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Increase Thermal Comfort by Integrating ELT at Building Foundation: An Alternative Recycling Way in Malaysia

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Abstract
Today, when people think of the environmental impacts of ELTs (end-of-life tyres), they mostly focus on the management of tyres at the end of their useful lives. Globally, an estimated one billion tyres reach the end of their useful lives every year. It is observed from literature that about 4 billion ELTs are currently in landfills and stockpiles worldwide and are disposed to unknown and illegal routes. It is also revealed that most of the countries currently are not experienced with the disposal of ELT with the framing of specific law or regulation to the disposal of ELT management. Hence ELT created a massive waste in management system which intern modified our environment. Recently it is obvious that should find out alternative ways as to reduce the massive ELT waste.This study has been designed to manage ELTs massive waste by experiment. In that reason we needed to set up an experimental set up to observe the real phenomena of ELT for passive cooling in hot humid and tropical climate and that compare with conventional construction materials and systems. Experimental setup foundations are constructed by using ELTs and other conventional foundation materials at IIUM (Gombak) campus. This paper presents the results, analysis and recommendations from the experimental tests and outputs.
Keywords: ELT, Thermal comfort, Heat Transfer, Malaysia and Experimental Setup.

1. Introduction

Most of the scrap tyres, annually generated in developing countries, are dumped in open or landfill sites. The scrap tyres is bulky and do not degrade in landfills. Therefore, open dumping of scrap tyres occupied a large space, presents an eyesore, and causes potential health and environmental hazards, *Georgia Department of Community Health (2010)*. Moreover, *Korenova (2005)* stated that scrap tyres contain oily chemicals that are flammable and tyre fire increased hazards. Burning tyres released hazardous chemicals into air, water, and soil. This is difficult to extinguish, and expensive to clean up. Because of their shape, scrap tyres can also store water and debris, which provided an efficient breeding and feeding place for insects and rodents carrying diseases. These are also a source of dirt, dust, moisture, and mold. Environmental issues continue to be a driving force behind ELT recycling. So, in developing countries, at present it is an emerging issue to find out alternative uses and alternative end of life pathways.

In Malaysia, there is a steady increase in ELT generated annually in the country. The number of ELT generated annually in the country is estimated to be 14 million, *WBCSD (2008)*. As stated by *Sandra & Thiruvangodan (2006)*, about 60% of the waste tyres are disposed via unknown routes; Waste tyres in Malaysia are neither categorized as solid waste or hazardous waste, it is generally considered as business or trade waste; hence currently, there is no specific law or regulation, which governs waste tyre management. At present, there is no institutional move toward managing waste tyre as a resource in Malaysia. Existing companies operate solely on business ethics with profit being the conclusion; without a policy and management structure in place, it is costly and difficult for the recycling companies to get a steady supply of waste tyres. *Sandra & Thiruvangodan (2006)* also uncovered that, In Malaysia landfill is the easiest and a legal avenue to dispose waste tyres; there is a serious lack of producer responsibility for waste tyre management in Malaysia; tyre producers or manufacturers are not concerned about the final disposal of their product at the end of its life; they leave it solely to their dealers to tackle this issue; The lack of producer responsibility in managing the waste makes the management of waste tyres a more difficult task. Lack of consistent and available information/data about waste tyre generation and management hinders the understanding of current management scenarios, which is critical to formulate pragmatic solutions, *Sandra & Thiruvangodan (2006)*.

But the tyre is made of rubber materials (polybutadiene, styrene-butadiene rubber and polyisoprene or natural rubber), carbon black and some fibrous materials, reviewed by *Korenova (2005)*. It has a high content of volatile compounds and fixed black carbon with a heating value higher than that of coal. Besides for thermo physical properties of rubber, *The Engineering Tool Box (2012) & Hyper textbook (2012)*, tyres can be performed as a high-quality heat sink and can be used an alternative construction material for tropical building to ensure the indoor comfortable thermal environment.

For many days researchers have been trying to find out alternative construction materials to ensure thermal comfort in tropical buildings which is wide reviewed in *Chenvidyakarn,(2007).* But, the effort to use hazardous scrap tyres as alternative building construction material is not much and it is still an investigation concern for built environment researchers.

The purpose of this study is to identify the current scenario and factors of massive ELT waste generation in Malaysia, its disposal practices. As well as to find out an alternative end of life pathway, that will positively increase the recycling and legal disposal rate of this massive waste.

The aim of this study is to study the thermal impact of massive ELT waste material to building. And the objectives are to study the current ELT management scenario in Malaysia. Next to do experiments on the ELT waste material to observe its real impact on a building indoor thermal environment.

2. Materials and Methods

To do experiments on ELT to observe the heat flow character its thermal impact on indoor thermal environment, we build an experimental setup by using three different types of foundation materials (refer to figure 2). We have used ELT and polystyrene as alternative foundation materials from waste and sand as a conventional foundation material.

2.1 Location of experimental set-up

The Experimental setup is located inside the (Refer to figure 1) at International Islamic University Malaysia (IIUM) campus, Gombak, Kuala Lumpur, Malaysia. IIUM is located at latitude 3.253o N and longitude 101.7375oE.

Picture 1*: image of experimental set-up

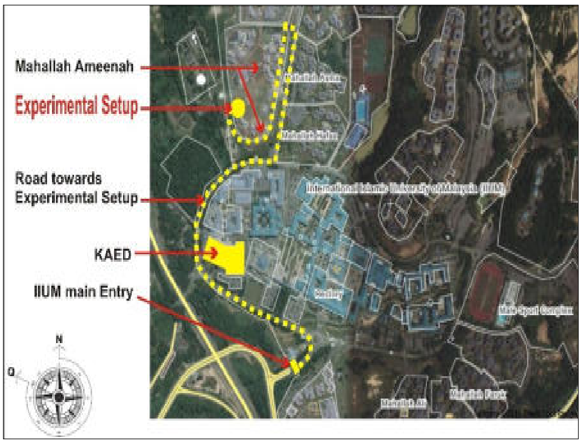

Figure 1*: Location of experimental set-up

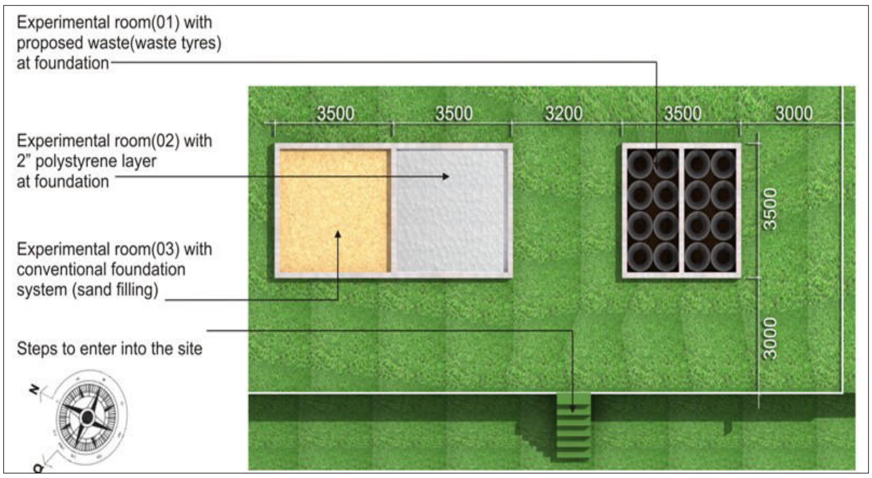

Figure 2*: Plan of experimental set-up

2.2Construction period of experimental set-up:

We started planning and designing process of experimental set-up on 7th April 2011. And the construction started on 23rd June 2011 and finished on 05th January 2012. We finished the set up of experimental equipments on 15th January 2012. From 16th January 2012 we started data acquisition. Data acquisition interval was only 10 seconds for micro scale observation. All construction materials and systems for all 3 experimental rooms are same except the foundation materials and system. So, physical and thermal properties of foundation materials including earth are listed in Table-1.

Table 1: Physical and thermal properties of Rubber, Sand and Earth

No	Material	Porosity	Density (kg/m3)	Specific Heat (Kj / Kg K)	Thermal Conductivity k - W/(m.K)	Emissivity Coefficient (ε) (On temperature 300 K)
1	Rubber	Non-porous	801	2.01	0.13	0.94
2	Sand	Porous	1281 (sand, dry)	0.8	0.15 - 0.25 (dry sand)	0.76
			1922 (sand, wet)		0.25 – 2 (moist sand)	
					2 – 4 (saturated sand)	
3	Earth	Porous	5500	1.26	1.5	

Source: The Engineering Tool Box (2012) & Hyper textbook (2012)

2.3Experimental output:

For discussion and analysis purpose we presented here only the data of ELT foundation based experimental room and compare its performance and impact on the indoor thermal environment with the conventional sand filling foundation based experimental room.

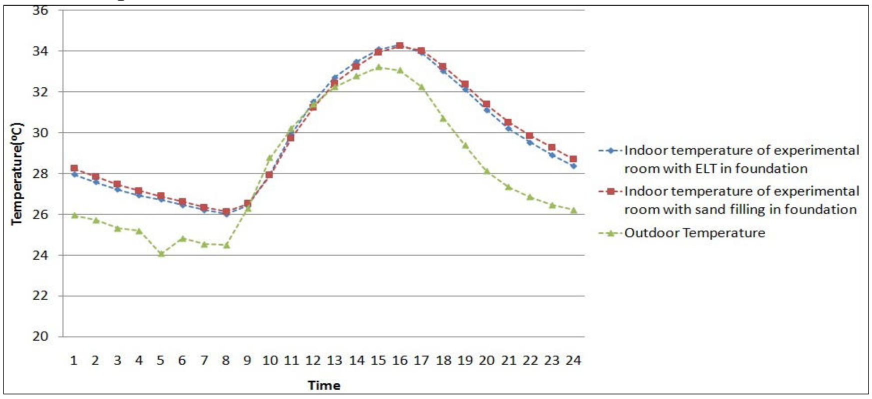

Figure 3*: Indoor temperature of experimental rooms in relation with time and Outdoor temperature from 1st – 28th Feb 2012

3. Results and Discussions

From experiment, data observation and analysis it is revealed that ground floor slab of experimental room integrated with ELT at foundation is much cooler than the ground floor slab of experimental room with conventional sand filling foundation (Table-2). At day time ELT integrated ground floor slab it is almost 1.95°C cooler than the sand filling based ground floor slab and during night time it is 1.35 °C cooler (Table-2). This clearly represents the high rate of heat release nature of the ground floor slab integrated with ELT at foundation. And this has happened because ELTs are performing as a heat sink here because of their physical and thermal properties. For high specific heat value (Table-1), ELTs always keep itself remain cool. As a result large amount of heat from above ground floor slab is absorbed by ELTs and immediately release heat to the earth because of its low density and low thermal conductivity (Table-1) and keep the above ground floor slab remain cool. And for high porosity, high thermal conductivity and high specific heat value (Table-1), earth continuously absorbing heat from ELTs and retains the absorbed heat.

Table 2: Comparison of indoor thermal comfort conditions of experimental rooms, Heat transfers from the envelops (wall, roof and slab) of experimental rooms, sand and earth

Temperature	Data acquisition period	Time	Average temperature (^{o}C) and Relative Humidity (%) of experimental room integrated with ELT foundation	Average temperature (^{o}C) and Relative Humidity (%) of experimental room with sand filling foundation	Indoor Air Temperature and Relative Humidity difference (^{o}C) of two experimental room {Sand filling experimental room –ELT integrate experimental room}
On floor surface	1st – 28th Feb 2012	(day) 7:27 am – 19:27pm	30.21(^{o}C)	32.16(^{o}C)	+1.95(^{o}C)
	1st – 28th Feb 2012	(night) 19:28 pm – 7:26am	29.08(^{o}C)	30.43(^{o}C)	+1.35(^{o}C)
Indoor Air Temperature	1st – 28th Feb 2012	(day) 7:27 am – 19:27pm	30.65(^{o}C)	30.80(^{o}C)	+0.15(^{o}C)
	1st – 28th Feb 2012	(night) 19:28 pm – 7:26am	28.39(^{o}C)	28.91(^{o}C)	+0.52(^{o}C)
Indoor Relative Humidity (RH)	1st – 28th Feb 2012	(day) 7:27 am – 19:27pm	62.11(%)	60.79(%)	+1.32(%)
	1st – 28th Feb 2012	(night) 19:28 pm – 7:26am	74.79(%)	65.72(%)	+9.07 (%)

On the other hand, from experiment it is revealed the ground floor slab with conventional sand filling based foundation rarely transfer heat to the sand. It continuously absorbs heat from sand (Table-2) and keeps itself heated. Main reason behind this reverse heat flow from sand to the above ground floor slab is for the physical and thermal properties of sand (Table-1). For high porosity, low specific heat value and high thermal conductivity, sand absorb heat from its above ground floor slab but all the heat retains in its volume and always keep hotter than its above ground floor slab (Table-2). Following the 1st law of thermodynamics, the hot sand continuously passes heat to the above ground floor slab. As a result ground floor slab with conventional sand filling foundation is always remaining hot as compared to the ground floor slab integrated with ELT at foundation (Fig-4).

And as a result for above heat gain, heat store and heat release character of ground floor slab of experimental rooms, their indoor air temperature and indoor Relative Humidity (RH) is also affected. From (Fig-3) and (Table-2) it is observed that at day time the indoor air temperature of experimental room with ELT foundation is almost 0.2^{o}C cooler than the indoor air temperature of experimental room with sand filling foundation. But at night, the indoor air temperature of experimental room with ELT foundation is more comfortable than day time. At night the indoor air temperature difference is between two experimental room is more than 0.5 ^{o}C (Table-2). Same as, the indoor Relative Humidity of experimental room with ELT foundation is almost 1.32(%) more than the indoor Relative Humidity of experimental room with sand filling foundation. But at night, the indoor Relative Humidity of experimental room with ELT foundation is more comfortable than day time. At night the indoor Relative Humidity difference is between two experimental room is more than 9(%) (Table-2)

4. Conclusions

Though Malaysia is in hot humid tropical climatic zone, here improve the indoor thermal environment of a building by exploiting the efficient heat drain out from building envelope is a multifaceted task that involves a high degree of integration in design, construction materials and construction technique. Besides, it is very important to control and minimize the indoor temperature, humidity and to minimize or avoid the reliance on air conditioning. And ELT heat sink can be performed great role here as key passive cooling method by increasing the heat loss from building, reduce the indoor air temperature, and minimize the indoor humidity as well as an alternative building construction material which interns can minimize the massive waste load of ELT in Malaysia. Strong legislation is required and law-rules should be imposed on the minimization of ELT waste here. Our next attempt is to investigate the Thermal impact of ELT in multistoried buildings in Malaysia.

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