving materials of outdoor constructions; viz. pedestrian walkways and recreational areas. The methodology included a literature survey to identify the current research status, an on-line questionnaire survey carried out on a sample of public to identify their perceptions and a statistical analysis performed on the collected data. The sample consisted of 149 respondents. Additionally, temperatures were measured on the top surface of selected pavements throughout the day. The outcome of the study indicates clay brick is preferred over concrete and asphalt as the paving material for pedestrian walkways and recreational areas.

Keywords: *Public perceptions, pedestrian walkways, recreational areas, outdoor built environment, paving materials*

1. Introduction

Pedestrian walkways along road sides and recreation areas are two of the prominent outdoor constructions especially in urban areas. In such outdoor constructions the priority received for the viability aspects generally differs from indoor constructions. For example, developers or local authorities seem

to be contended by technical and economic viability of outdoor constructions rather than the environmental or user comfort aspects (Scudo and Dessi 2006). Emmanuel and Johansson (2006) claim that urban planners and designers have paid little attention to human comfort in modern outdoor development work. Construction material is one of the important considerations to achieve user comfort. An analysis into the research literature indicates that it is important to develop new outdoor construction materials which are economical, use local raw materials and better suited for contemporary issues such as global warming and urban heat island (UHI) effect in micro climates such as urban open spaces. A preliminary requirement in the development of new materials is to understand the user perceptions on the available materials. This paper presents a detailed analysis of data collected from a sample of public representing a number of cities of Sri Lanka on their perceptions on walkways and recreation areas and the materials used for these constructions.

2. Background

In the recent attempts to modernize the Colombo and other cities in Sri Lanka intense attention has been paid to outdoor constructions, which have become part of everyday life. The following sections briefly present some of the previous research work on the perceptions of outdoor constructions and three artificial materials commonly used in Sri Lanka for such constructions.

2.1 PERCEPTIONS ON OUTDOOR CONSTRUCTIONS

Pedestrian walkways and recreational areas are the most prominent outdoor constructions in the recent city development and modernisation work in Sri Lanka.

Pedestrian walkways: A comfortable environment on the pedestrian pavements makes a journey by foot pleasant and enjoyable. Considerable achievements have been made in this respect with many models and techniques for designing pedestrian walkways around the world. Nevertheless it seems that further attention is warranted during design and planning and also in research to address the issues of pedestrians' safety as well as convenience in our cities. Rahaman et al. (2005) and many other researchers identify safety, security, convenience and comfort as important considerations of roadside walking environment.

Recreational areas: Van der Zee (1990) define recreation as "refreshment of body and mind by activities, or a planned inactivity, undertaken because one wants to do it, without any moral, economical, social or other pressure". Parks and recreation areas are perceived as especially important in urban areas to promote human health and wellness (Garcia et al. 2003).

Additionally, creation of recreation areas in the cities is claimed to have a positive economic impact of the region.

Literature on public perceptions on walkways and recreation areas discuss various parameters; placing of the walkways, route length or the travel distance and shade are often perceived to be important in the usage of walkways (Dayaratne 2011; Giles-Cortie 2005). However, previous studies on perceptions of construction or paving materials were not found in the available literature.

Nonetheless it is a well-known factor that these surfaces of outdoor constructions reflect part of the solar radiation received during the day time. The areas built up with heat absorbing materials such as asphalt and concrete disturb the balance of the natural process with elevated temperatures (Rosheidat and Bryan 2007). This phenomenon of elevated surface and air temperatures due to the retention and emission of solar heat from built-up areas is termed as Urban UHI effect. Heat islands are typically created when either the cities grow or are modified by replacing natural land cover with manmade pavements, buildings and other infrastructure (Wan et al. 2012). Development of heat islands is increasingly becoming a highly-complex environmental issue (Grimmond et al., 2010) and the paving material of walkways contributes to the UHI effect.

2.2 PAVING MATERIALS

In the development of new materials it is important first to understand the researched issues of available construction materials. Here we briefly discuss the research findings on technical aspects of the three artificial outdoor paving materials selected in this study; viz. Asphalt, Concrete and Clay Brick.

Asphalt: Asphalt, which has a lower thermal admittance than concrete, heats up more quickly during daytime and cools down rapidly at night. Halwatura and Jayasinghe (2007), Killingsworth et al. (2011) and Wan et al. (2012) have measured the temperature variations on asphalt-paved roads at different geographic locations and agree that asphalt surfaces can act as heated bodies, promoting higher surrounding air temperature during both day and night. The colour of the material plays an important role; the dark asphalt is the most unfavourable material when taking into account its thermal characteristics (Babic et al. 2012). Though the initial cost of Asphalt sidewalks are low, they are more susceptible to damage from weather and normally require more maintenance, increasing their economic cost over time (Mendoza et al. 2012).

Concrete: Concrete is considered consistent, durable and economic and hence it is the most common type of walkway worldwide (Mendoza et al. 2012; El Nouhy and Zeedan 2012; Killingsworth, et al., 2011). Among the researched favourable characteristics of concrete pavements compared to

asphalt pavements are its better skid resistance reducing accidents and increasing safety (Smith, 2000), its ability to tolerate significantly larger deflections without cracking (Soutsos, et al. 2011) and low temperatures which makes it favourable for using in cities for mitigating UHI effect (Babic et al., 2012).

Further, concrete blocks as paving material has the added advantage of using recycled industrial solid wastes (Sukontasukkul and Chaikaew 2006; Gencel et al., 2012; Ling and Poon, 2014) and construction and demolished (C&D) waste in its production (Poon and Chan 2006). They are mostly used as full or partial replacement of aggregate and/or to improve the engineering properties of concrete. Some examples of these materials are fly ash, silica fume, ground granulated blast-furnace slag, porcelain, and clay masonry (Gadja and Van Geem 2001). Rubber and recycled glass too have been researched in making concrete blocks (Sukontasukkul and Chaikaew 2006; Ling 2012). Recycled concrete aggregate and crushed clay brick are the C&D waste used as aggregates in the production of paving blocks.

Bricks: Brick is a popular construction material in many countries due to its durability, relatively low cost, availability, sound and heat insulation, fire resistance, adequate resistance to weathering and attractive appearance. Of the two major types of bricks, the conventional burnt clay brick is the mostly used type for construction worldwide, even though its production requires high energy and emits CO2 gas and causes environment pollution (Deboucha and Hashim, 2011; Reo and Kannaujiya, 2014). The alternative type is made with compressed soil (usually 'laterite') stabilized with relatively low percentage of cement (Jayasinghe and Mallawaarachchi, 2009).

3. Objectives and the Methodology

The main objective of this study is to find out the perception of people on outdoor development and the materials used for these developments. Pedestrian walkways along the roads and urban recreational area are thus focused in this investigation to understand the user satisfaction level on walkways and materials used. Questionnaire survey is one of the many methods to understand how persons respond to the outdoor development (Kelly, et al., 2011). An on-line questionnaire prepared on 'Survey Monkey' platform was employed to elicit the user perceptions on the research objectives. It is particularly designed to understand (a) the user perceptions on the requirement of pedestrian walkways along the roads and on the importance of having better visual identification between pedestrian walkway and the traffic pathway (b) the preferred material for pedestrian walkways and in recreational areas.

The data obtained through this questionnaire survey was statistically analyzed using Chi-Square test for the following null hypotheses.

a) H_{01}: The public preference to have a separate walkway along roads has no association with the fact whether a person is a pedestrian or a driver.
b) H_{02}: The public preference to have visual separation between walkways and roads has no association with the fact whether a person is a pedestrian or a driver.
c) H_{03}: The public preference to have separate areas for recreation is not gender specific.

Further, five pavement construction materials (three artificial - Asphalt, Concrete, Clay Brick and two natural - Soil, Turf) commonly used in Sri Lanka are selected to obtain the public preferences. The preferences of the surveyed sample were analyzed using percentage plots and with the following two null hypotheses tested using Chi-square analysis to draw conclusions.

a) H_{04}: The public preference on paving material on walkways has no association with the gender.
b) H_{05}: The public preference on paving material on walkways has no association with the experience as a pedestrian or a driver.

In the development of a better pavement material, thermal characteristics play an important role. The comfort of a pavement is impacted by its heat emission which is indicated by temperatures. Therefore, the ambient temperature and the temperature variations on the pavement surfaces were measured throughout the day for two materials viz: concrete and clay bricks, using data loggers on sample pavements. Further, public opinion on discomfort times on the urban walkways was elicited through the questionnaire survey. Perceptions obtained with regard to times of discomfort on pavements are then graphically compared with the temperature variations measured on material surfaces.

4. Results and Discussion

The on-line survey was responded by 149 persons with a response rate of 42%. Of this, 5 responses were discarded as they have failed to respond to all the important questions other than demographic questions. The investigation deliberately focused on main cities in Sri Lanka such as Colombo, Gampaha, Kandy, Galle and Kurunegala. Responded sample consisted of both male and female in a ratio of 71% : 29%. The respondents were categorised into five age groups and the majority (84%) was from age group 20-30 years (Figure 1).

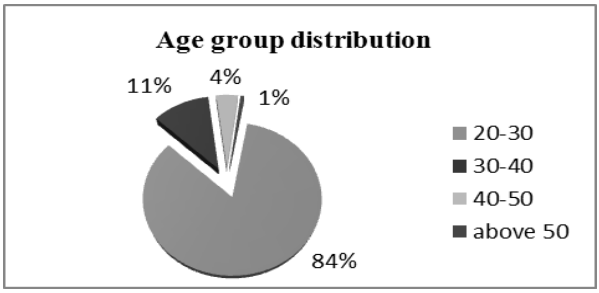
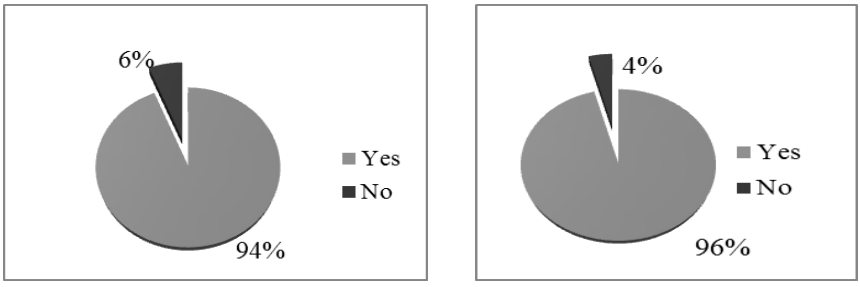


Figure 1, Percentage age group distribution of the sample

The respondents had varying degrees of professions and educational qualifications: 52% were employed and the others were students at tertiary level. The professions of employed respondents included engineers, medical officers, nurses and teachers. Their experiences on the road were three fold; (a) only as pedestrians, (b) only as drivers and (c) with both experiences. For the purposes of this study, the respondents were divided into two groups; those who possess driving experience and those who possess only pedestrian experience whose ratio was 36% (52): 64% (92) respectively.

4.1 PUBLIC PREFERENCES FOR SEPARATE WALKWAYS, THEIR VISUAL SEPARATION AND SEPATARE RECREATION AREAS

Responses were sought to elicit preference for having separate pedestrian walkway along the road and the preference for having visual identification between walkway and the traffic path (road). The analysed results shown in Figures 2(a) and 2(b) indicate that 94% of respondents are in favour of having separate pedestrian walkways and 96% of them wish to have visual identification between pedestrian walkway and the vehicle path.



(a) (b)

Figure 2, (a) separate walkway along the road (b) Visual identification between walkway and traffic path

The three null hypotheses H_{01}, H_{02} and H_{03} formed on the public preference for separate walkways, their visual separation and separate recreational areas were tested using Chi-square tests for the data given in Tables 1 to 3. The Chi-square statistics are shown below the respective table.

Table 1, Association of public preference to have separate walkways with the experience as drivers / pedestrians

Perception \ Road use	Driver	Pedestrian	Total
Separation required	51	87	138
Separation not required	1	5	6
Total	52	92	144

Chi-Sq = 1.026, DF = 1, P-Value = 0.311

Table 2: Association of public preference to have visual separation between walkways and roads with the experience as drivers / pedestrians

Perception \ Road use	Driver	Pedestrian	Total
Visual Separation required	51	89	140
Visual Separation not required	1	3	4
Total	52	92	144

Chi-Sq = 0.220, DF = 1, P-Value = 0.639

Table 3: Association of public preference to have separate recreation areas with gender

Gender \ Recreation Area	Required	Not required	Total
Male	88	8	96
Female	40	2	42
Total	128	10	138

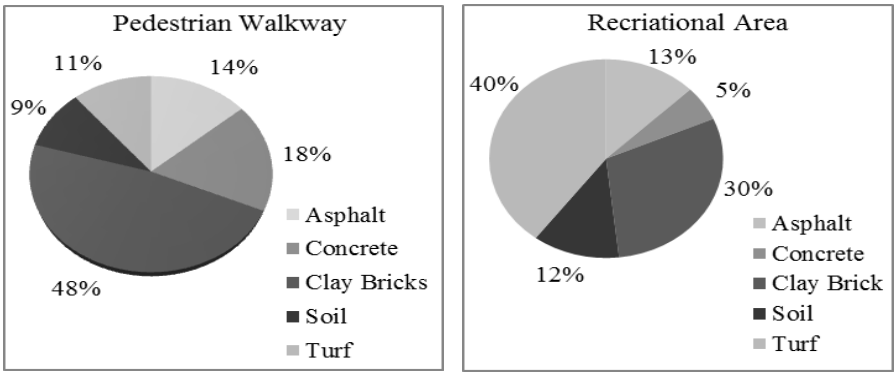
Chi-Sq = 0.554, DF = 1, P-Value = 0.456

For all tests Chi-square values (1.026, 0.220 and 0.554) are less than the table value of Chi-square statistic for degree of freedom 1, (3.84) at 95% levels of confidence and show no evidence to reject the null hypotheses.

4.2 PUBLIC PREFERENCES ON MATERIALS FOR WALKWAYS

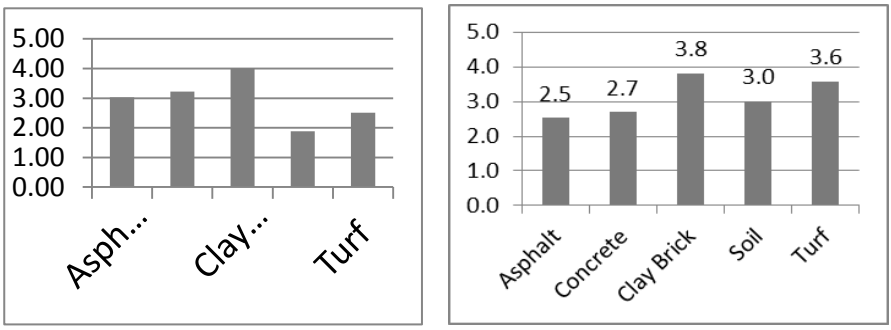
An important aspect of this survey was to obtain responses to understand the preferences among five different materials which are used for pedestrian walkways and in recreational areas, viz; asphalts, concrete, clay brick, soil

and turf. Responses were elicited by requesting to rank the five materials in the order of preference of the respondent of their suitability as a paving material first for pedestrian walkways and second in recreational areas. The first preferences converted to percentages are given Figures 3(a) and 3(b) and the weighted average scores (WAS) for the five materials are given in Figures 4(a) and 4(b)



(a) Materials for walkways (b) Materials for recreational areas

Figure 3, Preferred material for walkways and recreational areas



(a) Materials for walkways (b) Materials for recreational areas

Figure 4, Weighted Average preference for paving materials

The survey found clay brick as the highest preferred material with 48% of the respondents placing it as their first choice for pedestrian walkways, followed by concrete, asphalt and turf respectively. In contrast, in the case of recreational areas 40% voted for turf followed by 30% for clay bricks.

Asphalt, soil and concrete were voted less than 13% as paving material. Even if the next best alternatives are considered (Table 4), the highest preferred material is clay brick (WAS = 4.02) and soil was the least preferred (WAS = 1.88) for the walkways on pavements. However, the preferences for the recreational areas showed a remarkable difference where clay bricks, turf and soil were preferred over concrete and asphalt. Further analyses were made to understand the association of gender and road use experience on the public preferences of paving material by testing the two null hypotheses H_{04} and H_{05} for the data presented in Tables 4 and 5.

Table 4: Association of gender with public preference on paving materials

Material / Gender	Asphalt	Concrete	Clay Brick	Soil	Turf	Total
Male	15	14	49	10	15	105
Female	5	12	19	4	1	41
Total	20	26	70	14	16	146

Chi-Sq = 7.999, DF = 4, P-Value = 0.092

Table 5: Association of road experience with public preference on material

Material / Gender	Asphalt	Concrete	Clay Brick	Soil	Turf	Total
Driver	9	4	28	5	6	52
Pedestrian	11	22	40	9	10	93
Total	20	26	69	14	16	145

Chi-Sq = 6.297, DF = 4, P-Value = 0.178

For both tests Chi-square values (7.999 and 6.297) are less than the Table value of Chi-square statistic for degree of freedom 4, (9.49) at 95% levels of confidence and show no evidence to reject the null hypotheses.

4.3 PUBLIC PERCEPTION ON DISCOMFORT TIMES ON WALKWAYS AND THERMAL BEHAVIOUR OF PAVING MATERIALS

The most discomfort times (at one hour intervals from 8.00 a.m. to 7.00 p.m) of the day on public walkways obtained through the opinion survey are compared with the measured surface temperature variations of two paving materials, viz; concrete and clay bricks together with the ambient temperatures (Figure 5). The measurements recorded at the University of Moratuwa premises are considered representative of Colombo city for this study.

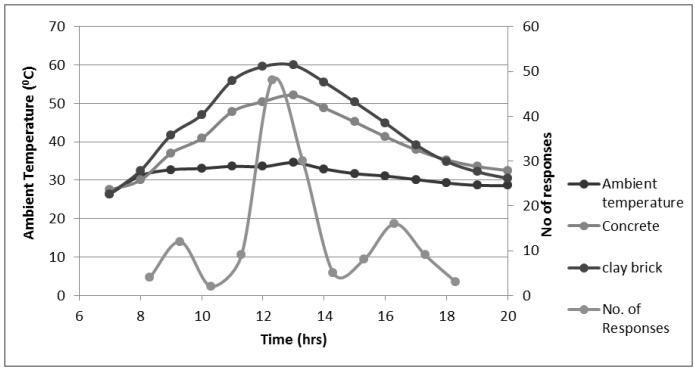


Figure 5, Survey responses on discomfort times with variations in measured ambient temperature and surface temperatures.

4.4 DISCUSSION

The on-line survey responses and their analyses lead to a number of important findings. Among them the first is the Chi-square test results which established that separate pedestrian walkways are preferred by the public irrespective of their experiences as pedestrians or drivers. Second, it is also established that the public preference is to have visual separation between pedestrian walkways and roads irrespective of their experiences as pedestrians or drivers. Thirdly, it is shown that separate recreation areas are preferred by public irrespective of their gender. These three findings emphasize the importance place by the public on separate pedestrian walkways with visual separations as well as separate recreation areas, irrespective of their experiences or gender. Such importance placed by the public warrants investigating into new sustainable and efficient materials for constructing walkways and recreation areas.

The public perceptions received through the opinion survey clearly show the low preference given to soil, asphalt and concrete as construction materials for both walkways and recreation areas. Turf has received mixed preferences with a low preference for walking and a high preference in recreation. In contrast, clay bricks have received the first and the second preferences in both areas indicating any new material developed need to be either based on clay bricks or should closely emulate the positive characteristics of clay bricks.

This paper argues that the public discomfort on walkways mainly arise due to excessive heat emissions from the walkway surfaces. There are also other contributing factors for discomfort such as excessive traffic flow. The

expressed perceptions on most discomfort times by the surveyed respondents show three distinctive peaks with one major peak. The major peak coincides with the times where the highest temperatures were observed and this could be attributed to UHI effect as the observed temperatures are even much higher than the ambient temperature. However, a contradiction is observed between the comparatively high heat emission by clay bricks and the high public preference for the same. This aspect needs to be further researched.

5. Conclusions

Separate pedestrian walkways and recreation areas are highly preferred by the public irrespective of their experience as drivers or pedestrians and also of gender. Clay bricks are the most preferred construction material for pedestrian walkways and the artificial material for recreation areas. Therefore, further research in development of new paving materials could either be based on clay bricks or its preferred characteristics. Further, studies are recommended to observe detailed public perceptions on thermal discomfort of walkways and the observed discrepancy between the high heat emission and the high public preference by clay bricks.

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