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Preface

The Civil Engineering Colloquium 2020 was successful held on the 4th March 2020 in Universiti Teknologi MARA, Cawangan Pulau Pinang. The colloquium aimed to provide a platform for our staff and post-graduate students to present and publish their research works. The presentations in the colloquium covered research works by the participants in a wide variety of discipline in civil and environmental engineering.

In this proceedings, the collection of articles submitted by the participants includes topics of Infrastructure Engineering, Structural Engineering, Material Engineering, Geotechnical Engineering, Highway Engineering and Project Management.

Here, we would like to express our sincere appreciation to all participants for their commitments and contributions to the success of participating the colloquium and publication of the proceedings.

DR. KUAN WOEI KEONG

Editor-in-chief
Proceedings of Civil Engineering Colloquium 2020
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Cawangan Pulau Pinang

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Throughfall Distribution in Relationship to Canopy Cover in Urban Forest

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Abstract

A study on the distribution of throughfall in relation to canopy cover was carried out in a Taman Tunku urban forest in Seberang Perai, Peninsular Malaysia. A plot of 12 m x 12 m was established to measure the distribution of gross rainfall, P_g and throughfall, T_f and to identify the correlation between throughfall and canopy cover in urban forest. Roving methods were used in this study to measure the spatial distribution of throughfall. Nine simple rainfall collectors with diameter of 22 cm were located at sub-grid within the plot and moved to other sub-grid after each rainfall event. One identical type of collector was located at open space within the study area to collect gross rainfall. This study was conducted during the month of March and April 2015 with 31 rainfall events. Hemispherical photography (HP) method using fisheye lens was utilized to capture canopy cover image and analysed using Gap Light Analyzer (GLA) software. The relationship between throughfall and gross rainfall for man-made urban forest shows a strong correlation with r2 values of 0.893. The range of throughfall distribution for this study is 17.4% to 33.3% of gross rainfall while the range of the canopy cover for this study is 53% to 70%. Pearson correlation coefficient was used to analyse the relationship between canopy covers and variation of throughfall. At different intensity of rainfall, the throughfall rate was significantly decreased with the increasing of percentage of canopy cover over the plot (n = - 0.717, p = 0.014 under moderate storm). Hence, the canopy cover was found to be influential in predicting throughfall distribution in urban forest.

Keywords: Throughfall, Urban forest, Canopy cover, Pearson coefficient

1. Introduction

Rainfall is one of the key elements in hydrological cycle. Generally, rainfall can be subdivided into three components; (1) throughfall which refers to rainfall falls through the gaps in canopy to the ground, (2) stemflow where the rainfall flows down via the tree stem and (3) interception loss where the rainfall retained at the canopy level and evaporated back to the atmosphere (Dunkerly, 2000). Forest structures such as canopy cover, basal area and stand density significantly affects these rainfall partitioning in forested watershed (Llorens and Domingo, 2007; Levia et al., 2017). Trees and vegetations, whether in natural rural forest or urban forest, also plays important roles in ecological and hydrological cycles (Šraj et al., 2008, Carlyle-Moses and Gash, 2011, Van Stan et al., 2014). Miller (1997) defines urban forest as all woods and vegetations within human settlements. Department of Irrigation and Drainage (DID) (2017) Malaysia highlighted that in an event of rainfall, convective rainfall with depth more than 60 mm within 2 to 4 hours may cause flash floods in urban area. Hence, by analysing throughfall via canopy-rainfall interception in urban forests, stormwater runoff can be reduced within the catchment by almost 22% (Inkiläinen et al., 2013). Nevertheless, trees in urban forest may intercept higher rainfall rate compared to rural forest due to wider canopy crown and higher evaporation rates resulting up to 60% less throughfall under individual trees in urban area (Asadian and Weiler, 2009; Xiao et al., 2000).

Conceptually, canopy cover is defined as the percentage of ground surface covered by the vertical projection of tree crowns (Crookston et al.,1999). Canopy cover or also known as crown cover, crown closure or canopy closure in forestry field. Canopy cover is usually underestimated as canopy closure if instrument with an angle view is used during the forest canopy measurement. Canopy closure measures the sky hemisphere segment from an observation point on the ground. Meanwhile, measurement of canopy cover is based on the presence or absence of canopy above a set of points across the forest area. (Korhonen et al., 2006). There are several techniques to accurately determine the percentage of canopy cover which includes ground-based measurement, statistical models where typical forest parameters (tree diameter at breast height (DBH), basal area, number of stems, height-to-crown-base) are required (Gill et al., 2000) and remote sensing method such satellite images, aerial photograph or laser scanner data. (Naesset et al., 2004). Nevertheless, ground-based measurement is vital to validate the data obtained from other methods and mostly preferred where accuracy is the important objective to be achieved (Fiala et al., 2006). Hemispherical photography, spherical densitometer (Fiala et al., 2006), Cajanus tube, LAI 2000 instrument (Rautiainen et al., 2005) are examples of field measurement techniques to determine canopy cover. Hemispherical photography (HP) method is one of the essential tools in ecological field study as it provides a wide-angle view of the canopy (Fiala et al., 2006). Traditionally, digital camera equipped with fisheye lens will be used to measure forest canopies and light regimes. However, in this current advanced technology era, use of smartphone with build-in fisheye lens has been an alternative to traditional camera in HP method. The smartphone outputs able to provide similar results to the traditional cameras with faster and cheaper approach, and reliable to be adopt in ecological studies (Bianchi et al., 2017).

Hence, the main aims of this study are to determine the throughfall distribution occurred in Taman Tunku urban forest in Pulau Pinang, Malaysia and to establish the correlation between canopy covers of tree stand using hemispherical photography (HP) method with the variation of throughfall.

2. Methodology

2.1 Study Area

This study was conducted at Taman Tunku Urban Forest, Pulau Pinang in Northern Malaysia from early of March 2015 to end of April 2015. The three hectares of the surrounded area is dominated with Areca Catechu species and is governed by Jabatan Lanskap Majlis Perbandaran Seberang Perai (MPSP). An area of 24 m^2 (12 m by 12 m) was set up to conduct the throughfall canopy cover study. The plot was subdivided into small grids of 1 m by 1m. All trees with minimum 10 cm diameter to breast height (DBH) in the study area was identified and tagged accordingly.

2.2 Data Collection

2.2.1. Throughfall (T_f) and Gross rainfall (P_g)

Throughfall and gross rainfall data were collected from early of March 2015 to end of April 2015. The throughfall was measured using nine simple collectors with diameter and depth of 22 cm and 20 cm respectively. The collectors were installed at the ground surface vertically under the tree canopy. The volume of throughfall was measured in a daily basis using a measuring cylinder then were averaged out. These collecting tanks were moved to different grids after rainfall event to account for spatial variation in throughfall (Llyord and Marques-Filho, 1998). The volumes of collected throughfall were measured in the field using a plastic measuring cylinder. As the canopy area of the forest stand is nearly dense, the volume of throughfall was divided with the receiving area of the collector to obtain throughfall value in depth (mm) (Yusop et al., 2003). Figure 1 shows the throughfall collectors within the plot area.

Meanwhile, for gross rainfall measurement, the rainfall is measured by placing a 22 cm diameter bucket at the study area. The plastic bucket was placed at the open area so it will receive direct rainfall as it should works as rainfall gauge. The rainfall volume was measured after each rainfall event. The gross rainfall collector should be placed near to the study area, preferably less than 30 m from the sampling area (Van Dijk and Bruijnzeel, 2001). The rainfall volumes were collected daily on-site using the plastic measuring cylinder. In this study, all related variables such as temperature, relative humidity, wind speed and wind direction were assumed to be homogeneous at all rainfall gauge locations. The rainfall distribution rate at study area are even and occur throughout the year.

Fig. 1: Throughfall Collectors within the Plot Area

2.2.2 Canopy Cover

Ground-based measurement using hemispherical photography (HP) method was adopted in this study to measure the canopy cover over the plot. A smartphone with the fish-eye lens was used to capture the image of canopy cover vertically at every point grid. The smartphone is levelled on a tripod approximately 1 m above the ground. The canopy images were analysed using Gap Light Analyzer (GLA) software program version 2.0. The GLA software is unable to measure the percentage of canopy covers directly. It can only measure the fraction of open sky or canopy openness. Canopy openness is referring to the amount of sky visible through the canopy (Gonsamo, Walter, & Pellikka, 2011). The output result from the analysis shows only the percentage of sky regions openness at each point. Hence, the percentage of the canopy cover is determined as below.

$$\text{Canopy cover, c (\%)} = 100 - \text{openness (\%)} \qquad (1)$$

Figure 2 below shows the canopy image captured using fisheye lens (left image) and the canopy image after analysed using GLA software (right image).

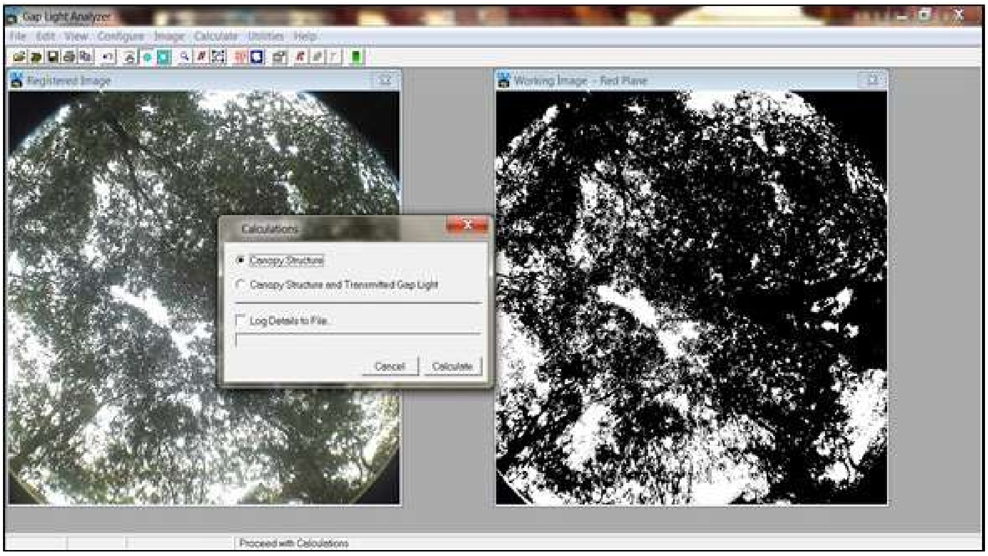

Fig. 2: Canopy Image Analysed Using GLA Software

3. Results and Discussion

3.1 Rainfall characteristics

31 rainfall events with a total amount of were recorded during the study period. Maximum gross rainfall recorded for month of March and April are 62.3 mm and 209.4 mm respectively. Based on the recorded data, 67% of the rainfall events categorized as very heavy rainfall intensities (depth more than 60 mm within 1 hour) which mostly occurred in the month of April. In the event-base data for 2 months collection period, the throughfall rate ranging between 17.4% to 33.3% of gross rainfall. There was a significant correlation between T_f and P_g is found in this study. The linear regression as in Fig. 3 shows that the amount of T_f depends profoundly with the P_g within the experimental site. The signifies that the consistent relationship trend between T_f and P_g in rural forested area also occurred in urban forest.

The highest throughfall rate almost the same average in the study conducted by Guevara-Escober et al., (2007) with 38% of T_f rate in an urban forest dominated by *Ficus benjamina* trees. However, the throughfall rate in this study is relatively low compared to other studies in urban forest which ranges from 46% to 88%. Asadian and Weiler (2009) conducted a study in variable landscape sites (streets, parks, and natural forested areas) achieved T_f rate of 46.2%, 58% in area of open-grown trees (Xiao et al., 2000) and the highest rate at 88.9% for primarily deciduous broadleaved urban residential forest (Inkiläinen et al., 2013). The relatively low throughfall rate in this study is predominantly due to denser canopy cover of tree stand in the study area.

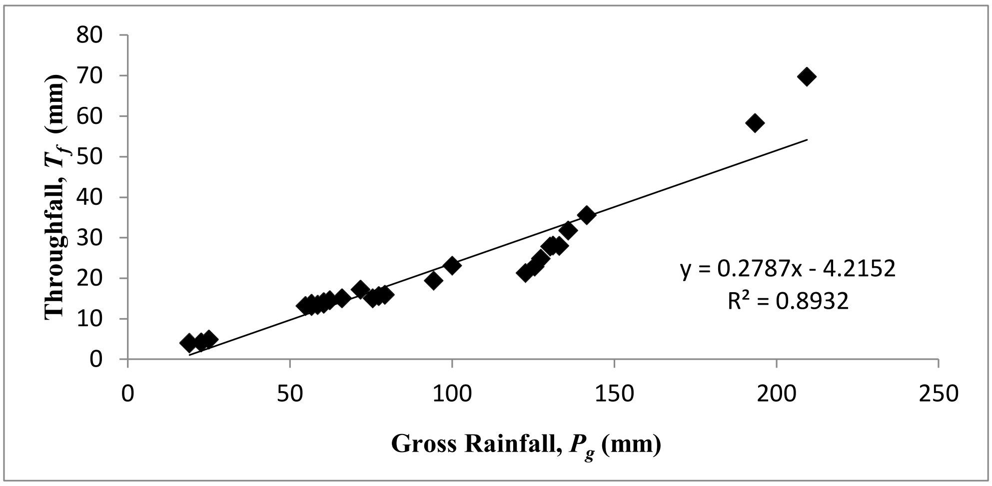

Fig. 3: Relationship Between Throughfall (T_f) and Gross Rainfall (P_g)

3.2 Relationship between throughfall and canopy cover

The canopy cover of study area was captured using hemispherical photography method and analysed using the Gap Light Analyzer (GLA) software. The percentage of canopy cover over the study area ranges from 53.07 % to 70.36 % with a mean of 61.95 %. Figure 4 shows the percentages of canopy cover captured at each point grid of the study plot.

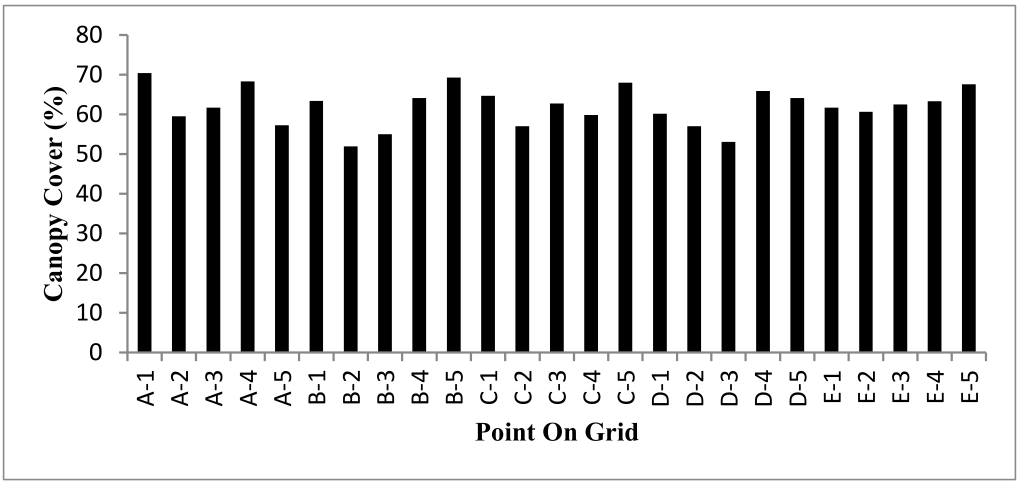

Fig. 4: The Percentage Canopy Cover of Study Area Ranges from 53% to 70%

The relationship between throughfall and canopy cover was determined by calculating the Pearson correlation coefficient. The correlation was analysed between the amount of throughfall at each sampling points and the percentage of canopy cover above the sampling points at different rainfall intensity as tabulated in Table 1. The classification of rainfall intensity is based on the Department of Irrigation and Drainage, Malaysia (DID, 2017). All recorded rainfall is more than 11 mm, thus, light storm category is excluded in this study. Based on the analysis, the throughfall rate is negatively correlated with the canopy cover for all three categories of storm: moderate, heavy and very heavy. This finding was also supported by previous study highlighted that canopy cover had the strongest negative correlation with throughfall. Significant negative correlation was also reported by Sun et al., (2017) (r = - 0.75), Inkiläinen et al., (2013) (r = - 0.33) and Staelens et al., (2006) (r = - 0.54) during leafed period. However, Sun et al. (2017) recommended that the stand density has the best linear relationship with throughfall rate, followed by canopy cover and basal area. Other forest structures such as number of trees per hectare, vertical structures of complexity (VSC) and leaf area index (LAI) also shown a good negative correlation with throughfall event (Inkiläinen et al., (2013).

Table 1: Pearson Correlation Coefficient Between Throughfall and Canopy Cover Based on Rainfall Intensity

Category of rainfall intensity	Rainfall intensity (mm in 1 hour)	r	p-value
Light	1 – 10 mm	-	-
Moderate	11 – 30 mm	r = - 0.717	p = 0.014
Heavy	30 – 60 mm	r = - 0.222	p = 0.28
Very heavy	> 60 mm	r = - 0.461	p = 0.11

4. Conclusions

In this investigation, the aim was to analyse the relationship between throughfall and gross rainfall over the plot area in Taman Tunku urban forest for two-consecutive months and establish the correlation between the measured canopy cover with the throughfall distribution. In term of rainfall depth, the throughfall increase linearly with gross rainfall and strongly fitted using linear regression. However, the study is constrained to short period of data collection and limited forest variables to correlate with throughfall distribution in urban forest. Nevertheless, several concluding remarks highlighted from the study are given below:

- The throughfall rate ranged between 17.4% to 33.3% of gross rainfall and strongly fitted using linear regression ($r^2 = 0.8932$).
- Percentages of canopy cover of study area which dominated with Areca Catechu species measured using a smartphone and fish-eye lens (HP method) ranged between 53.07% to 70.36% which is less dense than the rural forest.
- Amounts of throughfall in urban forest ranged greatly with 53% to 70% of canopy cover.
- Under different rainfall intensities, that canopy cover (%) had the strong negative correlation with throughfall (mm).

Hence, these findings may benefit future research on understanding the rainfall partitioning specifically in Northern Peninsular Malaysia and predicting throughfall distribution in relation to canopy cover of urban tree stand. The findings may also support in managing stormwater runoff by regulating the throughfall distribution in urban area. Still, more forest variables should be included to establish greater degree of accuracy on this forest-hydrology area.

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The Transcona Grain Elevator Failure Revisited Using Numerical Approach

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Abstract

The Transcona Grain Elevator failure is a classical bearing capacity failure example and appears in many textbooks and publications. As technology continue to evolve, engineer today tends to use modern tools to analyse and design geotechnical structure. Unlike in older days, the design relies heavily on the empirical approach. In this paper, the failure case of the Transcona Grain Elevator will be revisited using the modern geotechnical analysis tool. Finite element method with PLAXIS 3D software was adopted to examine the failure mechanism and obtaining the ultimate load of the foundation. The numerical results are compared with the true collapse load and the conventional analytical solutions. The findings bought out the issue of adopting average shear strength value and the limitation of current analytical solutions.

Keywords: Transcona Grain Elevator, bearing capacity, Failure, Numerical approach.

1. Introduction

Bearing capacity failure is a common failure mode for a foundation. Most of the conventional designs adopt classical Terzaghi bearing capacity theory (1941) for shallow foundations. In the era of technology today, designer has more advanced and modern analysis tools to aid the design process. However, back in 20th century, the design of foundation is mainly based on local experience or empirical approach. The Transcona Grain Elevator, Winnipeg, Canada is one of the examples. The construction of the structure was completed in September 1913. Before construction begun, small plate load test was performed at the design depth of foundation. The test indicated failure load of 400 kPa (Engineering News, 1913; Allaire, 1916) which is higher than the design load of 300 kPa. The engineers were satisfied. On top of that, they assumed the ground at this site was like other sites nearby where many heavy structures had been founded on.

Unfortunately, the Transcona Grain Elevator failed by general shear mode on 18 October 1913 after the elevator was loaded to 87.5% of capacity which is about 293 kPa. Investigation after the event was carried out immediately using wash boring but failed to reveal the actual cause of failure as the findings only showed that the uniform clay deposit below the site was in agreement with the geological history of the area. In 1951, Peck and Bryant (1953) made two additional borings and performed unconfined compression strength tests. The findings were eye-opening.

The soil below the ground looked homogenous in terms of grain size distribution and mineralogical content. However, based on the unconfined compression strength, cu, two distinct layers are identified: the upper stiff clay layer (cu = 54 kN/m2) and lower soft layer (cu = 31 kN/m2). This result implies that the most likely cause of failure is the insufficient bearing capacity of the elevator's foundation. The plate loading test failed to identify the soft layer 7.6 m below the ground as the failure mechanism of the plate was confined to the first layer due to the small size of the plate used. This case study becomes a good learning material for engineering student (Ng et al. 2017).

Numerical analysis is more rigorous than analytical method and require no assumption on failure surface. Thus, this paper aims to illustrate the Transcona Grain Elevator case from modern perspective where numerical analysis was performed to examine the failure modes and the ultimate bearing capacity of the foundation.

2. The Problem

Transcona Grain Elevator was built entirely of reinforced concrete which consisted of a work house and an adjoining bin house (Fig. 1). The bin house contained 65 large silos with five rows of 13 bins, each 28 m in height and 4.4 m in diameter. It was supported by a shallow raft foundation (B x L x t: 23.5 m x 59.5 m x 0.6 m) at a depth of 3.7 m below ground level. The bin house suffered major collapse while the bin house next to it was still standing firm on ground. Therefore, this study just focused on the failure of the bin house.

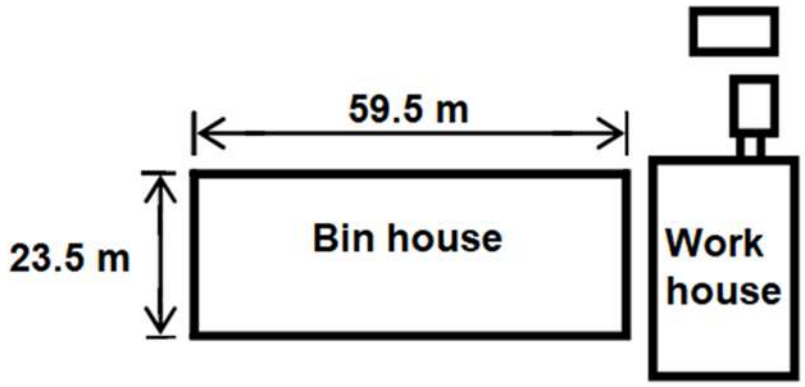


Fig. 1. Foundation plan

Table 1 shows the soil layers and the constitutive model parameters. There are total four distinguish layers at the site. The bedrock was found 14 m below the ground. The elastic-perfectly plastic soil model i.e. Mohr-Coulomb model was adopted in this study. The undrained shear strength values were assumed based on six boreholes (Peck and Bryant, 1953; Baracos, 1955). The ground water table at the site was taken as 2.4 m below ground.

Table 1. Physical properties of soils

	Clay fill	Brown clay	Grey clay	Glacial silt till
Material model	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Depth (m)	0 - 3.0	3.0 - 7.6	7.6 - 12.2	12.2 - 14.0
γ_{unsat} **(kN/m³)**	18.70	18.70	18.70	19
γ_{sat} **(kN/m³)**	18.7	18.7	18.7	19
E' (kN/m²)	20000	10800	6200	30000
ν'	0.3	0.3	0.3	0.3
c_u **(kN/m²)**	54	54	31	20

3. Numerical modelling

Numerical models were set up in two-dimensional plane strain and three-dimensional space as shown in Fig. 2 & 3. Due to symmetry, only half of the model was simulated in 3D analysis. To create plane strain model in 3D environment, the out-of-plane thickness of the model is 1 m. Horizontal boundary was placed at 4 times the foundation width for both models. Mesh sensitivity studies were performed prior to actual analysis to ascertain the current mesh sizes in the model does not affect the results. Type B Undrained analysis was performed with PLAXIS 3D finite element program. Uniform loading was applied instantaneously to simulate undrained condition. This is an assumption made on loading type as the soils below are fine grain with low permeability. The raft foundation was modelled as rigid volume elements.

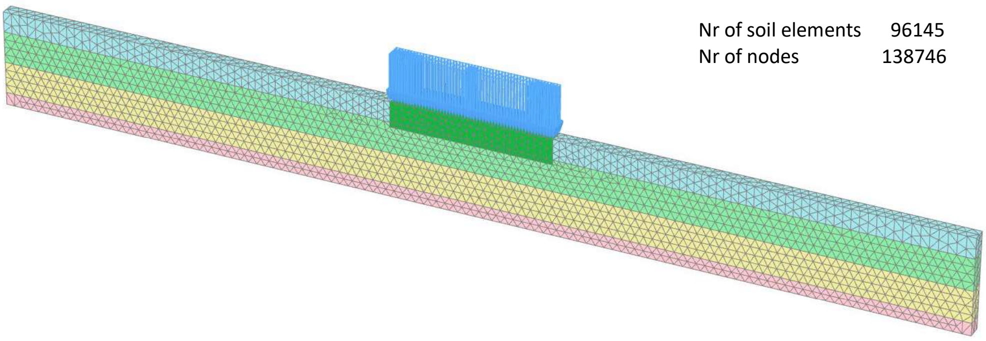


Fig. 2. Two-dimensional plane strain model

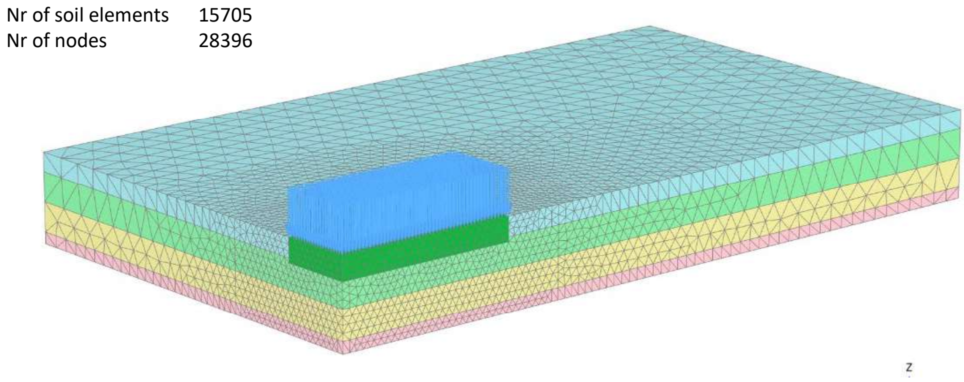
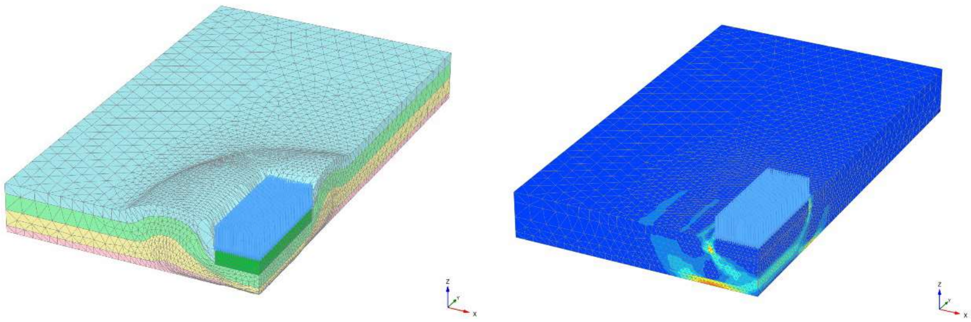


Fig. 3. Three -dimensional model

4. Results and Discussion

After the foundation was loaded to failure, the failure modes of the numerical models can be seen in Fig. 4 & Fig. 5. Both models yielded general shear mode as heaving can be seen at both side of the foundations due to volume conservation as the load was applied in undrained manner. In actual failure of the elevator, heaving was noticed as well but more to the west side as structure tilted to the west direction. Titling of the foundation to one side is common as the soil below the ground is not 100% homogenous. The failure surfaces of both numerical models were noted to extend down to the lower boundary of the glacial till. This is comparable to actual foundation where one side of it had settled 13 m below the ground and stopped in the glacial till layer.



(a) (b)

Fig. 4. Three-dimensional model: (a) Deformed mesh, (b) Incremental deviatoric strain

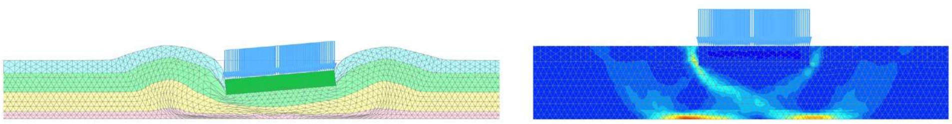


Fig. 5. Two-dimensional model: (a) Deformed mesh, (b) Incremental deviatoric strain

Table 1 shows the estimated failure load for different approaches. Plane strain model produced results which was in good agreement with the true failure pressure. However, it should be mindful that the assumption of plane strain was not strictly applied in this case as the structure length is not very long compared to its width. On the other hand, 3D model estimated 20% higher collapse load. The discrepancy of the results may be due to error in choosing the best estimate of the undrained shear strength. Further comparisons of results with different analytical approaches such as the use of weighted average for undrained strength, use of conservative value assuming soft layer throughout the depth, and use of two-layer strata kinematic failure mechanism approximation. The best estimate of results came from two-layered strata approach. However, neither the assumption of scoop failure mechanism nor weighted averaging in this approach is free of error. Furthermore, it should be understood that the determination of true failure load is subject to some uncertainty (Salgado, 2013).

Table 1. Numerical results and comparisons

Methods	Q_{ult} *(kPa)*	*Diff (%)*
Analytical: weighted average (Peck and Bryant ,1953)	314	7.2
Analytical: conservative (Puzrin et al., 2010)	251	-14.3
Analytical: two-layered soil (Puzrin et al., 2010)	297	1.4
FEM 2D Plane strain	304	3.75
FEM 3D	352	20.1
True failure pressure s_f = 293 kPa		

Further analysis using lower bound limit for undrained shear strength was carried out for 3D numerical model. The undrained shear strength was reduced from 54 kN/m^2 to 40 kN/m^2 for Brown Clay and from 32 kN/m^2 to 25 kN/m^2 for Grey Clay. The failure load obtained was now 320 kN/m^2 which is significantly closer to the true failure load. Therefore, the selection of 'correct' undrained shear strength is crucial in determining the actual ultimate bearing capacity of the foundation, and this requires careful engineering judgement. Hence, in this case, the selection of lower bound limit for undrained shear strength seems to be smarter choice.

5. Conclusions

Re-examination of Transcona Grain Elevator failure case using numerical approach was conducted. 2D Plane strain and 3D full model were used to investigate the difference in modelling approach. Few conclusions can be made from this study.

- 2D Plane strain analysis gave good estimation to the true failure pressure however the assumption of 2D plane strain is not strictly apply for this case as the length of foundation is not long enough with respect to its width.
- 3D full model gave 20 % overestimation as average undrained shear strength values were taken for soil layers.
- The failure modes by both numerical analysis are similar which show general shear failure with heaving on both side. However, more heaving was observed at west side of the elevator for actual foundation.
- Lower bound limit analysis matched the true failure load better.

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Experimental Study on Characteristics of Crushed Aggregate, Construction and Demolition (C&D) Debris and Roof Waste for Subbase Application

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Abstract

Road is a major component for mobility and accessibility as its main role is to transfer people and goods from one location to another. The function of road pavement is to support wheel loads, withstand the stresses imposed and distribute the loads to the lowest layer of subgrade. Based on Public Works Department of Malaysia's (PWD) Specification for Road Works (JKR/SPJ/2014), the materials for subbase are sand, laterite, crushed aggregate and cement stabilized. Overdependence on these conventional materials keep increasing the road construction cost. Utilizing the construction waste such as construction and demolition (C&D) debris and roof waste for subbase can partially replace the natural crushed aggregate. The water absorption, LA abrasion and aggregate crushing value tests have been conducted to investigate the performance of crushed aggregates, C&D debris and roof waste for subbase application with five different percentages of mixture. Based on the results obtained, 50% crushed aggregate - 50% C&D give the best result of performance for subbase application. The utilization of C&D in subbase also can reduce the road construction cost and solve the C&D waste disposal problem.

Keywords: Construction and demolition (C&D), crushed aggregate, roof waste, subbase.

1. Introduction

Pavement consists of four layers namely subgrade, subbase, base and surface layer (wearing course and binder course). The main function of subbase is to provide protection to the subgrade and offers a platform for base layer. Subbase also supports the surface layer and distributes the load to the subgrade. The subbase is used to enhance the stability of pavement and at the same time act as drainage to provide a better service life of pavement.

The designed life span for flexible pavement in Malaysia are generally from ten to fifteen years but recently, the condition of road cannot afford to carry load with the specified design life especially at the industrial area (Kordi et al., 2010). Subbase materials shall be produced from hard durable stone, recycled or suitable building material such as recycled asphalt and concrete and natural gravels. Saltan and Selcan (2008) stated that subbase course received less stress due to it is located pretty deep from the surface therefore resulted to lesser intense. The combined thickness of subbase, base and wearing surface must be great enough and possess an adequate strength to reduce the stresses and able to withstand the loads occurred in the subgrade.

The principle of sustainable development requires the society in general to be aware in the need of optimizing the existing resources and to minimize the residues (Potti, 2005). The use of secondary material of wastage need to be implemented as to reduce the demands on natural crushed aggregate. Road construction is highly recommended to implement the concept of recycle, reuse and reduce as it can save a lot of resources which indirectly reduce the cost of the construction and at the same time moving towards sustainability.

Every year construction industries generate millions of tons of solid waste. The construction and demolition (C&D) debris and roof waste are generated when the existing buildings and structures including streets and highways, bridges, utility plants, piers and dams are renovated or demolished including deconstruction. Construction and demolition materials are contained bulky and heavy materials like concrete and bricks. Due to rapid urbanization and industrialization, C&D debris and roof waste are continuous disposed in large quantity which can minimise the landfill space and also causing serious environmental pollutions.

Therefore, the aims of this study are to (a) investigate the characteristics of various mix proportions of crushed aggregate, construction and demolition (C&D) debris and roof waste as subbase material and (b) verify the toughness characteristics of various mix proportions of crushed aggregate, construction and demolition (C&D) debris and roof waste with JKR specification for subbase materials (JKR/SPJ/2014).

2. Materials

The granular material of crushed aggregate is commonly used in road construction. Gravel is formed from any natural rock and frequently contains a wide variety type of rock (Kendrick, 2004). The gravels form by varies mixture sizes of pebble or stones either have regular or irregular shape to provide angular force for the traffic load. The properties of crushed aggregate are suitable as subbase material due to its high strength and able to provide drainage for water movement through the pavement surface. According to Ozcelik (2011), the suitability of aggregates to be use in a given construction is determined by evaluating the material in terms of its physical and mechanical properties.

A research by Kolisetty & Chore (2013) proved that the waste materials acquired from construction and demolition waste (CDW) from household, commercial and industrial or from pavements can be reused in all of construction activities such as building and road constructions. According to the results obtained from several studies, construction and demolition waste is more efficient compared to the conventional material for the subbase material (Bolden & Johnny, 2013). Federal Highway Administration (FHWA) stated that recycled concrete materials have lower specific gravity, uneven surface texture and higher water absorption value when compared to natural aggregates. It was proved that the water absorption value of the recycled construction and demolition waste materials mostly dependant on the occurrence of highly porous ceramic materials (Fabiana et al., 2011).

Roofing materials are manufactured in variety types such as concrete, metal, shingle roof and clay roof tiles. Roofing material has a good durability under all exposure conditions. This roofing material are non-combustible, which give good protection from heat and fires. The used of roof waste or also known as roof shingles reduced the amount of materials disposed to the landfills. Roof wastes can be applied in granular base stabilization for layers underlying the pavement surface, patching materials for repairing potholes or in hot mix asphalt concrete and surface layers (Newcomb, 1993). Figure 1 shows the mixture of crushed aggregate, C&D debris and roof waste used in this study.

Fig. 1. Crushed Aggregate, C&D Debris and Roof Waste

3. Methodology

The crushed aggregate used in this study are obtained from Highway and Traffic Engineering Laboratory in UiTM Cawangan Pulau Pinang, while C&D debris and roof waste are collected from several building constructions in Seberang Jaya, Pulau Pinang. Various percentages of crushed aggregates, C&D debris and roof waste are prepared as shown in Table 1.

Table 1. The Percentage Mixture of Crushed Aggregate (CA), Construction and Demolition (C&D) and Roof Waste (RW).

Mixture	Percentage Mixture (%)		
	Crushed Aggregate (CA)	Construction and Demolition (C&D)	Roof Waste (RW)
M1 (control sample)	100	-	-
M2	50	50	-
M3	50	-	50
M4	50	20	30
M5	50	30	20

Wire basket method as shown in Fig. 2 is conducted in accordance to BS2386: Part II:1995 to determine the water absorption of the mixture. Firstly, the samples are washed in order to remove the fines material and placed in suspended wire basket before being immersed in water. After that, the basket is shake immediately to remove the entrapped air by lifting the basket completely immersed in water for a period of 24 hours. The basket and sample are removed from water and allowed to drain for a few minutes. After that, the sample are dried using absorbent clothes. Large particles are wiped individually to achieve a saturated-surface-dried (SSD) condition. The dried sample then are weighed and kept in an oven at a temperature of 110° C for 24 hours.

Fig. 2. Wire Basket Apparatus.

Los Angeles (LA) Abrasion test is a measure of degradation of mineral aggregates of standard grading resulting from a combination of action including abrasion and grinding in rotating steel drum containing specified number of steel spheres (Sohadi, 2001). The LA Abrasion test is performed in order to determine the resistance to abrasive wear of an aggregate in accordance to ASTM C131:2006. The mixtures are washed and oven-dried for 24 hours. Then, the mixture is placed inside the drum as shown in Fig. 3 with 11 steel balls. The drum is rotated for 500 revolutions at a speed of 30 to 33 rpm and the mixture is then sieved on a sieve size 1.7 mm. Then, the retained sample is washed and kept in oven for 24 hours.

Fig. 3. Los Angeles (LA) Abrasion Test.

Aggregate Crushing Value (ACV) test is a measurement of the resistance of material to crushing under a gradually applied compressive load. The ACV test is carried out on material that passing 14 mm and retained on 10 mm sieve size. The procedures for ACV test are in accordance to BS812-110:1990. The mixture is put in a standard mould and for a period of 10 minutes, the load of 400 kN is gradually applied to the mixture as shown in Fig. 4. The mixture is then taken out from the mould and being sieved with 2.36 mm sieve. The amount of material passing 2.36 mm sieve is then weighted.

Fig. 4. Aggregate Crushing Value (ACV) Test.

4. Results and Discussion

The results in Fig. 5 shows that M3 (50% CA - 50% RW) has the highest water absorption value which is 1.32% while the lowest value is from M2 (50% CA - 50% C&D) with 0.65%. The water absorption for control sample (M1) has the value of 0.28%. When added 50% of C&D in M2, it shows an increment of 0.37%, meanwhile when added 50% of roof waste in M3, the increment is 1.04%. The results indicate that the roof waste has increased the water absorption if compared to C&D which contained less porous ceramic materials. The increasing value of water absorption varies greatly according to the nature of the materials. For large occurrence of high porous ceramic materials like roof tiles, the water absorption increases significantly. From the result, it clearly shows that roof waste has the highest amount of water absorption, so this characteristic effected the roof waste strength. According to the Standard Specification for Road Works (JKR/SPJ/2014), the water absorption value for subbase material must less than 2% and from the results, all mixtures are fulfilled the specification.

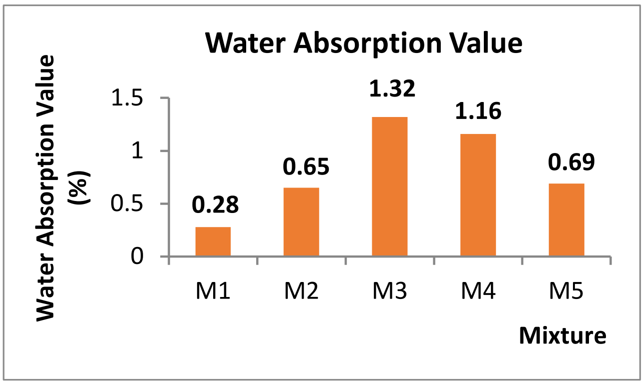

Fig. 5. Results of Water Absorption Value

The highest LA Abrasion Value (LAAV) is from M3 with 41.3%, while M4 and M5 give the LAAV results of 37.8% and 36.3% respectively as shown in Fig. 6. The results show that when 50% of roof waste added to the mixture (M3), 11.8% is increased compared to the control sample, while after 50% of C&D added to the mixture (M2), there is only small increment of 5.7%. The LAAV for C&D is lower than roof waste because C&D has less abrasion loss due to the bonding between particles of the materials is very high. So, from the results, it indicates that C&D has higher strength to abrasive wear during manufacture, placing and compaction than roof waste. All mixtures in this study are fulfilled the Standard Specification for Road Works (JKR/SPJ/2014) as the value of LAAV for subbase must not exceed 50%.

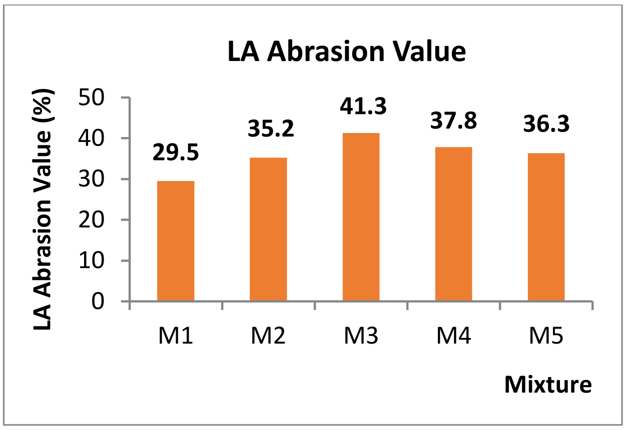

Fig. 6. Results of LA Abrasion Value

From Aggregate Crushing Value (ACV) test, M3 (50% CA - 50% RW) increases 5.66% if compared with control sample (M1), while M2 of (50% CA - 50% C&D) is also increases 1.62% from M1 as shown in Fig. 7. From the results, the lowest aggregate crushing value is 12.28% (M2), due to C&D debris are more resist to crushing under gradually applied compressive loads. All results have fulfilled the requirement of Standard Specification for Road Works (JKR/SPJ/2014) which is the ACV for subbase must less than 35%. The materials used for flexible pavement must be durable to sustain the weight of the machineries such as rollers during construction and also the crushing actions due to traffic. Thus, the aggregate must have a strong resistance to crushing.

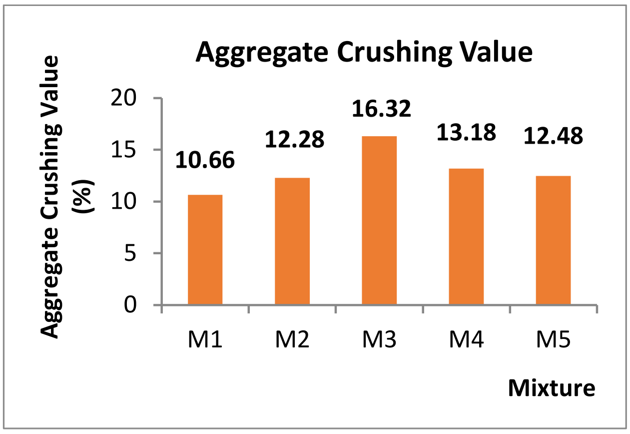

Fig. 7. Results of Aggregate Crushing Value

All results show that M2 (50% CA - 50% C&D) has the lowest value for all characteristics. It was proved that C&D is less porous ceramic material to absorb water if compared to roof waste. C&D also has high particle bonding and high resistance to crushing and abrasive wear. Therefore, it can be concluded that C&D materials are the best mixture for subbase application.

5. Conclusions

The effect of construction and demolition (C&D) debris and roof waste for subbase application are investigated and analysed in this study. The results indicate that the presence of C&D and roof waste effected the performance of the conventional subbase material. The water absorption, LA abrasion and aggregate crushing values of all mixtures have fulfilled the Standard Specification for Road Works (JKR/SPJ/2014). The best characteristics have occurred at M2 (50% CA - 50% C&D) which contribute the lowest water absorption, LA abrasion and aggregate crushing values. Thus, 50% CA - 50% C&D is recommended to be implemented for subbase layer.

From the results obtained, it can be concluded that the waste of construction and demolition (C&D) have good characteristics to replace the natural crushed aggregate for subbase application. In addition, the introduction of C&D will reduce the road construction cost and significantly will also solve the construction waste disposal and pollution problems.

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Carbon Footprint Reduction Measure in Soil Stabilization Using Sucrose as Cement Replacement

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Abstract

It is well known that the clay soil is very low in strength. Hence, to improve the compressive strength of the soil, it is vital to increase the chemical and physical bonding of the soil by adding admixture. Many types of admixture available in the market. However, the cost is high. Moreover, the stabilization agent is concentrated on using cement. It has become an environment concern since it causes enormous carbon emission generated during its production. Therefore, the objective of this study is to assess the suitability of sucrose as cement replacement in soil stabilization. This paper presents the laboratory results of treated soil with different percentages of sucrose (3%, 6% and 9% by weight of soil) and comparison was made with untreated soil. Unconfined Compression Test (UCT test) has been conducted for the purpose. Besides, the physical properties tests were conducted which includes particle size distribution, hydrometer, particle density and Atterberg limit. Standard proctor test was also conducted to determine the optimum moisture content. Based on the finding of the experiment, the suitability of sucrose as soil stabilizer are discussed. The results showed that by adding more sucrose, the strength will decrease dramatically. In conclusion, the sucrose may reduce the carbon footprint, but does not improve strength of clay. This finding will help the engineers to choose the right admixture for soil stabilization.

Keywords: Unconfined Compression Test (UCT), Sucrose, Ordinary Portland cement, compressive strength

1. Introduction

Soil settlement is a complex phenomenon and often associated with low soil strength. The soil settlement will directly involve the cost of maintenance of infrastructure such as highways and roads This situation become worst with the increasing population and number of projects. (Hussin et al., 2015).

Moreover, soil settlement occurs when the soil has a high organic content. Because of this factor, soil with occasional and high creep rates will be highly compressible. The unsuitable compressive strength characteristics of the soil can increase the potential threat of foundation failure. A soil deposit behaviour generally depends on different conditions during its creation and growth (Raghunandan and Sriraam, 2017). Over the years, consolidation settlement has always been associated with effective stress increase. However, in unsaturated soils, volume change behaviour of soils due to wetting is always complex due to changes of the soil when it is inundated (Md. Jais, 2014).

In addition, safety in the environment and economy is a very important factor that must be considered during the design and construction. Therefore, in order to match the variety of results, it is important to include the rational construction technique. Nowadays, based on demand of society which concern with the carbon footprint of the cement during its production, it is beginning to identify the important of the technique that combines different stabilization agent to produce greener admixture. It was reported by Jimenez et al. (2018), the emissions for concrete with 0.5 w/c were between 347 and 351 kg of CO2-e/m^3. There are many agents that can be used to stabilize the soil. However, no agent is ever successful in more than a limited number of soils due to great variability. The stabilization of soil is generally concerned with increasing volume stability, strength and durability (M'Ndegwa, 2011).

Therefore, this research is intended to assess the suitability of sucrose as cement replacement in soil stabilization. The outcomes from this research is beneficial in finding the cement replacement agent and improving the highway and road strength.

2. Methodology

Methodology gives brief introduction of the sample location, sample preparation and appropriate laboratory test methods used in order to achieve the objective of this study. Figure 1 shows the flow chart of methodology.

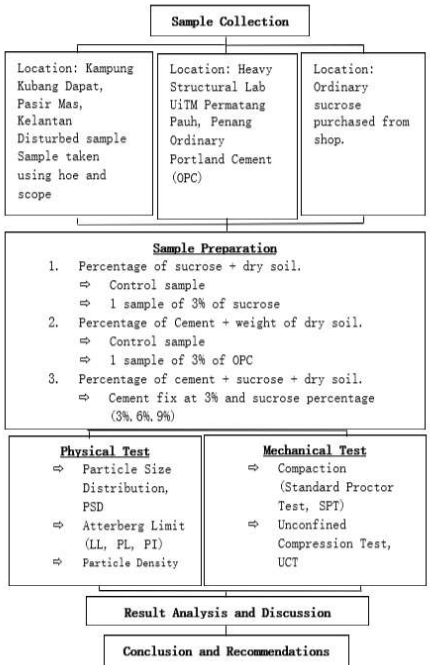

Fig. 1. Flow chart of methodology

2.1. Sample preparation

The samples were taken at Kampung Kubang Dapat, Pasir Mas, Kelantan. The undisturbed sample was taken and placed in gunny sack. The sample was placed on the tray to let the water out from the soil. Later, the soil was placed in oven for 24 hours.

2.2. Preparation of additives material

Sucrose and cement have been prepared for usage as stabilizer material for clay. Figure 2 shows the 24-hour oven-dried clay while Fig. 3 shows sucrose that have been crush into powder.

Fig.2. 24-Hour oven-dried clay

Fig. 3. Sucrose that have been crush into powder

2.3 Basic Properties test

The basic properties of soil are those required to determine its physical state of soil. From the basic properties test, classification of soil for the engineering purpose will be obtained according to BS 1377: 1990: Part 2 and Part 4. The test consisted of Particle Size Distribution, Hydrometer, Particle Density, Atterberg Limit Test and Standard Proctor Test. The optimum moisture content and maximum dry density of the soil have been determined from the Standard Proctor Test.

2.4. Engineering Properties test

The Engineering properties of soil are those required to determine the maximum compression strength of soil. It is in accordance to BS 1377: 1990: Part 7: Unconfined Compression Test (UCT).

3. Results and Discussions

3.1 Properties of Material

The index properties of the clay soil show that it is a Slightly Silt with very high plasticity (VH) using the Unified Soil Classification System, USCS. It has a Liquid Limit of 77%, Plastic Limit of 46% making its Plasticity Index equivalent to 31%. The particle density of soil is 2.55 Mg/m3. Maximum Dry Density and Optimum Moisture Content obtained from Standard Proctor Test for clay are 1.30 Mg/m^3 and 34.27%, respectively.

3.2 Unconfined Compression Test (UCT)

The variation of Unconfined Compression Test (UCT) with 100% of soil and the various mixes soil + cement + sucrose is conducted to determine the relationship between stress and strain during compression of the soil. Table 1 shows the maximum compressive strength for every percentages.

Table 1. Maximum compressive strength for every percentages

Percentage of sucrose and cement (%)	Maximum compressive strength, (kN/m2)	Maximum strain, (%)
Control sample (0%)	290.00	5.10
3% cement	300.00	5.22
3% sucrose	132.00	2.40
3% cement + 3% sucrose	141.00	2.50
3% cement + 6% sucrose	70.55	1.24
3% cement + 9% sucrose	35.27	0.56

The compression strength of soil is reduced with the addition of sucrose. It shows that sucrose has different properties than its counterpart which is molasse (Araya and Taye, 2015). So, sucrose cannot increase the strength of soil and not suitable to be used as soil stabilizer.

4. Conclusion and Recommendation

The analysis of the geotechnical properties of clay soils added with various percentages of cement and sucrose have been carried out in accordance to BS1377 (1990). The result shows that with the additions of sucrose, it did not increase the compressive strength of soil effectively. The additions of combination cement and sucrose still not improve the soil strength. The maximum strength of soil was recorded for 3% of cement when the test running until achieve 20% of axial strain. The strength is contributed by the chemical and physical bonding of the soil with cement and soil. The strength of the soil mixed with cement become higher than the mixture of soil, cement and sucrose. Sucrose can ‘dilute’ the cement, hence reducing the strength dramatically. All in all, the cement and sucrose are not a good combination for soil stabilizer. As a recommendation, the study on molasse should be conducted instead of using sucrose and chemical reaction should be studied as well.

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Review on Causes of Crane Accidents at Construction Sites

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Abstract

Cranes accidents in construction site still happened even though many researches have been carried out. A literature review was carried out to study the causes of crane accidents. Articles were first abstracted based on the types of cranes usually being used in the construction industry. The articles usually mentioned the causes of accidents in relevant to a particular type of crane. The factors that causes the accidents need to be categorised into relevant groups to produce relevant terms that understand by the industry and for research purposes. Our findings from articles show that the 2 frequent types of crane accidents are failure of crane components and struck by load; and the 2 primary causes of crane accidents are safety management issues and incompetent crane handler.

Keywords: construction site, accident, crane type.

1. Introduction

Malaysian construction industry involves infrastructure project such as railways, flyovers and bridges which require cranes mainly for lifting and hoisting material. Mobile cranes, tower cranes, crawler cranes were used to lift, transfer, transport and place building material loads in many parts of a construction project area (Abdul Hamid et al., 2019). Cranes normally equipped with hoist cables, hooks and jibs (Mohamad Ali and Mohamad, 2016). Mobile cranes and tower cranes are different in their respective arm length, mobility, load lifting capacity, and working space required.

2. Crane Accidents

One of the main causes of accidents in construction site is the use of cranes or derricks while the lifting operations been done (Beavers et al., 2006). 137 cranes involving deaths in the United States from 1997 to 2003 were analysed (Beavers et al., 2006) and from the analysis reported the most common types of accidents are struck by load (32%), electrocution (27%), crash during assembly/disassembly of cranes component (12%), and the failure of the boom or cable (12%). Accidents of mobile cranes failure mainly due to lack of raising balance, whereas tower cranes failure are due to cranes steel components support structures (Mohamad Ali and Mohamad, 2016). Mobile cranes are more susceptible to becoming unstable compare to tower cranes

(Beavers et al., 2006). Research study also found out that tower cranes injuries were recorded when the cranes or part of the tower cranes fall (Ismail and Muhamad, 2018); the cause of these accidents were always contributed by many factors, but the strongest contributing factor is overload of the crane. According to Abdul Hamid et al. (2019), types of crane accidents at construction sites in Malaysia were toppled and overturn with 39%, follow by struck by object 23%, falling 14%, struck by crane 11%, electrocution 4%, transportation 2%, and other 7%.

2.1. Overturn

The first type of crane accident occur is overturn/tip over. Beavers et al. (2006) had made a comparison of findings between him and OSHA study; and found that the four synonymous mode of failure are electrocution, overturn, fall and mechanical failure. Mohamad Ali and Mohamad (2016) studied about accident at flyover in Damansara Perdana on 12th January 2016; they found out that the mobile crane had overturn because of overloading, primary due to loss of stability on ground. The accident had led to the death of one worker and three others injured. Research by Abdul Hamid et al. (2019) dictated that 39% of cranes accidents is overturn. Yu (2017) studied crane overturning moment in detail due to the case that happened. Crane accidents may occur due to unsecured load, overloaded in lifting products, non-level ground, and poor communication (Abdul Hamid et al., 2019). Rigging accidents were caused by one or the combination of faulty tools, cost or time limitations, incompetent leadership, insufficient scheduling, unrealistic ownership or management demands, environmental conditions, contradictory orders, operator mistakes, situation shifts, and lack of training, expertise or abilities (Yu, 2017). Hazards occur when cranes carried heavy loads thus materials fell off and overturned. Crane accidents brought impacts to an organization, workers and possibly public such as pedestrians in term of finance, time, injury, and loss of life. NIOSH, DOSH and CIDB are the agencies that involve in ensuring safety procedures being practiced by crane operators. Yu (2017) identified that forensic investigation is necessary to identify the root causes of crane accidents.

2.2 Fail of component structure

When a crane is overloaded, it may not only overturn but make the structural components fail thus collapse (Ismail and Muhamad, 2018). Beavers et al. (2006) listed seven mode of crane failures which include failure of component booms and cables. Gharaie et al. (2015) analyzed Australian construction industry crane failures in which component structures contribute to 13.6% of failure. Abdul Hamid et al. (2019) found that structural failure was a contributor of crane accidents in Malaysia.

2.3 Struck of load

A common type of crane accident, struck of load, includes crane hitting workers, loads fell from the hook, structures collapse and hit workers. Beavers et al. (2016) finding showed that in USA from 1997 to 2003, struck by load with 32% was the largest type of crane accident. A study by Gharaie et al. (2015) in Australian construction field found that 45.5% from 22 cases involved struck of load. Struck of load in crane accidents was due to human error, technical, and nature (Ismail and Muhamad, 2018). In Malaysia, a study by Abdul Hamid et al. (2019) showed that struck by load contributed to 23% in crane accidents.

2.4 Human Factor

Cranes operators need to have a valid license, as cranes depend heavily on professional operators before variables likely to affect their safety (Zayed and Abbas, 2013). Crane accidents were started from human factors, which could be divided into crane operators themselves, lifting supervisors, and general workers. Research by Abdul Hamid et al. (2019) identified that crane handlers should be in good condition and they should not operate a crane continuously for more than four hours.

2.5 Mechanical

Each part of a crane have the tendency to fail if it is lack of maintenance or the part has been damaged. Mohamad Ali and Mohamad (2016) found out that toppling or overturning is the mechanical failures which resulted in a mobile crane collapse, whereas the most common mechanical failures resulted in a tower crane failure is the boom / jib frustration. Mechanical failure is corresponding with human factor as human is controlling the machineries. A study by Yu (2017) on crawler crane accidents identified breakage of tower's luffing hoist and wire rope of main boom, consequent allow deterioration and corrosion as the key mechanical failure of the wire rope and thus cranes fell. In the circumstances that may be hazardous to the proper operation or technical integrity of the crane, an operator should never operate a crane (Neitzel et al., 2001).

2.6 Safety Measures

Failure to prepare proper safety measures can result in severe crane accidents (Mohamad Ali and Mohamad, 2016). The management should not only depends on the Personnel Protective Equipment (P.P.E.) to avoid injury (Ismail and Muhamad, 2018). The competent person should master OSHA standard, update and carry out safety plans analysis (Beavers et al., 2006). OSHA had come up with safety standards to mitigate dangers and potential risks at site (Mohamad Ali and Mohamad, 2006). Without adequate planning and safety procedures for cranes operation at construction site, there are possibly enormous potential to loss of property and life (Neitzel et al., 2001). Riggers and signalers are an important parts of crane operations and need to be qualified in a similar way to crane operators (Neitzel et al., 2001). The number of crane accidents is still high even with the enforcement of regulations by government and great efforts by employers (Yu, 2017).

2.6.1 Limit switch system

When a crane is overloaded the cut off limit device would immediately turn off the tower crane power supply (Ismail and Muhamad, 2018). One of the common mistake that always occur in a tower crane is because of the limit switch system that had been bypassed during the operation work (Mohamad Ali and Mohamad, 2016). Yu (2017) believed that the limit switch system failed to operate sufficiently thus caused mode of failure to the tower crane. Research by Neitzel et al. (2001) stated that limit switches were mounted on tower cranes from raising over loads.

2.6.2 Competent operator and signalmen

Crane operations relied heavily on professional operators (Zayed and Abbas, 2013). Abdul Hamid et al. (2019) stated that it should be made mandatory for having accredited crane handlers in Malaysia. Survey by Mohamad Ali and Mohamad (2016) believed that all trained, educated and experienced operators can operate the crane well, as well as signalmen and riggers. Riggers and signalmen are in the key part of crane operations that will undergo equivalent instruction to that given to operators (Neitzel et al., 2001). A rigging course and an examination for signalmen must be performed before they can become one of a qualified signalmen (Ismail and Muhamad, 2018).

2.6.3 Proper maintenance

Improper maintenance was one of the common contributing factor to crane accidents (Yu, 2017). A proper scheduled preventive maintenance and repair routine must include all mechanical, electrical and hydraulic systems (Neitzel et al., 2001). Poor maintenance that did not do the maintenance work properly will lead to an accident (Mohamad Ali and Mohamad, 2016). Technicians being appointed to monitor the danger of cranes must be experienced, qualified and registered with DOSH (Ismail and Muhamad, 2018). Yu (2017) found that the crane manufacturer and the appropriate regulations failed to test and repair on the wire rope, thus crane boom fell and hit neighboring factory roof.

2.6.4 Site management

Insufficient risk control management system of site space was established as the key source of impact on the crane incidents (Gharaie et al., 2015). Ismail and Muhamad (2018) mentioned that the current high-rise building situations are the management unable to recognize the risks associated to the operation of the tower cranes. All levels of contractor management team must dedicate to safe crane operations at all times, even with schedule pressures (Neitzel et al., 2001). It is of utmost importance in ensuring that cranes are well maintained, appropriately deployed and operated, lifting operations are well prepared and well controlled to reduce the risks of accidents (Yu, 2017).

3. Discussion on Types and Causes of Crane Accidents

The summary of relevant mentioned articles regarding the types and causes of crane accidents are tabulate on following:

Table 1. Summary on types of crane accidents

	Overturn	Fail of crane components structure	Struck of load	Loss of load during operation	Assembly and dismantling crane
Gharaie et al. (2015)		X	X		
Ismail and Muhamad (2018)		X	X	X	
Mohamad Ali and Mohamad (2016)					
Abdul Hamid et al. (2019)	X	X	X		
Beavers et al. (2006)	X	X	X		X
Yu (2017)	X				
Neitzel et al. (2001)					
Zayed and Abbas (2013)					
TOTAL	**3**	**4**	**4**	**1**	**1**

Table 1 shows the summary of 8 articles regarding the types of crane accidents. The highest score was 4 articles that identified 2 types of accidents, i.e. failure of crane components structure, and struck by load. Abdul Hamid et al. (2019) identified crane accidents due to falling 14%, and struck by object 23%, after overturn with the highest score of 39%. However, Beavers et al. (2016) and Gharaie et al. (2015) in the respective researches found that struck by load was the largest type of cranes accident, as 32% in USA and 45.5% in Australia.

Even though overturn only achieved a score of 3 by articles, findings by Abdul Hamid et al. (2019) crane accidents at construction sites in Malaysia were primary toppled and overturn with 39%, whereas Beavers et al. (2016) did not mention the term overturn but failure of the boom or cable as the third highest type with the frequency 12%. Loss of load during operation, assembly and dismantling crane, both only mentioned once by the 8 articles.

Table 2. Summary on causes of crane accidents

	A	B	C	D	E	F	G	H	I
Gharaie et al. (2015)						X	X	X	
Ismail and Muhamad (2018)	X			X	X	X		X	X
Mohamad Ali and Mohamad (2016)	X		X			X			X
Abdul Hamid et al. (2019)		X		X	X	X		X	X
Beavers et al. (2006)						X			X
Yu (2017)			X			X			X
Neitzel et al. (2001)	X		X		X	X			X
Zayed and Abbas (2013)						X			X
Total	**3**	**1**	**3**	**2**	**3**	**8**	**1**	**3**	**7**

Note:
A* **Signalmen error**
B* **Poor communication**
C* **Mechanical failure**
D* **Human factor**
E* **Overload**
F* **Safety management**
G* **Layout or space**
H* **Structure failure Layout or space**
I* **Handle by incompetent handler**

The 8 articles in Table 2 totally mentioned the 9 causes (A to H) 31 times. Table 2 identifies that safety management is the main cause of crane accident, mentioned by 8 articles; follows by the problems of crane handling by incompetent handler, 7 articles. Both causes contribute 15 over 31 times or 48% of worth mentioning, as safety management has the highest score of 8/31 or close to 26%.

The other 4 causes with the score of 3 are signalmen error, mechanical failure, overload, and structure failure. A score of 3 over 31 times is near to 9.7%. Articles highlighted human factor 2 times, and lastly each 1 time for poor communication, and layout or space.

4. Conclusions

Based on the data, the summary of articles identified fail of crane components structure and, struck of load as the 2 main types of crane accidents; closely followed by overturn. Research on USA and Australia found that struck by load had the highest score; but it was the second largest type in Malaysia after overturn, in which the researches in both the abovementioned countries did not identify overturn as a specific type of crane accidents. Thus the 3 large types of crane accidents are, fail of crane components structure, struck of load, and overturn.

The main cause of crane accidents is safety management issues, immediate followed by incompetent handler. The secondary causes are signalmen error, mechanical failure, overload, and structure failure.

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Grading Characteristics of Soil: A Brief Review

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Abstract

This article provides a brief review on grading characteristics of soil. The important terminologies on soil gradation are provided, followed by several applications of grading characteristics. The comparison of grading characteristics between several textbooks are also provided. Finally, this article proposed the grading characteristics that should be employed by related industry in Malaysia.

Keywords: Grading characteristics, Coarse grained soils

1. Introduction

Grading characteristics of soil play an important role in classifying the soil. Grading characteristics is related to the size of soil particle, so it is significantly related to coarse grained soil. It is less important for fine grained soil, as it is governed by its consistency. Table 1 listed important terminologies related to grading characteristics of soil and their definition.

Table 1. Terminologies related to grading characteristics of soil.

Terminology	Definition
Effective size	D_{10}. Effective size is the diameter of an artificial sphere that will produce approximately the same effect as an irregularly shaped particle
Coefficient of uniformity Cu	D_{60}/ D_{10}
Coefficient of curvature Cc	$(D_{30})^2/D_{60}D_{10}$
Well-graded soil	Good representation of particle sizes over a wide range, and its gradation curve is smooth and generally concave upward
Poorly graded soil	Either an excess or deficiency of certain sizes or if most of the particles are about the same size

Holtz, Kovacs & Sheahan (1981) highlighted that uniformity coefficient is misnamed, since the smaller the number, the more uniform the gradation. So, it is really a coefficient of "disuniformity." It is similar with water content, where it is actually not representing the content of water in soil, but the ratio between mass of water and mass of soil particles.

2. Application of grading characteristics

There are many applications of grading characteristics in geotechnical engineering, such as determining suitability of soil that will be used for specific purpose. However, in this article, only several applications are highlighted.

2.1. Soil history

Grading characteristics can be used to investigate the soil history (McCarthy, 2014). For example, when the rock is subjected to weathering process, it will degrade to smaller fragments, and finally become a soil. If the soils are not transported, it is known as residual soil. The particle sizes of this residual deposit will change with time, as the particle break down to smaller size. The grading characteristics can be used to show different level of soil degradation. The grading curve will change, as the soil degrade from young residual soil to fully maturing soil. Young residual soil will consist of lesser coarse-grained soils, while fully maturing soil will consist of more coarse grained soils.

The origin of soils can also be indicated by its classification. For example, poorly graded soils are soil that are transported by water or by wind. Example for this category is beach sand. Gap-graded soils are also transported by water, but certain sizes are missing. Meanwhile, well-graded soils are formed due to bulk transport process, for example transportation by glacier.

2.2. Permeability

One of the famous applications of grading characteristics of soil is to estimate the permeability of soil. This was proposed by Hazen, using the following Equation (1):

$$k = (1/100)\ D_{10}^2 \qquad (1)$$

This empirical equation was developed from series of experimental laboratory works and it is limited to coarse grained soil only.

2.3. Evaluate risk of liquefaction

Liquefaction is a phenomenon where strength and stiffness are reduced, due to dynamic loading, mainly from earthquake. Probability of liquefaction to occur increase for soil with high content of coarse grain soil. Stocker & Walz (2002) highlighted that sandy soil with uniformity coefficient $Cu < 5$, particle diameters $D_{95} < 2$ mm and $D_{10} > 0.04$ mm have possibility for liquefaction to occur when subjected to dynamic load.

2.4. Filter design

Design of filter requires that the size of particles must be between specific range. Terzaghi, Peck & Mesri (1996) propose the following ratio: $D_{15(F)} / D_{85(S)} \leq 4$ to 5 and $D_{15(F)} / D_{15(S)} \geq 4$ to 5 where subscript F refer to filter, and subscript S refer to soil.

3. Comparison of grading characteristics

Most of the grading characteristics are mentioned in textbooks, but sometimes the original sources are not clear. The comparison between standards and textbooks are discussed in the following.

3.1. Comparison between British Standard and ASTM

BS1377 Methods of Test for Soils for Civil Engineering Purposes (last version 1990) and BS5930 Code of practice for ground investigations (last version 2015) do not mention explicitly range of value to classify soil based on grading characteristics.

On the contrary, ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) (last version 2017) had provide the grading characteristics to classify the soil, as shown in Table 1.

Table 1. Soil Classification Chart for Coarse Grained Soils (more than 50% retained on No. 200 Sieve)

Criteria			Group Symbol	Group Name
Gravels (more than 50% of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5% fines)	Cu ≥4.0 and 1≤Cc≤3.0	GW	Well-graded gravel
		Cu<4.0 and/or [Cc<1 or Cc>3.0]	GP	Poorly graded gravel
Sands (50% or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5% fines)	Cu ≥6.0 and 1≤Cc≤3.0	SW	Well-graded sand
		Cu<6.0 and/or [Cc<1 or Cc>3.0]	SP	Poorly graded sand

3.2. Comparison between textbooks

The following Table 2 summarize comparison of grading characteristics between several textbooks on soil mechanics and geotechnical engineering. For some textbooks (especially American based), it clearly indicates that they refer to ASTM D2487, while for others, it might be based on other standards, or based on authors experience.

Table 2. Grading Characteristics from Textbooks on Soil Mechanics and Geotechnical Engineering

Reference	Grading Characteristics
McCarthy (2014)	Cu > 10 (well graded) Cu < 5 (uniform graded)
Von Soos & Bohac (2002)	Cu < 5 (uniform (poorly) graded) 5 < Cu < 15 (non-uniform soil) Cu > 15 (strongly non-uniform soil) 0.5 < Cg < 2 (well graded soil)
Whitlow (2001)	Cu < 3 (uniform graded) Cu > 3 and 0.5 < Cg < 2 (well graded)
Smith (2014)	Cu < 4 (uniform graded)

	Cu > 4 (well graded or gap graded) – need to be determined visually
Budhu (2010)	Cu < 4 or 6 (uniform graded) Cg < 1, Cg > 3 (gap graded) Cu > 4 or 6, 1 < Cg < 3 (well graded)
Powrie (2010)	Cu < 10 (uniform graded) Cu > 10, 1 < Cg < 3 (well graded)

4. Proposed grading characteristics for Malaysia

As for our case in Malaysia, it is advisable to adopt classification as provided by British Standard. The latest BS related to grading characteristics is BS EN ISO 14688-2:2018, which replace BS EN ISO 14688-2:2004. The grading characteristics for both versions are shown in Table 3 and 4, respectively.

Table 3. Grading Curve Terms (BS EN ISO 14688-2:2018)

Term	Cu	Cc
Uniformly graded	<3	<1
Poorly graded	3 to 6	<1
Medium graded	6 to 15	<1
Well graded	>15	1 to 3
Gap graded	>15	<0.5

Table 4. Grading Curve Terms (BS EN ISO 14688-2:2004)

Term	Cu	Cc
Multi-graded	>15	between 1 and 3
Medium-graded	6 to 15	<1
Even-graded	<6	<1
Gap graded	usually high	Any (usually <0.5)

5. Conclusions

It can be concluded that, initially, British Standard did not provide specific value for grading characteristics. However, as it adopts BS EN, it starts to provide value for grading characteristic of soil. As Malaysia normally follow British Standard, it is good if Malaysian Standard could include this value in related standard, in order to avoid any discrepancy related to classification of coarse-grained soils. Faculty of Civil Engineering in all local university should start adopting this value in their course content.

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SOFT SOIL REINFORCEMENT USING NYLON FIBER

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Abstract

Soil reinforcement application for problematic soft soil increases as urbanization and population growth caused scarcity of buildable land. This study focuses on evaluating the suitability and performance of nylon fibres for soft soil reinforcement. Unconfined compression test (UCT) has been carried out to investigate stress-strain properties of original and reinforced soil respectively. Disturbed soil samples were obtained from a construction site at Bertam, Kepala Batas which owned by Bertam Properties Sdn. Bhd. Physical properties tests such as Atterberg limit, particle size distribution and particle density test are carried out to identify type soil soil. The consistency of reconstituted soil samples in the lab is controlled based on the optimum moisture content (OMC) and maximum dry density (MDD) values that was determined from standard proctor test. Soil mixtures were prepared at various percentages (0.25%, 0.5%, 0.75% and 1.0%) of nylon fiber with dry weight of clay soil samples. Experimental results shows increment in the performance of the soil shear strength around 43.1% compared to original clay soils. Finding confirms that synthetic fibre is suitable material for soil stabilization application.

Keywords: Nylon fibre, soil reinforcement, synthetic, soft soil.

1. Introduction

The shortage of buildable land has direct impact on the construction cost due to the requirement to stabilize the weaker land prior to construction. Soft soil that exhibits expansive behaviour practically have tendency of erratic volume changes due to change in moisture content. Thus, it is crucial to have strong and durable soil to support load that transferred from the structures. Soil improvement method has been successfully implemented to improve the strength and maintain the stability of the soil for many years. Reinforcement method using synthetic and natural fibres have gained momentum due to its benefit of sustainable construction and geo-environmental friendly materials (Hejazi, et. al., 2012).

Soil is the most abundance construction materials that exhibits weak behaviour in tension. The reinforcement of soils with fibre behaves as a composite material in which fibre can improve the strength of soil. Agarwal et al (2015), conducted CBR test on reinforced black cotton soil mixed with fly ash at 50:50 ratio and 6% lime. The reinforcement materials used in the study were nylon fibre and synthetic bag cut into 1cm and 2 cm length. Based on the finding, both reinforcement materials can be effectively used for ground improvement. However, nylon fibres exhibited better improvement compared to synthetic bag. The utilization of natural coir fibre as soil reinforcement conducted by Upadhyay & Singh (2017) indicated the improvement of the workability and the durability of reinforced soil. They performed the experiment using two types of soil samples collected from different construction site with percentage of mixture from 0.5%, 1.0% and 1.5%. Results obtained from the unconfined compression test (UCS) showed the increment of shear strength value around 49.8% compared to the unreinforced soil.

The paper focuses on the potential of nylon waste as soil reinforcement fibre due to the mass production of various plastic products based on nylon material nowadays. Nylon fibre is synthetic fibre material that human created to fulfil their basic daily needs, therefore by re-using nylon waste will helps reduce the pressure on demanding solid waste landfill and other related environmental issue. Good economic benefit from utilization of waste product to improve the performance of poor soil to be suitable for subgrade and embankments. From previous study, synthetic fibres also more superior in term of desirable engineering properties compared to the natural fibres where degradation due to microorganisms remains as a major challenge (Gowthaman, et. al., 2018).

2. Methodology

Undisturbed dam disturbed soft soil samples used in this study were obtained from construction site located at Bertam, Pulau Pinang. The undisturbed soil samples are taken from trial pit using cylindrical steel tube to maintain the soil moisture content and its fabric. The undisturbed sample was place in the cylinder mould to maintain the natural moisture content and behaviour of soil. Disturbed sample shown if Fig. 1 was dried in oven for 24 hours with a constant temperature of 104°C and then crushed down into finer soil to prepare the sample for further testing.

2.1. Synthetic nylon fiber and mixture preparation.

Nylon fibre reinforcement material used in this study is cut into small pieces with certain length around 5mm -10mm as shown in Fig. 2. The percentage of mixture used were as follow; 0.25%, 0.5%, 0 75% and 1.0% respectively based on the dry weight of soil. The mixing process was manually performed before the mixture is transferred into cylinder steel mould for controlled compaction process. After the compaction process was completed, the compacted soil will be trimmed out to prepare specimen for unconfined compression test. Reliable reconstituted samples are obtained through consistent 27 blows of hammer for each layer during systematic process of sample preparation.

Fig. 1. Dried fine clay soil.

Fig. 2. Nylon reinforcement strip.

3. Experimental Results and Discussion

The index properties of the soil sample indicated that it is clay of high plasticity, CH having a Liquid Limit of 54.15%, Plastic Limit of 28.03% making its Plasticity Index equivalent to 26.13%. The particle density of soil is 2.53. Maximum Dry Density and Optimum Moisture Content obtained from Standard Proctor Testing for soil samples are 1.78 Mg/m^3 and 15.11%, respectively. All properties of soil sample were tabulated in Table 1.

Table 1. Geotechnical Properties of Soil Sample

Charateristic	Results
Plastic Limit	54.15 %
Liquid Limit	28.03 %
Plasticity Index	26.13 %
Optimum Moisture Content	15.11 %
Maximum Dry Density	1.78 Mg/m^3
Particle Density	2.53

3.1 Unconfined compressive strength of reinforced clay soil

The primary purpose of unconfined compression test (UCT) is to evaluate the undrained shear strength improvement of reinforced clayey samples with nylon fibers and compare it with untreated soil. To determine the unconfined compressive strength by mixed the fiber into the soil to improve it performance. The test helps to evaluate the undrain cohesion. The more percentage of fiber is apply, the more it increase in UCS values.

Initial results from stress-strain behaviour of UCT shows increased in strength with the increment of nylon fiber percentage. Figure 3 displays comparison of stress-strain curve for various percentage of nylon fibers and Fig. 4 shows the steady improvement of unconfined compression strength from 0% to the maximum 1.0% of fibre content. The maximum of 43% of strength increment was observed for 1.0% of nylon mixture. Table 2 presents the tabulation data of unconfined compression strength with various percentage of fibers. Similar finding of steady improvement of CBR values was also observed by Agarwal et al (2015) when they mixed the treated black cotton soil with nylon fibers. Estabargh et. al. (2011) also reported the significant increase in shear strength and friction angle of soft soil with the addition of nylon fiber. In addition to that, the pre-consolidation pressure decreases and the coefficient of compression increases with the increment of fiber content.

Table 2: Unconfined Compression Test Results

Soil mixture	UCS (kN/m^2)
Clay soil + 0.00% nylon fiber	1022.57
Clay soil + 0.25% nylon fiber	1055.03
Clay soil + 0.50% nylon fiber	1244.36
Clay soil + 0.75% nylon fiber	1264.81
Clay soil + 1.00% nylon fiber	1463.58

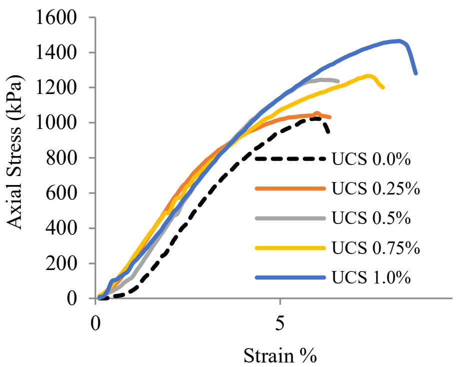

Fig. 3. Stress-strain Curve for Various Percentage of Nylon Fibres.

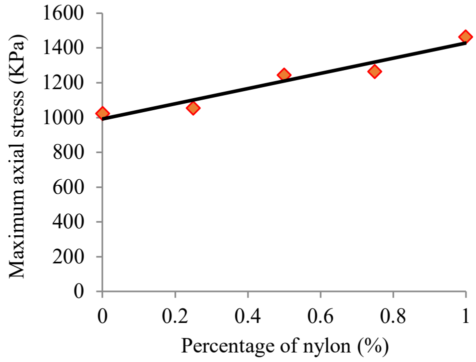

Fig. 4. Relationship Between Percentage of Nylon and Maximum Axial Stress.

4. Conclusions

The experimental results obtained from unconfined compression test carried out concluded that the shear strength of soft soil increased with the additions of the nylon fibers. Thus confirmed the suitability of nylon fibers as reinforcement materials for soil stabilization purpose. The additions of nylon fibers at 1% mixture have greatly improved the soil strength with the maximum increment of 43.13% from 1022.57 kN to 1463.58 kN. Comparison to the previous published data, indicated that the linear increment soil's strength is depending on percentage of nylon fibers. Therefore the usage of waste nylon fiber not only can improve the performance of the soil but also will potentially reduce the solid waste and extend the life of landfill

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Symbolic Solution for Euler Beam Differential Equation of Simply Supported Using MATLAB: A New Teaching and Learning Structural Engineering Methodology in Era of Industrial Revolution Version 5.0

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Abstract

Many applications in civil engineering technology require solving differential equation problems. Frequently, engineering students had a hard time solving this equation by manual approach and require a substantial amount of time. Lacking the graphical picture of the solution, students and educators were uncomfortable with the entire process of solving these equations. In this paper, the capabilities of new teaching technology on solving the differential equation by symbolic means using MATLAB are presented and demonstrated on one simple beam problem. The governing beam equation, Euler beam differential equation, is solved by effortless means and quick manner using *dsolve* MATLAB built-in command. The generated symbolic solutions agreed well with the theoretical solution provided by various textbook authors. This teaching and learning technology should be employed and emphasized in the engineering higher learning institution curriculum in line with the Industrial Revolution version 5.0.

Keywords: Symbolic solver, Differential equation, Euler theory, Beam's theory, MATLAB.

1. Introduction

A beam element design criterion is commonly governed by its bending rigidity rather than its strength. This bending rigidity of beam governs an important behaviour of beam response under any arbitrary loads, i.e. the deflection. For instance, structural design codes specify to limit the beam's maximum deflection on avoiding problems such as damages to other parts of the buildings. Commonly, the maximum deflection of a beam is limited to 1/360 of its spans or 20 mm, whichever is the lesser (Baker et al., 1995).

The need for a computing beam's deflection is very pertinent and inevitable in structural engineering analysis and design activities. A variety of analytical methods on determining the beam's deflection can be found in many engineering textbooks. The ground on such deflection expression determination is from a famous fourth-order differential equation, i.e. Euler beam's theory, that can be expressed as the following Eq. (1) (Hagedorn & Gupta, 1988);

$$\frac{d^4w}{dx^4} = -\frac{q}{EI} \qquad (1)$$

where

w is the transverse displacement of beam in the vertical direction

x is the horizontal distance along the beam's mid plane

q is the load acting on the beam in the vertical direction

EI is the bending rigidity of the beam

The solution of such an equation is complicated because the bending moment is a discontinuous function, which requires integration in piecewise fashion on the discontinuous bending moment function. This situation also requires engineering students to recall their previous knowledge in basic mathematics skills. There is a situation in which the beam has non-uniform material properties throughout its length, which leads to a more complex problem and hard to be solved and time-consuming. Therefore, a more feasible approach to this issue needs to be addressed to engage the student's learning time on problem understanding and higher-level synthesis (Hodge & Luck, 2013). The intention on solving various mathematical tasks be means of a computer with a possibility of visualization of all stages of calculations, termed as Computer Algebra System (CAS), has been identified as a future mathematical skills among the mathematics teachers (Velychko et al., 2019), which can be applied to the engineering educators, as well.

The objective of this paper is to introduce a new teaching and learning methodology on solving Euler beam differential equation on obtaining the beam deflection expression by using MATLAB symbolic solver. It is hypothesized that this approach has the possibility to increase problem solving skills abilities among the students than focusing time on mastering the previous engineering mathematical skills and solving by manual approach.

2. Symbolic Solution Of Euler Beam's Differential Equation Using Matlab

2.1. MATLAB symbolic differential equation solver feature *dsolve*

MATLAB (Matrix Laboratory) is a commercial programming platform designed especially for engineers and scientists. This software allows matrix manipulation, graphing plotting and offering its superb symbolic solution capabilities on differential equations.

MATLAB has an extensive library of functions for solving differential equations, either numerically or symbolically. In order to solve symbolically Eq. (1), MATLAB uses a built-in function dsolve with the following syntax as follows;

dsolve('equation1', 'equation2', ….., 'condition1', 'conditon2',….,'t')

Generally, the built-in function symbolically solves the ordinary differential equations i.e. equation1, equation2, … using the independent variable 't'. Initial conditions or the boundary conditions are specified in the conditions' statement i.e. 'condition1', condition2'.

During the phase of equation registration (differential equation definition and boundary values) in MATLAB, the equations were stored in the MATLAB's memory in the general form without numerical values substitution to the original equation itself. This registration feature eliminates the need to solve the constant of integration that usually calculated by students by solving sets of simultaneous linear equations. Eventually, the student will enjoy solving the problem directly without having to know the previous mathematical skills, i.e. linear algebra knowledge and calculus. These skills are essentially important when they work on a project that must be done within a very limited time.

2.2. Visualizing the solution generated by MATLAB's symbolic solver

In order to appreciate and interpret the solution given by the symbolic solver, students and educators will able to visualize the generated solutions on a graph. The graphical solution gives a better intuitive feeling towards the beam's response depending on the boundary conditions. Student's will be to experiment their self to understand the effect of changing the boundary conditions on the beam's deflection solutions. This will serve as a motivation for them to explore a more complicated beam problem later.

3. Application of MATLAB differential equation symbolic solver on solving simply supported beam under uniformly distributed load

The fourth-order differential equation from Eq. (1) that describes the beam response (deflection) under uniformly distributed load with arbitrary boundary condition is used here. Four main lines of MATLAB code that written to describe the governing fourth-order differential equation and the initial conditions of the beam are shown below in Fig. 1. The simply supported beam that is under consideration is depicted in Fig. 2.

```
clear all
clc
eqn1 = 'D4y = w/EI';
init = 'y(0)=0,D2y(10)=0','Dy(0)=0','D3y(10)=10*w';
```

Fig. 1 MATLAB Code to Solve Beam's Differential Equation

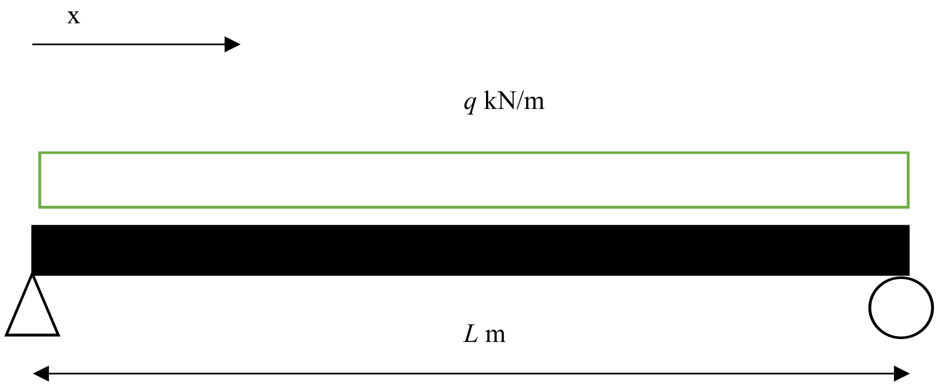

Fig. 2 A General Simply Supported Beam with Load under Consideration

The governing differential equations (Equation (1)) and its relevant boundary condition are given as follows;

$$EI\frac{d^2w}{dx^2} = 0 \text{ (at } x = 0 \text{ and } x = L) \qquad (2)$$

$$w(0) = 0 \; and \; w(L) = 0 \qquad (3)$$

The differential equation, Eq. (1) is registered to the MATLAB's memory by equation at line 3 while the incorporation of boundary conditions as given by Equation (2) and (3) are written by line 4 as shown in Fig. 1. To solve the differential equation with the boundary conditions, the symbolic differential equation solver is written as follows in MATLAB, where the solution of the beam's displacement is stored in variable y as shown in Fig. 3;

y = dsolve(*eqn1*, init, '*x*')

```
y =

(w*x^4)/(24*EI) - (5*w*x^3)/(6*EI) + (125*w*x)/(3*EI)
```

Fig. 3 The Generated Solution Equation After Executing Figure 1 MATLAB Commands

In Fig. 3, it is apparent that the general displacement solution was generated in terms of variable *w*, *EI* and *x*, which matched the various textbook solution of the similar problem (Hibbeler, 2011). The students able to enjoy the specific beam solution by substituting the corresponding values of *w* (the uniformly load acting on beam) and *EI* (the bending rigidity). In this case, *w* = 10 kN/m and *EI* is 10000 kNm-2. The following command in Fig. 4 substitutes the corresponding *w* and *EI* values and its specific output as shown in Fig. 5.

```
syms w EI
y = subs(y,[w,EI],[10,10000]);
pretty(y)
```

Fig. 4 The Generated Specific Solution by Substitute w and EI Values

```
   4        3       
  x        x       x
----- - ---- + --
24000    1200    24
```

Fig. 5 The specific Displacement Solution of Beam After Substitution

The numeric values of the beam displacement along the beam's span, *x*, can be obtained by discretized the beam's span into a small number of interval length, Δx, by using the following equations;

$$\Delta x = \frac{L}{N} \quad (4)$$

where *L* is the beam's span and *N* is the number of equal divisions along the span. In this case, *N* is taken as 10, and *L* is taken as 10 m. The following MATLAB command is shown in Fig. 6 to discretise the beam's span; which convert the computed symbolic deflection to vectorized displacement and plot the solution. The displacement plotting is shown in Fig. 7.

```
%% Discretise the independent variable x
x=0:0.1:10;

%% Create numeric solution for displacement by first vectorize the symbolic eqn
ysol = eval(vectorize(y));
figure(1)
plot(x,ysol)
grid on
```

Fig. 6 Discretisation of Beam's Span and Plot the Solution

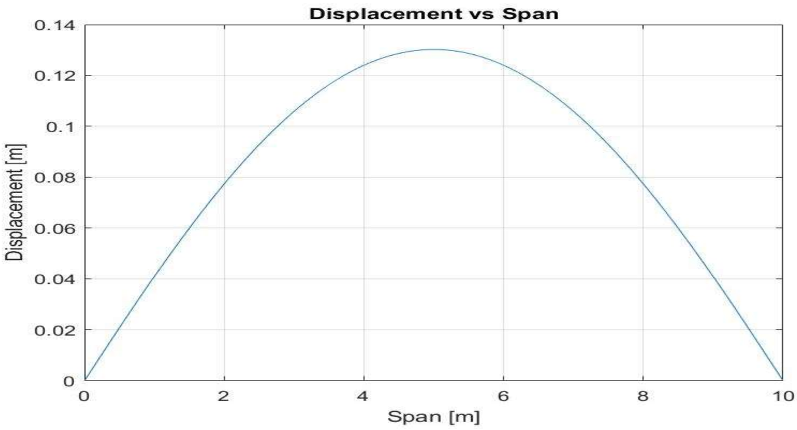

Fig. 7 Beam Displacement Plotting

The bending moment expression of the beam can be computed symbolically by executing the MATLAB command as shown in Fig. 8 and its diagram is shown in Fig. 9.

```
%% Compute symbolically the Moment Equation
M = EI*diff(y,'x',2)
%% Substitute w and EI to the symbolic moment eqn
M = subs(M,[w, EI],[10,10000]);
pretty(M)


%% Create numeric solution for Moment by first vectorize the symbolic eqn
Msol = eval(vectorize(M));
figure(2)
plot(x,Msol)
grid on
```

Fig. 8 Derivation of Moment Expression and Its Plotting

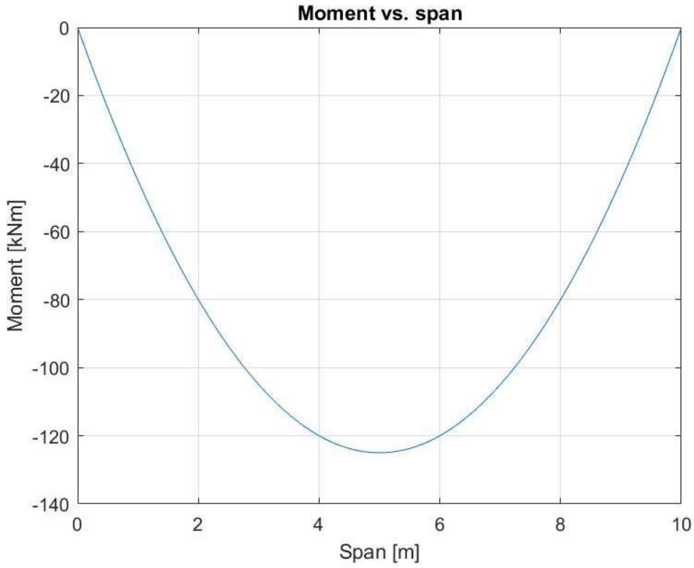

Fig. 9 Bending Moment Plotting

4. Conclusions and Recommendations

An interesting way on learning and teaching beam response solution under uniformly distributed load was demonstrated. using MATLAB software. The solution of displacement was generated with the following features;

- The general solution of the beam's responses was generated symbolically, effortless and require less time for solution.
- The general solution can be specifically formulated by substitute the relevant parameters.
- Student can focus only on solving the beam's problem without have to struggle with the previous knowledge. This is very essential for student's project that emphasised on solving the problem within a very short period
- Educators able to enjoy a more better teaching means to their students by providing graphical plots of the beam responses.

5. Further Research

The applications of this simply supported beam under uniformly distributed load can be extended to more complicated loading such as triangular load, sinusoidal load and various boundary conditions as well. This method has the potential on solving multi-span beam system where students can learn the response of such system.

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The Compressive Strength Performance of Soil Stabilized Using Polypropylene Fiber (PPF)

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Abstract

In current state of affairs, whilst developing new task or improvement for any project on site, the condition of the soil on the site for supporting the structures, lack of space and monetary motivation are number one motives for the use of soil improvement techniques with bad soil condition. Consequently, the stableness of structure systems can be assured with the aid of the improvement of the soil at site. The principle precept of ground improvement is to create adequate strength for earthwork structures for them to withstand weathering conditions, such as the exposure of stabilized soil to soaking due to rainfall or floods. This study provides experimental research evaluating the compaction characteristic and compressive strength of soil stabilized with certain percentage of polypropylene fiber (PPF) and comparing the performance of percentage of PPF in an effort to enhance the soil. This study was focusing on the soft soil that categorized as problematic soils in Malaysia. The disturbed sample of clay soil was used. The preliminary phase of the experimental work includes study of PPF on maximum dry density (MDD) and optimum moisture content (OMC) of the soil with different percentage of PPF inclusion. Compaction tests conducted on a clay soil samples with 0%, 0.8%, 1.0% and 1.2% of PPF addition (via dry weight of the soil sample). The second phase of the experimental work emphasized on unconfined compression analysis. The results of unconfined compression test on the inclusion of 1.2% of PPF in clay has accelerated the compressive strength of the soil as much as 695 kN/m^2 as compared to the unreinforced soil which only have the compressive strength of 111.24 kN/m^2. Consequently, it is proven that the addition of PPF to clayey soil have advanced drastically the engineering properties. This fiber can be use practically to increase the compressive strength of clay especially for earthworks along with pavements, pipelines and buildings.

Keywords: Soil stabilized, Polypropylene fiber, Unconfined compressive strength.

1. Introduction

In this era, due to rapid growth in modernization leads to less amount of land is available for construction. The limited availability of sites for construction and increasing value of land these days will lead the construction to carry on land having weak or soft clayey soil. Altering the physical properties of soil so that we can improve the strength, durability or different qualities is mentioned as the process of soil stabilization. According to Kazemian et al (2010), soil stabilization is defined as a technique to improve the engineering characteristics such as shear strength, compressibility, density, and hydraulic conductivity. Usually, that is crucial for earthwork, road construction and different issues related to the building. Soil that has been stabilized has improved the bearing capacity, extensively more resistant against damaged by the weather in Malaysia. In addition, soil stabilization is the everlasting physical and chemical alteration of soils to enhance their physical and engineering properties. This could accelerate the compressive strength of the soil, as a consequence improving the load bearing capacity of the soil to support pavements and foundations.

In current state of affairs, whilst developing new task or improvement for any project on site, the condition of the soil on the site for supporting the structures, lack of space and monetary motivation are number one motives for the use of soil improvement techniques with bad soil condition (Gaafer, et al., 2015). In order to ensure the stability of a structure, the soil around it plays a very critical role (Teja, 2016).

Soil stabilization was implemented but due to usage of out-dated techniques and no proper technique, the soil stabilization disfavour. For instance, cement stabilization are widely used. Cement is harmful for the environment as cement is one of the primary producers of carbon dioxide and potent greenhouse gas. Cement causes damage to the most fertile layer of the earth, the topsoil. Moreover, the cement may contribute to surface runoff that may cause soil erosion, water pollution and flooding. Hence, soil should be stabilized with more environmental friendly material and have a very good properties of materials such as natural or synthetic fibers.

There are many previous researches has been done in soil stabilization using these methods such as Dutta (2012), Ayininuola & Oladotun (2016), Teja (2016), Hasrajani (2015), Kalantari (2012) and many more. Marto et al. (2013) stated that, soil stabilization techniques using additive either by replacing or adding reinforced materials, was justified as more economical methods, either in terms of performance and ease of work rather than using other methods.

Therefore, this study focusing on using another potential material which is low in cost, easier to get, environmental friendly and have strong properties to stabilize the soil which is polypropylene fiber (PPF). The aim of this study were to determine the compaction characteristics and compression strength of soft soil stabilized using PPF at different percentage hence, evaluate the efficiency of PPF in improving the soil performance.

2. Methodology

2.1. Sample preparation

2.1.1. Soil

The soil used in this study was soft clay which collected from Tasik Gelugor, Penang, Malaysia. The undisturbed sample is collected by using hand auger at depth of 0.5m from ground surface to reduce possibility of organic matter. The proper procedure was followed during handling and storing before bringing to the laboratory for sample preparation. The soil was oven-dried for 24 hours to remove existing moisture content.

2.1.2. Polypropylene

The polypropylene fiber (PPF) as in Fig. 1 was used in this study has the properties as stated in Table 1 below.

Fig. 1. Polypropylene Fiber (PPF)

Table 1. Properties of the Polypropylene Fiber (PPF)

Properties	Value/characteristics
Color	White
Length	19 mm
Mass (Denier)	1 g/9m (1000 denier)
Specific gravity	0.90 kg/dm^3
Aspect ratio	Nil
E-modulus	3900 N/mm^2
Tensile strength	400 N/mm^2
Tensile at break	35N per 1000 denier
Elongation at break	15% (Average)
Chemical Composition	C-33%, H-67%
Melting point	160-170°C
Ignition point	590°C
Thermal conductivity	Low
Electrical conductivity	Low
Acid and alkaline resistance	High

2.1.3. Soil mixture

In order to evaluate the effectiveness of the PPF in improving the soil compressive strength, the soil samples were tested at different percentage of PPF content. In this study, 0%, 0.8%, 1.0% and 1.2% of PPF were used for constant dry weight of soil as stated in Table 2. The PPF were mixed randomly distributed in the soil to become homogeneous mixture and tested for exact volume needed while the excessive soil mixture was removed.

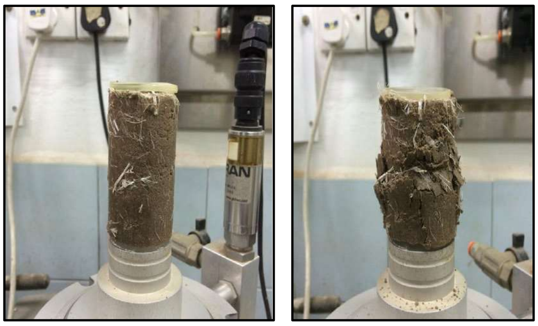
Table 2. Mixture of soil and various percentage of PPF

Soil Sample	Soil (%)	Polypropylene Fiber (PPF) (%)
Sample 1	100	0
Sample 2	100	0.8
Sample 3	100	1.0
Sample 4	100	1.2

2.2. Laboratory test

Several laboratory tests were conducted to determine the basic physical properties and engineering properties. Physical property tests were conducted such as cone penetrometer and specific gravity test only since the sample is fine soil type. While, engineering properties test conducted were standard Proctor and unconfined compression test. All the procedures were conducted in accordance to BS 1377: 1990.

In order to achieve the aim of this study to evaluate the compressive strength performance of the soil reinforced with PPF, standard Proctor test was carried out to determine the maximum dry density (MDD) and optimum water content (OMC) of soil sample for preparation of remoulded sample for unconfined compression test (UCT) purpose. The UCT test was conducted to determine the compressive strength of unreinforced and reinforced soil using PPF. The soil sample used has a diameter of 38 mm and 76 mm height. The example of soil mixture before and after UCT test is shown as in Fig. 2 below.



(a) (b)

Fig. 2. Sample of soil reinforced with PPF (a) before UCT test and (b) after UCT test

3. Results and Discussion

3.1. Physical properties

Since the soil sample used is fine grained soil collected from paddy field area, only cone penetrometer and specific gravity test were conducted to identify the type of soil and its physical properties. The results are shows in Table 3. It was found that the soil is CLAY of low plasticity (CL) with average specific gravity of 2.71

Table 3. Physical properties of soil sample

Soil properties	Value/Characteristic
Liquid Limit (w_L)	29%
Plastic Limit (w_P)	21%
Plasticity Index (I_P)	8%
Type of Soil	CL
Specific Gravity (G_s)	2.71

3.2. Standard Proctor Test

Standard Proctor test were carried out to determine the MDD and OMC of each soil samples. The compaction curve for each sample is shown as in Fig. 3. Based on the graph, it was found that the unreinforced clay soil had a higher maximum dry density compared to reinforced soil.

The reduction pattern obtained when percentage PPF increased but instead, the optimum water content obtained were increased.

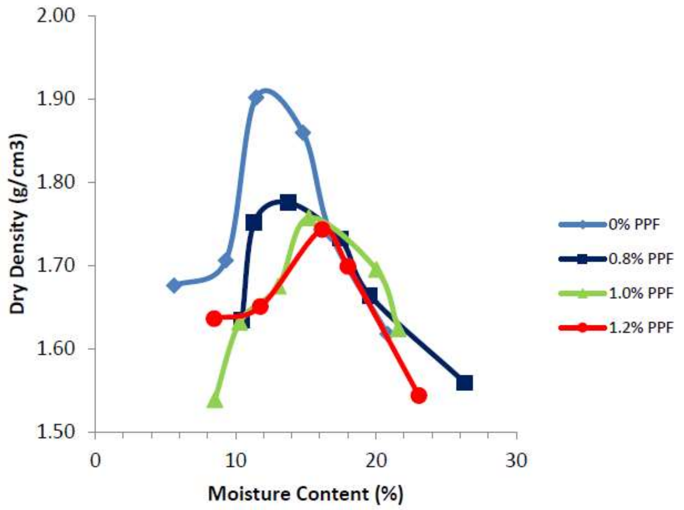


Fig. 3. Compaction Curve from Standard Proctor Test of Unreinforced and Reinforced Soil at Various Percentage of PPF

The results show that the MDD and OMC value of unreinforced clay is found as 1.91g/cm^3 and 12%. But, when clay reinforced with 0.8%, 1.0% and 1.2% of PPF, the MDD reduced to 1.78g/cm^3, 1.76g/cm^3 and 1.75g/cm^3 while it OMC increased from 13.5%, 15.3% and 16.5% respectively

This behaviour may be attributed to the reduction of average unit weight of solids in the mixture of soil and fiber, and also water absorption in the PPF. The more percentage of fiber used, the more water needed. The result obtained was aligned with the research done by Malekzadeh and Bilsel (2012) when applied to expansive soil.

3.3. Unconfined compressive strength

The samples used in this testing was prepared using remoulded sample, mixed with water at OMC value obtained from standard Proctor test. The results of unconfined compression test for various soil sample reinforced with PPF is shown in Fig. 4. From the figure, the enhancement in unconfined compressive strength can be observed with an increment of percentage of PPF inclusion.

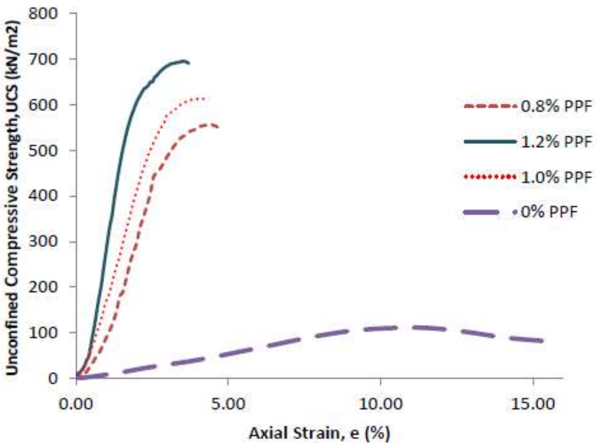


Fig. 4. Unconfined compressive strength of unreinforced and reinforced soil at various percentage of PPF

Without any PPF inclusion, the compressive strength of clay is found as 111 kN/m^2. When clay reinforced with 0.8% of PPF, the compressive strength reached up to 556 kN/m^2, which increased almost 400%. Meanwhile, at 1.0% of PPF, the compressive strength increased up to 450% with the value of 613 kN/m^2. Lastly, at 1.2% content of PPF, the compressive strength of the soil up to 695 kN/m^2 or five times increment compared to unreinforced soil as shown in Fig. 5. The result obtained was aligned with the study conducted by Pal et.al. (2015) where the compressive strength increases as the percentage of polypropylene fiber increased. That mean, the increases in the percentage of PPF will results in improving the compressive strength of clay soil.

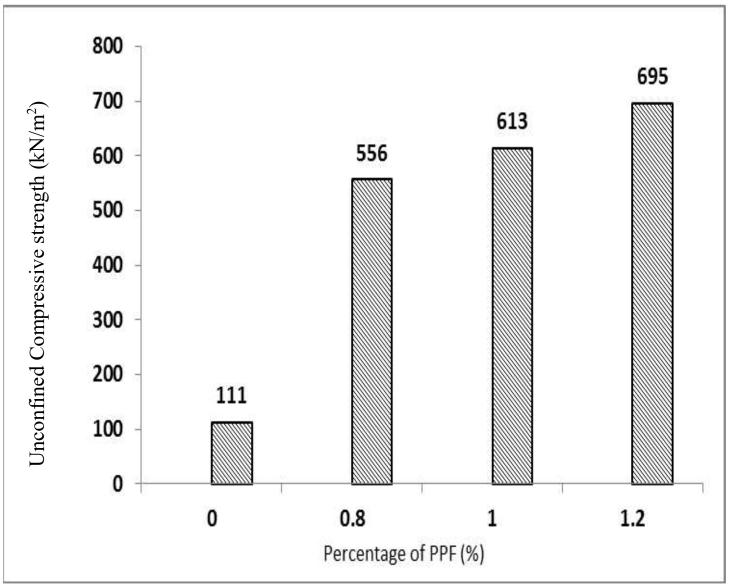


Fig. 5. Compressive Strength of Clay Reinforced with Various Percentage of PPF

4. Conclusion

The study focused on the performance of polypropylene fiber (PPF) in improving the compressive strength of soft soil. The standard Proctor test and unconfined compression test were conducted. From the results, it shows that PPF has a high potential to be commercialized as construction material for ground improvement such as in slope stability, pavement or embankment. The following conclusion can be drawn;

- The maximum dry density (MDD) of soil reinforced with PPF decreases with increasing the percentage of fiber used.
- The unconfined compressive strength of clay was increased 4 to 5 times higher when reinforced with 0.8% to 1.2% of PPF.
- Clay reinforced with 1.2% of PPF is identified as the best mixture which perform 5 times increment of unconfined compressive strength where the value increase from 114 kN/m^2 up to 695 kN/m^2.

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A Preliminary Study on Shear Strength Composite Soils Using Artificial Neural Network (ANN)

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Abstract

Problematic soil has a high compressible, low shear strength and low permeability. Soil stabilization is necessary for poor natural soils such as soft marine soil and peat soil. The shear strength parameters of treated soil are important to describe failure and deformation when subjected to loadings. These strength parameters are found by carried out large number of experimental and theoretical studies. However, the laboratory measurements are time consuming and require large effort, leading to the desire to develop a simple approach for estimating shear strength. The aim of this study is to predict the strength parameters of treated soils (composite soils) with different percentage of soil stabilizer and plasticity index using artificial neural network (ANN). For this purpose two input with 16 data hidden layer are produced and one hidden output layer is generated. Results indicate that the ANN-based model is superior in determining the relationships between percentage of soil stabilizers and plasticity index of composite soils and shear strength parameters.

Keywords: Stabilization, Composite soil, Cohesion, ANN.

1. Introduction

The soil stabilization is necessary for poor natural soils such as soft marine soil and peat soil. In Malaysia, marine soils can be found alongside coastal area in the Peninsular of Malaysia. For purpose of road construction on the soft ground soil, subgrade is important in the long-term performance of pavement. The good road pavement is depending on subgrade as a foundation for pavement and supporting the traffic loads which transmitted from overlying layers.

Problematic soil has a high compressible, low shear strength and low permeability. In construction sites dealing with problematic soils cause to inadequate bearing capacity, excessive settlement and instability on excavation and developing embankments. Soil treatment or enhancement can be done by replacing existing soil, admixture and stabilization and reinforcement. Treated soil with stabilization process can overcome the problems by adding admixtures. Theoretically Mohr-Coulomb theory are using in describing the failure of soils from failure envelope. It is presented by cohesion and internal friction angle parameters which can be obtained from experimental works. The shear strength parameters of treated soil are important to describe failure and deformation when subjected to loadings. However, the laboratory measurements are time consuming and require large effort, leading to the desire to develop a simple approach for estimating shear strength of saturated soils (Goktepe et al., 2008).

The objectives of this paper is to predict the strength parameters of treated soils (composite soils) with different percentage of soil stabilizer and plasticity index using artificial neural network (ANN). For this purpose two input with 16 data hidden layer are produced and one hidden output layer is generated.

2. Prediction of Shear Strength Composite Soils with ANN

Many studies have been carried out for the prediction of the shear strength of soft soils (Goktepe et al., 2008, Pham et al., 2018, Taleb Bahmed et al., 2017, Imran et al., 2018) using machine learning or artificial neural network. The prediction models of material properties such as plasticity limit, liquid limit and plasticity index are useful for prediction shear strength parameters in bearing capacity, slope stability, and earth pressure problems.

Artificial neural networks are a form of artificial intelligence; they try to simulate the behaviour of the human brain and nervous system. They have the ability to relate the input data and the corresponding output data, which can be defined depending on the single or multiple parameters employed to solve the linear or nonlinear problems (Ornek et al., 2012).

2.1. Shear Strength of Composite Soils

By considering the Mohr–Coulomb failure criterion is based on the existence of soil failure on any plane when resolved shear stress (τ_f) reaches the critical state. Eventually, the shear stress value is defined in Eq. (1):

$$\tau_f = c + \sigma_n tan\emptyset \qquad (1)$$

where σ_n is the normal stress on considered plane, c the cohesion parameter, and ϕ is the angle of internal friction.

2.2. Artificial Neural Network (ANN)

The ANN approach in this study by assigning two input values which are percentage of soil stabilizer and percentage of plasticity index of composite soils. The expect output prediction is cohesion. Basically, there are three layers with a group of neurons in ANN structure. They are layer of input data, layer of hidden simulation data and layer of output data in the ANN structure. Figure 1 shows a network architecture formed in the study consist of 2 input data, 2 hidden layers and 1 output layer. In order to predict strength of composite soils, the general equations are adopted in Eq. (2) and Eq. (3).

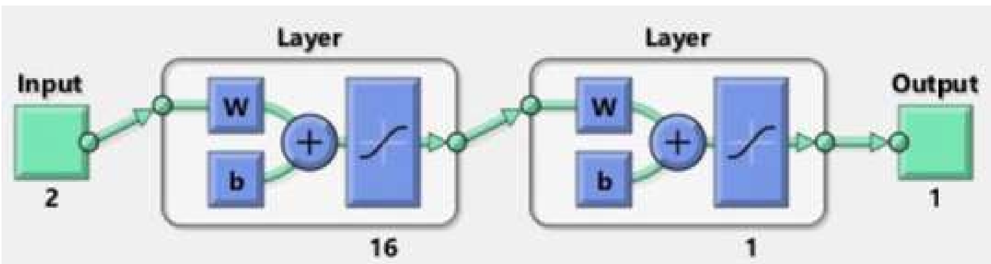

Fig. 1. Network Architecture

$$z = b + \sum_{i=1}^{N} a_i w_i \quad (2)$$

$$a_{out} = g(z) \quad (3)$$

where *b* , *a* dan *w* are random bias , w is weights. The selected activation function used for all layers is the 'tansig' function. The learning rate was set as 0.01 in the study to simulate the learning progress during the ANN training on all datasets.

3. ANN Application

Table 1 shows summary of secondary data used as an input in the ANN application which consist of 16 data from different types of soils and different types of stabilizers. The percentage of stabilizers and plasticity index of composite soils are considered to be data input which generated one output layer for prediction cohesion parameter of composite soils. Most composite soil cohesion data for all data were obtained from unconfined compression test (UCT).

Table 1. Raw Data

Types of Soil	Types of Stabilizer	Percentage of Stabilizer (%)	Plasticity Index (%)	Composite Soil Cohesion (kPa)
Clay	Seashell powder	15	16.7	71.3
Black cotton	Seashell powder	16	45.9	314.6
Black cotton	Seashell powder	16	45.9	261.0
Clay	Calcium carbide residue and coconut shell ash	4.0	25.9	542.3
		6.0	46.0	542.3
Clayey sand	Cement kiln dust	30.0	19.0	277.8
Clayey	Plastic fibre	0.5	0.0	50.0
Soil	Lime	10.0	11.9	193.2
Expansive	Soiltech	5.0	30.0	21.6
Clayey	Eggshell	6.0	37.3	41.0
Black cotton	Glass powder	4.0	55.8	140.0

Expansive	Corncob ash and eggshell powder	16.0	38.7	148.7
Clay	Plastic granules	0.5	22.7	14.0
Black cotton	Sugarcane bagasse ash	16.0	16.9	2177.5
Expansive	Bottom ash	20.0	30.0	360.3
Natural	Almond shell	2.5	31.5	64.2

Table 2. Neural Network Parameters

Algorithms	
Training	Gradient Descent with Momentum
Performance	Mean Squared Error (MSE)
Calculation	MEX
Progress	
Epoch	50000 iterations
Performance	0.00496
Gradient	0.00317

Table 2 shows the neural network parameters used in the study for training and accessing the ANN model performance. In this study, there are 16 input datasets which consist of the two column vectors values. The first input vector is storing the percentage of stabilizer and second one stored the plasticity index percentage values of the investigated soils. The targeted output, the shear strength of the composite soils, was set to be as one column vectors with similar matrix dimension as the input datasets.

During the training of the datasets, Gradient Descent with Momentum, a learning algorithm was implemented on the input and targeted vectors by feedforward network. The training performance of the ANN model is monitored by Mean Square Error (MSE) and epoch number. MSE value can be expressed by the following equation;

$$\text{MSE} = \frac{1}{n}\left(\sum_{i=1}^{n}(y_i - y_T)^2\right) \quad (4)$$

where

i = no of datasets

y_i = the predicted shear strength of composite soil value at ith data by ANN model

y_T = the targeted shear strength of composite soil value at ith data

4. Result and Discussion

The prediction of the strength parameter of composite soils by ANN is shown in Fig. 2. It shows the predicted cohesion values are close to actual cohesion parameter obtained from experimental. Moreover, scatter graphs for measured and predicted data input were plotted for composite soils of cohesion parameter. Later, the R value of the ANN model was also calculated and found to be 0.99 for cohesion network. As can be seen, the network's performance is successful, and many data points are close to the line of equality and shows the accuracy of the ANN prediction is precise and successful for the considered problem.

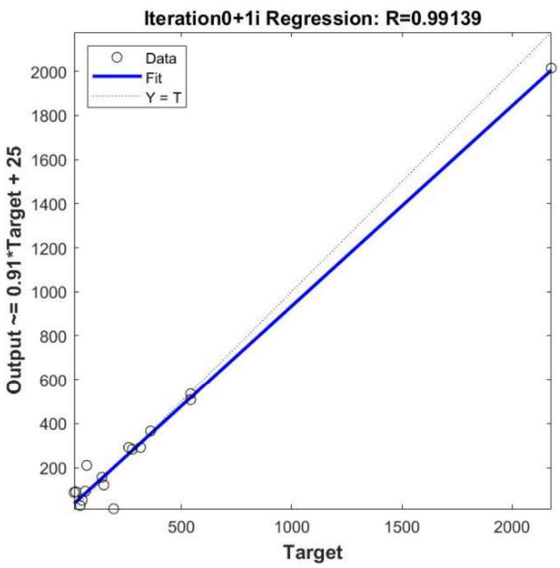

Fig.2 R Value

5. Conclusions

A preliminary study has been made on the prediction shear strength of composite soils. The cohesion strength parameter was predicted by ANN shows the accuracy results with R value is close to one.

Acknowledgments

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Awareness of Conceptual Framework to Improve the Current Practice Related to Machinery Accident in Construction Site : A Case Study for Building and Infrastructure

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Abstract

Machinery at construction site which referred to heavy duty vehicles are specially designed for executing construction works in order to realize a project especially for building and infrastructure work. However, without proper safety management of construction machinery at construction site, accident could happen. The objectives of this research are to determine the main causes attributes to machinery accident at construction sites, to determine the main safety practice attributes to improve current practice related to machinery accident at construction site and establish a conceptual framework to improve current practice related to machinery accident at construction site. Data were obtained through questionnaire survey from 30 respondents at residential construction site and analysed by SPSS Software 23.0 using ranking analysis (Mean and Standard Deviation). In addition, direct observation was used to support finding from questionnaire and analysed through frequency analysis. The result indicates majority of the respondents agreed that the most significant causes attribute to machinery accidents are poor machinery and construction plant, poor site management and monitoring and individual characteristic. Thus, inspection on machinery and construction plant, site management and enforcement, health protection and safety promotion are required as their corresponding safety practice to each main cause. With the aid of obtained results, awareness conceptual framework was established to improvise the existing guideline in Occupational Safety and Health (OSHA) 1970.

Keywords: Machinery accident, Residential construction site, Safety practice.

1. Introduction

Construction sector recorded the highest numbers of death among other sectors with 23 number of victims from January to March 2020 by Department of Occupational Safety and Health (DOSH). The statistic of accidents at construction sites give us an illustration that Malaysia's construction industry is one of the critical sectors that need a huge and fast overhaul from the current site safety practice (Hamid et al., 2008). Although there is an improvement on the safety performance in construction industry, the injury rate of the industry is still one of the highest compares to other industries. Besides causing human tragedy and economic losses, construction accidents also affect the productivity and reputation of the construction industry (Yunus et al., 2017).

In construction industry, machineries and construction plants are one of important resources required to complete the construction phase of a project. Machinery and construction plant are limited in natured and need to be manage efficiently to not be a barrier the progress of a project (Razali & Manaf, 2007). Previous study has recorded that vehicle and mobile heavy equipment were the major source of fatalities in construction from 1992 to 2010 resulting in 404 deaths annually. Fatalities of machinery and construction plant not only categorized as causes of death, it also causes collisions, non-collisions, struck by and caught in or between.

Thus, there is a need to establish awareness conceptual framework to improve current practice related to machinery accident at construction sites. To achieve the goal, this research study contains three (3) objectives including determining the main causes attributes to machinery accidents at construction sites, determining the main safety practice attributes to improve current practice related to machinery accident at construction sites and establishing the awareness conceptual framework to improve current practice related to machinery accident at construction sites.

2. Research Framework

Qualitative and quantitative method was adopted in this research study to collect data. Figure 1 shows the research framework for this research study. The data was collected from primary and secondary sources. The primary sources consist of administration questionnaire and direct observation at construction site. Meanwhile, the secondary sources consist of publications and articles from the news media and internet.

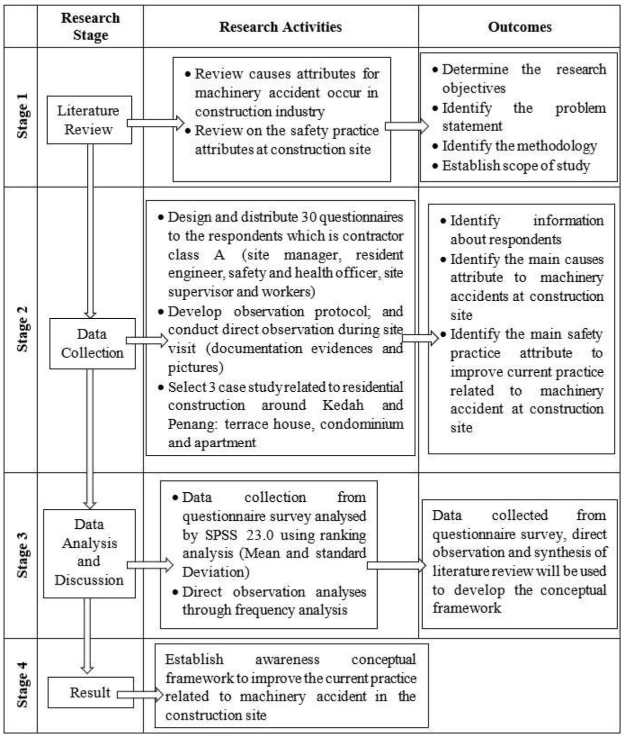

Fig. 1. Research Framework

3. Results and Discussion

The establishment of awareness conceptual framework is to improve current practice related to machinery accident at construction sites was done based on research framework shown in Figure 1. The main causes attributes to machinery accident at construction sites and main safety practice attributes to improve current practice related to machinery accident at construction sites are analysed in this paper.

3.1 Main Causes Attributes to Machinery Accident at Construction Sites

Table 1 shows the ranking of main causes attributes to machinery accident at construction sites. Based on the ranking analysis through mean and standard deviation value, it shows that there are three (3) main causes attributes to machinery accident at construction site which are poor machinery and construction plant, poor site management and monitoring and individual characteristic.

3.1.1. Poor machinery and construction plant

As illustrated in Table 1, majority of the respondents agreed that the most critical causes attributes to machinery accident at construction sites is poor machinery and construction plant which shows the highest mean value of 4.15. Poor maintenance of machinery and construction plant contribute to machinery accident. Besides, worker use unsafe method in handling machinery and construction plant, defect on construction plant and lack of supervision during operation of machinery and construction plant. According to Williams (2018), construction workers are the victims of accidents at construction site who involved in high risk of activities through the engagement of equipment, machinery, tools and other construction related items. Poor maintenance of machinery and construction plant have high contribution in machinery accident. In other hand, to keep the plants productive and safe, Aadal et al. (2014) has concluded that maintenance required different activities which refer to the mechanical keeping and repairing plant.

Table 1. Ranking of Main Causes Attribute to Machinery Accident.

Causes Attribute to Machinery Accident	Mean	Std. Deviation	Rank	Overall Means	Overall Std. Deviation	Overall Rank
Poor Machinery and Construction Plant						
There is poor maintenance of construction plant	4.23	0.430	1			
Workers use unsafe method handling construction plant	4.20	0.407	2	4.15	0.471	1
There is defective on construction plant	4.17	0.592	3			
Poor Site Management and Monitoring						
There is lack of strict safety operational procedure	4.53	0.507	1			
There is lack of technical guide for safety at construction site	4.17	0.379	2	4.11	0.479	2
There is no supervision at construction site	4.17	0.648	3			

Table 1 (continued).

		Individual Characteristic				
Worker have lack of awareness about site safety and regulation	4.40	0.563	1			
Workers are acting reckless and not discipline during handling machinery	4.20	0.847	2	4.06	0.763	3
Workers are failed to wear personal protective equipment (PPE)	4.17	0.747	3			
		Poor Site Coordination				
There is poor safety awareness from project manager	4.20	0.407	1			
There is ineffective communication among workers at construction site	4.20	0.551	2	4.05	0.553	4
There is lack of teamwork at construction site	4.13	0.507	3			
		Local Worksite Hazard				
There is poor housekeeping at construction site	4.17	0.531	1			
There is lack of warning safety signage board	4.03	0.414	2	4.05	0.607	5
There is unsafe workplace condition at construction site	4.00	0.695	3			
		Lack of Knowledge				
Workers are lack of knowledge related to safety regulation and procedure at construction site	4.00	0.263	1	3.91	0.628	6
Company failed to conduct toolbox meeting at construction site	4.00	0.788	2			

3.1.2. Poor site management and monitoring

The second ranking of main causes attributes to machinery accident at construction sites agreed by total respondents is poor site management and monitoring with a mean value of 4.11. Complexity of construction procedure and project time could be affected by poor plant and equipment management. The attribution of poor site management and monitoring at construction site are lack of strict safety operational procedure, lack of technical guide on safety at construction site, lack of supervision, lack of enforcement safety regulation, lack of inspection and audit, company does not provide personal protective equipment (PPE) for worker, lack of accident record and official safety data and inappropriate hazard elimination at the construction site.

3.1.3. Individual characteristic

Individual characteristic has a mean value of 4.06. Individual characteristic including workers have lack of awareness about safety and regulation, reckless workers and not discipline during handling machinery, failed to wear personal protective equipment (PPE), ignoring safety regulation, workers that under influence of drug and alcohol, work under fatigue and work under poor health condition. Study conducted by Raymond et al. (2017) found that reckless worker during machine operation of ignore safety regulations, don’t have safety conscious and lack of personal protective equipment were listed as most significant factors affecting safety in construction sites. Besides that, there are criticisms on the personal protective equipment (PPE) related to poor fit and comfort.

3.2 Main Safety Practice Attributes to Improve Current Practice Related to Machinery Accident at Construction Sites

As illustrated in Table 2, the responses from the questionnaire survey at residential construction site in Northern Malaysia had shown that majority of total respondents agreed that inspection should conduct on machinery and construction plant. Machinery and construction plant should have scheduled maintenance have a highest mean value of 4.30. It is essential that supervision is effective to ensure that unsafe acts are minimised. The supervisor therefore needs to record and arrange for the repair of any damage seen or have been reported, check that tasks are only carried out by competent or authorised people and being used correctly. Prajeesh & Sakthivel (2016) stated that policies are set to regulate machinery performance during operation for keeping it in excellent condition. Equipment operators should be assigned to perform routine maintenance especially when the equipment is on site.

Table 2. Ranking the Main Safety Practice Attribute to Improve Current Practice Related to Machinery Accident at Construction Sites

	Attribute for Safety Practice	Mean	Std. Deviation	Rank	Overall Means	Overall Std. Deviation	Overall Rank
	Inspection on Machinery and Construction Plant						
Poor Machinery and Construction Plant	There is schedule maintenance of construction plant	4.30	0.596	1	4.12	0.495	1
	There is site supervisor supervise work using construction plant	4.20	0.551	2			
	Company hire competent workers to handle construction plant at site	4.17	0.531	3			
	Site Management and Enforcement						
Poor Site Management and Monitoring	There is regular supervise at construction site	4.20	0.484	1	4.10	0.392	1
	Company provide personal protective equipment (PPE) for workers	4.20	0.664	2			
	There is effective implementation safety policy and safety and health regulation	4.13	0.345	3			
	Health Protection						
Individual Characteristic	There is emergency medical support at construction site	4.27	0.583	1	4.10	0.618	1
	There is periodic medical checking for workers	4.17	0.699	2			
	There is drug and alcohol testing on workers	3.87	0.571	3			

Table 2 (continued).

			Safety Promotion				
	There is compulsory for workers non-compliance to safety requirements	4.33	0.480	1			
	There are safety poster and banner to promote safety	4.23	0.466	2	4.10	0.630	2
	There is level of punishment in suspension from work for discipline problem	4.13	0.521	3			
			Well-Structured Organization				
	There is poor safety awareness from project manager	4.33	0.480	1			
	There is ineffective communication among workers at construction site	4.30	0.466	2	4.15	0.564	1
Poor Site Coordination	**There is lack of teamwork at construction site**	4.27	0.521	3			
	There is regular toolbox meeting before work commences	4.20	0.610	2			
	There is safety seminar and program for workers	4.13	0.507	3			
			Workplace Inspection				
	There is daily inspection by site supervisor	4.23	0.430				
	There is proper monitoring on the hazard and control hazardous activities at construction site	4.17	0.379		4.18	0.414	1
	There is scheduled site safety inspection and audit	4.13	0.434				
Local Worksite Hazard			**On-site Precautionary**				
	There are prerequisites for workers to wears personal protective equipment (PPE) at construction site	4.17	0.592	1			
	Prohibit the work when there are potential hazards	4.13	0.346	2	4.09	0.424	2
	There are safety signages at construction site	4.10	0.403	3			
			Education and Training				
	There is safety training for workers	4.27	0.450	1			
Lack of Knowledge, Education and Training	**There is regular toolbox meeting before work commences**	4.20	0.610	2	4.17	0.455	1
	There is safety seminar and program for workers	4.13	0.507	3			

Next, site management and enforcement were agreed by total respondents as the main safety practice attributes to improve current practice related to machinery accident at construction sites. Site management and enforcement such as regular supervision at construction site, company provide personal protective equipment (PPE) for workers, effective implementation safety policy and safety and health regulation. Subramani and Lordsonmillar (2014) reported that safety policy defining clear procedures and providing safety standards such as the Occupational Safety and Health Act (OSHA) 1970 is effective in the development of safety level within an organization.

This research study found that health protection as one of main safety practice attributes to improve current practice related to machinery accident at construction site. Health protection such as emergency medical support at construction site, periodic medical checking for worker and drug and alcohol testing on workers. Hinze (2003) discovered that construction project implementing drug tests have better safety performance because there are higher injury frequency rates when the percentage of positive drug test is high.

Besides that, safety promotion has higher mean score at 4.10. Safety promotion must be done at construction site such as compulsory for workers non-compliance to safety requirements, safety poster and banner to promote safety, level of punishment in suspension from work for discipline problem, impose drug policy as part of discipline policy and supplies safety booklets to workers. Based on a study done by Keng et al. (2014), for company in construction industry that emphasized the importance of wearing and using the personal protective equipment (PPE) in the workplace, this practice starts from the induction training for workers as well as the sub-contractor to avoid the probabilities of accidents from happening. The basic of personal protective equipment (PPE) that compulsory to be used by all people at construction site are safety helmets and safety boots.

Meanwhile, based on direct observation has proved that these companies have well-managed safety management on construction site. It can be seen that the companies emphasize the safety practice such as compulsory for workers non-compliance to safety requirement, impose drug policy, emergency medical support at construction site, implementation safety policy and regulation, provided personal protective equipment (PPE) for workers, accident report and record, regular supervise, hire safety committee, technical expertise and competent manpower, scheduled inspection and audit, scheduled maintenance on machinery and inspection on machinery at construction site. Table 3 shows the frequency of the main safety practice attributes to improve current practice related to machinery accident at construction sites.

Table 3. Attribute to Improve Current Practice Related to Machinery Accident at Construction Sites

Number of Observation Description	1 Yes	 No	2 Yes	 No	3 Yes	 No	Frequency
Safety Promotion							
There is compulsory for workers non-compliance to safety requirements	/		/		/		3
Company impose drug policy as part of disciplinary policy	/		/		/		3
Health Protection							
There is emergency medical support at construction site (e.g.: first aid)	/		/		/		3
Education and Training							
There is toolbox meeting before work commences	/		/		/		3
Site Management							
There are implementation safety policy and regulation	/		/		/		3
There are provided personal protective equipment (PPE) for workers at construction site	/		/		/		3
There are accidents report and record at construction site	/		/		/		3
Management and Enforcement							
There is regular supervise at construction site	/		/		/		3
There is safety record at construction site		/	/		/		2
There is risk assessment conducted at construction site		/	/		/		2
Well-Structured Organization							
There is safety committee at construction site	/		/		/		3
There are technical expertise and competent manpower at construction site	/		/		/		3
Workplace Inspection							
There is scheduled site safety inspection and audit	/		/		/		3
There is daily inspection by site supervisor	/		/		/		3
There is proper monitoring on the hazard and control hazardous activities at construction site	/		/		/		3

Table 3 (continued).

	Inspection on Machinery and Construction Plant			
There is scheduled maintenance of construction plant	/	/	/	3
There is site supervisor supervise work on construction plant work	/	/	/	3
There is inspection on machinery and construction plant	/	/	/	3

3.3 Establishment of the Awareness Conceptual Framework for Machinery Accident

In the first stage of the awareness conceptual framework consist the main causes attribute to machinery accidents and each of the attribute of causes have their own sets of sub-causes for machinery accidents as listed in Figure 2. Therefore, the attribute of causes has listed and ranked according to the mean and standard deviation to determine the most critical attribute of causes. There are 3 main attributes of causes selected as the essential causes that lead to machinery accidents at construction site as determined from objective 1 including poor machinery and construction plant, poor site management and monitoring and individual characteristic.

In the next stage of the awareness conceptual framework consist the main safety practice attributes to improve current practice related to machinery accident at construction sites. Questionnaire survey and direct observation method were used to determine the attributes. There have listed sub-causes of attribute of safety practice to improve current practice at construction site in Figure 2. The finding of main safety practice attribute to improve current practice related to machinery accidents at construction site was analysed by using ranking analysis for questionnaire survey and frequency analysis for direct observation. The purpose of the establishment of the awareness conceptual framework to improvise the existing guideline in Occupational Safety and Health (OSHA) 1970.

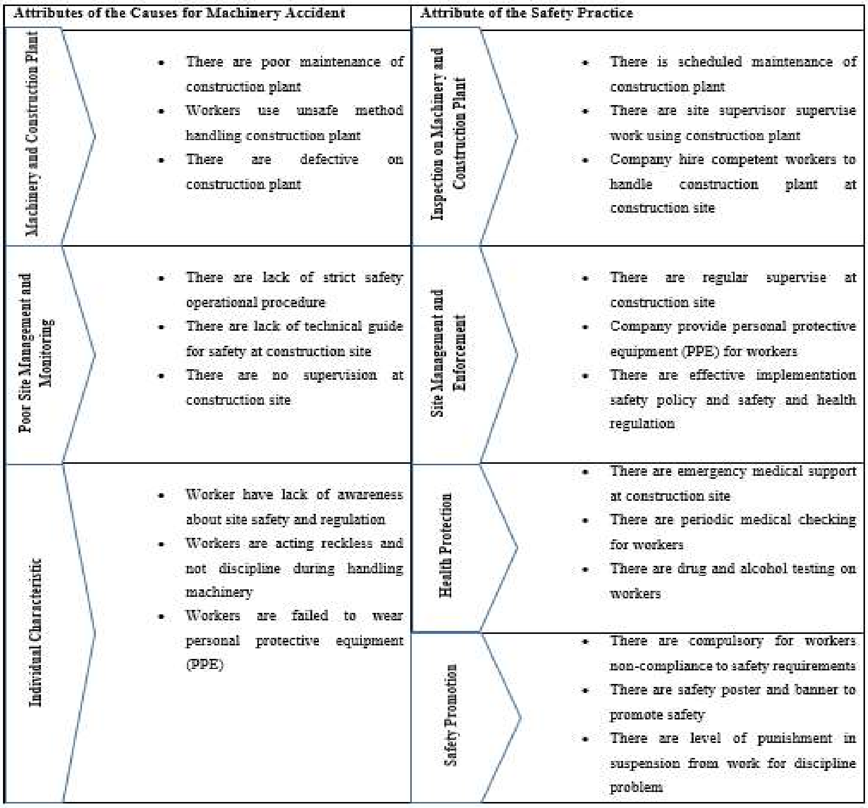

Fig. 2. Attribute to Improve Current Practice Related to Machinery Accident at Construction Sites

4. Conclusions

This research study determines the causes attributes to machinery accident at construction sites and safety practice attributes to improve current safety practice related to machinery accident at construction sites. In the end of this research study, an awareness conceptual framework to improvise the existing guideline in Occupational Safety and Health (OSHA) 1970. The findings from the questionnaire survey found that three (3) essential causes attributes to machinery accident which are poor machinery and construction plan, poor site management and monitoring and individual characteristic.

Meanwhile, finding of the main safety practice attribute to improve current practice at construction site from questionnaire survey and direct observation are inspection on machinery and construction plant, site management and enforcement, health protection and safety promotion. Therefore, awareness conceptual framework was established to improve the existing guideline in Occupational Safety and Health (OSHA) 1970.

It is important and highlighted that research study limitations are only cover three different residential construction projects including structure and infrastructure phases handled by main contractor in Northern Malaysia which is Kedah and Penang. Further research could cover other side of Malaysia or all states in Malaysia and examine specific safety practice effectively to improve the main causes attributes to machinery accident at construction sites. In addition, further research could also focus on types of machinery and construction plant in residential construction project and determine the ones that have highest hazard and finally design the safety framework to overcome the problem.

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The Establishment of Conceptual Framework to Improve the Current Safety Practice Related to The Accidents in Material Handling at Construction Sites: A Case Study for Residential and Infrastructure Works in Pulau Pinang

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Abstract

Material handling is part of occupational duties at construction sites. Recently, there were many accidents due to material handling which occurred in various construction sites every year where it received widespread publicity in the local media which raised great concern and anxiety among the public and also industry players. Thus, the objectives of this research are to determine the causes of accidents in material handling, investigate the main attributes of safety practice as a prevention tool for material handling accidents, and establish the conceptual framework to improve the current safety practice related to the accidents in material handling at construction sites. The data was collected through a questionnaire survey from 42 respondents and analysed using SPSS Software version 21.0 using ranking analysis (mean and standard deviation). Besides, a direct observation method was also used and the data was analysed using frequency analysis. The results showed that most of the respondents agreed that the critical causes of material handling accidents are worker-related factors, management-related factors and material and equipment-related factors. The safety practices attributes matched the suitable main causes and the result of the synthesized literature review. From the survey, it was found that there were three (3) priority safety practice attributes for every cause of material handling accidents which are; individual involvement, management commitment and on site precaution. Finally, all the findings have been consolidated to establish a conceptual framework where capable of improving the current safety practice related to the accidents in material handling at construction sites. This proposed conceptual framework will serve as a guideline to construction practitioners especially for the contractors to monitor and take preventative action in future to minimize the occurrence of material handling accidents in general as to impose safety at the construction sites especially in the residential and infrastructure works.

Keywords: Material Handling Accident, Safety Practice, Construction Site.

1. Introduction

The construction productivity is currently being recognized as a major economic strength in Malaysia. Construction industry helps in improving the quality of life for Malaysians by providing job opportunities for approximately 800,000 people (Hadadak,2013). However, construction is a risky activity in which different parties engage in more challenges in one environment (Ayob et al, 2018). (Chong & Low, 2014) state that the construction industry has been identified as one of the most hazardous industries in many parts of the world that have led to the loss of life, property, workers, money and time.

In the construction industry, material handling refers to the movement, delivery, transferring, storage and control of materials. Improper and incorrect procedure in handling materials will result in injuries. The accidents related to material handling occur mostly in transportation or storage work. A study on workplace accidents in materials transfer by Perttula and Salminen (2012) has found that slips and trips and injuries due to being struck by objects has become the most frequently reported injuries during material transfer operations. According to OSHA, (2018), there are hundreds of thousands of accidents related to material handling every year.

Accidents due to material handling have occurred at various sites in the country. These reports were given wide publicity in the local media and have accordingly raised great concern and anxiety among the public. It is also being recognized that the construction industry in Malaysia is one of the critical sectors that need a huge and fast service from the site safety practices. Thus, time has come for construction site players to re-evaluate the safety at their workplace and determine whether the construction industry has done enough to ensure safety for workers at construction sites.

Even though there is a guideline related to material handling provided by OSHA (2002), there is still a need of improvement for the guidelines in order to prevent material handling accidents at the construction sites. Therefore, there is a need to establish the conceptual framework to improve the current safety practice related to accidents in material handling at construction sites and enhance the existing guidelines produced by OSHA. Thus, in order to establish the proposed conceptual framework, this research study would determine the main causes of accidents in material handling at construction sites and investigate the main attributes of safety practice as a prevention tool for material handling accidents at construction sites. Based on the information and study done on the objectives with the literature review, the conceptual framework has been developed as a mechanism to improve the current situation. This framework would show the comprehensive flows and process of the proper safety practice in the management that will assist in enhancing the current practice in the construction industry to benefit the industry players towards sustaining the environment perspectives.

2. Methodology

The methodology used is based on the mixed method approach combining qualitative and quantitative research techniques. The selection of these methods is due to Fellows and Liu (2008) and Kumar (2005) where this mixed method employs plural methods, ‘bridges’ involves linking two or more research methods to make them more mutually informative, whilst maintaining the distinct contributions and integrity of each independent approach. Moreover, according to Fellows and Liu (2008), the mixed method also can be powerful to gain insight and results to assist in making inferences and in drawing conclusions.

Generally, this study consists of three (3) research stages including: (1) review the causes contribute to accident related in material handling at construction site and review of the safety practice to minimise accident in material handling at project; (2) conducted the case study among three (3) projects and distribute questionnaires to the 42 numbers of respondents where consists of employers (e.g. site manager, site engineer, safety and health officer and site supervisor) and employees (e.g. skilled and unskilled workers). Figure 1 shows the research framework for research study.

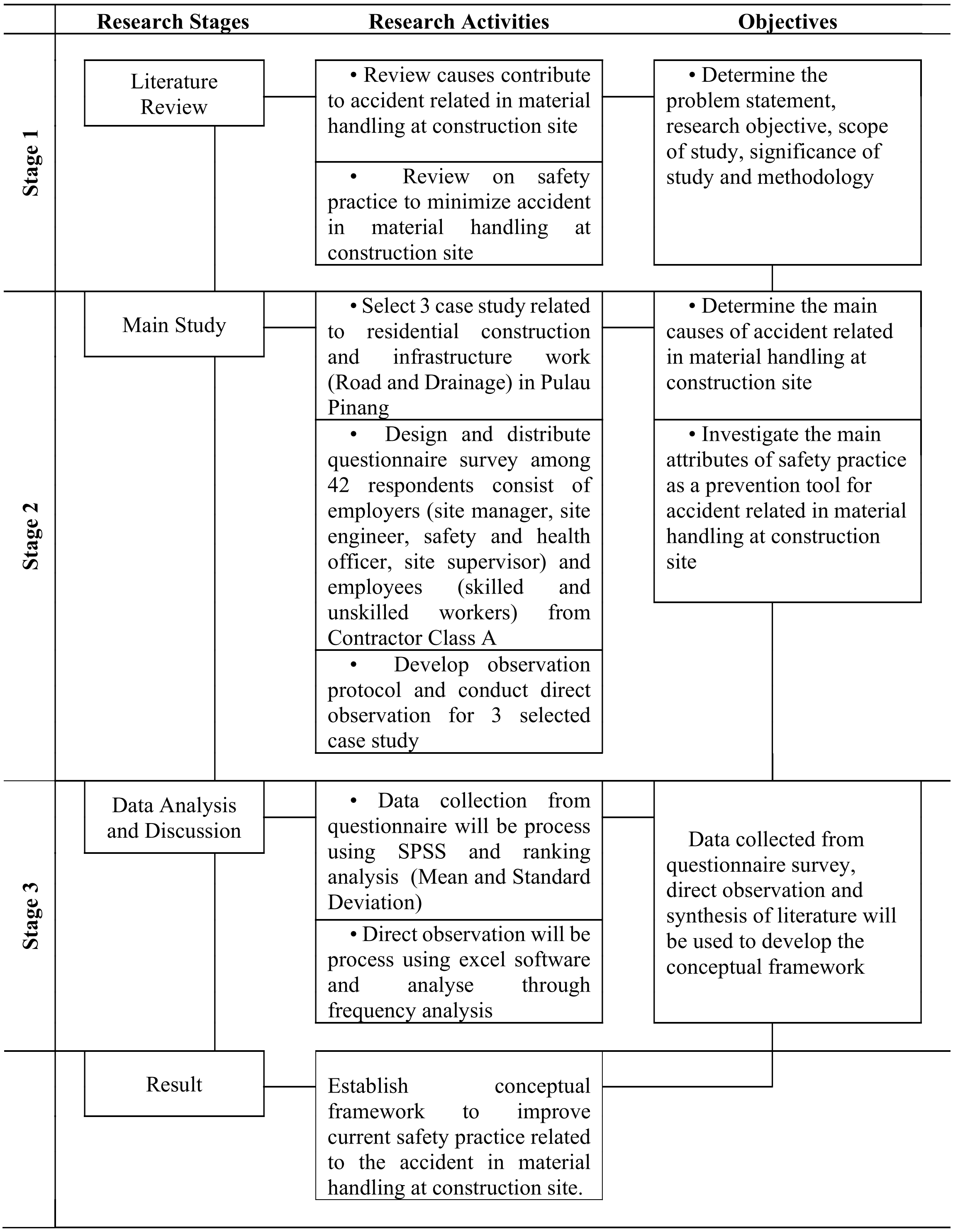

Fig. 1. Research Framework for Research Study.

3.0 Results and Discussion

3.1. Attributes for main causes of material handling accident at construction site

Table 1 shows the ranking of the causes for material handling accidents at construction sites. Based on the ranking analysis through mean and standard deviation value it shows that there are three (3) main causes of material handling accidents at construction sites which are worker-related factor, management-related factor and material and equipment-related factor. Meanwhile, Table 2 shows frequency of the attribute for causes of material handling accidents at construction sites based on the observation of 3 selected case studies.

3.1.1. Worker-Related factor

As illustrated in Table 1 the majority of the respondents agreed that worker-related factor are the main cause that contributed to the accidents in material handling at construction sites which shows the highest mean value of 4.20. Workers are the main contributors to material handling accidents because of their behaviour in rushing to finish their work and ignore the safety practices. The failure of workers to wear Personal Protective Equipment (PPE) during material handling is the sub factor that causes accidents to happen at the construction sites during material handling. Improper and unsafe working procedures implemented by the workers during material handling and their bad attitude and behaviour towards safety have also become the top rank of causes attributed to material handling accidents at construction sites.

3.1.2. Management-Related factor

Management-related factor shows the second rank as the cause attribute to material handling accidents at construction sites with the mean value of 3.90. The analysis indicates that the top sub cause of accident under management-related factor is the failure of management to provide adequate method of statement and safe work procedures for the workers, lack of supervision on workers' working action by safety supervisor, inadequate provision of PPE by the company also contributed to the occurrence of accidents related in material handling at construction sites. The failure to provide enough PPE for workers' protection at construction sites have caused them to do their work without wearing the proper PPE which may expose them to the risk of injuries during working progress.

3.1.3. Material and equipment-related factor

Last but not least, material and equipment-related factors are one of the main causes attributed to material handling accidents at construction sites with the mean value of 3.71. Many respondents had agreed that the heavy objects handled by the workers can contribute to the occurrence of material handling accidents. According to Wiliams et al. (2018) accidents that mostly occur on construction sites are the falling of heavy objects during lifting. In addition, inappropriate transport and lifting equipment that are used at the construction sites also become the top rank of sub causes of material handling accidents as being mentioned by Ayob et al. (2018) in their study. Transport and lifting equipment including scaffolding, crane, lift and elevator, lorry, motor vehicle, pulley block, tractor and truck are not being used appropriately at a construction site and may result in the occurrence of accidents. Physically defective and failure in equipment used for construction work may also contribute to the causes attribute of material handling accidents at construction sites.

Table 1. Ranking of Causes of Material Handling Accident at Construction Sites.

Causes Attribute to Material Handling Accident	Mean	Std. Deviation	Rank	Overall Mean	Overall Std. Deviation	Overall Rank
Worker-Related Factor						
Workers are failed to wear Personal Protective Equipment during material handling at construction site	4.45	0.633	1	4.20	0.584	1
Improper and unsafe working procedure implement by the worker during material handling at construction site	4.31	0.563	2			
Worker's poor attitude and behavior towards safety and lack of safety awareness among workers	4.31	0.563	3			
Worker's unsafe act	4.26	0.445	4			
Unsafe position and posture during material handling by the workers	4.24	0.576	5			
Workers ignoring or non-compliance with safe work procedure	4.21	0.520	6			
Workers have lack of knowledge, education and training	4.19	0.634	7			
Inappropriate operative action by the workers	4.17	0.537	8			
Poor communication due to different language	3.67	0.786	9			
Management-Related Factor						
Inadequate provision of method of statement and safe work procedure provided for the workers.	4.10	0.692	1	3.90	0.708	2
Lack of supervision on worker's working action by the safety supervisor at construction site	4.07	0.712	2			
Inadequate provision of Personal Protective Equipment by the company	4.07	0.894	3			
Lack of risk assessment by the management of company	4.05	0.539	4			

Table 1. **Ranking of Causes of Material Handling Accident at Construction Sites (Cont')**

Causes Attribute to Material Handling Accident	Mean	Std. Deviation	Rank	Overall Mean	Overall Std. Deviation	Overall Rank
Lack of safety enforcement by the management of company	4.05	0.731	5			
Lack of mitigation plans to prevent accident at construction site	4.00	0.442	6			
Hire unqualified person for specific work	3.95	0.582	7			
Lack of proper instruction to the worker	3.90	0.759	8			
Company provide lack of proper training for the worker to implement the job	3.90	0.821	9			
Poor site management by the company	3.79	0.606	10			
Lack of commitment	3.71	0.708	11			
Poor communication in term of delivery information between safety officer and workers	3.60	0.828	12			
Project Manager have lack of experience at construction site	3.52	0.890	13			
Material and Equipment Related Factor						
Workers have to handle heavy object	4.21	0.606	1	3.71	0.774	3
Inappropriate transport and lifting equipment is being used at construction site	4.14	0.647	2			
There are physically defective and failure in equipment used for construction works.	4.00	0.733	3			
There is inadequate in provision of equipment at construction site	3.98	0.644	4			
There is usage of poor material	3.52	0.890	5			
There are physically defective tools used for construction work	3.43	0.859	6			
The way material were supply is inappropriate	3.29	0.944	7			

Table 1. **Ranking of Causes of Material Handling Accident at Construction Sites (Cont')**

The packaging of material as being transport to the site	3.07	0.867	8			
Environmental-Related Factor						
The working condition is unsafe for the workers	4.14	0.608	1	3.23	0.760	4
The walking and working surface is uneven	4.02	0.643	2			
There is poor housekeeping at construction site	4.02	0.749	3			
There is no hazard identification at the construction site	3.57	0.941	4			
There is poor warning signage at the construction sites	3.52	0.943	6			
There is insufficient of space availability at the construction site	3.33	0.874	7			
The working surface is wet	3.31	0.680	8			
There is poor site layout	3.31	0.924	9			
There is insufficient lighting at the construction sites	3.24	1.031	10			
Bad weather may affect the working condition at construction site	3.12	0.968	11			

Table 2. **Frequency of the Causes Attributes to the Material Accident at Construction Sites.**

Number of Observation	**1**		**2**		**3**		**Frequency**
Description	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	
Management-related Factor							
There is inadequate provision of PPE by the company	/			/	/		2
There is inadequate provision of method of statement and safe work procedure provided for the workers		/	/		/		2
Lack of supervision on worker's working action by the safety supervisor at construction site		/		/	/		1
Lack of proper instruction to the worker		/		/	/		1

Table 2. Frequency of the Causes Attributes to the Material Accident at Construction Sites (Cont')

Workers-related Factor							
Workers are failed to wear Personal Protective Equipment during material handling at construction site		/		/		/	0
Improper and unsafe working procedure implement by the worker during material handling at construction site	/			/		/	1
Worker's unsafe act	/			/		/	1
Inappropriate operative action by the workers		/		/		/	0
Unsafe position and posture during material handling by the workers		/		/		/	0
Workers ignoring or non-compliance with safe work procedure		/		/		/	0
Environmental-related Factor							
There is poor housekeeping at construction site	/		/			/	2
The working condition is unsafe for the workers	/			/	/		2
The walking and working surface is uneven	/		/		/		3
The working surface is wet		/		/		/	0
There is no hazard identification at the construction site		/		/		/	0
There is insufficient of space availability at the construction site		/		/		/	0
There is poor warning signage at the construction sites		/		/		/	0
There is insufficient lighting at the construction sites		/		/		/	0
Material and Equipment-related Factor							
There are physically defective and failure in equipment used for construction works.		/		/		/	0
Inappropriate transport and lifting equipment is being used at construction site		/		/		/	0
There is inadequate in provision of equipment at construction site		/		/		/	0
Workers have to handle heavy object		/		/		/	0
There is usage of poor material		/		/		/	0
There are physically defective tools used for construction work		/		/		/	0

3.2 Attributes of safety practice as a prevention tool for material handling accident at construction site

As represented in Table 3, the majority of the total respondents agreed that individual involvement is the main safety practice attribute to improve the current practice related to material handling accidents at construction sites. The above finding is supported by the previous study by Ali et al. (2010). They examined that Personal Protective Equipment acts as an important role in order to prevent the occurrence of accidents at construction sites. Many of the respondents agreed that it is important to ensure that all the workers or individuals involved in the construction sites must always wear PPE to minimize the occurrence and lower the rate of accidents. A proper and appropriate usage of PPE according to their usage and its condition will provide protection in the form of protective clothing, helmets, harnesses and also lifeline. However, a hazard will not be eliminated if the PPE fails and the failure is not detected. Besides, the finding of the questionnaire survey had revealed that the use of proper working methods at the construction site can reduce the occurrence of accidents. According to Perttula and Salminen (2012), the most common type of injuries due to material handling accidents at the construction site are dislocations and sprains and strains, providing that proper working methods should be paid more attention in order to prevent this type of injuries from happening. Other than that, it is important to ensure that workers have good behaviour towards safety awareness which may help them to comply with the safety rules. Complying with the safety rules could help to introduce actions preventing material handling accidents at construction sites.

The findings of the questionnaire survey had revealed that most of the respondents agreed management commitment is one of the attributes of safety practice which shows the mean value of 4.08. They agreed that a worker who failed to wear PPE during work will be given a penalty. This to ensure they are aware about the importance of PPE in order to protect themselves from potential hazard at the construction site. Moreover, according to Paringga (2010), education and training should be designed to prevent human error which may contribute to the occurrence of material handling accidents at construction sites. Education and training are important to improve workers' skills and their abilities to identify hazards during performing their task. Other than that, many respondents agreed that it is management's responsibility to provide adequate PPE as their alternative to emphasize the importance of using and wearing the PPE to their workers. Keng and Nadeera (2014) stated that safety helmets and safety boots are the basic PPE that being compulsory to be used by all of the construction site players in order to minimize probabilities of accidents from happening. The safety helmets to be provided need to obtain approval from SIRIM and the workers must use helmets according to the colour code that has been identified.

On site precaution also has a high mean value of 4.01 which has been agreed as one of the effective safety practices in order to minimize the occurrence of material handling accidents at the construction sites. According to Solis and Poot (2014), it is necessary for the employers to provide proper instructions for every worker before implementing the job to allow them to improve their work competency and productivity. Besides, weekly tools inspection at construction sites also shows the high rank of the attribute of the safety practice to prevent material handling accident. Furthermore, according to Cheung (2005) safety inspections were conducted to ensure all the devices and equipment are in a good condition and well-functioning. All the equipment has to be inspected by the qualified person before coming into operation to avoid any failure of equipment which may lead accident to happen. A proper storage of material on site also could be one of the effective attributes of safety practice as a prevention tool to minimize the occurrence of material handling accidents at construction sites.

Table 3. Ranking of Attributes for Main Safety Practices of Material Handling Accident at Construction Sites.

	Attribute for Safety Practice	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank	Overall mean	Overall Std. Deviation	Overall Rank
Worker Related Factor	**Individual Involvement**							**4.14**	**0.525**	**1**
	Workers always wear PPE at construction site	4.24	0.484	1	4.14	0.525	-			
	Workers use proper working method at the construction site	4.21	0.645	2						
	Workers have good behavior towards safety awareness	4.14	0.521	3						
	Workers use proper lifting method	4.10	0.484	4						
	There is analyzed of job characteristics by the workers at construction site	4.10	0.576	5						
	Workers aware of potential injury during material handling at construction site	4.05	0.439	6						
Management Related Factor	**Management Commitment**							**4.08**		**2**
	There is penalty for those who not wear PPE during work	4.48	0.551	1	4.13	0.517	1			
	There is education and training provided by the company	4.17	0.581	2						
	There is adequate Personal Protective Equipment (PPE) provided by the company	4.14	0.566	3						
	There is safety policies developed by the company	4.02	0.468	4						
	There is provision of safety book and manual for the workers	3.86	0.417	5						
	Management Measures									
	There are periodic safety meetings regularly by the company	4.17	0.537	1	4.02	0.561	2			
	There is safety bulletin board provided by safety committee at the construction site	4.12	0.504	2						
	There is safety organization/committee assign by the company	4.12	0.550	3						
	There is enforcement of Safety and Health rules and regulation by the company	3.93	0.558	4						
	The company did safety audit regularly	3.77	0.656	5						

Table 3. Ranking of Attributes for Main Safety Practices of Material Handling Accident at Construction Sites (Cont').

	Attribute for Safety Practice	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank	Overall mean	Overall Std. Deviation	Overall Rank
	On Site Precaution							**4.01**	**0.563**	**3**
Material and Equipment Related Factor	Employers gives proper instruction to the employees before implement the job	4.29	0.508	1	4.01	0.563	-			
	There is weekly tools inspection at construction site	4.05	0.539	2						
	There is proper storage of material on site	4.02	0.604	3						
	There is adequate provision of material handling equipment at the construction site	3.95	0.539	4						
	There is appropriate usage of material handling equipment at the construction site	3.74	0.627	5						
	Implementation							**3.92**	**0.588**	**4**
Environmental Related Factor	There is regular supervise at construction site	4.07	0.677	1	3.92	0.588	-			
	There is regular toolbox meeting held at the construction site by the safety officer/safety supervisor	4.05	0.582	2						
	There is identification on hazardous condition at construction sites	3.88	0.550	3						
	There is proper housekeeping on the site	3.90	0.576	4						
	There is conduction of site safety inspection by the company	3.71	0.554	5						

3.3 The establishment of safety practices conceptual framework for material handling accidents at construction sites.

The first stage of the framework consists of the main causes of material handling accidents and each of the main causes will have their own sets of sub-causes of material handling accidents as the same as each of the safety practice attributes will also have their own sets of sub-safety practice attributes as listed in Fig. 2. There are 3 main causes which are selected as the most important causes that lead to material handling accidents as determined from objective 1 including worker-related factor, management-related factor, and material and equipment-related factor.

The second stage of the framework consists of the main attributes of safety practices as a prevention tool for material handling accidents at construction sites. They were listed and ranked according to their priority. Figure 2 shows the safety practice framework for this research. The purpose of the establishment for safety practice framework for material handling accidents at the construction sites are to guide the construction practitioners especially contractors and workers to implement a good practice during working at construction sites especially for residential and infrastructure works.

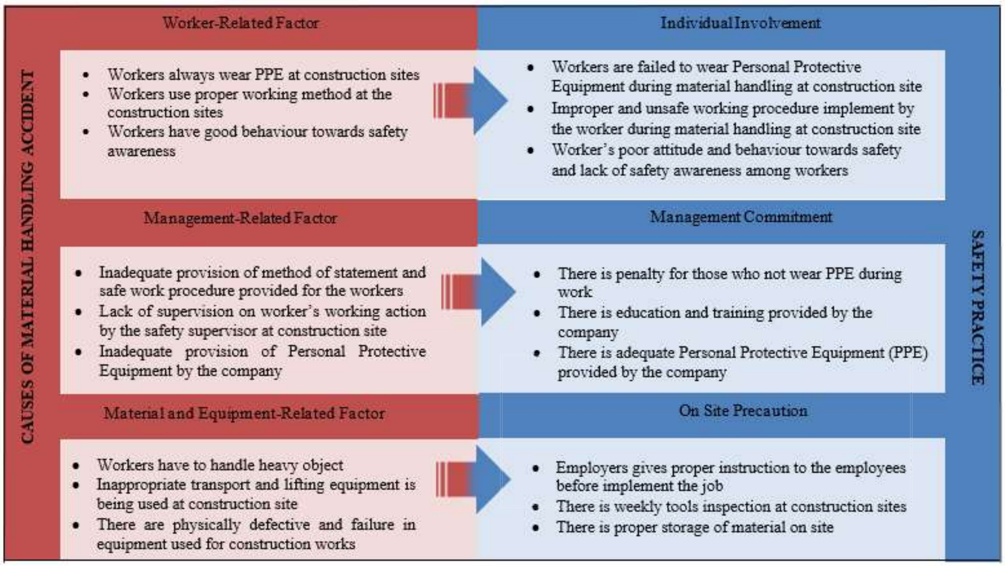

Fig. 2. The Safety Practices Conceptual Framework for Material Handling Accidents.

3. Conclusions

An investigation has been done to determine the causes attributed to material handling accidents at construction sites and safety practice attributes to improve current safety practice related to material handling accident at construction sites. At the end of this research study, a conceptual framework of safety practice related to material handling accidents is built to enhance the existing guidelines produced by OSHA (2002). The synthesis of causes attributed to material handling accidents found in the literature review are the negative attitude of workers toward safety, who refuse to wear PPE, unsafe work environment and poor housekeeping, poor site management and lack of knowledge, education and training Meanwhile, a questionnaire survey and direct observation were conducted in order to determine the main causes attribute to the material handling accident. The finding of the questionnaire survey found the causes attributes to material handling accident are failure of worker to wear PPE, improper and unsafe working procedure implemented by the workers during material handling, and worker's poor attitude and behavior towards safety under worker-related factors. Other than that, management-related factor highlighted a few sub causes which are inadequate provision of method of statement for workers, lack of supervision on worker's action by the safety supervisor at construction site, and inadequate provision of PPE by the company. Last but least, a few sub causes are under material and equipment-related factors such as workers having to handle heavy objects, inappropriate transport and lifting equipment is being used at construction sites.

In the meantime, a synthesis from literature review and questionnaire survey are used to determine the main safety practice attribute to improve current practice related to material handling accidents. The synthesis of literature review had found that the safety practice attributed to current practice related to material handling accidents are educational training, proper site condition, conduction of site safety inspection and proper storage of material. The finding from the questionnaire survey had found that there is need of individual involvement such as always wearing PPE, using proper working methods, and having a good behavior towards safety awareness in order to overcome the occurrence of material handling accidents. Moreover, management commitment is also important to mitigate this problem. A penalty which is being charged to the person who does not wear PPE during work, provision of education and training by the company and also adequate provision of PPE are the list of safety practices that can be used by the management to minimize the material handling accident at the construction sites.

Lastly, the material handling accident also can be reduced with the proper instruction of the employers to the employees before implementing the job, weekly tools inspection and proper storage of material are the safety practices under on site precaution. Thus, the conceptual framework is established in order to improve the existing guideline provided by OSHA (2002) which will be used as a strategic guideline in selecting appropriate safety practices as a prevention tool of material handling accidents at construction sites.

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Plastic Coated Aggregates for Bituminous Pavement Surface

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Abstract

This paper presents the utilization of plastic waste as a coating material of road aggregate. Waste material especially plastic waste is a serious environmental issue. Plastic waste is a non-biodegradable material and hard to be disposed of, recycling, or turning it into useful material is the only effective means. Three types of plastic waste were explored in this study: plastic bags, plastic bottles, and polyethylene (PE). The plastic bags and bottles used are in a raw form while PE is from plastic scraps that have been granulated into granules form. This study aims to evaluate the properties of plastic coated aggregate and compare it with conventional aggregate. Plastic coated aggregate was prepared by coating the plastic waste on the aggregate surface at a high temperature. Conventional aggregate is the one without any coating material. Physical and property tests were performed on the conventional and plastic coated aggregate namely specific gravity and water absorption, Los Angeles abrasion, and aggregate impact test. The plastic coated aggregate shows promising results: lower impact loss, reduce water absorption, and better resistance to abrasion force when compared to a conventional aggregate. Hence, by coating plastic over aggregate, not only can improve the aggregate properties but also reduce plastic waste.

Keywords: Plastic coated aggregate, Plastic waste, Bituminous pavement surface.

1. Introduction

Aggregates constitute a major portion of the road pavement structure. Approximately 95% of asphaltic concrete consists of aggregate, where another 5% is bitumen which acts as a binder to binds the aggregate. Aggregates should be hard, strong, durable, and clean from dust or other particles. The properties of the aggregate are important as they need to carry the load imposed by the traffic.

Plastic waste is undoubtedly a major environmental issue, due to its non-biodegradable nature (Koushal et al., 2014). Plastic has been used widely in the industries in almost every sector such as agriculture, construction, automobile, and consumer products, due to its inexpensive, lightweight, and durable properties. Several studies have been carried out to incorporate waste materials such as plastic waste, polymers, and rubbers in flexible pavement. The utilization of waste materials into asphaltic concrete can be either by a dry or wet process. In the dry process, the waste material will be added to the aggregates before mixing with the bitumen.

Whereas in the wet process, the waste material will be added into the bitumen before mixing the modified bitumen with aggregates.

Rajasekaran et al. (2013) stated that the plastic waste is safe to be heated at their melting point between 110 – 140 °C, as there is no toxic gas emitted from the heating process. When added to the aggregate, the melted plastic covered the aggregate surface and form a thin film which fills the pores of the aggregate. A previous study by Harnadh et al. (2015) attempted to utilize waste plastic in pavement construction. From the study, it was found that plastic coated aggregate shows a better resistance towards impact and abrasive forces compared to conventional aggregate. However, at a lower percentage of plastic (less than 3%), the aggregate crushing value was higher which contradicts other findings. Rajput and Yadav (2016) investigated the effect of plastic waste on the properties of aggregate. Shredded plastic waste was mixed with the aggregate at 0.5, 0.55, and 0.6% by weight of aggregate. The study concluded that there is a reduction in aggregate impact value and aggregate crushing value on plastic coated aggregate. Plastic waste also helps to reduce water absorption but shows a decrement in aggregate specific gravity.

According to Mishra and Gupta (2017), a higher percentage of plastic (11%) results in a thick coating which is responsible for higher crushing value, higher impact value, and higher abrasion value compared to 7% and 9%. Further evaluation has been made on bituminous mixes by incorporated 5%, 7%, 9%, 11%, 13%, and 15% of plastic by weight of bitumen to the mix. It was found that the optimum plastic content as a modifier was 9%. The modified bituminous mix with 9% plastic shows higher stability and flow value, a lower bitumen content, and tensile strength ratio (TSR) is at a maximum of 98.93%. Vamshi (2015) stated that the bleeding of pavement surface decreases in hot weather conditions since polymer modified bitumen can withstand higher temperature and the optimum content of plastic waste to be used is range between 5% and 10%. Awwad and Shbeeb (2007) found that the air void of the polyethylene modified mixture is comparable to the conventional mixture. The study concluded that the utilization of polyethylene in a bituminous mixture reduces pavement deformation, increases resistance to fatigue, and provides better adhesion between the bitumen and the aggregate.

The objective of this paper is to evaluate the properties of aggregates coated with three different sources of plastic waste: plastic bags, plastic bottles, and polyethylene and compare it with conventional aggregate.

2. Methods

This study consists of laboratory works divided into two stages. In the first stage, the materials involved namely aggregate and plastic waste was prepared. The second stage is where the physical and properties tests were performed on the conventional and plastic coated aggregate: specific gravity and water absorption, Los Angeles abrasion, and aggregate impact test. The physical properties of aggregate are important since they affect the performance of the bituminous mixture. All properties conform to Standard Specification for Road Works (JKR/SPJ/S4-2008).

2.1. Materials Preparation

The aggregates were crushed granite supplied by Kuad Quarry Sdn. Bhd, Pulau Pinang. This type of aggregate is commonly used in pavement construction in Malaysia. Plastic bottles and plastic bags were collected, cleaned, and shredded into small pieces. A plastic bag is made of LDPE, a moderately low tensile strength and lightweight material whereas plastic bottles are made of polyethylene terephthalate (PET), a strong and light material. Polyethylene consists of two types: Low-Density Polyethylene (LDPE) and High-Density Polyethylene (HDPE). HDPE is more rigid, harder, and higher in tensile strength compared to LDPE. The PE, both in granular shape were obtained from Lim Seng Plastic, Perak. An optimum value of 2% by weight of aggregate of plastic waste and polyethylene was utilized in this study (Shah et al., 2018). The dry process was adopted where plastic waste was added during the aggregate heating process up to 160°C to enable plastic or polyethylene melt and create a film to coat the aggregate surface. The percentages of plastic are shown in Table 1.

Table 1. Percentage of Plastic Waste.

Waste Materials	Percentage by weight of aggregate (%)
Plastic bottles	2
Plastic bag	2
Polyethylene	
- Low-Density	1
- High-Density	1

2.2. Laboratory Tests

Laboratory tests were performed on the aggregate samples to evaluate the properties of conventional and plastic-coated aggregates:

a) Aggregate Impact Value (IS: 2386 (Part IV) – 1963): to determine the percentage of loss when the aggregate is subjected to impact load.

b) Los Angeles Abrasion Value (ASTM C131): to assess the resistance to crushing and abrasive wear of an aggregate

c) Specific Gravity and Water Absorption (ASTM C127): to measure the strength or quality of the aggregate

A comparison of the properties between conventional aggregate and plastic coated aggregates were made.

3. Results and Discussion

Figure 1 compares the aggregate impact value according to the coating material. The higher the value, the higher the loss due to the impact load. Without the coating, the conventional aggregate reported a value of 26%. The coating of plastic on the aggregate surface increases the strength of the aggregate. This can be seen by a reduction in impact value. Coating the aggregate with plastic bags (LDPE) resulted in a 3.85% reduction in impact loss. This is expected as LDPE is softer compared to other coating materials due to the branching of molecular chains, keeping it apart, lower the bonds, therefore resulting in lesser strength (Shebani et al., 2018). A combination of LDPE and HDPE offers tougher material with a reduction of loss of up to 30%. The blends of LDPE and HDPE may alter the properties and structure of the polymer and produce better composite material. This finding is aligned with Shebani et al. (2018), where it was found that the HDPE/LDPE blend has the highest impact strength and better mechanical properties compared to LDPE or HDPE.

As shown in Fig. 2, the Los Angeles abrasion value is lowest on polyethylene-coated aggregate. The graph shows a similar pattern of aggregate impact value. By coating the aggregate with plastic, the aggregate hardness is increased. A thin film of plastic coating protects the aggregate surface from rubbing between each other and steel balls in the abrasion machine, hence increase the resistance to abrasive wear. The maximum reduction of abrasion loss is by using PE which is 31.8%.

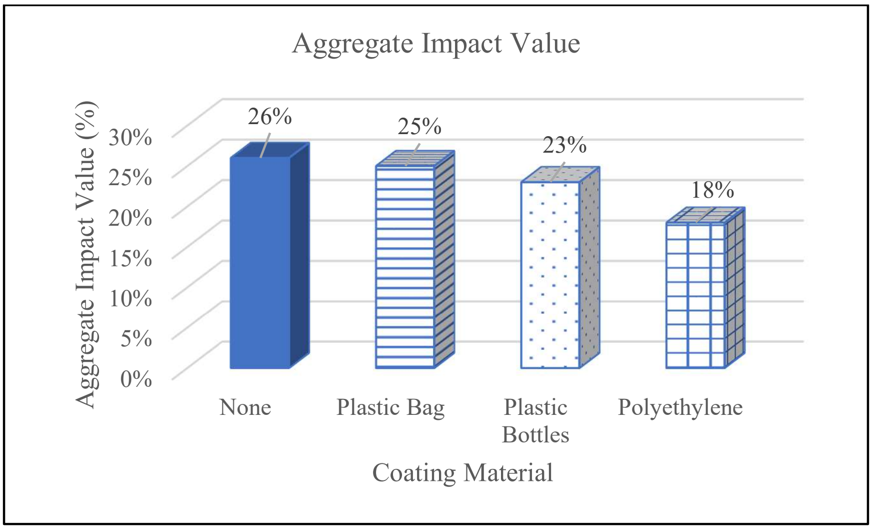

Fig. 1. Aggregate Impact Value.

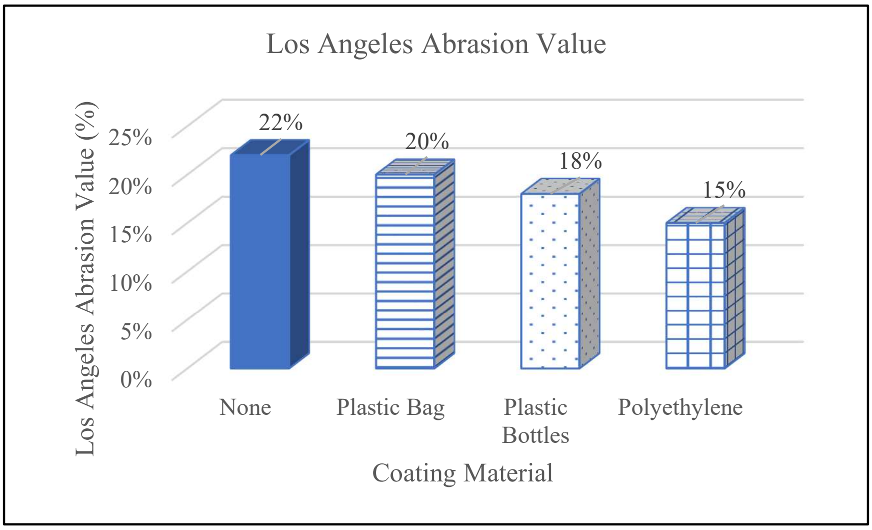

Fig. 2. Los Angeles Abrasion Value.

Figure 3 shows the comparison of specific gravity between conventional and modified aggregate with plastic bags, plastic bottles, and polyethylene as a coating material. The specific gravity of the aggregate regardless of the coating material type is higher than the conventional aggregate. Since the specific gravity of a material directly related to the density, this can be explained that by coating the aggregates with plastic waste fills the voids and surface pores, therefore resulted in denser aggregates. Both aggregates coated with plastic bags and bottles did not show a significant amount of differences in specific gravity compared to conventional aggregate, with an increment of 0.35% and 0.7%, respectively. A study by Elango and Indhu (2018) found that incorporating 5% of a plastic waste mix (LDPE, PET, and PP) resulted in a 1% increment in aggregate specific gravity. A higher amount of plastic waste (up to 20%) increases the specific gravity by only 1.5%. Generally, stronger aggregates have higher specific gravity than weaker aggregates. Hence, the polyethylene coated aggregate shows a slightly higher value of specific gravity than the others.

The water absorption test determines the amount of water absorbed by the aggregate pores. Plastic waste created a thin film of coating on the aggregate surface, as mentioned previously. Therefore, as shown in Fig. 4, with coating, the water absorption is reduced. A conventional aggregate has water absorption of 1%. When coated with plastic bags and plastic bottles, the water absorption reduced to 0.9% and 0.85%, respectively. PE coated aggregate shows the lowest water absorption with 0.7%.

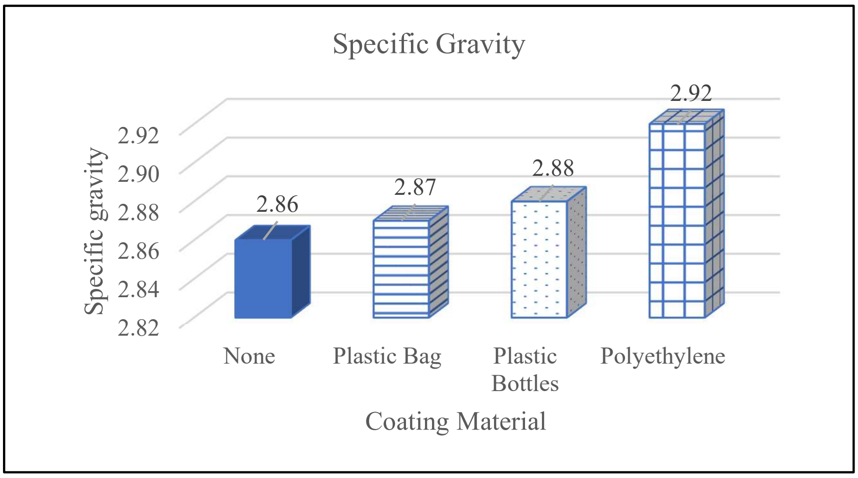

Fig. 3. Specific Gravity.

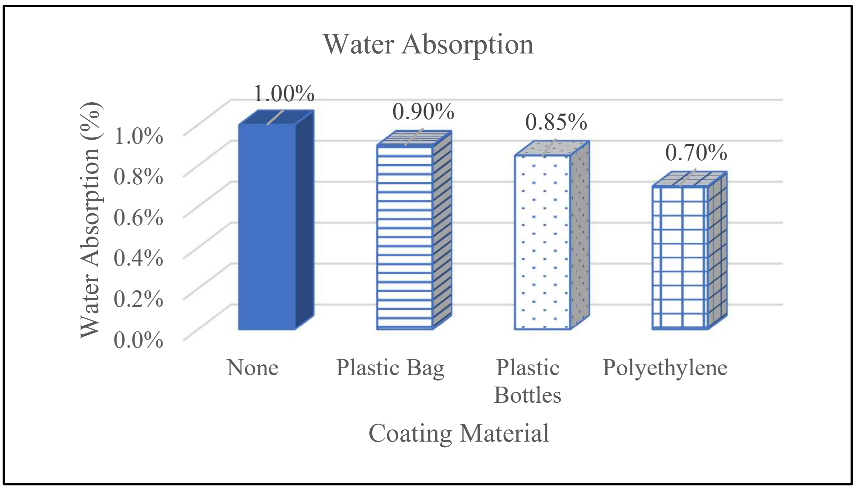

Fig. 4. Water Absorption.

4. Conclusions

The study adopted a dry process where the aggregate is modified by coating it with a thin film of plastic during the heating process. Coating the aggregate with plastic instead of mixing it in bitumen, allows higher plastic content can be incorporated into the bituminous mixture. From the findings, it can be concluded that

- Plastic waste can increase aggregate toughness, hardness, and better resistance to abrasion forces. This is supported by a reduction in aggregate impact value and aggregate abrasion value.

- Plastic coated aggregate exhibits a higher specific gravity and lower water absorption. Since the properties reflect the strength and quality of aggregate, therefore plastic can improve the quality of the aggregate. Lower water absorption means less porosity that leads to a higher resistance to stripping.
- The best modifier is polyethylene in granules form. It does not only provide better aggregate properties compared to the others but also eliminates the tedious process of collecting, cleaning, and shredding the plastic waste.
- In the long stretch, the application of plastic coated aggregates in road pavement replacing conventional ones should be considered to provide a better and stronger road. This also can help in reducing plastic waste.

Acknowledgments

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Compressive Strengths of Lime Stabilized Soil Reinforced with Treated Coir Fibre (T-CCF)

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Abstract

This paper studies the effect of treated coconut coir fiber (T-CCF) with Sodium Hydroxide solution on the compressive strength of the problematic soil in Pulau Pinang. The soils need to be modified to withstand the designated load from the proposed structures. One major method of improving soil strength capacity is to strengthen the soil with natural or artificial fibers. T-CCF can be one of the new sources of raw material that can be potentially replacing the expensive and non-renewable synthetic fiber and will help an ecological balance in nature. Soil samples were mixed with different percentages of coconut coir fiber (0%, 1.0%, 1.5%, and 2%) and stabilized with 5% of lime content as a binder. The experimental study of the Unconfined Compressive Test (UCT) discovered that there is a gradual increase in the compressive strength values with the increase of the stabilizers (Lime and Treated Coconut Coir Fibre) percentage.

Keywords: Problematic soil, treated coconut coir fibre, lime, unconfined compressive strength, stabilizer

1. Introduction

In Pulau Pinang, Malaysia, many construction projects have been carried out tremendously to develop good infrastructure and facilities to serve citizens. However, due to rapid growth in modernization, it leads to less amount of land available for construction. The limited availability of sites for construction and increasing value of land requires the construction to carry on land with problematic soft clayey soil. Soft soil such as silty, clayey peat or organic soil is considered as the problematical deposits for civil engineering constructions since they are subject to change in volume due to seasonal variations. Changes in the characteristics and properties due to climatic inconsistencies will destroy structures constructed on them.

Soil stabilization is widely used in the construction industry such as building sites, landfills, embankments, roads, slope protection, soil stabilization, and so on because of the long-term economic outcomes and service life concerns specifically on the problematic soils. Therefore, the stabilization of these soft soils should be undertaken to achieve the required engineering properties. Soil that has been stabilized will have enormously enhanced in the bearing capability and significantly more resistant to being damaged by water, weather, or inclement conditions. The stabilization of soil can increase the shear strength of soil or continually lower the soil's permeability to water; control the shrink swells properties of a soil, thus improving the load-bearing capacity of a subgrade to support pavements and foundations.

In this study, the additive method and chemical method using treated coconut coir fiber (T-CCF) and lime (L) are combined to improve the properties of soil. CCF is obtained from the fibrous layer of the coconut and it is separated from the hard shell manually by driving the fruit down onto a spike to split it. The main weakness of natural fiber is moisture absorption, so it is bound to change its surface by using chemicals (Bongarde & Shinde, 2014). To enhance the adhesion properties of fibers, the surface modification method by using alkaline treatment is adopted. In this study, sodium hydroxide solution has been used as the alkaline treatment.

The coir fibers instead of going to waste are explore for new usages, which in turn provide gainful employment to citizens and can generate new income to the country. Due to its high lignin content, untreated coir degradation takes place much more slowly than in other natural fibers. As discussed by Maurya et al. (2015) the coir fiber is also very long-lasting, with an infield service life of 4–10 years. Meanwhile, Mittal and Singh (2014) describe that the coir fiber is one of the hardest natural fibers available because of its high content of lignin; coir is much more advantageous in different application for erosion control, reinforcement, and stabilization of soil and is preferred to any other natural fibers.

Today in the construction industry, the use of cement mixes with soft soil is very common because of the low cost and effectiveness that can bring by Ordinary Portland Cement (OPC) on improving the shear strength properties of soil. However, the OPC contributes significantly to global warming, releasing numerous amounts of carbon dioxide (CO2) during its production. This problem can be settled by replacing the cement with lime. The lime modification will show an increase in strength brought by the exchange of cation capacity instead of the cementing effect brought by pozzolanic reaction as explain by Sherwood (1993).

Anggraini et al. (2014) reported that treating marine clay with coir fibers and lime stabilized improved the soils, give better strength, and more economical compared conventional methods. Meanwhile, Ramesh et al. (2010) stated that the strength properties of black cotton (BC) reinforced with lime and coir fiber appreciably better than untreated BC or BC alone with coir fiber.

This paper study the possibility of stabilizing the problematic soil in Penang by improvising its physical properties with a stabilizer agent which is lime and treated coconut coir fiber (T-CCF) are investigated. This research will attempt to study the compressive strength of soil when the natural fiber additive and chemical method were combined.

2. Materials and Method

In this study, disturbed soft soil sample collected from Paddy Field at Permatang Pauh, Pulau Pinang was used in the experimental work. The soil was obtained from a depth of 2.0 m below the ground level by using a hand auger. Series of tests like wet and dry sieve analysis, specific gravity test, and Atterberg's limit test were conducted in the laboratory to determine the index properties of the soil. The soil was classified as per the British Standard Code of Practice (BS 1990) based on the index properties of the soil.

Coconut Coir Fibre (CCF) is a natural fiber extracted from the bunk of coconut as shown in Fig. 1. CCF is acquired from the coarse surface of the coconut and manually breaks apart from the coconut shell by driving the fruit down onto a spike. The CCF was light, has initial strength, low light resistance, elastic, and high durability. The CCF was obtained from a plant nursery in Butterworth, Pulau Pinang. The CCF is cut into the required size ±10 mm for an easy and uniform mix with soil because lengthier fibers make the mixing and molding difficult. After that, the CCF was treated with a sodium hydroxide solution. The soaking of fiber in sodium hydroxide solution will result in decreasing the cellulose content but then increasing the bonding strength between coconut fiber, lime, and soils.

About 6% of alkali-treated coconut fiber is used in this study as suggested by Mydin, et. al, (2018) because this is the optimum percentage amount that drives the highest value strength. Then, the treated Coconut Coir Fibre (T-CCF) is added to the dry soil mix with 5% lime by 1.0%, 1.5%, and 2.0% as described in the soil specimen mix design Table 1.

Table 1. Mix Design.

Soil Specimen
Soil A (Soil + 0% Lime+ 0% Treated Coconut Coir Fibre) - Control Sample 1
Soil B (Soil + 5% Lime+ 0% Treated Coconut Coir Fibre) - Control Sample 2
Soil C (Soil + 5% Lime+ 1.0% Treated Coconut Coir Fibre)
Soil D (Soil + 5% Lime+ 1.5% Treated Coconut Coir Fibre)
Soil E (Soil + 5% Lime+ 2.0% Treated Coconut Coir Fibre)

Standard Proctor test (SPT) was conducted on unreinforced soil as control specimen 1 (Sample A), unreinforced soil with 5% of lime as control sample 2 (Sample B) and with 5% of lime but with varying percentage of CCF (1.0%, 1.5%, and 2.0%) to determine the maximum dry density (MDD) and optimum moisture content (OMC). Remoulded soil specimens for the Unconfined Compression Test (UCT) were prepared based on the OMC & MDD obtained from Standard Proctor Test (SPT).

Fig. 1. Sample of Coconut Coir Fibre (CCF)

The testing was carried out based on the proposed mixture design that was done for all samples. All the standard procedure was followed BS 1377: Part 4: 1990. The UCT is by far the most popular method of soil shear strength properties of soil. Firstly, a cylindrical sample was prepared. The dimensions of the specimen were measured and recorded. The specimen was weighed and recorded. Then, the specimen was placed on the bottom plate of the loading device of the testing machine. After that, the upper plate was adjusted to contact the specimen. The deformation dial gauge was fixed in position. The deformation and proving ring dial was adjusted to zero and the strain rate was set to 0.5 mm/min. The axial load was applied with a pre-set strain rate. The force and deformation reading was recorded at suitable intervals. The test was continued until the specimens fail or 20% of axial strain was reached. The failure pattern of the specimen was then carefully sketched.

3. Results and Discussions

Results of the tests conducted in the laboratory to determine the index properties of soil are presented in Table 2. The soil sample was classified as per British Standard Code of Practice 1377 based on the index properties of the soil.

Table 2. Soil Classification.

Physical Properties	
Specific gravity, SG	2.71
Liquid limit, W_L (%)	29
Plastic limit, W_P (%)	21
Plasticity index, I_P (%)	8
Optimum moisture content, (OMC), (%)	12
Maximum dry density (MDD), ρ_{dry}(Mg/cm^3)	1.91
Sieve Analysis	Gravel= 0 Sand= 32.25% Silt & Clay= 67.75%
Soil classification	SILT of Low Plasticity

3.1 Standard Proctor Compaction Test (SPT) on soil blended lime with varying percentage of T-CCF

Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) values obtained from SPT conducted on different soil Mix Design as referred in Table 1 and were plotted in Fig. 2 and Fig. 3. Table 3 shows OMC and MDD obtained from SPT for soil with varying percentages of T-CCF.

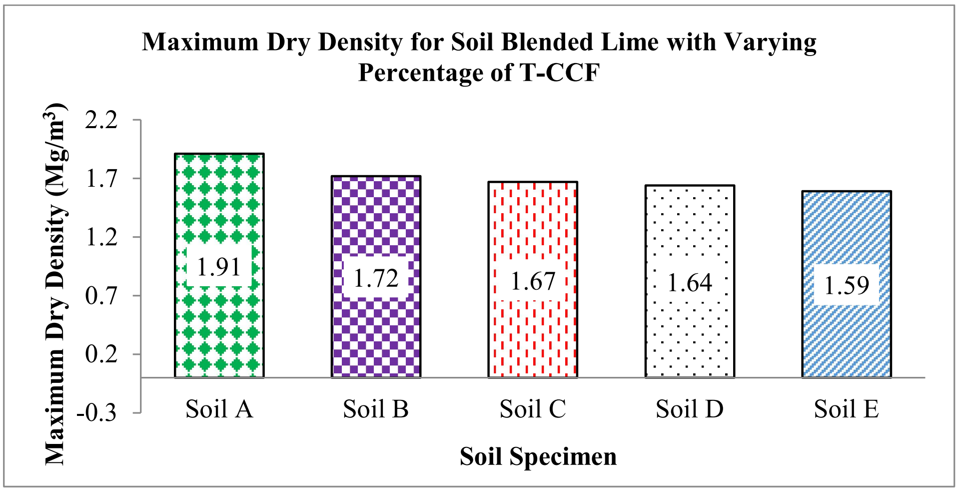

Fig. 2. Graph of Maximum Dry Density (MDD) vs Soil Specimen.

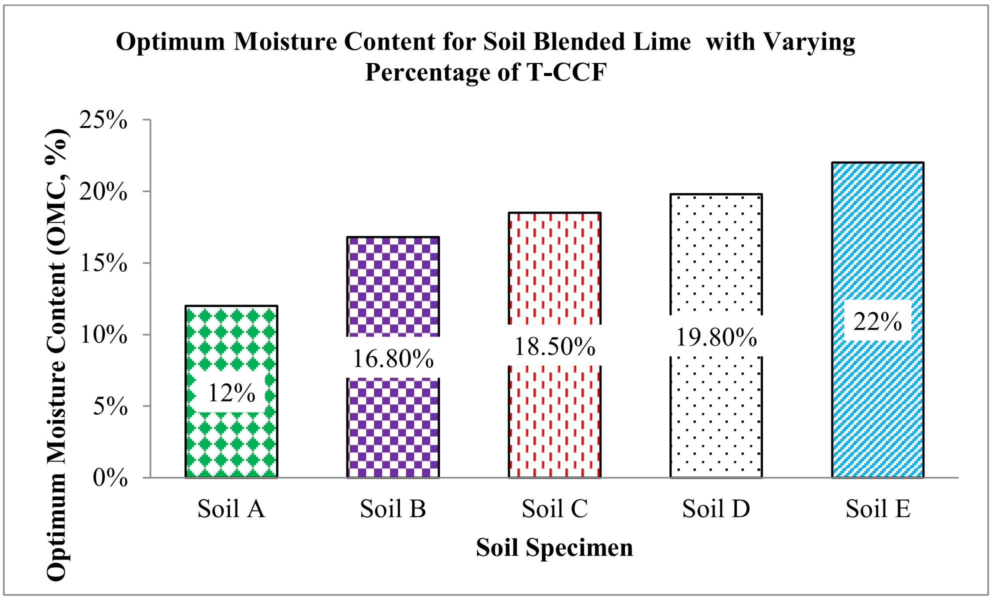

Fig. 3. Graph of Optimum Moisture Content (OMC) v/s Soil Specimen.

From the results, it can be observed that the control sample in which soil A has the highest value of MDD and the lowest value of OMC compared to the Control Sample Soil B and other soil specimens. Therefore, it is inferred that the Lime (L) content in sample B influence the reading of OMC and MDD where the value of OMC increases from 12 % to 16.8 %, meanwhile the value of MDD decreased from 1.91 Mg/m^3 to 1.72 Mg/m^3. The rise of OMC, which continued even though the surface area was reduced through flocculation and agglomeration, is attributed to the added of fine contents to the samples which required more water and involve additional water to initiate the pozzolanic reactions.

It is anticipated that the elevated OMC with the introduction of lime can be attributed to water adsorption by lime. The circumstance on decreasing of the MDD could also be traced to the coating of soil by lime. The consequential larger particles widen the void, and this leads to a reduced density of the soil (Bell, 1996 and Sharma, et al., 2012). Additions beyond this point do not bring about any adjustment in the plastic limit, but they do elevate the strength of the soil.

The results also show that when the percentage of T-CCF in soil with the admixture of 5% of lime was increased from 0 to 2.0 %, the OMC was found to increase from 16.8 % to 22% and MDD was found a decrease from 1.72 Mg/m^3 to 1.59 Mg/m^3. According to Hejazi et al. (2012), the percentage of water absorption increases with an increase in the percentage of coir. Thus, it can be concluded that water gets retained within soil due to the presence of T-CCF because of which OMC increases and MDD decreases with an increasing percentage of T-CCF. Also, the presence of T-CCF in soil interferes with the interlocking of soil particles thus decreasing MDD with an increasing percentage of T-CCF.

3.2 Unconfined Compression Test on soil blended lime with varying percentage of T-CCF

Table 3 shows the Compressive Strength of soil blended lime with varying percentage of T-CCF and the amount increasing of compressive strength when the soil is treated with lime and coir fibers.

Table 3. Unconfined Compressive Strength of Soil Blended Lime Specimen with Varying Percentage of T-CCF

Soil Specimen	Compressive Strength (kPa)	% Increase in Compressive Strength w.r.t. Control Sample A
Soil A (Control Sample 1)	111.24	-
Soil B (Control Sample 2)	233	109.46
Soil C	306	175.08
Soil D	372	234.41
Soil E	509	357.57

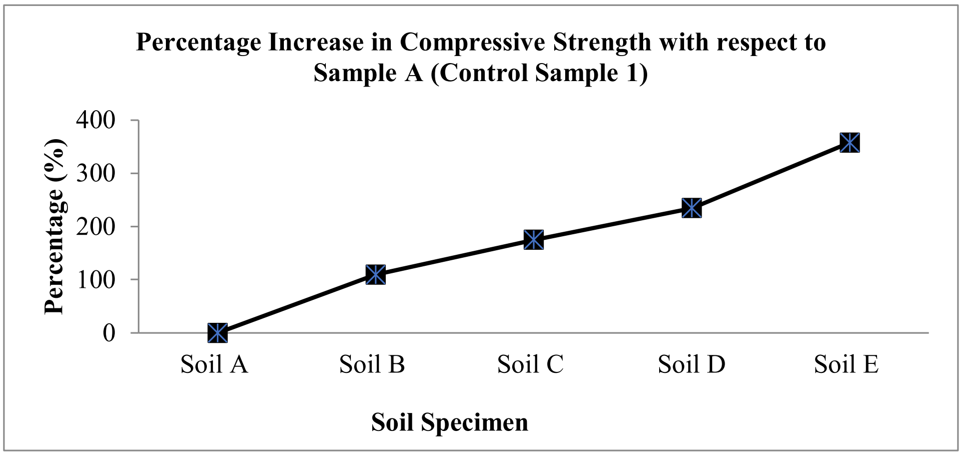

Fig. 4. Graph of Percentage Increase in Compressive Strength with Respect to Sample A (Control Sample 1).

Sample A is the untreated soil while Sample B is a treated sample combination of soil and 5% of lime (L). Both samples are considered as the control samples that need to be prepared as guidelines to the other samples with T-CCF. The value of compressive strength of soil blended lime mixed with T-CCF was drastically increased compared to untreated soil (Soil A). Figure 4 shows the variation percentage (%) of T-CCF with its corresponding compressive stress. It is indicating that the compressive stress value was increased when the percentage of CCF is increased.

When 5% of Lime and 1.0 % of T-CCF (Soil C) were added into the soil, the compressive stress increased from 111.24 kPa to 233 kPa which is a175.08% increment. The value of maximum compressive stress keeps increasing when 5% lime and 1.5 % coir fiber (Soil D) were added, the value of compressive stress is 372 kPa and the percentage of increment compared to Control Sample soil A is 234.41%.

As soon as 5% of lime and 2% T-CCF (Soil E) was added, it is recorded the highest value of compressive stress with the 509 kPa and the percentage of increment stated 357.57%. This is explaining that discrete inclusion incorporated into soil mass develops its load-deformation behavior by interacting with the soil particles mechanically through surface friction and by interlocking. Fiber reinforcement works as a frictional and tension resistance element. Thus, interfacial friction characteristics upsurge with an increase in the fiber content of the soil. As a result, the compressive strength of soft soil keeps on increasing when the percentage of coir fiber increased to 2%.

According to Anggraini et al., (2015) the development of interfacial force and interlock between fiber inclusion and lime treated soil in the compacted soil specimens possibly give an improvement in the friction resistance to force application and consequently the strength of the soil and fiber with lime mixtures increased in percentage used. This is in line with the study conducted by Harianto et al., (2008) which reported that fiber content is found as the major element that affects the strength of soil specimens. Overall, based on the data obtained, it has been found that compressive strength increases in samples added with CF up to 2%. Thus, the minimum percentage of coir fiber need to mix with the soil to increase the strength of the soil is as low as 1.0%.

4. Conclusions

Soil stabilization using lime and coconut coir fiber possesses many favorable since it's enhanced the engineering property's strength of the soil as shown in the results.

- With an increasing percentage of T-CCF, OMC was found to increase and MDD was found to decrease.
- For soil with varying percentage of T-CCF, maximum compressive strength was observed to be 509 kPa at 2 % T-CCF
- Soil with 2.0 % T-CCF was found to show 357.57% increase in compressive strength compared to Control Sample A and 118.5% compared to Control Sample B.

It can be concluded that the treated coir fiber with lime can be considered as a good earthen reinforcement material that causes a vital role of enhancement and alteration in the engineering properties of soil. The result from this study is in line with previous research (Anggraini et al., 2015; Mittal & Singh., 2010; Ramesh et al., 2010; and Maurya et al., 2015) that uses Coconut Coir Fibre as additive mixtures which could be utilized for improving the soil for pavement and road, embankment, construction, etc. Further work can be done with an increasing percentage of T-CCF to determine the optimum percentage of the T-CCF. Additional work similarly can be done on the degradation of coir waste inclusion in soil blended lime and how to increase the life span of the combined sample.

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Strengthening of Subgrade Soil Using Hybrid Natural Stabiliser for Road Works

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Abstract

In Malaysia, the volume of waste generation from various sources has increased year by year. Due to the large production of wastes, our nation is facing serious problem with the handling disposal. One of the most effective options of managing this problem is by recycling the agricultural waste. The agriculture waste can be recycling to use in infrastructure work for example to improve the strength of subgrade soil. Therefore, the aimed of this study is to investigate the effect of Rice Husk Ash (RHA) and Coconut Shell (CS) on engineering properties of the expansive soil for road subgrade layer. The performance of soil mixed with CS and RHA in the proportion of constant 2.5% RHA content mix with 2%, 4%, and 6% of CS correspondingly is examined with respect to Standard Proctor (SPT) test and California Bearing Ratio (CBR) tests. The results obtained shows an increment in optimum moisture content (OMC) and decrease in the maximum dry density (MDD) with the addition of 2.5% RHA and increasing amount of CS. The CBR values for the sample are also increases.

Keywords: CBR, Coconut shell, Rice husk ash, Road work, Subgrade.

1. Introduction

Pavement is an integral part of the roadway. It is also the most important for the development of the country. Pavement provide a smooth and durable in all order of all weathers travelling surface that benefits a range of vehicles such as cars, trucks, busses, lorries and also bicycle. The pavement structure should be able to provide a surface of acceptable adequate riding quality, skid resistance, less deformation and low noise pollution. Pavement can be categorized in two categories which are flexible pavement and rigid pavement. The durability and quality of a flexible pavement depends on the strength and stabilization of subgrade layer (Chakraborty et al., 2014). Therefore, this layer needs to be strong enough to cater the load from moving loads on top. However, the weak and untreated soil, such as laterite has low strength rather than treated one. The materials selected for use in the road construction of subgrade must have the adequate strength and at the same time it must be economical for use and follow compaction requirements. Soil improvement could either be by stabilization or improvement or both (Amu et al., 2011). Soil stabilization is the treatment of soil to enable their durability and strength to be improved such that they become totally suitable for construction ahead of their original classification (Kumar et al., 2014) The aim of improvement of the soil is to enhance the soil strength. Agricultural waste can be used as stabilizer to stabilize subgrade layer. By using recyclable waste its help in reducing the waste production at landfill rather than being economical to surrounding. Therefore, in this study agricultural waste such as coconut shell and rice husk ash are used to enhance the strength of subgrade layer. As studied by Osie (2013) found that the agricultural waste such as coconut shell (CS) has a potential to use as replacement for conventional aggregate which can improve in environmental protection and cost reduction measure. The CS also is suitable as soil stabilizer due to its ability which good in durability, high toughness and abrasion resistance as stated by Ranjitha et al., (2016). Whereas, RHA contains around 85%-90% amorphous silica (Koteswara, 2012). The silica in the rice husk that obtains from the milling also refers to be a good pozzolanic material (Oviya, 2016). Therefore, this study uses the mixture of CS and RHA as CS will act as an aggregate which is to increase the bearing capacity of the soft soil and RHA will act as cement material to bond the mixture. By using natural resources as an additive material, it will give less impact to the environment and will lower the cost.

2. Methodology

The main purpose of the study is to analyse the properties of laterite as a road subgrade layer and to investigate the potential of coconut shell mixed with rice husk ash as stabilization agent to the laterite type subgrade layer. The stabilization materials are prepared based on the suggested size and are chosen because of the good properties.

2.1. Preparation of samples

The soil samples used in this study was laterite soil located at landslide area in Tanjung Jaga, Yan Kedah. This is the undisturbed samples taken on site. The coconut shell size that is required is those samples passing 14mm and retained at 10mm sieve size. The size was selected based on studied by Osie (2013). His study found that the coconut shell has a potential to use as replacement for conventional aggregate which can improve in environmental protection and cost reduction measure. The crushed coconut shell also is suitable as soil stabilizer due to its ability which good in durability, high toughness and abrasion resistance as stated by (Ranjitha et al., 2016) (Table 1).

Table 1. Coconut Shell Properties (Ranjitha et al., 2016).

Physical and Mechanical	Value
Moisture Content (%)	4.2
Water Absorption (24 Hours) (%)	24.0
Specific Gravity (Mg/m^3)	1.4
Impact Value (%)	8.15
Crushing Value (%)	2.58
Abrasion Value (%)	1.63
Bulk Density (kg/m^3)	55.0
Shell Thickness (mm)	2-8mm

During milling of paddy about 78% of weight is received as rice, broken rice and bran. The rest 22% of the weight of paddy is received as husk. The sample of RHA is taken from BERNAS, Penang. The chemical composition of rice husk ash (RHA) studied by Oviya (2016) is similar to the coconut shell that obtained in this study since both location exhibits similar weather condition which is tropical country. The detail chemical composition is tabulated in Table 2.

Table 2. Chemical composition of rice husk ash (Oviya,2016).

Chemical Composition	Percentage(%)
Silica(SiO_2)	90.80
Aluminium(Al_2O_3)	3.50
Iron(Fe_2O_3)	1.32
Calcium(CaO)	1.57
Magnesium(MgO)	1.20
Sodium(Na_2O)	0.15
Potassium(K_2O)	0.24
Loss on ignition	0.67

The sample was divided into portions which RHA is constant and various percentage of CS. Table 3 shows the proportion of soil, CS and RHA used in this study. There are three different proportions of CS. The percentage use for CS is 2%, 4% and 6%. Next, 100% soil without additive is also prepared as a control sample. This sample is important to isolate the effect of experimental treatment and to ensure that the treated sample results are reliable. According to Table 3, there are two stages of proportions testing. First batch is for sample 3,4 and 5, where soil sample is mixed with RHA. Out of these three samples, due to limitation of samples and workability of mixture, 2.5% was chosen as constant value for RHA. Then the second batch is done for sample 6,7,8 with different proportions of CS. This range is chosen based on previous study (Ramli, R, 2018) where they found out that the optimum value is within this range.

Table 3. Proportion of Coconut Shell in soil samples.

Sample	Proportion of Sample (%)		
	CS	RHA	Soil
1	0	0	100
2	2	0	98
3	0	1	99
4	0	2.5	97.5
5	0	5	95
6	2	2.5	95.5
7	4	2.5	93.5
8	6	2.5	91.5

2.2. Testing of samples

The preliminary test was conducted in early stage of testing to determine the properties of soil sample. The testing was continued with the main laboratory test which are Standard Proctor Test (SPT) and California Bearing Ratio (CBR) Test. These tests were used for identifying the Optimum Moisture Content (OMC) and CBR value of soil sample.

3. Results and Discussions

The basic geotechnical soil properties were determined in the early stage. The basic tests that were conducted such as Specific Gravity Test, Moisture Content, Atterberg Limit Test and Particle Size Distribution Test. The geotechnical properties of soil samples were tested based on British Standard guideline and the results are summarized in Table 4. Based on soil classification test, it is known that the soil sample is belongs to the type of well graded sand. The plasticity index value shows that it conforms to the soil type as it is within the stipulated range.

Table 4. Soil Properties Before Stabilization.

Soil Properties	Test Results
Moisture Content (%)	22.98
Liquid Limit (%)	33%
Plastic Limit (%)	28.72%
Plasticity Index (%)	4.28%
Soil Classification	Well graded SAND
Maximum Dry Density (Mg/m^3)	1.72
Optimum Moisture Content (%)	16.61%

The Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the control sample, and combination RHA with various percentage of CS which are 2%, 4%, and 6%, were determined by performing the Standard Proctor Test. The values of OMC and MDD with various percentages of admixtures are tabulated in Table 5.

Table 5. OMC and MDD Values for Testing Samples.

Sample name	OMC	MDD
Control	16.61	1.72
Soil+2%CS	13.03	1.68
Soil+1%RHA	16.00	1.63
Soil+2.5%RHA	17.90	1.60
Soil+5%RHA	18.20	1.57
Soil+2.5%RHA+2%CS	14.39	1.74
Soil+2.5%RHA+4%CS	15.34	1.72
Soil+2.5%RHA+6%CS	15.65	1.76

Figure 1 shows the relationship between OMC with percentage of admixture. It is clearly shown from the graph that optimum water content ranging from 14.39% to 16.61%.

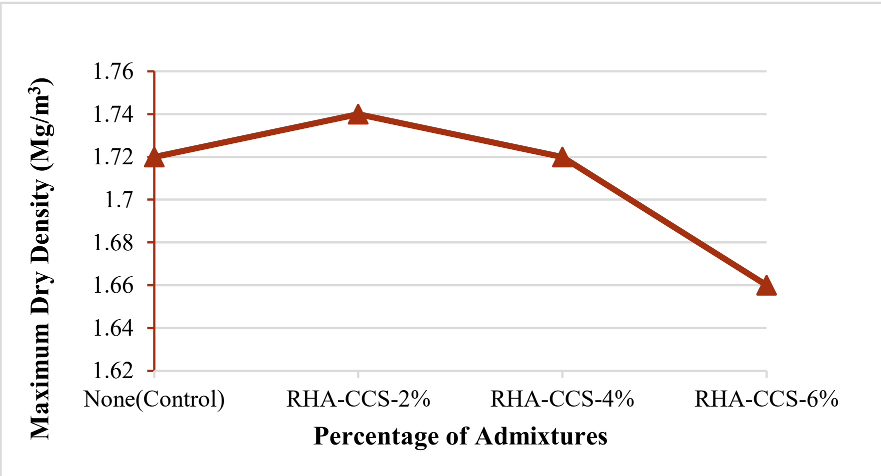

Fig. 1. OMC vs Percentage of Admixture.

Figure 2 shows the relationship between the MDD and percentage of admixture. The graph shows the maximum dry density range between 1.67 Mg/m^3 to 1.74 Mg/m^3. Figures 1 and 2 show an inverse trend between both OMC and MDD. This result complies to a study by Paul et al. (2014) as the percentage of admixture increase, the OMC will increase and the MDD value will decrease. The inverse trend between OMC and MDD of the mixtures is deduced due to the increasing volume of CS and inclusion of RHA, the surface area of the particles is also enlarged which requires more water to lubricate the entire matrix of the mixture to complete the chemical process of hydration and exchange actions that leads to strength gaining.

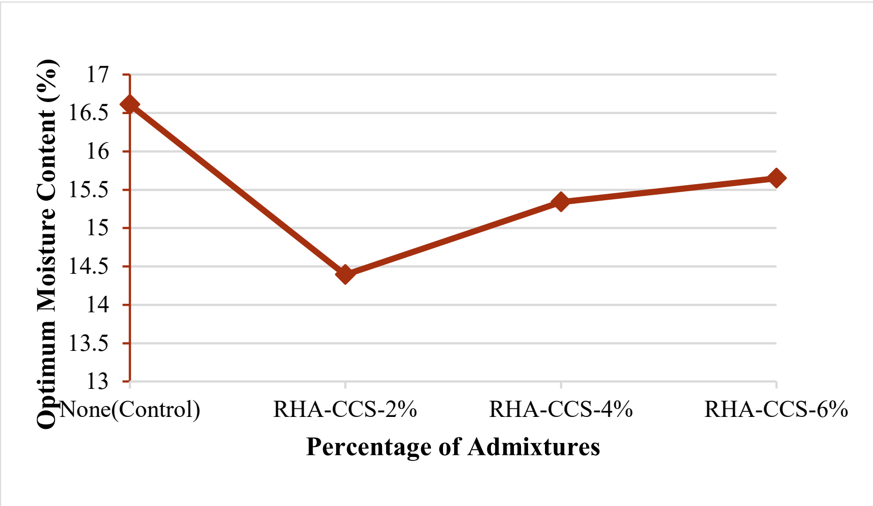

Fig. 2. Maximum Dry Density (MDD) vs Percentage of Admixture.

3.1 California Bearing Ratio (CBR)

The main laboratory tests were then conducted by using treated soil with CS and RHA to find the engineering properties. CBR test is the main laboratory works in this study. The CBR test measures the shearing resistance of a soil under controlled moisture and density conditions for soaked. Soaked CBR is test that representing the condition of road way in wet condition. This condition requires soil sample to be kept soak in water for 4 days duration before testing. After 4 days, the penetration test was conducted at the top part and bottom part of the specimen. Therefore, the result for the top and bottom for soaked CBR testing is shown as Table 6.

Table 6. CBR Value for Soaked Condition at Top and Bottom Part.

Sample name	CBR Value	
	Top	Bottom
Control	4.13	5.75
Soil+2%CS	7.13	10.25
Soil+1%RHA	3.63	6.88
Soil+2.5%RHA	7.13	8.375
Soil+5%RHA	16.25	18.75
Soil+2.5%RHA+2%CS	8	16
Soil+2.5%RHA+4%CS	4.75	8.5
Soil+2.5%RHA+6%CS	4.63	8.75

Figure 3 showing that CBR value at bottom part is higher than top part. This phenomenon happen due to the specimen is more compact at bottom part compared to the top part. On the other hand, for specimen 2.5% RHA and 80% soil has zero CBR value at bottom part because the soil starts to swell during the penetration test. In soaked condition, the CBR value was found to increase correspondingly with the addition of CS and RHA. The CBR value was found to increase appreciably with addition of CCS and RHA. Hence, the use of 5% of RHA and varying percentage of CS can benefit in improving soil engineering properties.

This finding was in accordance to the results found by Shabana (2014) which showed improvement in CBR values with the inclusion of CS. In the study, it was observed that the maximum improvement occurred when 25 grams of CS was added. Whereas the study by Anupam et al. (2013) on RHA mimics a similar finding with this study when RHA admixing improves the CBR values substantially up to 25% of soil replacement.

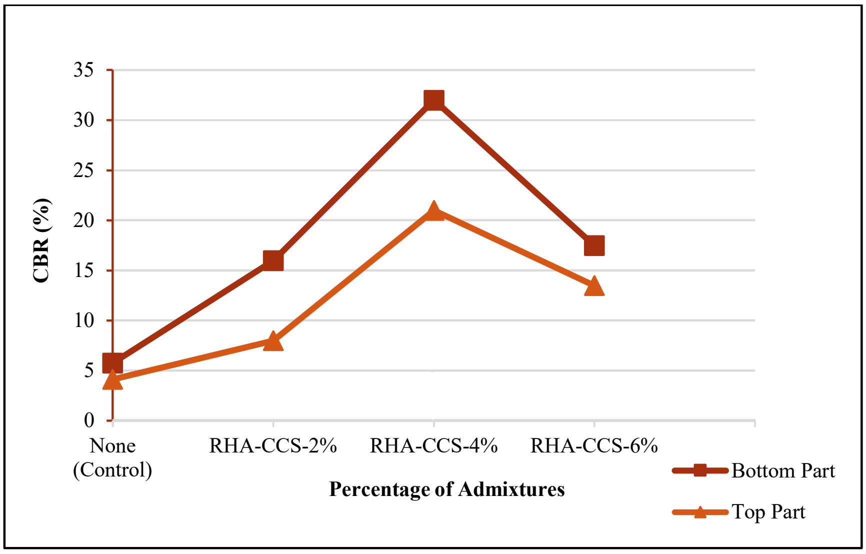

Fig. 3. CBR Value for Soaked Condition.

4. Conclusions and Recommendations

From the result obtained, we can conclude that the addition of RHA and CS shows some increment of the soil strength and also its properties. The presences of CS and RHA contribute to the decrease of OMC and increasing value of MDD. As a conclusion, these natural waste materials, CS and RHA have a high potential to improve the subgrade strength and also increase the engineering properties.

The recommendation from this study is to vary the size of CS and its shape as different shape with react differently with the soil. For example, irregular and smaller size of CS will allow a greater contact area between the materials that will help to enhance the reaction process. Next, the percentage of RHA can be more vary in order to find the most suitable percentage and also the optimum strength of subgrade soil.

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Identification of Management & Personal Risk Factors in High-Rise Building Construction Project Based on The Relative Importance Index (RII)

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Abstract

Construction is one of the most dangerous industries due to unique, dynamic, and temporary nature. High-rise building construction project remains predominant for high accident rates counted yearly. This study aims to address the significant management and personal risk factors associated with the high-rise building construction projects in Malaysia. Responses obtained within the construction management personnel are evaluated using relative importance index (RII) to understand the hidden critical risk factors. The result shows the insufficient/ lack of housekeeping and carelessness and negligence are identified as the most critical risk factors during high-rise construction projects. Successful investigations of the research will lead to the development of an accident prevention model for high-rise building construction projects.

Keywords: Risk factors, Management factors, Personal factors, High-rise building, Relative importance index (RII)

1. Introduction

Construction industry has an important role towards the development of the economy. Although the construction industry is not the main sector that contributes to Malaysia economy growth, it is acts like a catalyst to other sector of economy such as education, finance, manufacturing, and others. This means that the construction industry can be represented as one type of economic engine in Malaysia. Besides, the construction industries in Malaysia have an important role to produce wealth and improvise the quality of living in this country. In addition, from the establishment of this industry, there are many jobs can be offered to the citizen and this can help the growth of other industries in Malaysia. In response to economic development, construction industry at present took a new turn towards high rise building construction i.e., hotels, commercial buildings, office complexes and high-rise dwellings. However, the statistics on occupational accidents revealed that high-rise building construction is as one of the riskiest workplaces in Malaysia (Hsu et al., 2008). Construction workers who work within the construction industry face a greater risk of fatality than workers in other industries (DOSH, 2019).

To prevent the accidents during construction works, we need to know the causes of accidents in the working environment i.e., inherently hazardous construction projects, personal and project factors, and mechanisms or equipment that lead to accidents.

The objective of this paper is to find out the most significant management and personal risk factors associated with the high-rise building construction projects in Malaysia using Relative Important Index (RII).

2. Literature Review

2.1. High-Rise building construction project

According to the Council of Tall Buildings and Urban Habitat High rise are buildings whose height creates different conditions in the design, construction, and use than those that exist in common buildings of a certain region and period." There is no precise definition of high-rise building that is universally accepted. Nevertheless, various bodies have tried to define what 'high-rise' means.

The National Fire Protection Association (NFPA 2000) defined a high-rise building as a building taller than 75 feet (23 meters) in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story. Whilst, in another opinion says a high-rise structure is one that extends higher than the maximum reach of available fire-fighting equipment and it is between 75 feet and 100 feet. A particular building is deemed a high-rise specified by the fire and building codes in the area in which the building is located (Craighead, 2009).

Building is defined by the US Uniform Building Codes as a high- rise building when it has floors for human occupancy which are more than 75 feet above the lowest level of fire department access. Second definition as stated in under the Malaysia Uniform Building by law (UBBL), high rise is the building that meet the definition, to be equipped with an automatic fire sprinkler system designed in accordance with requirements in Uniform Building Codes Building codes vary in their definition of high-rise buildings, but the intent is to define buildings in which fires cannot be fought successfully by ground-based equipment and personnel.

Furthermore, High-rise buildings are not inherently dangerous structures, but they do require additional systems and features that other buildings do not (Craighead, 2009). It is common that when a building exceeds a certain size (high-rise), the inspection must be made by the construction licensing and supervisory authorities after corresponding plans have been submitted to them. This inspection procedure not only encompasses aspects under the building code, but also the safety of the people.

2.2. Accidents causation (Risk factors)

An accident can be defined as an unplanned, undesirable, unexpected, and uncontrolled event. An accident does not necessarily result in an injury. It can be in term of damage to equipment and materials and especially those that result in injuries receive the greatest attention (Hinze, 1997). In high-rise building construction project, accidents mostly occur at temporary structures that the failure prone than the permanent structure because it is easily getting damaged due to frequent dismantle and reuse (Sofwan et al., 2016). It is extremely difficult to talk about construction safety management in the absence of an understanding of the causes of accidents. Before one can embark on effectively and efficiently improving safety on the project site, one must first understand the theory of accident causation and prevention. Theories of accident causation are used to predict and prevent accidents in construction project. The famous accidents causation models started from domino theory produced by Heinrich (1930) and multiple causation theory developed by Petersen (1971).

3. Methodology

The research methodology for this study contains two stages. The first stage included a literature survey. The literature review was carried through books, conference proceedings, articles, internet, and international construction related journals. As the outcome of this phase, factors are identified which are directly affecting on safety performance on high-rise building construction site. These factors categories are: Management factor, Personal factor, Jobs factor and Environment & heredity factor. But only management and Personal factors discussed in this article.

The second stage includes preparation of survey questionnaire based on literature survey and Relative Important Index (RII) method used for ranking of risk factors which effecting safety performance during high-rise building construction projects. A five-point Likert scale measurement format in which respondents are required to select a scale level of each item, ranging from strongly disagree (scale 1) to strongly agree (scale 5) is used. Based on relevant literature all the factors are categorized as given below in Table 1.

Table 1. List of Risk Factors

A. MANAGEMENT FACTORS	
1	Reluctance to invest for safety
2	Lack of concern for safety by management
3	Lack of technical guidance
4	Lack of training
5	Lack of experience project managers/ skilled workers
6	Lack of enforcement of safety regulation
7	Low level of education of workers
8	Lack of first aid measures
9	Lack of organizational commitment
10	Poor information flow
11	Shortage of safety management &/or manuals
12	Shortfall of safety personnel on site
13	Insufficient/lack/housekeeping program
14	Insufficient/lack of written work practice program
B. PERSONAL FACTORS	
1	lack of concern for safety
2	Carelessness and negligence
3	Poor safety consciousness of workers / managers
4	Poor safety awareness from top leaders
5	Lack of awareness of presence of risk
6	Very concern to safety
7	Lack of awareness of safety regulations

8	Lack of personal protective equipment
9	Lack of innovative technology on safety measures
10	Misjudgement of hazardous situation
11	Distracting/unsafe actions of workers or others

4. Results and Discussion

The questionnaire distributed to construction stakeholder i.e., engineer, safety officer, site safety supervisor, contractor, client by email, google form and by hand. Only 30 respondence collected back from 100 questionnaire set distributed. The questionnaire form distributed in Penang state only as the study area. The risk factors categories in questionnaire have four categories, but only management and personal factors discussed in this article.

4.1. Management factors results

Table 2 shows the management factors with RII and rank of risk factors. The risk management factors are clearly indicated in the mentioned table, together with the relative importance index (RII) and ranking of each types of management factors. The RII as indicated in the table shows the insufficient/ lack housekeeping program (RII = 0.820) is the most critical risk factors in management category, following by poor information flow & shortage of safety management (RII = 0.787) and lack of training (RII = 0.780). The most less risk factor affecting the safety performance is lack of first aid measures.

Table 2. RII and Ranking of Management Risk Factors

A. MANAGEMENT FACTORS	RII	RANK
Reluctance to invest for safety	0.773	4
Lack of concern for safety by management	0.773	4
Lack of technical guidance	0.773	4
Lack of training	0.780	3
Lack of experience project managers/ skilled workers	0.753	7
Lack of enforcement of safety regulation	0.753	7
Low level of education of workers	0.760	6
Lack of first aid measures	0.687	8
Lack of organizational commitment	0.753	7
Poor information flow	0.787	2
Shortage of safety management &/or manuals	0.787	2
Shortfall of safety personnel on site	0.787	2
Insufficient/lack housekeeping program	0.820	1
Insufficient/lack of written work practice program	0.767	5

4.2. Personal factors result

Table 3 shows the personal factors with RII and rank of risk factors. The risk personal factors are clearly indicated in the mentioned table, together with the relative importance index (RII) and ranking of each types of personal factors. The RII as indicated in the table shows the carelessness and negligence (RII = 0.827) is the most critical risk factors in personal category, following by lack of concern for safety (RII = 0.820). The most less risk factor in personal category is very concern to safety (RII = 0.547).

Table 3. RII and Ranking of Personal Factors

B. Personal Factors	**RII**	**Ranking**
lack of concern for safety	0.820	2
Carelessness and negligence	0.827	1
Poor safety consciousness of workers / managers	0.813	3
Poor safety awareness from top leaders	0.813	3
Lack of awareness of presence of risk	0.773	5
Very concern to safety	0.547	10
Lack of awareness of safety regulations	0.760	6
Lack of personal protective equipment	0.680	9
Lack of innovative technology on safety measures	0.700	8
Misjudgement of hazardous situation	0.733	7
Distracting/unsafe actions of workers or others	0.780	4

To enhance safety and health in high-rise construction projects, there is need to identified risk factors that related to construction site. Thereby, the safety risk factors can be classified into management, personal, job and environmental & heredity categories. Based on the result, here the stakeholders can do a planning and program of safety properly and effectively in term of reduce or eliminate the accident during construction projects.

5. Conclusions

This study investigates the safety risk factors in management and personal categories which is affecting safety performance during construction high-rise building projects. The result shows the insufficient/ lack of housekeeping in management risk factor and carelessness and negligence in personal risk factor are identified as the most critical risk factors during high-rise construction projects. Thus, the stakeholder whose involve in construction industry i.e., developer, consultant, contractor, workers, suppliers, manufactures, governing agencies stick together to find out the effective solution to prevent the accidents during high-rise building construction project. The successful of this research will lead to develop the accident prevention model for high-rise building construction projects.

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Case Study: Prevention Methods of Mud Pumping in Railway Track System

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Abstract

Mud pumping is an ordinary issue that usually happens in the Railway system, which spent a lot of expenses in maintenance work per annual as it required a deep excavation and installation of additional ballast layers. The track will have a potential risk on track safety when there is no treatment on the source of the problems. The problem track will quickly derail as excessive settlement happened. Other countries such as India, China, and Australia had further developed their researchers focusing on mud pumping problems as most of the railway track was built on problematic soil. Meanwhile in Malaysia less information regarding mud pumping problem. Some of the researchers more focused on the superstructure element and ballast layer compared to the subgrade layer, which significant role in supporting the overall structural system. Several case studies on prevention methods for railway construction were discussed to use as guidelines or references for future development. The purpose of this study was to identify which prevention technique suitable to reduce the mud pumping or control the penetration of fine-grained soil through up the ballast surface. Prefabricated vertical drain (PVD) method is preferable to use because it can improve the drainage system for saturated soil as it enables the reduction of dissipation pore water pressure in subgrade soil. The right selection of ground treatment technique resulting in better track performance and longevity effect services. Instead of focusing on the prevention technique, further soil behaviour in geotechnical studies is required to investigate more on the mechanism of mud pumping under the repetitive loading.

Keywords: Mud pumping, prevention method, railway subgrade, PVD.

1. Introduction

Track stability or serviceability is important to ensure the comfortable of passenger and their safety during train operation. Railway subgrade mud pumping is one of the common problem of subgrade degradation in ballasted railway track. This track distortion lead to uneven track geometry caused by differential settlement whereby create a hazard to track safety. Therefore, many of expert researcher are trying to figure out on suitable shielded method to protect the track deterioration that causing increment in maintenance expenses. There are three main factors that are directly associated with the mud pumping problem are unfavourable subgrade, water and dynamic loading. This attrition phenomenon occurs when the ballast layer in direct contact with the subgrade layer without any prevention layer or filter layer like sub-ballast (Alobaidi & Hoare, 1999).

Moreover, due to repeated loading of train and water existence, the fine-grained soil quickly forced upward toward the ballast void cause the contamination of ballast layer (Li & Selig, 1995). The fouled ballast can cause the differential settlement and potential of derailment which required a regular maintenance of services to ensure the passenger safety and smooth operating track system. Thus, the additional prevention method is a compulsory to mitigate the problem and reduce the demanding cost of maintenance work. The placement of sub-ballast layer as separator between granular layer and subgrade layer is a good approach to reduce the slurry formation. However, in considering high speed train and heavy freight load development on track are required better prevention work for excellent stability of track performance. The selection of prevention method must depend on soil condition beneath the track to ensure the effectiveness of the method when applied on certain soil type.

This study focuses on the effectiveness of various methods in ground improvement techniques applied on previous repair work of problematic soil to solve ballasted track's settlement and mitigate mud pumping effect on the trackbed. It is essential to review and compare the previous technique proposed by other researchers as a guideline to identify the best prevention method to reduce the mud pumping

In ballasted railway track consist of the superstructure element (rail, sleeper and fastening system) and substructure element (ballast, sub-ballast and subgrade). Figure 1 below illustrates the ballasted railway components (Selig & Waters, 1994). Each of the elements in the structure has its contribution to ensure the safety of track during services. However, the subgrade layer plays an essential role as it provides a stable platform for the overall track structure. The subgrade stiffness must strong enough as it influenced overall track performance. Differential settlement possibly occurs on typical weak subgrade, exceptionally cohesive soil hence the prevention method is required to improve the stability of subgrade track.

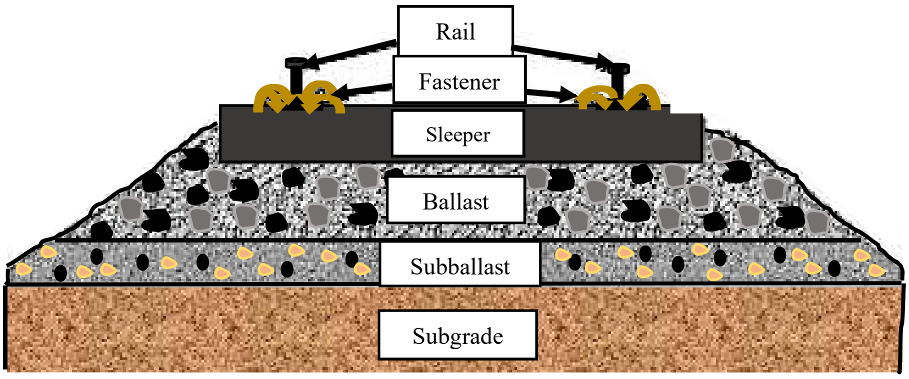

Fig. 1: Main Component of Ballasted Track.

2. Mud Pumping Mechanism

Accumulation of mud which lies on the ballast surface due to fine particle migration from softening subgrade soil when the track is under repeated loading. However, there are different mechanism reported for this phenomenon. The movement of the fine particle through the ballast surface caused by the suction effect generated by the movement of ties which illustrate well in Fig. 2 (Takatoshi, 1997). The suction effect depends heavily on the ties-ballast distance as the gap increases, the mud pumping will actively move (Sussmann et al., 2017). Moreover, as load increases, the vibration generated from cyclic loading will initiate the suction of fine particle to move up and down through the ballast (Wang et al., 2014).

Pore water pressure development is the main influence on the dissipation of fine grained particle of subgrade soil which causing the occurrence of mud pumping (Duong et al., (2014). High intensity of water content in subgrade soil surface enables the rapid rate of pore water pressure diffusion provoked by suction force through loading and unloading process. A model designated by Tadatoshi, (1977) reveals the saturated soil experiencing a vacuum phenomenon as a train passing through the track.

Involvement of geotechnical investigation during the construction process is crucial to determine the soil composition before selecting the prevention technique that reliable based on the type of soil grained particle. Soft soil is the one of problematic soil which prone to the mud accumulation as fine grained soil and high amount of silt particle causing the soil unable to resist the excessive dynamic impact due to its high compressibility when subjected to cyclic loading.

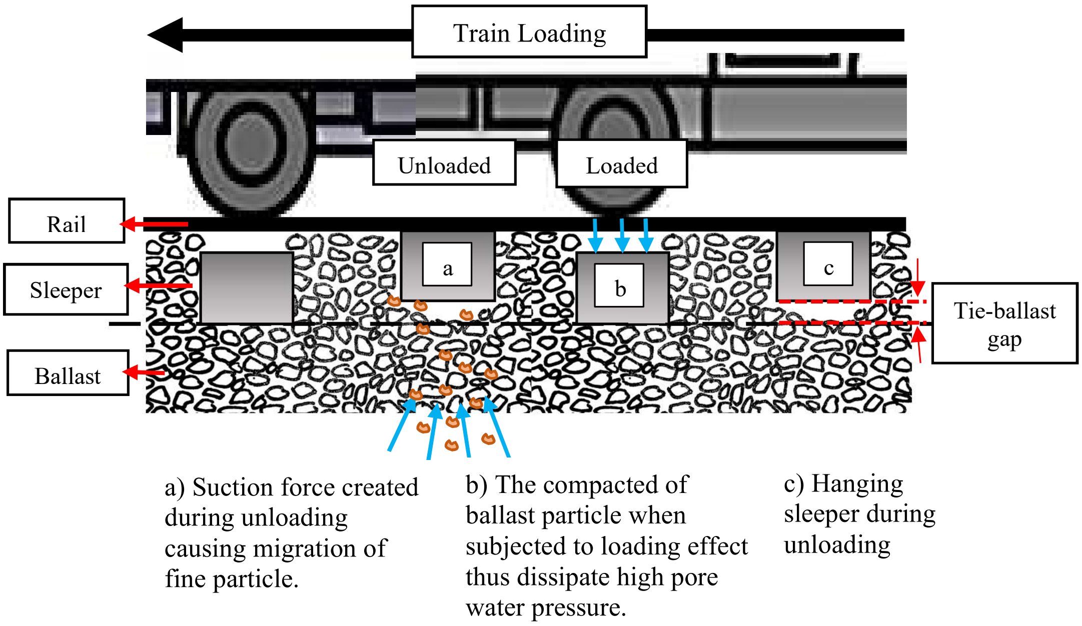

Fig. 2. Behaviour of Mud Pumping under Train Loading.

2.1. Soil Classification Prone to Mud Pumping

Accumulation of mud pumping occur when ballast layer contaminated by the migration of fine particle from subgrade track and coal dust filling ballast void. There are many factor causing the mud pumping effect and subgrade soil properties is one of the element which contribute major impact in term of overall track performance**.** In Taiwan, 30 cases of mud pumping were reported in May 2015 and majority occur on hill and curve area (Kuo et al., 2016). Based on the particle grained size test conducted on pumped mud resulting about 50% of ML (mud) and the others were CL (clay) or SM (sand) type. According to Yu et al., (2016) railway in China were construct on low subgrade standard based on statistic data on 882 mud pumping cases happened in 2008 on Shuo–Huang railway which affecting required maintenance cost and safe operation.

Most of weak subgrade soils normally consist of fine grained soil with low to medium plasticity due to high moisture content that allowed greater compressibility take place under repeated loading (Singh et al., 2019). In Malaysia, 50% of the area for double-track project covered on alluvium deposits which consist of soft subsoil layer with highly compressible subjected to dynamic loading (Yean-chin & Peir-tien, 2007). For the loose or saturated sandy soil type are capable to increase the development of pore water pressure as undergo liquefaction process under massive vibration impact (Chen et al., 2019). All the problematic soil areas must implement the prevention approach to ensure that unnecessary subgrade deformation and failures from encounter causing any destruction on track services. Soil plasticity could be controlled as approaching the right implementation of ground treatment technique thus mitigate the mud pumping creation (Indraratna et al., 2020).

3. Prevention Method on Mud Pumping Mechanism

Settlement or mud pumping is the current problems that happen at railway track. Railway industry usually implements ballast addition and track realignment as the remediation work but these methods ineffective for mud pumping solution. The subgrade failure acquire the maintenance work expenses to increase depending on the seriousness problem on the track-bed. The contaminated soil is required to undergo a deep excavation and installation of additional ballast layers when facing the subgrade failure. Thus, the mitigation method is vital during the construction phase to ensure the service continuance of the track and reduce a massive amount of maintenance for cost implement.

The installation of geotextile, geogrid, prefabricated vertical drain (PVD) and stone column have been used as ground improvement method in Malaysia for double track project to improve the stability of soil foundation (Yean-chin & Peir-tien, 2012). These installations aimed to enhance the balance of the subgrade layer by focusing on the reduction of pore water pressure in soil formation or drainage systems that can contribute to the settlement. Meanwhile, in the worldwide context, the PVD method is recognised as the most effective soil treatment technique among all the prevention methods (Indraratna, 2017). The PVD method has the efficiency to reduce the consolidation process by applying a shorter radial drainage path and speeding the dissipation of pore water pressure (Singh et al., 2019).

The right selection of ground treatment method must able to reduce the main parameter that contribute to the mud pumping phenomenon such as reduction of migration of fine particle and dissipation of pore water pressure of subgrade soil. These main parameters will determine the effectiveness of ground treatment method toward mitigation of mud pumping. In this study will discuss the most suitable method used to prevent mud pumping mechanism by comparing the previous researcher ideas. However, some of the prevention techniques are not reliable with the mud pumping mechanism due to several limitations.

3.1. Geotextile and Geogrid

The pumping effect was examined as a phenomenon of migration fine particle through the ballast surface. Water existence will soften the subgrade layer thus agitated the suction process of mud into the ballast void. The transition phase or liquefaction of soil due to water existence resulting in the increment of compression effect on ballast and high impact depression on subgrade layer. These factors will lead to uneven settlement of rail track to occur under excessive dynamic loading. Therefore it is required a filter to prevent the movement of fine grained soil which similar to a sand blanket to place between subgrade and ballast layer as shield the ballast from fouled.

Geotextile is multifunction material that acts as a separator, filter and drainage layer between ballast and subgrade soil proven by Chawla and Shahu (2016) as adopted a model to investigate the efficiency of geosynthetic in railway track. They exposed on mud pumping cases whereby the reduction of penetration fine grained and allow water discharge at subgrade surface can be achieved only using geotextile fabric rather than relaying the thicker ballast layer. However, settlement response will not indicate anything relation about the benefit using geotextile in terms of the mitigation of mud pumping (Chawla & Shahu, 2016). Other optional for overall soil stability purposed is implementation of a combination of non-woven geotextile and geogrid to increase the soil bearing capacity. The composite material is more preferable than using geotextile alone as geogrid give better reinforcement providing lateral confinement to the weak or cohesive soil (Selig & Water, 1994; Chawla & Shahu, 2016). The reduction of lateral spread reduces the tendency of settlement on track as increasing the tensile strength of subgrade soil which undergo better stress distribution under the dynamic impact.

The pavement system also faced a similar pumping phenomenon as the railway track which indicate a 70 percent reduction in the percentage migration of fine particles resulting installation of geotextile at the subgrade subbase of the pavement (Kermani et al., 2019). Even though geotextile material is more effectiveness in term of preventing the mud pumping mechanism but it unavailable to sustain the dynamic loading impact due to distribution stress issue that can cause uneven settlement of rail track. Consequently, the geotextile cannot be used as soil strengthening material since geotextile is temporary replacement material rather than permanent purposed. This material need supportive reinforcement material like geogrid to control the lateral spread which lowers the induced stresses from above loading.

Therefore, each of the material has its own characteristic which can provide benefit to complete the needs for better soil performance as geogrid material acquire better restraint stress distribution purposed while geotextile material contributes in prevention of the intermixing granular ballast into subgrade soil and also penetration of fine grained particle into void ballast. The composite material causing the subgrade track to survive for long term services from the settlement and mud pumping erosion.

3.2. Prefabricated Vertical Drain (PVD)

Pore water pressure development is the main influence on dissipation of fine grained particle of subgrade soil which causing the occurrence of mud pumping (Duong et al., 2014). An efficient drainage system in substructure track is crucial to prevent any water detention on subgrade surface. High intensity of water content in subgrade soil surface enables rapid rate of pore water pressure diffusion as induced by train moving load.

The prefabricated vertical drain is a method that used to solve the underlying problem relating to the drainage system whereby it provided a shorter radial drainage path to assist soil consolidation process under cyclic loading. This technique is reliable with subsequent placement of surcharge to speed up the consolidation process of soft soil (Bo et al., 2007; Yean-chin & Peir-tien, 2012). However, high surcharge embankment can affect the soil stability by increasing the lateral movement on track. Thus, application of vacuum is required to reduce the height of filled surcharge by maintaining the similar rate of consolidation process (Indraratna, 2017).This combination can eliminate the instability issue and avoid any lateral movement (Indraratna, 2017).

A greater scale cyclic triaxial test with PVD was conducted on clay soil (kaolinite) indicates the reduction of excess pore water pressure achieved by 50-80% (Indraratna et al., 2010). Implementation of PVD with minimal cost is possible where the spacing of PVD in horizontal direction must below than 5m c/c to assist water discharge from the sand layer (Yean-chin & Peir-tien, 2012). Besides, it is essential to provide the crusher run at the end of the sand layer to prevent the discharge outlet clogged. The blockage of discharge outlet can enable the development of pore water pressure on soil, thus encourage the formation of mud pumping phenomenon.

The PVD is the method major attribute for reduction of pore water pressure in subgrade soil as speeding the rate of consolidation process either for road embankment or railway substructure. Mitigation of mud pumping is reliable using implementation of PVD as an effective drainage system. The ground improvement is a must step to implement before start a construction of railway track project on soft subgrade area. Other than that, the installation of stone column and chemical treatment method are compatible to be used in stabilising subgrade track rather than using PVD method.

3.3. Stone Column

The pumping grained from subgrade surface will cause the track to undergo settlement and poor track geometry. (Wheeler et al., 2017). Wide range area for soil treatment needs high efficiency of a ground treatment technique for better improvement of problematic soil.

The stone column is suitable to use for critical subgrade soil which difficulty to sustain the loading such as expansive soil or peat soil. Among all ground improvement techniques, the stone column is more preferable to apply on soft soil due to capability in settlement reduction and rapid the consolidation process (Ahmed & Patil, 2018). The geotechnical problem can be solved using this in-situ method by reducing the soil compressibility and increase the shear strength of soft subgrade soil (Yean-chin & Peir-tien, 2012).

The stone column is a giant version of PVD method capable to accelerate consolidation settlement and thus shorten the construction period. Even though the soft soil bearing capacity was improvised, the stone column method still required on other geosynthetic encasements to improve the better result of low lateral confinement and provide better performance under upper loading impact (Ahmed & Patil, 2018). Other than benefits in soil improvement, this method can be implemented in an economical way by reducing the diameter size of the stone column and increase the column space (Shehata et al., 2018).

4. Compilation of Case Study on Prevention Method.

This compilation is used to identify the preferable prevention technique proposed by the researchers in mitigating the subgrade problems. Table 1 shows the previous researchers indicate that the prevention method can improve subgrade performance by reducing the dissipation of excess pore water pressure of soil. However, not all prevention is capable of enhancing the phenomenon of mud pumping due to its concept and limitation on the specific type of soil. All the researchers below agreed that geotextile can reduce the rate of migration of fine particle or intermixing between two-layer as placing between subgrade layer and the ballast layer. Several researchers identifying on the efficiency of PVD method in mitigating of mud pumping as increasing the dissipation of pore water pressure (Yean-chin & Peir-tien, 2012; Singh et al., 2019; Madhat Shakir Al-Soud, 2015).

Table 1: Prevention Method Proposed by Previous Researchers

Citation	Ground Treatment Method					Finding
	Prefabricated Vertical Drain	Geotextile & geosynthetic	Stone Column	Excavation & Replacement	Geogrid	
Yean-chin & Peir-tien, (2012)	√	√	√	√		- Investigation on subsoil behaviour - Determine the concepts of each ground treatment technique and its limitations. - Combination of prevention method provide better subgrade performance

						- Example: Surcharge and PVD.
Singh et al., (2019)	√	√				- Effectiveness is highly dependent on the type of subgrade soil. - Geotextiles successfully act as a separator by inhibiting the rate of rising of the slurry which reducing excess PWP dissipation.
Madhat Shakir Al-Soud, (2015)	√	√				- Good drainage condition provided as PVD accelerate the pore water pressure (PWP) dissipation which increase degree of consolidation (29-68%).
Chawla and Shahu, (2016)		√			√	- Geotextiles is reliable to remediate the pumping problem on rail tracks. - Geogrid improve stress distribution on track as reducing the tie displacements.

5. Conclusions

This study reviewed the case study done by previous researchers on the prevention method. Most of the problematic soil that prone to the mud pumping is silty clay type with low to medium plasticity. The selection of prevention techniques depends on the soil classification, and it is vital to consider the trigger element that causing mud pumping to occur, such as the complex phenomenon of fines migration and the excess pore water pressure generation. Thus, the PVD method is preferable to use because it can improve the drainage system for saturated soil as it enables the reduction of dissipation pore water pressure in subgrade soil. Other than that, the geotextile was used as a filter, separator, and drainage, which have a better response in mitigating the mud pumping problem as reducing the migration of fine particles compared to geogrid. However, when considering the ballast strain, especially for the clay soil type, the geotextile will become less effective compared to the geogrid unless both of the geosynthetic methods have been used together to improve the reinforcement of the reduction of stress on subgrade soil. Therefore, better track performance and longevity effect services can be achieved using the right selection on the combination of two or more prevention method. Instead of focusing on the prevention technique, further soil behaviour in geotechnical studies is needed to investigate more on the mechanism of mud pumping under the cyclic impact.

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Determination of Deflection versus Time for Prestressed Concrete Sleepers Located at Butterworth to Kobah Route

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Abstract

Keretapi Tanah Melayu Berhad (KTMB) is one of the authorities handling railways trains in Malaysia. The services trains at Tanah Melayu around the 1800s were transferred from the rural area to the city. Until the 1900s trains services brought rubber to passenger transportation. Meanwhile, the railway track used a wooden sleeper. Development railways tracks in Malaysia were started in the 1990s which KTMB had changed wooden track to precast concrete sleeper. Since the lack of sources wood in Malaysia, compared with concrete might be sustainable until 20 years to 50 years old. The blossoming development railways track in Malaysia caused the accident and had been reported in the media. The accident has been explored to find the root cause. The accident comes from the derailment trains, the cracked sleeper, soil condition etc. In this study, a site investigation was carried out on selected Precast Concrete Sleepers (PCS) located at the route of Butterworth, Pulau Pinang to Kobah, Kedah. The deflection versus time for three car seats and six car seats passenger trains were recorded using the piezometer Sirius-M. Therefore, this research would have helped the authority to find the cause behind the accident and created a safety factor to authority for railways track in Malaysia.

Keywords: Prestressed concrete, sleeper, static, dynamic, railway, KTMB, train, loading

1. Introduction

Nowadays railways are one the most important transportation in Malaysia and Keretapi Tanah Melayu Berhad (KTMB) is a railway authorised to maintain all railways track. KTMB began operating in 1885 from Taiping to Port Swettenham. The railways development in Malaysia started increasing gradually around the 1990s which was introduced in 1995. Northern region which covered Perlis, Kedah and Penang which the electrified double track has finished at the end of 2014 and started operating in mid of 2015. Since 2015, KTMB has supplied commuter trains to the northern region by starting three car seats as a trial for taking passengers daily and every hour. The increasing passengers forced KTMB brought six cars set from Klang Valley to the northern region for the smooth operation.

There are many cases of accident reported in the news about the collision between trains and derailment on the railways tracks. The collision between trains was caused by accidents that always came from the trains driver or signalling system from the authorities. Meanwhile, the derailment trains on the railways recommendations have been highlighted to KTMB for further action. In most cases, the problems were measured by KTMB.

Railways track sleeper is the main part of railways structures (Remennikov and Kaewunruen, 2009). Its major roles are to distribute loads from the rail foot to the underlying ballast bed. PCSs are the most popular railway sleepers around the world generally, and Malaysia especially. This is because the PCSs get easily from the manufacturer who supplied the sleepers. Other than hand, it is more sustainable until more than many years.

Prestressed concrete sleepers (PCS) are the most commonly used on the railroad. They played some roles to support and absorb the variety of trains loading transferring to the ground. The railways track (explained railways structure can be subdivided into two groups; Superstructure and substructure. Superstructure consists of the rails, rail pad, and concrete sleepers and fastening system. Meanwhile, substructure is associated with a geotechnical system consisting of ballast, sub ballast and subgrade (formation).

The previous research has studied the material on PCS as (Kaewunruen & Remennikov, 2007) has presented the effect of improper ballast tamping on PCS. This study, which highlights the influence of uneven and asymmetrical ballast support on free vibration behaviors of the in situ railway concrete sleeper. The base support such as soil condition also needs further explanation and experimentation.

Meanwhile, Sadeghi (2010) study has explained the behavior of dynamic with the different loading In these investigations the variations in the sleeper supporting conditions during track life-time were taken into account. The influences of the dynamic characteristics of the trains moving load on the behaviour of the sleepers were investigated. The result showed compared the uniform pressure between field investigation and experimental laboratory testing. In experiments to find the uniform pressure the pressure increases from the sleeper's edge and reaches its maximum value under the rail-seat position.

Salim et al. (2012) has investigated the prestressed concrete sleeper due to simulation of train loading. The deflection against cycle simulation has been determined by fatigue test in accordance with the Australia Standard. The behaviours of prestressed concrete sleeper can be shown by deflection, cracks and strain.

According to Ikmal et al. (2018) the deflection of prestressed concrete sleepers was compared between finite element LUSAS and the experimental result. Static load is measured for comparison with dynamic loading. The testing would be carried with the different loading applied on concrete sleeper. LUSAS was used as the alternative for saving cost and time in modelling the testing. Figure 4 showed that experimental results greater than LUSAS due the LUSAS and a numerical element which provided prediction of deflection of structures.

Therefore, the lack of research on prestressed concrete sleepers in Malaysia brought a motivation of this study. In this study, site investigation was carried out on selected Precast Concrete Sleepers (PCS) located along the route of Butterworth, Pulau Pinang to Kobah, Kedah to record the deflection versus time of the PCS using the piezometer Sirius-M.

2. Methodology

An on-site investigation along the Butterworth to Kobah route has been conducted and almost 80 readings of the train have been recorded. Two locations were selected: Pinang Tunggal and Kobah. Figure 1 shows part of the railway track along the route. The method of storing the data is undisclosed. As KTMB staff informed that Butterworth to Kobah area was the most severe location maintenance always occurred. The area was found to have some settlements which needed frequent maintenance.

Figure 2 showed the equipment called Sirius Mini to measure the acceleration against time of trains tamping on PCSs. The piezometer sensor was attached to selected PCS and connected to the computer as shown in Fig. 3. Dewesoft is software to store the data taken at site investigation. It is storing deflection, sound and acceleration reading. The measurements were taken for the type loading of the train as per title six car set and three cars set coaches which are called commuter as daily ride for passengers from Padang Besar to Butterworth and vice-versa. 10 days data collected from the site investigation. The raw data train loading was captured by Dewesoft software as shown in Fig. 4, before they were extracted to Microsoft Excel.

Fig. 1. Site investigation along Butterworth to Kobah route.

Fig. 2. Measuring data equipment called Sirius-M

Fig. 3. The installation piezometer on prestressed concrete sleeper

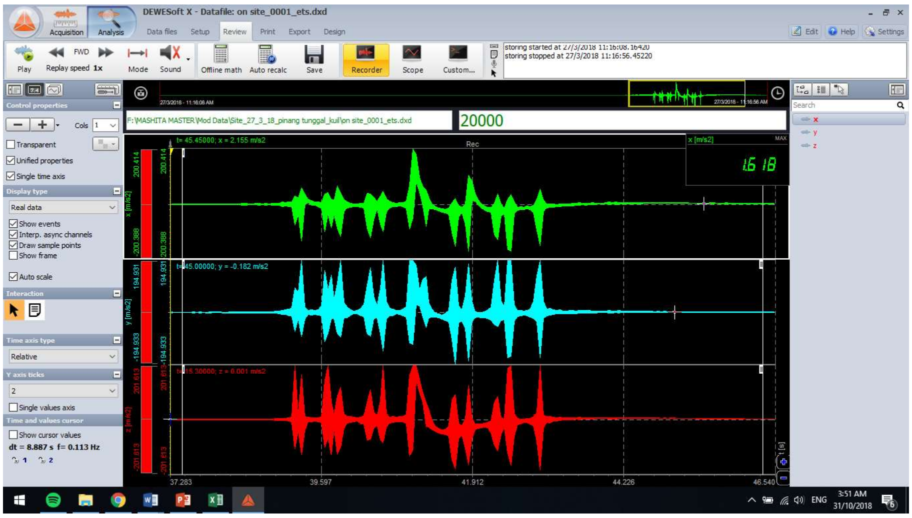

Fig 4. Data captured by Dewesoft Software

3. Data Analysis and Discussion

Figure 5 showed that the different deflection between three coaches and six coaches train going through the PCS at Pinang Tunggal. Both trains were quite similar at the beginning when train wheel touched PCS which was being installed piezometer. This is because the early train wheel had high impact. Three coaches had the high deflection was 0.63 mm at the time 0.70 sec. Meanwhile, six coaches trains had the highest deflection was 1.01 mm at 0.955 sec. This is showing that six coaches train as commuter had been contributed of the deflection of prestressed concrete sleepers.

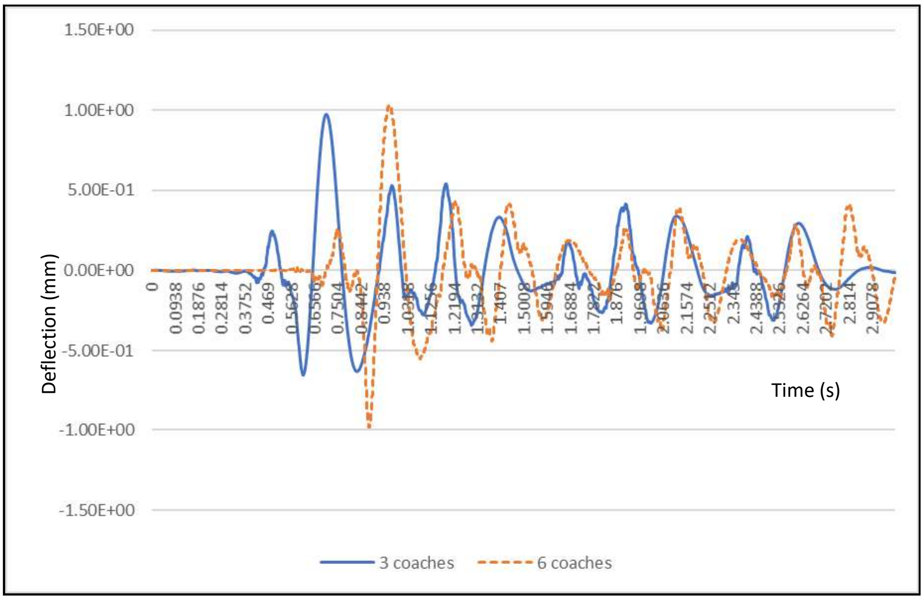

Fig.5. Deflection vs Time at Pinang Tunggal

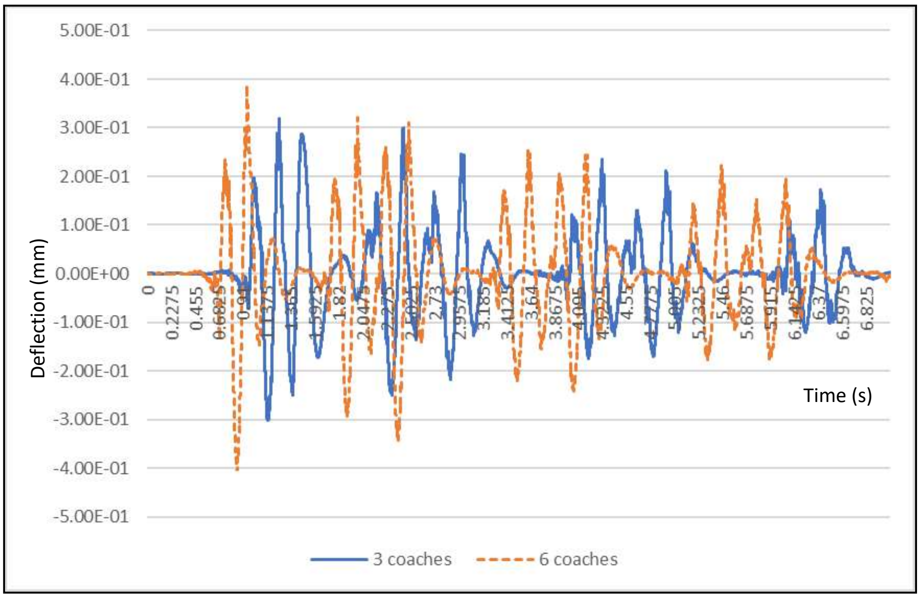

Fig. 6. Deflection vs Time at Kobah

Figure 6 showed the graph of deflection versus time at Kobah.This graph has shown different of deflection three coaches and six coaches train. The deflection both trains were extremely going through this area. The highest deflection PCS for six coaches trains is 3.89 mm at 0.94 sec. Meanwhile, for three coaches train is 3.14 mm at 1.25 sec. It was found that soil condition this area called as soft clay have displacement made PCS has affected the deflection.

4. Conclusion

The different of soil condition would be affected to deflection of PCS. From the results presented above showed that, soil condition at Kobah needs maintenance at 1m to 2 m distance of railway track. Meanwhile, at Pinang Tunggal had less deflection. This is because trains going through the PCS has piezometer brought less deflection on PCS and indirectly soil condition that area also having a few deflection from the load pressure on it.

5. Acknowledgement

Many thanks to Keretapi Tanah Melayu Berhad (KTMB) Cawangan Utara Mr. Zailan who was given permission for our team doing site investigation along 10 days. Unforgettable, Eastern Pretech (M) SdnBhd supplied sleeper as actual experimental and Kementerian Pengajian Tinggi (KPT) on their financial support through an awarded grant for making this research become real.

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Investigation on the Influence of Cut-off Wall to Groundwater Contamination using Numerical Method

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Abstract

Cut-off walls or vertical barriers are widely used to control the spread of contamination by restricting the groundwater flow. In this study, numerical simulation using PMWIN software was used to examine the effects of cut-off wall to the behaviours of contaminant transport. A conceptual model that represented leakage of leachate from an abandon landfill area with a general setup of cut-off was simulated. Five simulation models were developed that included cases to examine the width, penetration depth and arrangement of cut-off wall to the influence of contaminant transport and spread. The results showed that by extending the width, adopting keyed-in wall design, and installing upgradient cut-off wall, the effectiveness of cut-off in retaining the contaminant could be increased.

Keywords: Cut-off wall, Groundwater Pollution, Groundwater Protection.

1. Introduction

In Malaysia, water resources for portable water supply are mainly come from the surface water. Full dependency of surface water as main water supply resource could face problem when water scarcity occurred, and therefore alternative source of water supply needs to be considered in long term water supply planning. One of the best alternative sources is groundwater due to its availability in Malaysia. However, groundwater can be easily contaminated due to anthropogenic activities. It involves human activities like excessive use of pesticide, fertilizer and animal waste in agriculture (Ahmad et al., 1996). The pollutant can infiltrate into the ground aquifer and contaminate groundwater system. It is dangerous if the contaminated groundwater reaches the drinking water pumping well as it moves through the aquifer (Egboka et al., 1989). The transport behaviours of contaminant entering the soil depend on both physical, chemical, and biological properties of the contaminant and porous medium. The contaminant will tend to move slowly and remain concentrated in the form of plume. The velocity of plume depends on the amount, solubility, type, density of the contaminant and the groundwater flow velocity (USEPA, 1989).

Landfill is categorized as point source contaminant because it can be easily identified. In urban area, large volume of solid waste is collected and disposed at the landfill area. Due to the varies source of solid waste collected, some may contain hazardous waste. When a landfill area is operating without proper leachate collecting and managing system, like an old or abandoned landfill site, the possibility of groundwater resources to be contaminated by the leachate leaking due to rainfall and surface runoff into the aquifer could increase. In Malaysia, groundwater contamination has been reported at Ampar Tenang Landfill, Selangor (Taha et al., 2011). The aquifer at Ampar Tenang was contaminated by the leachate that has caused higher COD and concentration of Cd, Pb and Fe at the downstream of the aquifer. Leachate from the landfill was found to penetrate the ground and pollute the groundwater.

Therefore, it is crucial to retain the contaminant at its source to prevent further spread of the contamination to the groundwater system. The cut-off wall has been used as a method to contain groundwater contamination. Cut-off wall is also known as a vertical barrier wall. It is a low permeable wall that is installed in the ground for the purpose to contain the contaminant from outside or act as obstacle in groundwater flow path to prevent groundwater contaminant from spreading. The present of the cut-off wall in the pathway of the groundwater flow will alter the flow direction and reduce the velocity of the groundwater flow. It therefore indirectly retains the contamination plume from spreading. Depend on the characteristic of the contaminant, cut-off wall can either be constructed keyed in into low impermeable layer or hanging without reaching the low impermeable layer. The configuration is determined according to the need at site to treat different types of contaminant (Daniel and Koerner, 1995; USEPA, 1984).

Cut-off walls always works with extraction wells in groundwater remediation and waste containment techniques. However, the effectiveness and the suitability of this method depends on the accuracy prediction on the behaviour of transport of contaminant. By understanding the behaviour of the groundwater flow and the transport of the contaminant in the presence of cut-off wall, the engineers are able to design effectively and apply the method in retaining the contamination. In this study, numerical modelling software, PMWIN (Chiang and Kinzelbach, 1998) was used to investigate the behaviour of groundwater flow and contaminant plume transport in the presence of cut-off wall as in open barrier designs under various conditions.

2. Methodology

2.1. Description of Numerical Model

In this study, a numerical field scale model was developed to illustrate a common contamination scenario from an abandon landfill area (Fig. 1). The situation demonstrated an abandon landfill area had led to contamination of groundwater and the leachate generated by the landfill penetrated the ground and contaminated the groundwater aquifer in the simulated site. The study domain was simulated as homogeneous unconfined aquifer with dimensions of 1000 m in length and 400 m in width to cover the extent of contaminant spread and movement within the simulated area. The model consisted of a soil layer with total depth of 12 m and was divided into three layers. In each layer, the domain was divided into small mesh of 100 columns x 40 rows with the size of 10 m x 10 m. The mesh was further refined at landfill area and along the contaminant flow path. The West and East sides of the aquifer were bounded by fixed water levels of 11.5 m and 10 m respectively with the hydraulic gradient of 0.0015. The hydraulic conductivity of 5 x 10^{-3} m/s was assumed in the model which was similar to a typical coarse sand layer. The horizontal to vertical hydraulic conductivity ratio was set as 10:1. The effective porosity was assumed to be 0.30 for the aquifer layer. The landfill area was simulated as 40 m x 40 m and located on ground surface with a depth of 4 m. The landfill area was set as fixed concentration cell to imitate the situation where the landfill area constantly discharged leachate into the ground. A constant concentration contaminant was released from the contaminated site. The longitudinal and transverse dispersivities were set as 10 m respectively. No chemical or biochemical reactions was included in the simulation.

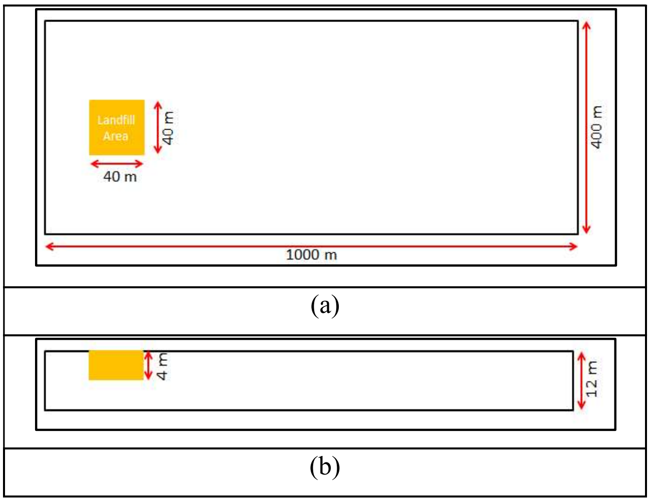

Fig.1 (a) Plan and (b) Side View of Numerical Model

2.2. Study Cases

In this study, the investigation on the effects of cut-off wall to contaminant transport was conducted through four study cases that involving five simulation models (Table 1). The study case 1 investigated the behaviour of contaminant movement due to the presence of cut-off wall (Models 1 and 2). The study case 2 (Models 2 and 3) and study case 3 (Models 2 and 4) studied the behaviour of contaminant movement under different width and depth of cut-off wall. The study case 5 investigated the effect of the position of cut-off wall toward the contamination transport in groundwater aquifer (Models 2 and 5).

Table 1: Summary of Cases Study and Model Involved

Case	Model	Variable	Evaluation criteria
Case 1	Model 1	No cut-off wall	Presence of cut-off wall
	Model 2	100-m width cut-off wall	
Case 2	Model 2	100-m width cut-off wall	Width of cut-off wall
	Model 3	200-m width cut-off wall	
Case 3	Model 2	12-m depth cut-off wall (keyed-in)	Depth of cut-off wall
	Model 4	8-m depth cut-off wall (hanging)	
Case 4	Model 2	Downgradient wall	Position of cut-off wall
	Model 5	Upgradient and Downgradient walls	

3. Result and Discussion

3.1 Case 1: Presence of cut-off wall

Figures 2a-2c show the contaminant movement after 1, 2 and 3 years of simulation for Model 1. The contaminant plume started to spread towards downgradient of contaminant source driven by the groundwater flow and slowly approached Observation well 1 (OW1) which was located

100 m from the contaminated site. In Model 2, the spreading of the contaminant was retarded when the contaminant reached the cut-off wall location. The contaminant was retained behind the cut-off wall and prevented from transporting further downgradient from the contaminated site. However, the open cut-off wall design was not able to contain the contaminant. As the simulation time increase, the contaminant was able to travel along the wall toward downgradient of the wall. However, the transport distance is lesser compared with Model 1 in the second and third year. Since the investigation was not focused on a specific site condition, the relative concentration (Resulting Concentration/Initial Concentration, C/C_0) was adopted to demonstrate the change of concentration in the study area. Figure 3 shows the relative concentration in OW 1 for Model 1 and Model 2. The gradient of relative concentration for Model 1 was higher than Model 2. This shows that the contaminant plume in Model 1 has travelled to downgradient of contaminated site faster than Model 2. Therefore, presence of cut-off wall in the contaminant transport path has slowed down the movement of the contaminant plume. This indicated that presence of cut-off wall has restricted the contaminant plume movement in groundwater aquifer. The result also showed that cut-off wall can act as a buffer to the groundwater contamination from spreading further. Similar result has also reported in the study of Basha and Rashwan (2010) where vertical sheet pile that was placed at down gradient of the contaminant source has provided buffer effect to the spread of contaminant.

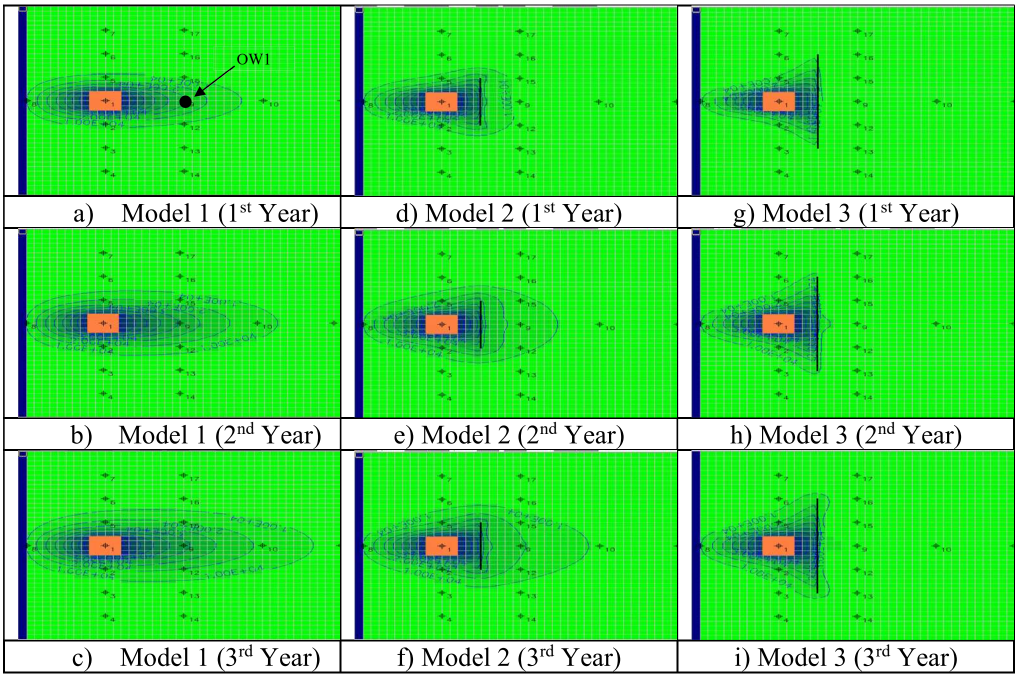

Fig. 2. Contaminant Plume Transport of Model 1, (a) to (c) Without cut-off wall; Model 2, (d) to (f) with 100-m width of keyed-in cut-off wall and Model 3, (g) to (i) with 200-m width keyed-in cut-off wall. The contour lines indicate the relative concentration at 10% interval.

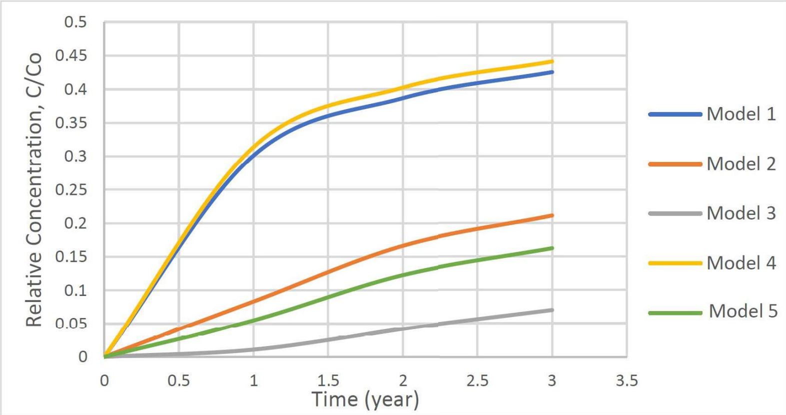

Fig. 3. Simulated Relative Concentration of Contaminant in Observation Well 1 (OW1)

3.2 Case 2: Width of cut-off wall

The increment of the cut-off wall width from 100 m to 200 m has significantly enhanced the function in containing groundwater contaminant (Figs. 2d-2f). The cut-off wall was able to contain the contaminant plume in the first year of simulation. The time taken for the contaminant plume to travel downgradient of the cut-off wall has significantly increased in Model 3 when compared with cut-off wall width of 100 m in Model 2. Wider wall has increased the travel distance and caused the contaminant plume to take longer duration to travel downgradient of the contaminated site. The relative concentration in OW1 has reached 21% for Model 2 and 7% in Model 3 after 3 years (Fig. 3). The gradient of relative concentration for Model 2 was also higher than Model 3 that indicated the transport rate of Model 2 towards OW1 was to than Model 3. In this study case, wider width of the cut-off wall has significantly increased the effectiveness of the cut-off wall in containing groundwater contamination from spreading and travel further downgradient.

3.3 Case 3: Penetration depth of cut-off wall

The reduction of the depth of the cut-off wall from 12 m (keyed-in) to 8 m (hanging) has reduced the effectiveness of cut-off wall in restricting contaminant movement (Figs. 4d-4f). The result shows that the contaminant plume driven by the groundwater flow continued spreading and travelled further downgradient from the contaminated site in Model 4 when compared to Model 2. In Model 4, the travel and spread pathway of the contaminant was similar to Model 1 without cut-off wall (Figs. 2a-2c). This happened when the contaminant was allowed to travel underneath the cut-off wall in Model 4 (Fig. 5b). The results showed that by reducing the depth of cut-wall (hanging), the effectiveness of the cut-off wall in retaining contaminant has been lowed. The relative concentration in the OW1 was 44% in Model 4 which was higher than the relative concentration of 21% in Model 2 (Fig. 3) after 3 years. The higher gradient of relative in Model 4 was caused by the shorter travel distance in Model 4. The result was almost identical to Model 1 (without cut-off wall). Therefore, penetration depth of cut-off wall is critical in controlling contaminant movement. Study conducted by Basha and Rashwan (2010) has also shown similar results where the increment of penetration depth has decreased the transport rate of the contaminant.

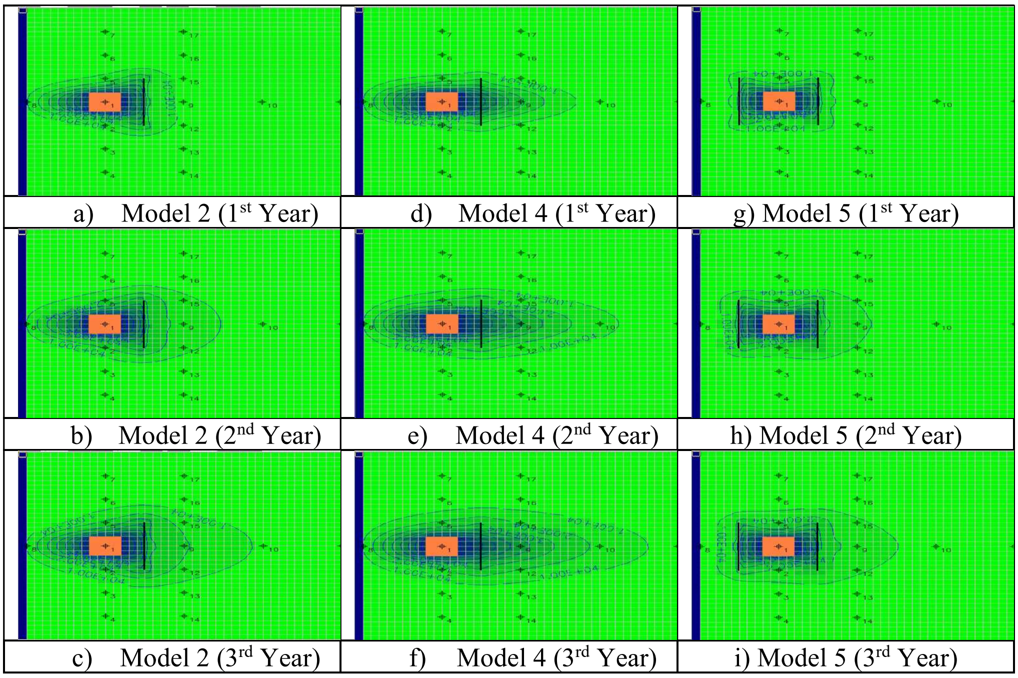

Fig. 4. Contaminant Plume Transport of Model 2, (a) to (c) with 100-m Width Keyed-in Cut-off Wall, Model 4, (d) to (f) with 100-m Width Hanging Cut-off Wall, and Model 5, (g) to (i) with 100-m Width Cut-off wall at upgradient and downgradient of contaminated site. The contour lines indicate the relative concentration at 10% interval.

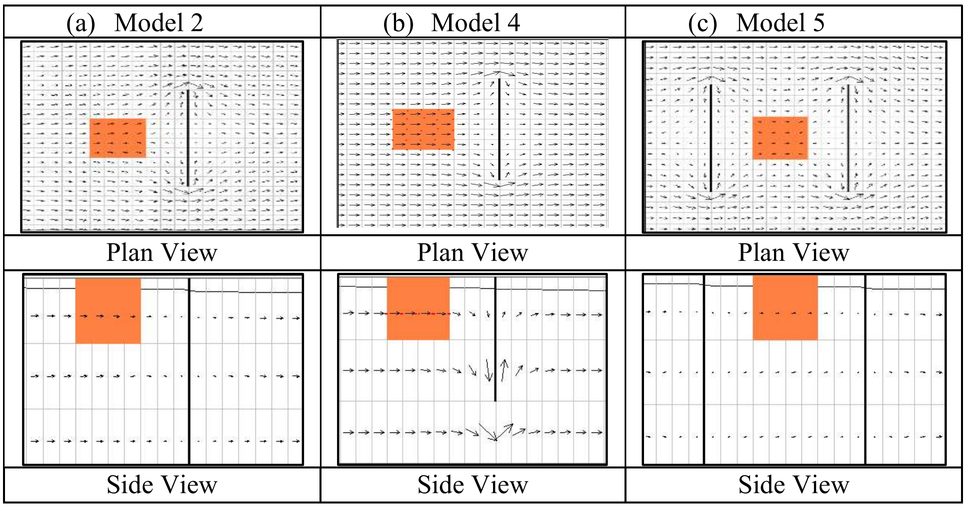

Fig. 5. Velocity Vector and Flow Path for (a) Model 2, (b) Model 4 and (c) Model 5

3.4 Case 4: Position of cut-off wall

Study case 4 demonstrated the effect of contaminant transport by adding upgradient cut-off wall at contaminated site (Model 5, Figs. 4g-4i). The transport of contaminant plume was found to contain between the two cut-off walls located upgradient and downgradient of contaminated site (Figs. 4g-4i). When the groundwater flow blocked by the upgradient cut-off wall, the groundwater discharge was diverted and acted as a buffer zone to reduce groundwater flow toward the contaminated site. The rate of contaminant plume that travelled toward the second cut-off wall was reduced significantly compared to Model 2 with only downgradient cut-off wall (Figure 4a-4c). Similar finding was also reported in the study of Bayer et al. (2004). The relative concentration in OW1 was 21% for Model 2 and the value was only 16% in Model 5 after 3 years (Fig. 3). The gradient of relative concentration for Model 2 was higher than Model 5 that showed the contaminant plume in Model 2 has travelled faster than Model 5. The results have also proven that by installing upgradient cut-off wall able to block the groundwater flow and subsequently reduced the concentration and spread of the contaminant plume from the contaminated site.

4. Conclusion

This study has demonstrated the behaviours of contaminated plume under various arrangement of cut-off wall. The results showed that by extending the width, adopting keyed-in wall design and installing upgradient wall could help to increase the effectiveness of cut-off in retaining the contaminant. Due to the assumptions made in the numerical simulations, there are some improvement that could help to validate the findings in this study which include the following:

- To compare simulation results with other actual site conditions to validate the prediction from the current simulation as the current study was conducted based on conceptual model and a general setup of a cut-off wall.
- To integrate remediation technique such as pumping and treat in the simulation since application of cut-off wall can only contain the contaminant.
- To evaluate the behaviours under different soil type (hydraulic conductivity). The groundwater flow could vary under different soil type and directly affect the behaviours of contaminant plume.
- A homogeneous aquifer is assumed in this study. The heterogeneity of the aquifer that reflect the complexity of the aquifer should be considered for further study.

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Comparison of Load vs Displacement between Site Investigation and Experimental Work of Prestressed Monoblock Concrete Sleeper (PMCS) Under Dynamic Loading

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Abstract

The purpose of the research was to study the behaviour of the prestressed monoblock concrete sleeper (PMCS) under dynamic loading experimentally and through site investigation. In order to obtain the objective, research progress was carried out with the aid of Heavy Structure Laboratory of UiTM Penang, Post-graduate supervisor, Keretapi Tanah Melayu Berhad (KTMB) Permanent Way Infrastructure Research Group UiTM (PWI) and Eastern Pretech (Malaysia) SDN BHD for the samples provided. From this research, the value of deflection base on acceleration of concrete sleepers have been obtained. This research has shown the relationship and correlation between the deflection of concrete sleepers under the rail track. After all, the research is including experimentation process which includes experimental investigations for dynamic loading of prestressed monoblock concrete sleepers (PMCS) were examined in terms of its capability to accommodate their own design capacity and the relationships between load and displacement happened within the concrete sleeper. From experimental test, the highest deflection on KTMB and EPMI rail seat section is 1.35 mm and 1.04 mm respectively. From site investigation at KM20.75, the highest deflection occurred is 5.993 mm which is lower compared to the highest deflection at KM26.25 with the value of 7.06 mm.

Keywords: Prestressed Monoblock Concrete Sleeper, Sirius M, Australian Standards, KTMB.

1. Introduction

Railway tracks consist of components grouped into two categories, superstructure and substructure. Superstructure consists of rails, rail pads, fastening system, and sleepers. Ballast, sub-ballast, and subgrade are classified as a substructure (Domingo et al., 2014). Among those components, the roles of sleepers are noticeable which is used to support the rail and maintain the track gauge, to withstand vertical and longitudinal movement of rails, and to transfer and distribute loads from rail to ballast (Javad et al., 2015). Prestressed concrete sleeper with longer life cycles and lower maintenance costs brought many technical and economic advantages to the railway engineering (Shokrieh et al., 2006). With their great weight, prestressed concrete sleepers assure the stability for the train (Zakeri et al., 2012). A previous study of constant amplitude of prestressed concrete sleeper (PCS) subjected to three coaches train (Rozli et al., 2015) has determine the pattern of load applied to the PCS as the load pattern is important in designing and lifetime of PCS. Method used in this study was collecting a raw data from site measurement at Kajang-UKM railway station and using strain ratio method in determining the constant amplitude. Besides, Rainflow cyclic counting method was used to determine the number of cycles of load applied by the moving three car set train on the PCS. The data that gained were analysed using Microsoft Excel software. From the study, amplitude values from the raw data of load by the moving trains were produced as in Fig. 1. The study had concluded that the maximum strain value under three car set train due to several data was 55.4762 5mm/m. The higher strain found on PCS were under load produce at front and back wheel of train.

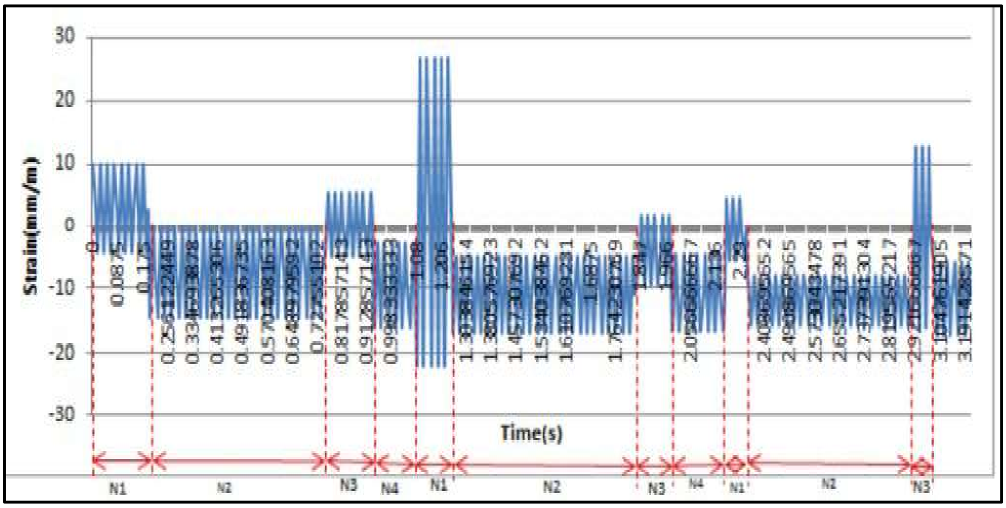

Fig. 1. Constant Amplitude Graph Stains versus Time

The study of loading capacity of prestressed concrete sleeper under harmonic function (Sharulnizam et al., 2014) has determined the ability to withstand the fatigue loading during services and the flexural behaviour of PCS under low velocity impact. The study also has produced harmonic functions that express the amplitude waveform through numerical modelling constant amplitude. The site measurement was made at KTM Kajang and the pattern of strain versus time history of PSC under cyclic loading was determined as in Fig. 2.

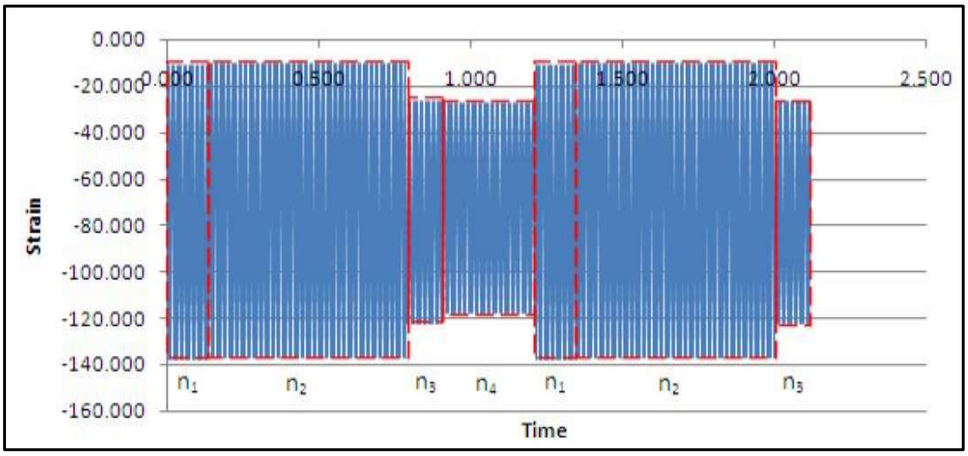

Fig. 2. Constant Amplitude Block Sequence Graph Strain versus Time

The highest and lowest load subjected on PCS were indicated by relating the past investigation of the consistent amplitude of PCS exposed to three coaches train (Rozli, 2015) that appeared in Table 1 as the information was determined by utilizing rainflow cyclic checking technique. The information depended on three coaches sets passenger train that gathered at Kajang-UKM railroad station, Selangor, Malaysia.

Table 1. Minimum and Maximum of Load Applied on PCS.

Load,P (kN)		
Maximum(kN)	**Minimum(kN)**	**Ratio of Cycles**
87	41	1.38
61	26	7.30
81	43	1.32
70	30	2.33

Following the Australian standard (AS 1085.12) (Standards, 2012), a repeated load for 3 million cycles are applied varying uniformly with each cycle. After that, the repeated loading cannot exceed 600 cycles per minute which means less than 10 Hz per cycles. In other words, 3 million cycles of repeated loading will be applied on each of the rail seat of PMCS (KTMB and EPMI) followed by the no. of cycles as stated in Table 2. By using equation (1) until (4), number of cycles can be identified to imitate actual freight train.

Table 2. Minimum and Maximum of Load, Hertz and No. of Cylcles Applied

Load,P (kN)		Hertz (s^{-1})	No. of Cycles
Maximum (kN)	Minimum (kN)		
87	41	1.0	1.38/ 335766
61	26	1.0	7.3/ 1776156
81	43	1.0	1.32/ 321168
70	30	1.0	2.33/ 566910

$$1.38/\sum 12.33 \times 3 \text{ million cycles} = 335766 \text{ cycles} \quad (1)$$

$$7.30/\sum 12.33 \times 3 \text{ million cycles} = 1776156 \text{ cycles} \quad (2)$$

$$1.32/\sum 12.33 \times 3 \text{ million cycles} = 321168 \text{ cycles} \quad (3)$$

$$2.33/\sum 12.33 \times 3 \text{ million cycles} = 566910 \text{ cycles} \quad (4)$$

2.Site Investigation

In this investigation, two sites were chosen to be investigated. The site was picked by KTMB because it is known as a non-problematic and also a problematic site condition (in terms of PCS movement). The sites chosen were Pinang Tunggal (KM20.75) and Pinang Tunggal (KM26.25). This investigation was carried out to determine the deflection of PCS located at a different site location. Most of the site is located far away from the nearest electrical source thus limiting the capability to continuously collect data. Site investigation only can collect data from 8.00am until 12.00pm because the battery of laptop can only hold for about 4 hours. During the 4-days site investigation, almost 20 data on all types of train were able to be gathered and upon further analysis, only 17 data were extracted to be analysed. KM20.75 locations consist of soil settlement due to settlement of culvert beneath the subgrade of the rail track. The location was surround by paddy field which consist of soft alluvial soil. The culvert is functioned to provide route to deliver the water stream into and out of paddy field. The second location are located at KM26.25 of route in Pinang Tunggal. This route consists of railway bridge infrastructure. These locations are selected due to its suitability to compare with data at problematic soil as the rail track was builds on a well-structured facility. The data collection will be among two types of train which is freight train and Electric Train Services (ETS). The data for KTM Komuter also will be taken as additional data. Figure 3 and 4 shows the images of the site location at KM26.25 and KM 20.75 respectively taken from Google Earth in plans view geographically.

Fig. 3. The Site Location at KM26.25 Which Consist of Bridge at Pinang Tunggal

In this investigation, Sirius M instrument was selected to collect the data at site location. Sirius M consist of few parts such as piezometer sensor to detect the vibration of concrete sleepers. The piezometer sensor was link to the edge of concrete sleepers by binding with specific 'glue' without affecting the value of vibration, similar nature to fatigue load test arrangements of Sirius M's piezometer. It was connected to software on computer to observe the chart of acceleration of concrete sleepers. The position of piezometer sensor must be recorded because it consists of 3 direction acceleration (x, y and z). This will provide acceleration data for concrete sleepers when receiving load wave carry by train. Direct data collection will be in unit of mm/s2 which is in term of acceleration. By data recorded, the value of deflection can be obtained by double integration the value of acceleration. In theoretical view of mathematical integration, the integration is the opposite of the derivative. If the acceleration of an object is known, the position data can be obtained if a double integration is applied (assuming initial conditions are zero): Thus, in this research the concept of double integration were used to convert the obtained data into deflection value. Figure 5 and 6 shows the image taken from both actual site investigation (KM20.75 & 26.25).

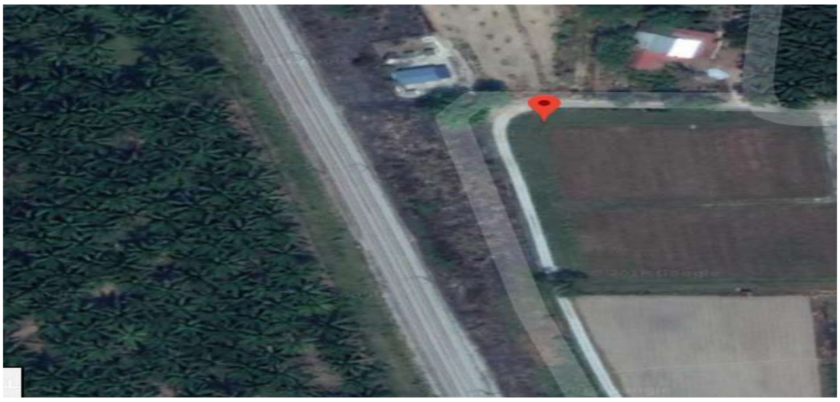

Fig. 4. The Site Location at KM20.75 Which Consist of Paddy Field Area at Pinang Tunggal

Fig. 5. Site location (KM20.75)

Fig. 6. Site location (KM26.25)

3. Experimental Test

For this research, a strain gauge length of 60 mm and a LVDT of 30 mm type was used. The rail seat repeated load test was done by referring fourth edition of Australian Standard, Part 14 Prestressed concrete sleepers (AS 1085.3 - 2012) (Standards, 2012) that was prepared by Committee CE-002, Railway Track Material and was approved on behalf of the Council of Standards Australia. Australian Standard was used as reference for laboratory testing for this study because of this standard has been used widely by railway transport system in Malaysia especially KTMB. The load cell was positioned above the PMCS at area where PMCS will receive dynamic load that transferred from a moving train through a rail. Neoprene supports pad of two 25 x 165mm plywood and loading plate were placed directly under load cell to help in distribution of loading as requirement from Australian Standard. The vertical dynamic load was applied on precast PMCS at the positive moment of PMCS. Location of the support and its loading condition were figured by referring to Australian Standard (AS 1085.14 – 2012) (Standards, 2012). Instead of using neoprene, plywood was used as the replacement for fatigue load test. By using marker pen, marking was made to made sure the location of the support and the plywood are at the accurate location. From the center of the load subjected to the PMCS, a length of 330 mm to the left support and 330 mm to the right support, making the full length of support to support to be 660 mm in total are to be marked by marker pen. Also, 45 mm of length from the center of the load to the left and 45 mm to the right at the top of PMCS in normal condition are marked too as the place to put the plywood below the load plate.

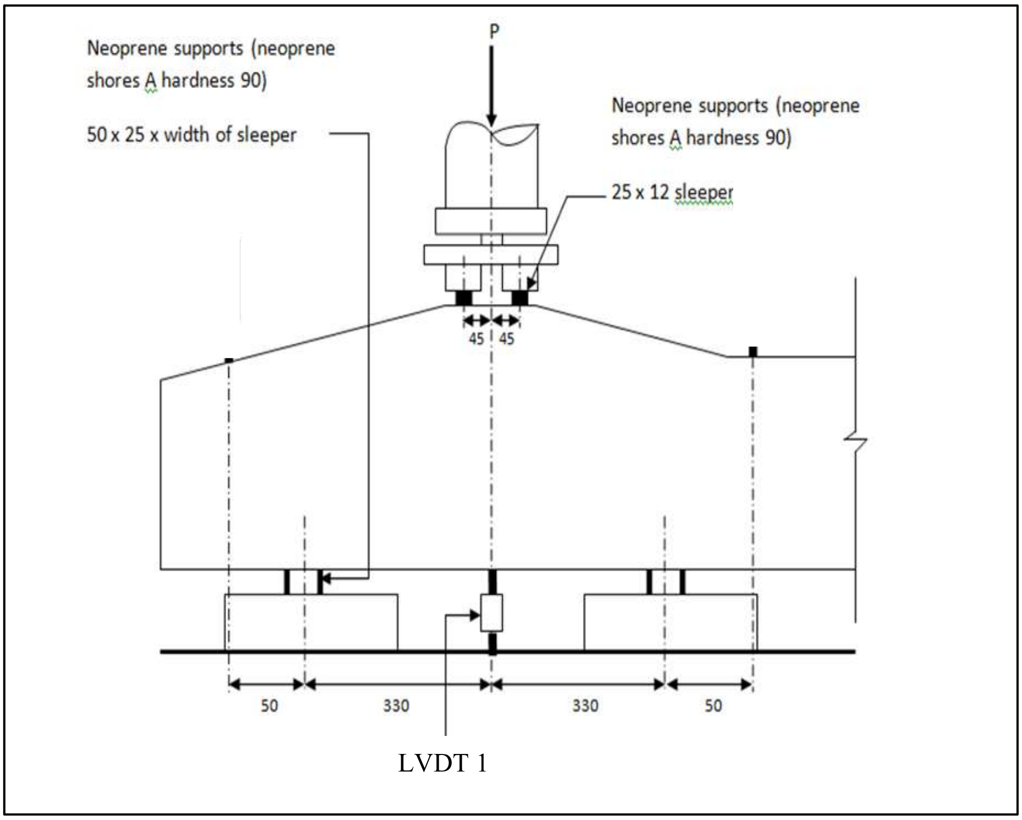

Fig. 7. Location of the Support and its Loading with Accurate Dimensions (Fatigue)

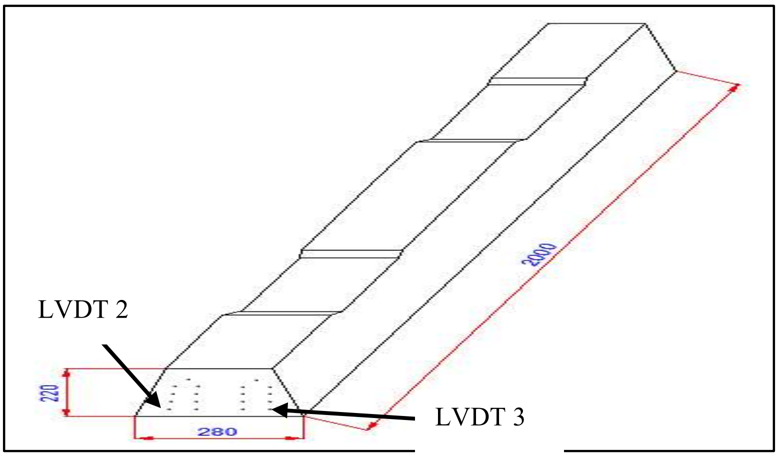

Fig. 8. Isometric Sketch of Prestressed Monoblock Concrete Sleeper with LVDT 2 & 3 Location (Fatigue)

For clear illustration, Fig. 7 shows the location of the support to put plywood and its loading condition for this test, provided with the dimensions in millimetre. For fatigue load test, there have two supports only and one loading subjected on the rail seat one side at the time. So, the other end will be in free hanging condition. Figure 8 shows the side of the PMCS with its tendons (16 totals) and the location to assign the LVDT and its callsign number. 3 LVDT was used, one at the bottom, directly under the applied load, assigned as LVDT number 1 to check the deflection of the concrete sleeper and 2 LVDT at the side and on the last tendon of the concrete sleeper, assigned as LVDT number 2 and 3 to check the deflection of the tendon as shown in Fig. 8. Figure 10 shows the isometric sketch of the locations of LVDT 2 & 3 at PMCS for fatigue test. Meanwhile, Fig. 9., shows the plywood positioned below the plate directly under the hammer before dynamic cycling testing.

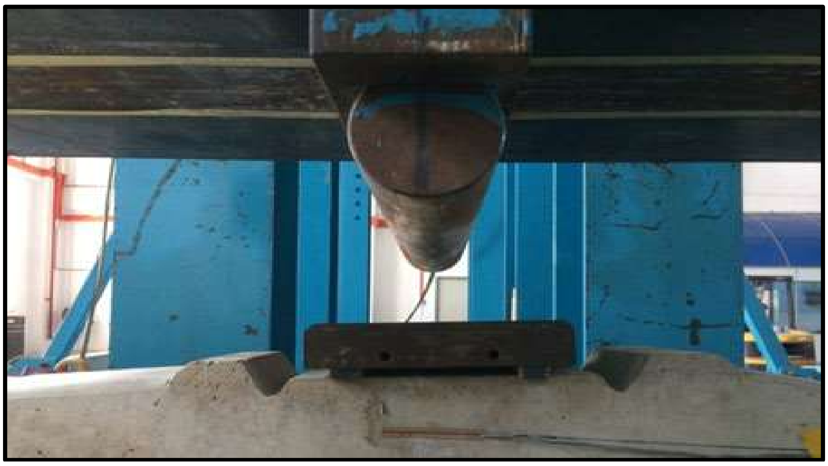

Fig. 9. Plywood Supports Positioned in Laboratory Testing

4. Results and Discussion

From the studies, the value of deflection from site investigation and experimental were gathered and compared to show its relationships. Figure 10 shows the highest deflection on KTMB rail seat section in form of graph. As we can see in the graph, dynamic cycling of freight train occurs between the maximum load of 87kN and minimum load of 41kN as mentioned in Table 2. Figure 11 shows the highest deflection on EPMI rail seat section, also in graph format. Table 3 shows the tabulated reading of deflection on KTMB and EPMI rail seat section in experimental test.

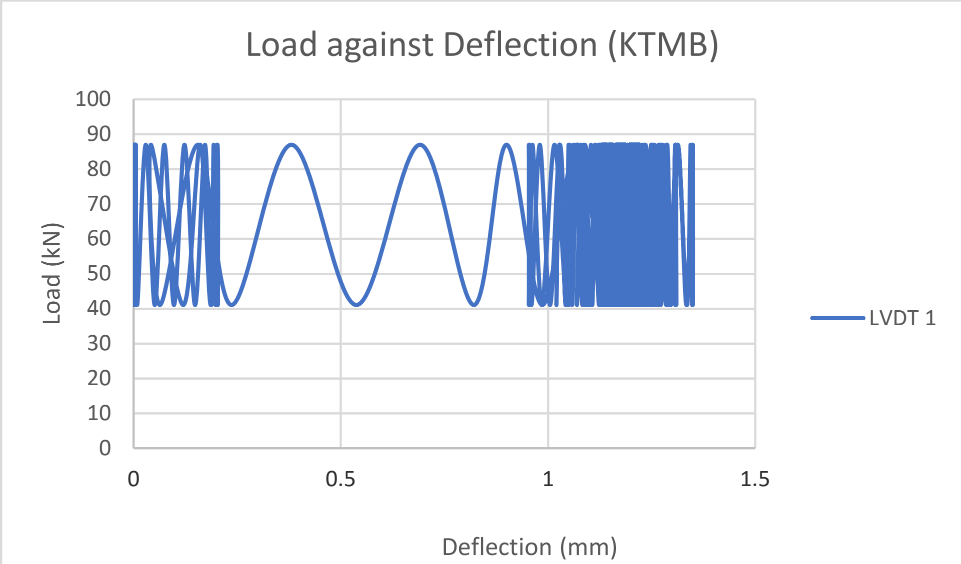

Fig. 10. Highest Deflection on KTMB Rail Seat Section (Experiment)

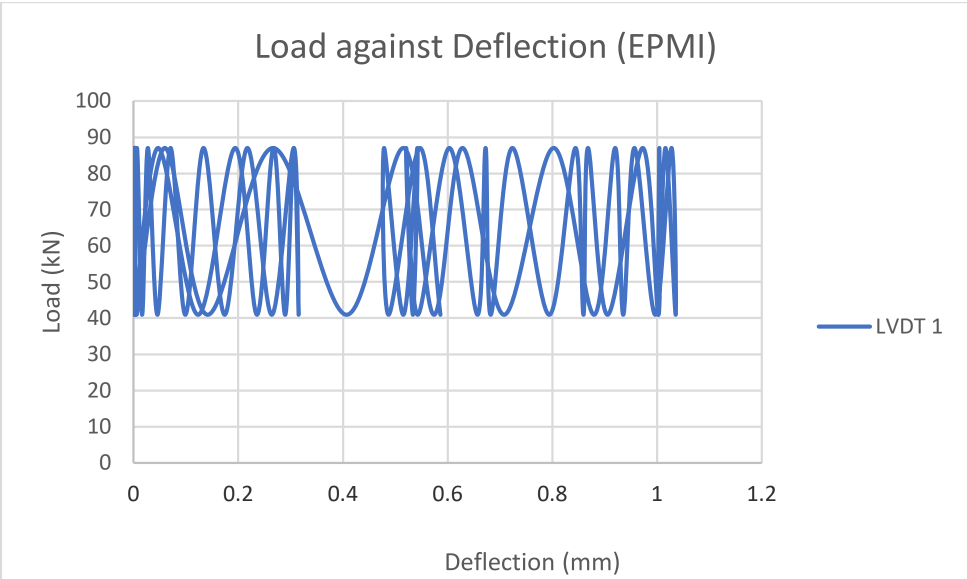

Fig. 11. Highest Deflection on EPMI Rail Seat Section (Experiment)

Table 3. Tabulated Data of Highest Deflection for Each Load Cases

Load (kN)		LVDT 1 (EPMI) (mm)	LVDT 1 (KTMB) (mm)
Maximum	Minimum		
87	41	1.04	1.35
61	26	0.89	0.91
81	43	0.84	0.8
70	30	0.82	0.9

Figure 12 shows the graph of load against deflection produced from site investigation at KM20.75. The train consists of 15 coaches and travelling at speed of 60km/h. The highest acceleration recorded was 229.62m/s^2 and the highest deflection was 5.993 mm. Figure 13 depicts load – deflection graph from railway site at KM26.25. This train travelling at speed of 70km/h. The highest acceleration recorded was 70.13 m/s^2 and the highest deflection was 7.06 mm. Finally, Table 4 shows the comparison of acceleration and deflection of PMCS for freight train at KM26.25 and KM20.75.

Table 4. Comparison of Accelaration and Deflection of PCS for Freight Train at KM26.25 and KM20.75

Type of Train	Speed (km/h)	Highest Acceleration (m/s^2)	Highest Deflection (mm)
Freight (KM26.25)	70	70.13	7.06
Freight (KM20.75)	60	229.62	5.993

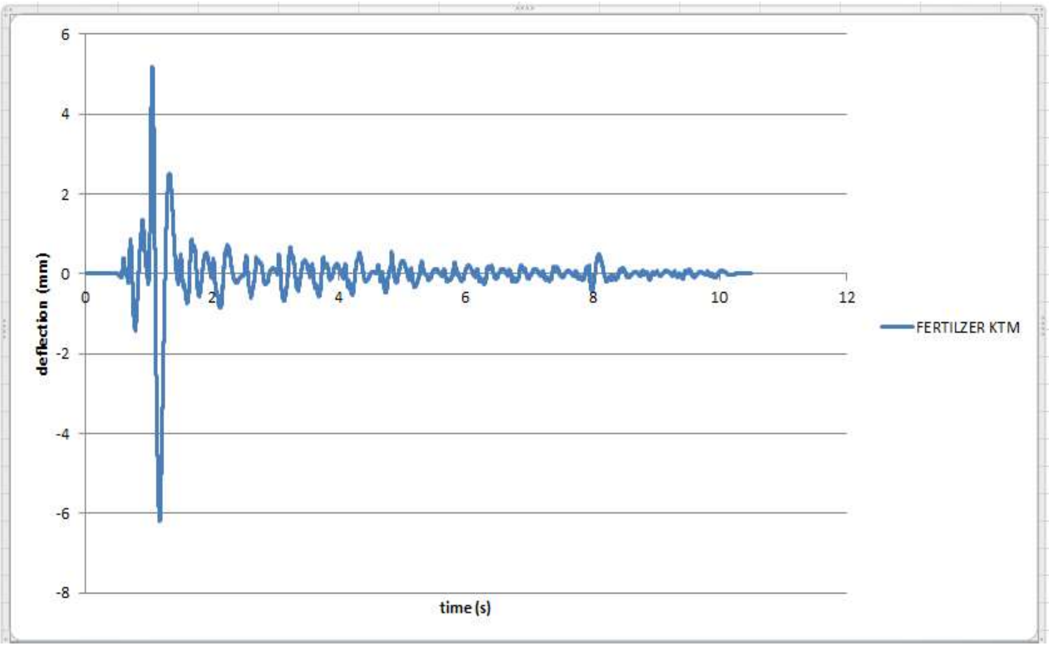

Fig. 12. Graph Of Time Vs Deflection Of Freight Train Calculated By Using Dewe Software (KM20.75)

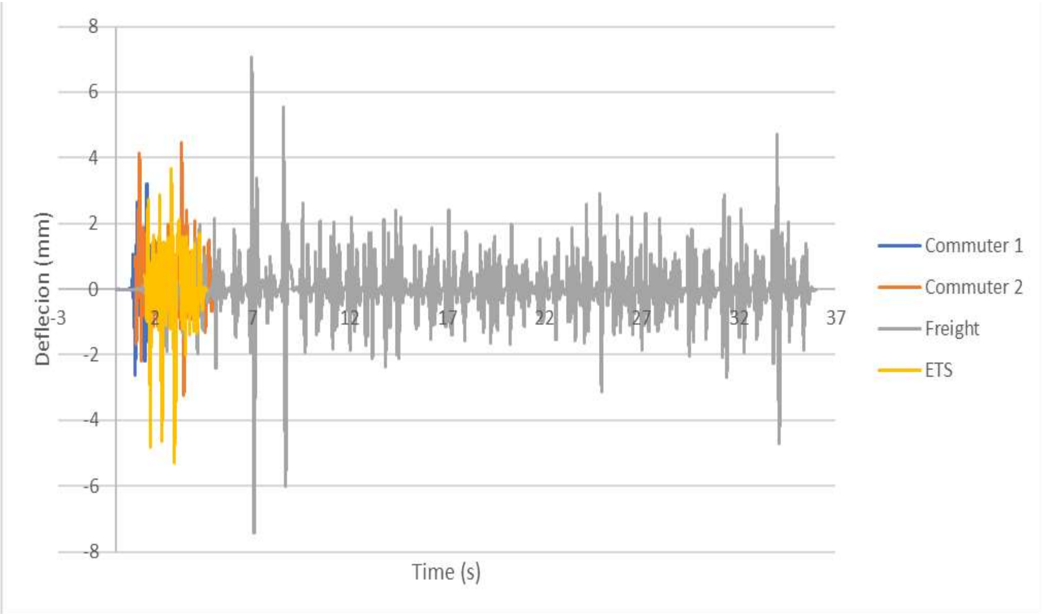

Fig. 13. Graph Of Time Vs Acceleration Data From Freight Train Calculated By Using Dewe Software (KM26.25)

5. Conclusions

Findings from the research, the relationship and correlation between the deflection of concrete sleepers under the rail track contributes in knowing further the behaviour of concrete sleepers and becomes a benchmark for the performance of concrete sleepers in delivering the services. As shown in the results, the deflection for freight train at KM26.25 is higher than at KM20.75. This happens due to differences between the material that freight train carried during the test and the acceleration produced between both trains. At KM26.25, the freight train carried the domestic luggage which was heavier than fertilizer carriage. Furthermore, the acceleration produced by freight train on KM26.25 are higher than KM20.75. Acceleration rate and weight of the train carried also influence the deflection occurred on the PMCS. Last but not least, the maximum deflection on KTMB rail seat section turned out to be 1.35 mm and 1.04 mm for EPMI rail seat section. This research can be more details in future due to a lot of weather condition can be concern during investigation. In order to improve the reliable of the acceleration data, the investigation can be carried out in various season in a year. The consideration can be including rainy season and dry season due to changes of density in concrete sleepers. Also, reaction frame in the laboratory should be maintained regularly so that calibration of the equipment is always in accurate conditions.

Acknowledgments

The authors would like to express their sincere gratitude to the main sponsor for this research, the Ministry of Education Malaysia (MOE) for the funding under the FRGS scheme (600 IRMI/FRGS 5/3 (089/2017)). A special appreciation also goes to the Research Management Centre (RMC), Faculty of Civil Engineering, UiTM Cawangan Pulau Pinang and Shah Alam, and Keretapi Tanah Melayu Berhad (KTMB) for providing facilities and guidance that helped this research to be completed.

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Performance on The Use of Tiles Waste and Rice Husk Ash in Stabilization of Subgrade Layer in Variation of Moisture Content

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Abstract

The unstable type of soil is very difficult to design and build any road that cater for a heavy traffic load. If the problematic soil is not properly stabilized, the road structure will tend to fail. In the process of designing the highway, the importance of having natural soil as subgrade layer is crucial to ensure the quality of road itself. Thus, the underlying soil or subgrade becomes ineffective in these cases and can lead to settlement, as the design road has a potential for failure. These soil conditions make soil stabilization crucial, reducing bearing capacity failures and differential settlement before any construction takes place. Waste generation is increasing year by year due to the large amount of waste produced in Malaysia. That included tile waste (TW) and rice husk ash (RHA). The disposal of TW and RHA is currently a major problem in Malaysia in which it can be effectively used for soil stabilization. One of the attempt in this study is to make use of TW as an additive and RHA as an activator to stabilize clayey soil whereby this type of soil will have low bearing capacity which it is generally swell when in contact with moisture and shrink when the moisture squeezes out. The effect of moisture content in soil is play an important role to identify strength. So, some variation amount of moisture content need to be study to identify the optimum moisture content that can be apply to achieve the maximum strength in soil sample. This paper is study the performance on the use of tiles waste and rice husk ash in stabilization of subgrade layer in variation of moisture content. It was found that soil was stabilized with five proportions of TW (15%, 20%, 25%, 30% and 35%) and constant RHA of 10% was used as an activator agent. The amount of water adding in soil is at Optimum Moisture Content (OMC), 5% more from the OMC to represent rainy season condition and 5% of water was reduced from the OMC to represent dry season condition. The specimens were then cured for 0, 7 and 14 days before being subjected to the unconfined compression test (UCT). Soil strength with adding 30% TW added with 10% RHA gives higher value strength which is 317.9kN/m2 at 14% moisture content (OMC-5%). This sample was cured for 7 days. This improvement is due to the interaction of soft soil and moisture content with tile waste and rice husk ash as an activator agent. It is proven that the lower the moisture content the higher the unconfined compression strength of soil. For these reasons, it can be concluded that for best stabilization effect, the proportion of soil: rice husk ash: tile waste was found to be 60:10:30 with OMC-5% moisture content.

Keywords: Soil stabilization, Unconfined compression test, Moisture content, Subgrade layer

1. Introduction

Soft soil is a general term that represents a variety of earthen material with different contents and characteristics. In particular, clay subgrades can provide insufficient support, especially if saturated. Subgrade soils are an essential component of the pavement structure and poor subgrade performance causes many premature pavement failures. Soil stabilisation is physical and mechanical modification or adjustment of the main soil properties. It is a method that has been used since prehistoric times to provide a solid foundation that is powerful enough to accommodate the loads imposed by buildings, highways and bridges (Hejazi et al., 2012). Thus, soil stabilisation is an effective method of improving the properties of soft soil with poor engineering performance.

According to Upadhyay and Kaur, (2016) clayey soils do not have enough strength to support the structure loads that come on them during the structure's construction or service life. Clay has a big surface area relative to its particle diameter, while silt is susceptible to modifications in moisture content. Peat and organic soils are extremely rich in water (up to 2,000%) and (up to 75%) of organic content (Makusa, 2012). Kazemian et al., (2011) it indicated that peat soil is difficult for the building construction due to its moisture content and organic content, very low strength and high compressibility. Soil stabilization is an efficient technique of enhancing soft soil characteristics with poor engineering results.

Ceramic powdered tiles waste are widely used as an environmental additive in soft soils to increase their index and mechanical properties. The tile waste consists mainly of calcium oxide (CaO) and Silica. Because of its chemical and physical properties, it is a very reactive pozzolanic material. By using tile waste, it will help in term of reducing waste materials on earth other than it is a cost effective situation (Sumayya et al., 2016). Rice husk ash (RHA) become one of the waste challenges in disposal due to its properties-improper disposal will be affect to eco-system (Azizan, et al, 2020). Rice Husk Ash is obtained from rice husk burning, which is a by-product of the rice milling industry. Ash was categorized under pozzolanic with approximately 67-70% silica and approximately 4.9% of alumina and 0.95% of iron oxides respectively (Jha and Kaur, 2016).

The effect of moisture content in soil is play an important role to identify strength. If the moisture content is less or more, the bonding of the soil cannot sustain by itself and will later fail. So, some variation amount of moisture content need to be study to identify the optimum moisture content that can be apply to achieve the maximum strength in soil sample. This paper is study the performance on the use of tiles waste and rice husk ash in stabilization of subgrade layer in variation of moisture content.

2. Methodology

The main material used in this study is tile waste, rice husk ash, and the soft soil shown in Figs. 1 and 2 was brought from marine area located at Batu Kawan. The tile waste was crashed into powder to enable material preparation for the soil sample. Rice husk ash was taken from the rice factory in Kuala Kedah, Kedah.

Fig. 1. The Soft Soil Brought from Marine Area Located at Batu Kawan

Fig. 2. Tile Collected from UiTM Pulau Pinang and Rice Husk Ash from Factory in Kuala Kedah

Several tests were carried out as per BS1377 (1990) to determine the physical properties of soil, including Particle Size Distribution, Hydrometer, Atterberg Limit Test and Particle Density Test. Liquid limit was obtained using Cone Penetration apparatus. Plastic limit was determined by rolling the soil between the palms of the hand. The soil sample was compacted using Standard Proctor Compaction Test. About 3 kg of soil was compacted in a mould of 105 mm diameter using a rammer of 2.5 kg in 3 layers with 27 number of blow each layer. These tests were conducted to find the maximum dry density (MDD) and optimum moisture content (OMC) needed in the soil. Then, 5% of water from the OMC was added to the sample to represent rainy season condition and 5% of water was reduced from the OMC to represent dry season condition. These 3 conditions were applied to prepare the specimen for unconfined compression test (UCT) (Fig. 3).

Fig. 3: Preparation of UCT Specimen

Specimen was prepared by replacing the soft soil with tile waste passing 4.25mm. To find the optimum percentage of tile waste for stabilization of soft soil, tile waste was varied from 15% to 35% at increment of 5% with a constant 10% of rice husk ash as an activator agent as shown show in Table 1. Soil sample was compacted in a mould with 38 mm diameter and 76 mm height. All specimen is then cured for 0, 7 and 14 days of curing period. Specimen were tested for unconfined compression test (UCT) at a strain rate of 1.25mm/min in triaxial machine show in Fig. 4.

Table 1. Preparation Specimen Mixture for UCT

Soil (%)	RHA (%)	TW (%)
100	0	0
75	10	15
70	10	20
65	10	25
60	10	30
55	10	35

Fig. 4. Unconfined Compression Test Machine

3. Results and Discussions

The results of the laboratory work are divided into two parts which are physical properties results and engineering properties results.

3.1. Physical Properties

In physical properties, the tests that were conducted are particle size distribution, hydrometer, particle density, atterberg limit test and standard proctor test. Physical properties of soft soil results are shown in Table 2.

Table 2. Physical Properties of Soft Soil

Properties	Value
Specific Gravity, Gs	2.24
Liquid Limit, %	51.1
Plastic Limit, %	35.4
Plasticity Index, %	15.7
Maximum Dry Density, Mg/m^3	1.695
Optimum Moisture Content, %	19.07
Classification : SILT of High Plasticity, MH	

3.2. Engineering Properties

Meanwhile for the engineering properties, the main laboratory test that was conducted is Unconfined Compression Test. The result on the strength of soil with 10% of RHA (activator agent), various percentage of tile waste and optimum moisture content were then analysed.

3.2.1. Unconfined Compressive Strength Result at OMC with Various Percentage of Tile Waste and Different Curing Period

From Table 3, UCS value at OMC with various percentage of tile waste and different curing period has been categorized. On the other hand, the graph expressed in Fig. 5 display the comparison for different period of curing day which are 0,7 and 14 days of curing. As demonstrated from the figure, the soil reaches their maximum strength at 30% of tile waste for each curing period. Conclusion can be made that the reaction between soil and additive composition bonded well at this percentage of additive as it reaches their optimum. Any further increment of the additive will result in reducing the strength of the soil. Besides, the soil shows the highest strength at 30% of tiles waste at days 14 curing period which is 250.6kN/m². Therefore, a longer curing will give period a higher of the soil.

Table 3. UCS Value with Varying Percentage of Tile Waste with Different Curing Period

TW (%)	UCS Value (kN/m^2)		
	Curing Period (Days)		
	0	7	14
15	145.6	167.4	192.8
20	151.2	205.7	218.6
25	160.0	215.4	247.9
30	**165.5**	**217.3**	**250.6**
35	140.4	157.8	163.7

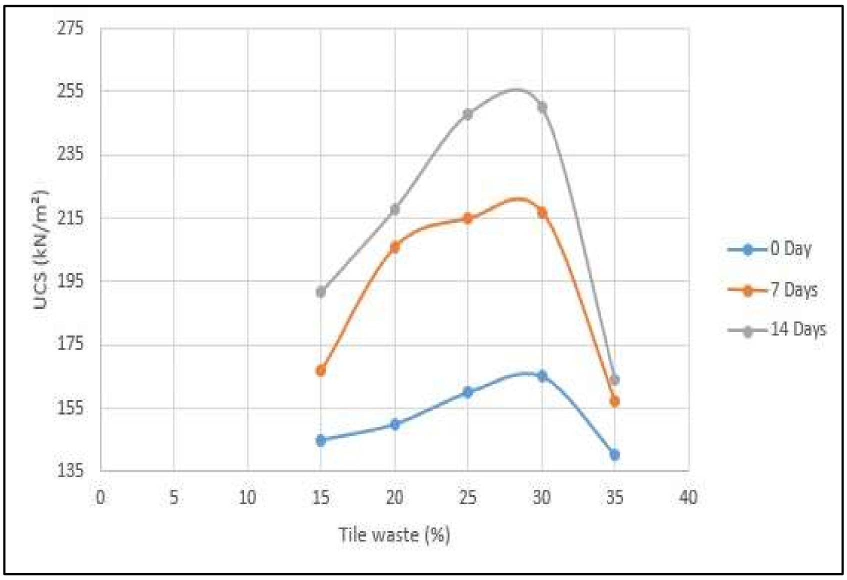

Fig. 5. The Curve Line of 0, 7 and 14 Curing Day with Different Percentage of Tile Waste

3.2.2. Relationship between Different Percentage of Tile Waste with Different Moisture Content

For this section, referring to Arshad and Abd. Rahman (2008), specimen were prepared at 3 (three) different level of moisture content consist of optimum moisture content (OMC), -5%OMC and +5%OMC. The -5%OMC stimulate the dry condition while the +5%OMC stimulate the wet condition. The UCS value with different moisture content for 0 curing period was displayed in Table 4. The effect of unconfined compressive strength at different level of moisture content with different percentage of tile waste for 0 curing period was illustrated in Figure 2. From the graph, it shows that -5%OMC gives the highest value of unconfined compressive strength at 30% of tile waste addition which is 266.0kN/m². This is due to the lower moisture content which produce stiffer specimen. However, it started to reduce to 73.6kN/m² as further increment of tile waste percentage. As we can see, the optimum moisture content shows highest strength for 30% tile waste which is 165.5kN/m² compared to ±5%OMC for 0 curing age. On the contrary, +5%OMC shows the lowest strength for all different percentage of tile waste for 0 curing period. This marked that higher moisture content reduced the strength of the soil.

Table. 4. UCS Value with Different Moisture Content for 0 Curing Period

TW (%)	UCS Value (kN/m^2)		
	Moisture Content (%)		
	-5%OMC	OMC	+5%OMC
15	133.9	145.6	64.7
20	169.7	151.3	70.6
25	208.0	160.0	81.0
30	**266.0**	**165.5**	**138.4**
35	73.6	140.4	60.9

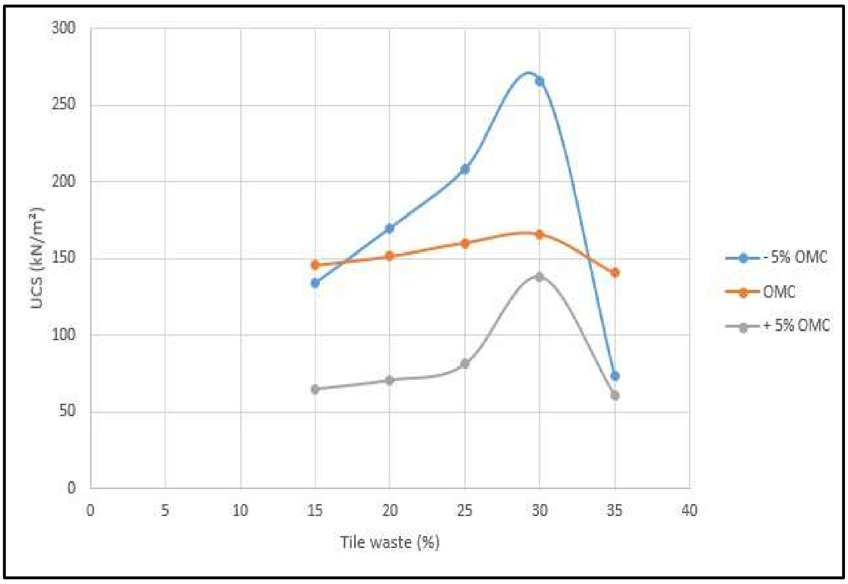

Fig. 6. Effect on UCS Value at Different Level of Moisture Content with Different Percentage of Tile Waste for 0 Curing Period

Table 5 presented the UCS value with different moisture content for 7 curing period. Based on the Figure 3, the graph demonstrated the effect of unconfined compressive strength at different level of moisture content with different percentage of tile waste for 7 curing period. The value of -5%OMC indicates the higher unconfined compressive strength which is at 317.9kN/m² with addition of 30% of tile waste. It shows that lower moisture content which produced stiffer specimen that makes the soil and additive composition generate a strong bonding along the period. Furthermore, for +5%OMC it indicates lower unconfined compressive strength compare to OMC and -5%OMC for 7 curing period. It can be seen from the graph, for each level of moisture content, the strength increases as the additional of tile waste increase until it reaches the maximum at 30% of tile waste adding. It can be concluded that with any further increment over 30% of tile waste will reduce the strength of the soil.

Table 5. UCS Value with Different Moisture Content for 7 Curing Period

TW (%)	UCS Value (kN/m^2)		
	Moisture Content (%)		
	-5%OMC	OMC	+5%OMC
15	201.8	167.4	107.8
20	213.5	205.7	126.4
25	259.9	215.4	137.6
30	**317.9**	**217.3**	**221.1**
35	148.8	157.8	107.8

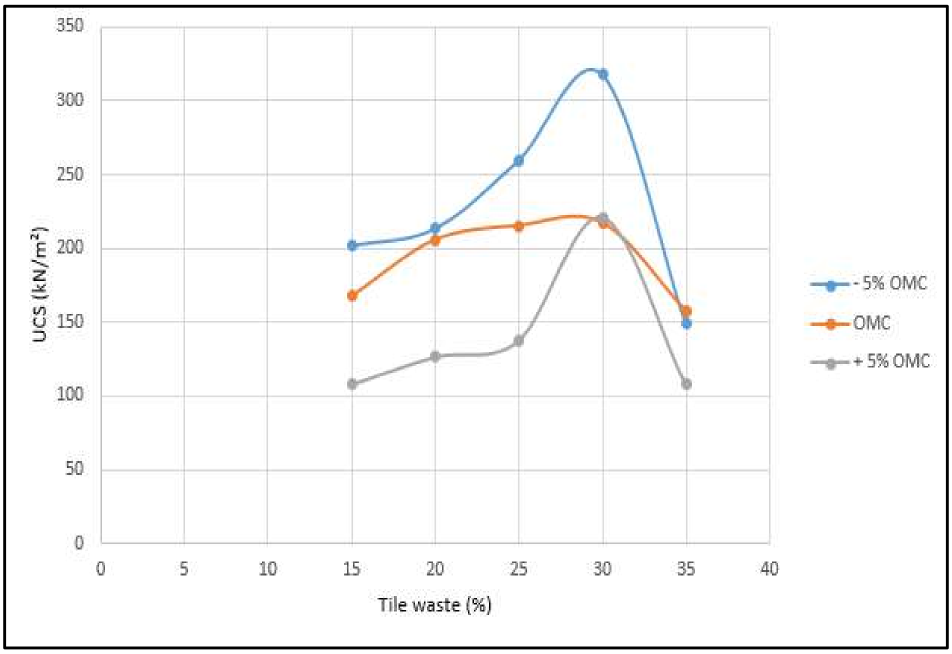

Fig. 7. Effect on UCS Value at Different Level of Moisture Content with Different Percentage of Tile Waste for 7 Curing Period

The UCS value with different moisture content for 14 curing period was tabulated in Table 6. The effect of unconfined compressive strength at different level of moisture content with different percentage of tile waste for 14 curing period was illustrated in Figure 4. For the OMC value as illustrated in the graph, the unconfined compressive strength at 15% of tile waste is 192.8kN/m² and keep on increasing along the increment of tile waste's percentage until it reaches optimum at 30% of tile waste which gives the strength of soil at 250.6kN/m². The strength of soil started to reduce as the additional of tile waste increase which then indicate the strength of soil at 163.7kN/m². For -5%OMC, the highest strength of the soil is 232.8kN/m² at 30% of tile waste and then reduce as the amount of tile waste increase. As for the +5%OMC, the strength of soil for 15% of tile waste is 117.5kN/m² and it increase rapidly until 211.1kN/m² at 30% addition of tile waste. Then it dropped about 110.0kN/m² as the added amount of tile waste percentage increase.

Table 6. UCS Value with Different Moisture Content for 14 Curing Period

	UCS Value (kN/m^2)		
	Moisture Content (%)		
	-5%OMC	OMC	+5%OMC
15	145.1	192.8	117.5
20	197.2	218.6	132.4
25	205.7	247.9	189.5
30	**232.8**	**250.6**	**211.1**
35	232.0	163.7	110.0

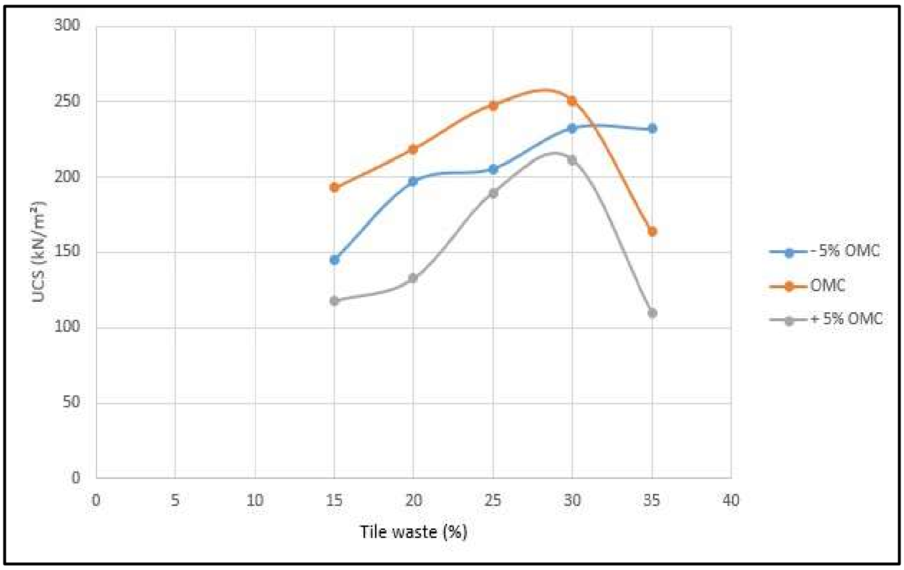

Fig. 8. Effect on UCS Value at Different Level of Moisture Content with Different Percentage of Tile Waste for 14 Curing Period

4. Conclusion and Recommendation

In order to verify the variation of moisture content, OMC-5% which is 14% indicate a dry moisture condition and OMC+5% which is 24% indicate a wet moisture condition due to real site condition for application either drought or raining monsoon.

Due to chemical bonding between the additive and the soil, soil strength with adding 30% TW added with 10% RHA gives higher value strength which is 317.9kN/m2 at 14% moisture content (OMC-5%). This sample was cured for 7 days. This improvement is due to the interaction of soft soil and moisture content with tile waste and rice husk ash as an activator agent. It is proven that the lower the moisture content the higher the unconfined compression strength of soil. For these reasons, it can be concluded that for best stabilization effect, the proportion of soil: rice husk ash: tile waste was found to be 60:10:30 with OMC-5% moisture content.

Recommendation of improvement on continuing this studies, the used of different sizes of tile waste to get data variations where that can be compare and analyse effectively.

5. Acknowledgment

I would like to take this opportunity to express my gratitude thanks to Mr. Muhamad Azrul Aswad and Mrs. Suzana for their help in laboratory exercise. A highly sincere and mostly appreciation to Universiti Teknologi MARA Cawangan Pulau Pinang for providing the space, machinery and positive encouragement to finish this project.

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The Performance of Waste Plastic Drinking Straws-Modified Bitumen

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Abstract

Plastics had become a significant problem in solid waste management due to their inability to degrade when they disposed of at the landfill site. Therefore, plastics must be recycled and reused to reduce plastic waste accumulation in the landfill and haphazard waste in cities, municipalities, and the countryside. Secondly, increment in the number of vehicles unusually heavy vehicles and also variation in daily or seasonal temperature has put us in a demanding situation to think of some alternatives to improve the pavement characteristics and quality by applying some necessary modification. In this study, a variety of 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9% and 10 % waste plastic drinking straws used as a modifier in 60/70 PEN Grade of bitumen and their ability to enhance the bitumen physical properties assessed. Study finding shows that penetration and ductility value decreases while softening point increases by the addition of waste plastic straws. The enhancement of modified bitumen was observed compared to conventional (60/70 PEN Grade), which is the key objective of this study. In conclusion, the addition of 2% plastic straws by weight of bitumen leads to a lessen chance of deformation and enhances the temperature susceptibility characteristics of the conventional paving bitumen.

Keywords: Bitumen properties, Ductility test, Penetration test, Polypropylene, Softening Point Test

1. Introduction

Modification of bitumen asphalt has also considered enhancing the quality and serviceability of roads. Polymer modified bitumen is emerging as one of the essential construction materials for flexible pavements. Asphalt alone tends to be temperature susceptibility in which they become fluid at high pavement temperatures, causing rutting and bleeding, and they are brittle at low temperatures, causing cracking. Therefore, the polymer is adding to exhibit higher resistance to rutting and thermal cracking. Besides, it decreased fatigue damage, stripping, and improved temperature susceptibility (Moreno et al., 2018). The use of polymers as additives in bitumen modification has shown to significantly enhance the performance of conventional bitumen, thus improve the performance of road pavement. Asphalt polymer modifiers may be dividing into four major types. These are natural rubber, synthetic latex, block copolymers, and plastics like low-density polyethylene (LDPE), high-density polyethylene (HDPE), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET) and others (Giriftinoglu, 2007).

Further, these polymers can have divided into two classes: plastomers and elastomers (Awwad & Shbeeb, 2007). Plastomers include plastics where incorporation of plastomer-type polymers may require high shear mixing, depends on the modification process. They increase the viscosity and stiffness of bitumen, but they do not increase the elasticity of bitumen significantly. Elastomers include natural rubber, synthetic latex, and block copolymers. As the name implies, elastomers are elastomeric, which describes the ability of a material to return to its original shape when a load removed. In contrast with plastomers, these polymers increase ductility value and elasticity of the bitumen when being used as a modifier.

Athira & Sowmya, (2015) stipulates a standard method to improve the quality of bitumen. In their article, mention that modifying the physical and engineering properties of bitumen by blending with organic synthetic polymers like rubbers and plastics exhibit an improvement in the performance of the modified asphalt mixes. It has proven possible to improve the performance of bituminous mixes used in the surfacing course of road pavements, with the help of various types of additives or modifiers to bitumen such as polymers, rubber latex, and crumb rubber (Kwabena et al., 2017). In the meantime, plastic is everywhere, from single-use cutlery, straws, and water bottles to components in our electronics, cars, and other everyday products. Due to its numerous applications in various sectors such as packaging, protecting, agriculture, construction, and even disposing of all kinds of consumer goods (Yadav, 2016), plastic constitutes a significant part of municipal solid waste (MSW), which inundated our cities and towns.

Management of plastics found in municipal solid waste (MSW) is a very critical sector because of its non-biodegradability and direct harmful effect on flora, fauna, and environment. Currently, the standard waste disposal methods employed are landfilling, incineration, and haphazard littering in the cities, municipalities, and the countryside. The study conducted by Moghaddam et al. (2013), stated the increase in number and frequency of passing vehicles, especially heavy vehicles such as trucks and vans, which have higher gross weight than passenger cars, has decreased the service life of road pavement. Furthermore, another study (Awwad & Shbeeb, 2007) also stated that the increase in traffic loading repetitions caused an accelerated deterioration of the road network.

The goal of this study is to investigate the suitability of waste plastic drinking straws to had used as a modifier in bitumen binder for flexible pavement. This aim can have achieved by mixing different percentages of waste plastic drinking straws by the weight of the bitumen to modify the conventional bitumen. There are two primary aims of this study: 1. To determine the physical properties of modified bitumen with different percentages 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, and 10 % waste plastic drinking straws by weight of bitumen from a penetration test, softening point test and ductility test. 2. To evaluate the optimum percentage of waste plastic drinking straws.

2. Methodology

Basic experimental approaches and detailed tests were used in this research to investigate the effect of different percentages of waste plastic drinking straws as modified bitumen on 60/70 PEN grade bitumen performance to enhance excellent asphalt binder properties.

2.1. Material preparation

In this study, Bitumen 60/70 is recommended by Jabatan Kerja Raya (JKR) Malaysia for the construction of flexible pavement. Bitumen 60/70 has stored at room temperature in air sealed condition. The bitumen properties for 60/70 PEN Grade bitumen, as shown in Table 1.

Polypropylene (PP) plastic-type polymer had utilised, and waste drinking straws were chosen based on a significant amount of waste drinking straws generated day by day. Waste plastic drinking straws used through the research had obtained from cafeterias on the campus. The drinking straws were firstly washed thoroughly and rinsed with distilled water before they were let to dry, then cut into a reduced size of a maximum of 4 cm, as shown in Fig. 1.

Fig. 1. Plastic Drinking Straws Waste Cut to 4 cm of Maximum Length

Table 1. Bitumen Properties based on JKR Standard

Properties	ASTM Equivalent	60/70		60/80	
		Min	Max	Min	Max
Penetration at 25 ºC (1/100 cm)	D5	60	70	60	80
Softening point (ºC)	D36	49	56	48	56
Ductility at 25 ºC (cm)	D113	100	-	100	-

2.2. Sample preparation

The mixing procedure has determined by literature review and trial and error method to ensure uniform mixture based on visual inspection. First, the bitumen was prepared in the laboratory by heating until the fluid condition in small empty containers. Then, waste plastic drinking straws with reduced size of maximum 4 cm had added according to the percentage of 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9% and 10% by weight of the bitumen contained in the small containers and left heated up to 170°C in the oven. After 24 hours, the modified bitumen was mixed manually for about 2 minutes to ensure homogenous mixtures. Immediately after mixing, the mixture had prepared according to each test specimen before tested. Figure 2 illustrates the diagram of the utilization of plastic drinking straws in bitumen.

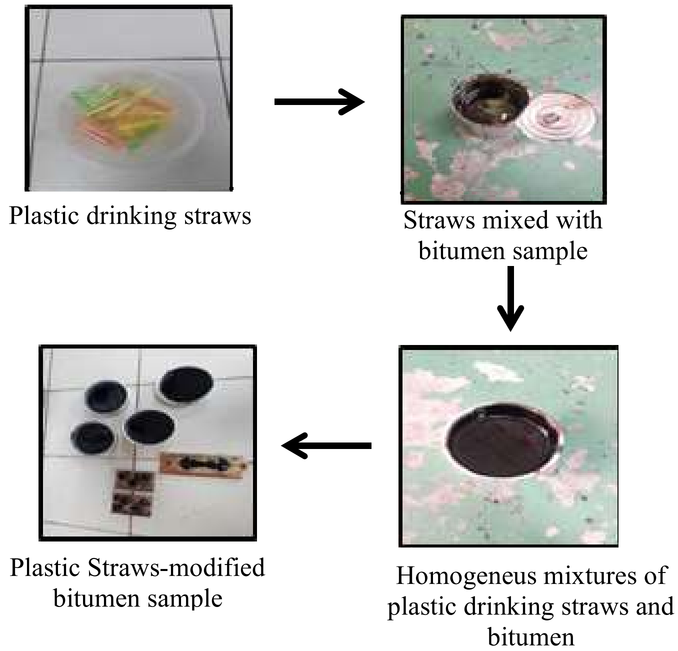

Fig. 2. Process of Utilisation for Modified Bitumen

2.3. Laboratory work

Standard physical tests such as penetration test (temperature, load, and time are 25ºC, 100g, and 5sec respectively), softening point test, and ductility test (at temperature 25 ºC) have determined in compliance with the American Society of Testing and Materials (ASTM).

2.3.1. Penetration Test (ASTM, 2006)

In preparing the test specimens, the bitumen had heated until it became fluid to pour in a container. The samples have left for approximately 1 to 1.5 hours at room temperature, and then the samples were put in a 25 ° C water bath 1 hour before the experiment.

The samples were left in room temperature for approximately 1 to 1,5 hours and then placed in a 25 ° C 1-hour water bath. The samples have placed at room temperature for almost 1 to 1.5 hours, and then the samples were placed in a 25 ° C water bath 1 hour before the experiment.

The samples have left in room temperature for about 1 to 1.5 hours, and then the samples were placed in a water bath with 25°C 1 hour before the test. The penetration test is determined by first mounted the needle on the bitumen by slowly lowering until its tip touched the surface of the bitumen. The pointer has brought to zero, and the needle was allowed to penetrate freely for 5 seconds. The penetration in tenths of a millimetre (decimillimetre, dmm) was measured. At least three determinations at points on the surface of the specimen had made not less than 10 mm from the side of the container and not less than 10 mm apart.

2.3.2. Softening Point Test (ASTM, 1995)

Bitumen sample had been heated, and it had been stirred slowly to remove air bubbles. The rings were heated, and some glycerin was added to the surface on which the samples had be mounted Glycerin helps to extract the samples from the surface. The bitumen had been filled in it, and the test specimens had been cooled for at least 30 minutes.

For softening point, the apparatus was assembled with the specimen rings, ball centering guides, and thermometer in position then the bath had been filled so that the liquid depth was 105±3 mm with the apparatus in place. Ice is used to reach the proper starting temperature, which should be below 5°C, then they had been left for 15 min. Two steel balls were placed in the bottom of the bath so they could reach the same starting temperature as the rest of the assembly. The bath has heated and continuously stirred by using a gas burner/electric heater from below with a rate of 5°C/min. Each temperature the thermometer indicates when the bitumen surrounding the ball touches the bottom plate. Noted that if the difference between the temperatures that each ball reached the bottom exceeded 1°C, the test has to repeat.

2.3.3. Ductility Test (ASTM, 2007)

The bitumen specimen had been heated and poured into the mould mounted on a brass plate, where a glycerin solution is added to all bitumen-exposed briquette mould surfaces. The filled mould is allowed to cool at room temperature for around 30 minutes after the specimen is poured into the mould. Then, place the mould assembly containing a specimen in a water bath maintained at 25°C for 90 minutes. The sides of the mould were removed, and the clips are hooked to the testing machine without causing any initial strain. The two clips were pulled apart at uniform speed as specified (5 cm/min) until the specimen ruptures or reaches the length limitations of the testing machine. The distance in centimetres through which the clips have been pulled to produce fracture or final length is measured.

3. Result and Discussion

3.1. Penetration Test Result

Figure 3 shows the result obtained for penetration value after different percentages of waste plastic drinking straws were added to the bitumen. It was found that the penetration value decreased as the content of waste plastic drinking straws increased. The penetration value gradually decreases from 70 to 31 when the content of waste plastic drinking straws is increased from 1% to 10%. Figure 3 shows that Drinking waste disposable straws include has a good effect in increasing the stiffness of modified bitumen binder and made it less susceptible to deformation by reducing the penetration value.

This result further justifies the following findings by authors Zahra (2010) and Kwabena et al. (2017). Zahra (2010) stated that modified bitumen becomes harder and more consistent with increasing polymer contents, whereby this leads to a reduction in the measured penetration value. That statement also happens supported by Kwabena et al. (2017), which revealed a higher concentration of polymer in the bitumen increases the hardness of the modified bitumen as the viscosity increases.

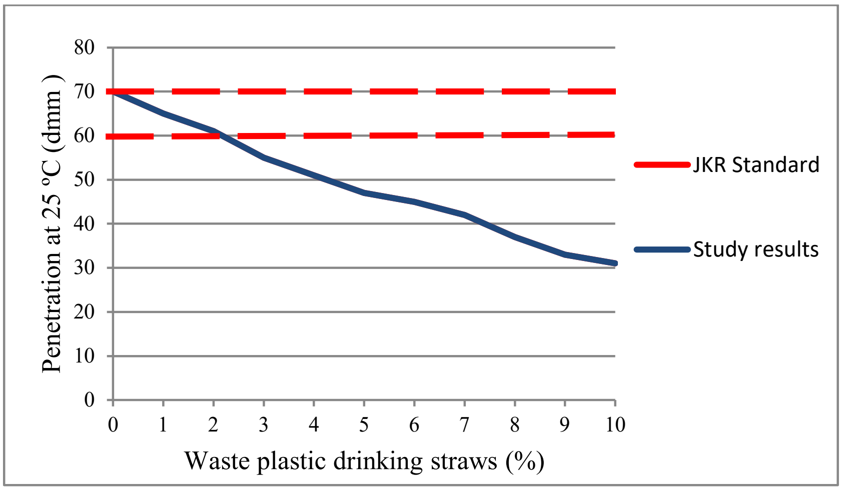

Fig. 3. Graph of Penetration vs Percentage of Plastic Drinking Straw Waste.

3.2. Softening Point Test Result

The result of the study indicates that the softening point is the reverse of penetration value when higher viscosity of the modified bitumen due to an increase in plastic straws content leads to a higher softening point. The results are plotted, as in Fig. 4.

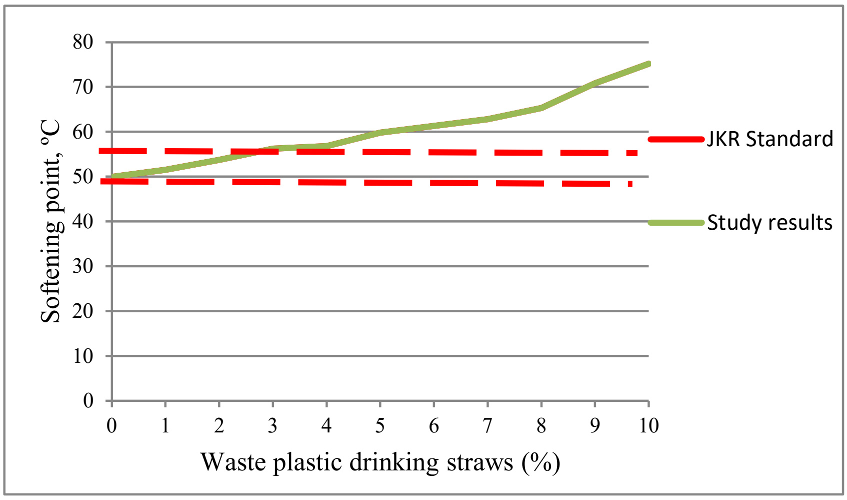

Fig. 4. Graph of Softening Point Value vs Percentage of Plastic Drinking Straw Waste.

It can be observed that the addition of plastic waste is added at the highest percentage of 10% by the weight of bitumen, the softening point is 75.2ºC, which is noticeably higher than unmodified bitumen where the softening point is 50ºC as presented in Table 2. This phenomenon indicates that the resistance of modified bitumen binder to the effect of heat increases. Thus, modified bitumen will exhibit a reduced tendency to soften in hot weather. When the softening point is increasing, there is a reduction of susceptibility at high temperatures. Higher softening points offer better rutting resistance at high temperatures which reflects the findings of Zahra (2010). This most expected that the modified bitumen will resist the flexible pavement against rutting along wheel tracks due to its higher softening point value.

Table 2. Result of Penetration Index (PI)

Waste plastic drinking straws (%)	Penetration at 25 ºC (dmm)	Softening point, ºC	PI
0	70	50	-0.5
1	65	51.5	0
2	61	53.7	0
3	55	56.2	+0.5
4	51	56.8	+0.5
5	47	59.8	+0.6
6	45	61.3	+1
7	42	62.8	+1.5
8	37	65.3	+1.5
9	33	70.8	+2
10	31	75.2	+2.5

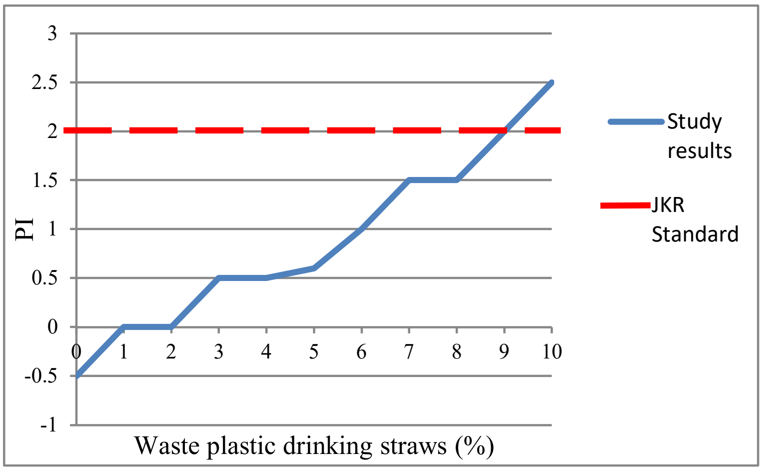

Fig. 5. Graph of Penetration Index vs Percentage of Plastic Drinking Straw Waste.

From Fig. 5, PI values are inconsistent for all of the addition percentages. Based on the results, it shows that adding more waste plastic drinking straws increased PI value. The results obtained are acceptable and within the range between -2 to +2 for conventional paving bitumen except for the highest percentage of waste plastic drinking straws added, which is 10%. Too high waste plastic content may be seen as too much, which results in PI value out of range (beyond redline) and is not suitable to be used for road pavements.

3.3. Ductility Test Result

From Fig. 6, the findings of the study found that the ductility of the modified bitumen tends to decrease at modification of 2% waste plastic drinking straws with 101 cm. Meanwhile unmodified and 1% of modified bitumen having a constant value of ductility of 150 cm. The decreasing trend in ductility value when bitumen is modified with a higher percentage of waste plastic drinking straws indicates that the modified bitumen becomes harder and brittle at higher modification levels. However, as required by JKR Standard, bitumen binder properties must exceed 100 cm elongation to pose better elasticity in the proper plastic region. Hence, 3% onwards of plastic straws content in bitumen seems to be preferable.

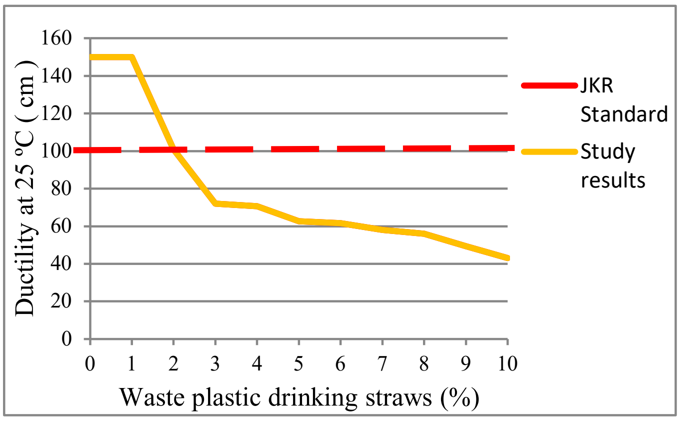

Fig. 6. Graph of Ductility Value vs Percentage of Plastic Drinking Straw Waste.

Past studies (Asyiqin et al., 2013; Karmakar & Roy, 2016; Remadevi et al., 2015) have reported that an increase in stiffness makes the bitumen binder stable and hence improves the resistance against rutting. Besides, regarding its harder and stiffer bitumen, this can be beneficial to the pavement as the bitumen material results in better load spreading capabilities of the structure, thus makes the pavement be able to resist heavy vehicles and warmer climate with fewer chances of rutting.

4. Conclusion

Incremental content of waste plastic drinking straws to modify the bitumen decreases the penetration values and ductility values, which indicate the following viscous properties, followed by an escalating trend in the softening point values. PI values of all such modified bitumen remain within the range of -2 to +2 except for the highest percentage of 10% plastic straws, indicating the improvement in temperature susceptibility characteristics. Therefore, 2% of plastic straws content had suspected of providing the best enhancement of the properties of modified bitumen to sustain satisfactorily in increasingly high traffic loads and adverse weather conditions according to JKR Standard. Waste plastic drinking straws have a noticeable effect on bitumen performance.

Modified bitumen experienced less chance of rutting and cracking at high temperatures and will be able to resist the combined effect of adverse traffic loading and extreme weathering conditions. Waste plastic drinking straws can conveniently have used as a modifier for asphalt mixes for sustainable management of plastic waste as well as for the improved performance of asphalt considering the optimum content to has added found to be 2% by weight of the bitumen.

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Causes That Contribute to the Failure of Construction Project Among Small Contractors in Pulau Pinang

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Abstract

Small contractors have more opportunities to get involved with project in construction industry business. However, it must be noted that not all the construction projects can be completed on time or earlier than scheduled. It is also not unusual for construction projects that will be delayed, failed or quit for various reasons. The objective of this paper is to analyse the causes that contribute to the failure of construction project among small contractors in Pulau Pinang and to assess the causes contributed to the failure by using AHP (Analytic Hierarchy Process) method. A questionnaire survey was developed and distributed among 40 contractors, engineer, project manager and top management for obtaining their feedback and to assess the most critical causes behind failure of construction project in Pulau Pinang. Causes of failure have been identified and evaluated by using AHP by selecting 20 factors and 40 respondents that have background in the construction work. It is concluded that the most crucial causes of construction project failures among small contractors are financial, managerial, external and political. These results can be helpful to the contractor in order to receive work in any construction project. It is beneficial because it could minimize the failure of construction project.

Keywords: Failure construction project, Small contractor, Analytic Hierarchy Process.

1. Introduction

The Malaysian construction industry is an important asset and a major sector that contributes to the national economy. In the last five years 2008-2012, this sector has accounted for an average of more than 3% of the total gross domestic product (BNM 2013). In 2012 the value of construction projects in Malaysia amounted to RM 112.5 billion and has opened many opportunities to help improve the country's economy (CIDB Malaysia 2013).

However, it must be noted that not all the construction projects completed on time or earlier than scheduled. It is also not unusual for construction projects that will be delayed, or in the worst possible scenario although failures of the project and quit for various reasons. The construction business is a large business and it act as main role in the economy but in recent years show in increasing number of construction projects failure. The construction business is a fraction, very sensible to economic cycles, political and have obviously higher rates of business failure. The building features of many contractors generate persistent competitive contracting firm in the market and most of the business failures is high (Enshassi et al., 2006). Many people open the contractor company without any experience in construction industries and only have knowledge supporting by their start-up capital that they owned.

Failures in the construction business failure rate is among the highest in the business sectors. There is various definition of business failure. Business failure is defined as a business that been stopped operations due to bankruptcy; cease operating with losses to the creditors after actions such as seizure or attachment; voluntarily withdraw, leaving unpaid debts; and is involved in court actions such as reception, restructuring or a voluntary arrangement with the creditors. The causes of construction project failure among small contractor can be categorize into four main causes such as managerial, financial, political and external causes.

The objective of this study is to analyse and assess the causes that contribute to the failure of construction project among the small contractor in Pulau Pinang and provides the palliation step that could be initiate to avoid them or reduce their impacts. This study will give benefits to owners, contractors and sub-contractor that involve in the industrial projects.

2. Causes of construction project failure

Several researchers have studied the reasons of construction project failure. Osama (1997) presented a study of the factors that contributed to the failure of the contractor in Saudi Arabia and discovered that the most important factors are; the difficulty in acquire work, poor judgment, lack of experience in the firm line of work, difficulty with cash flow, lack of management experience, and low profit margins. Strischek and McLaughlin (2008) identified three categories of causes of construction project failure among contractors. They are strategic reasons, organizational reasons and uncontrolled reasons. The causes of strategic inclusive not realistic growth, overexpansion, unknown new market, or entering a new kind of construction technologies, obsession, unrealistic promises and bad contract, or poor project election. The causes of the organization include not enough capital or profit, lack of business knowledge, poor financial management, poor sales skills, or insufficient marketing and weak leadership. The causes unregulated including industrial or economic disadvantage, banking and changes of guarantor.

Enshassi et al. (2006) mentioned that the main cause of construction project failure among contractors are: delays in collecting dibs from customer (donor), closing, dependent on the banks and pay higher profits, lack of capital, cash flow management, lack of experience in the line of work, lack of construction regulations, low-margin profit due by competition, award the contract to the lowest price, and the lack of experience in contract. Kivrak & Arslan (2008) conducted a study among 40 construction companies small and medium on the critical factors that led to the failure of the project among small construction companies. The country's economic situation and lack of business experience was found to be the most influential factor for the failure of the company. Arditi et al. (2000) have found issues and the macroeconomic budget as a major cause of the failure of a construction company in the United States. Over 80% of failures are caused by five factors, namely the profit is insufficient (27%), and weakness of the industry (23%), the operating expenditure weight (18%), of insufficient capital (8%) and loans institutions charge (6%).

2.1 Semi- structured interview

A semi-structured interview was selected for this study to obtain the qualitative data required and provide an appropriate balance in data collection and subsequent analysis. Semi-structured interview was one of the technique of data collection method. Improving the data collection method will enhance the accuracy, validity, and reliability of research findings. In this research, the researcher using semi-structured interview to obtain the sub criteria for each category. Interviews are defined as discussions, usually one-on-one between interviewer and an individual to gather information, opinion and perception that needed on specific topic. They can be used to gather information on past or present behaviours or experiences. In semi-structured interviewing, a guide is used with questions and topics that must be covered. The interviewer must have questions to ask that have been standardized and must ask the same questions to every respondent.

2.2 Analytic Hierarchy process (AHP)

AHP is a multiple criteria decision-making tool that has been used in numerous and variation of application related with decision making. Vaidya & Kumar (2006) have been establish an overview of application of Analytic Hierarchy Process (AHP). Out of many variations of AHP, they have been published the application of AHP such as selection, evaluation, benefit and cost analysis, allocation, planning and development, priority and ranking, decision making, forecasting, medicine and related fields where AHP was applied with QFD (Quality Function Development). Lai et al. (2002) used AHP for software selection called Multi-media Authoring System (MAS). They use the group decision making technique, which included six software engineers. Three products of MAS were evaluated. The hierarchy of pair-wise comparison was performed that consisted of four level. The criteria in the level three were evaluated. These criteria are development interface and graphics support. The six software engineers were trained to use AHP, and they were asked to pair-wise by comparing the different criteria. Expert choice software was used in decision making. To arrive at a selection consensus, the geometric mean methodology was preferred.

3. Methodology

3.1 The sample size

The number of sample size is needed to be determine before distributing the questionnaire. The targets of respondent (population) to distribute the questionnaires are come from construction companies who had registered with Construction Industry Development Board (CIDB) and located in Penang. From equation that representative the sample size of population Bower (2018), the sample size in this study is 40.

3.2 Applying Analytic Hierarchy process (AHP)

Based on previous research and information from professional in construction industry, a list of causes that contribute of failure construction project among small contractor was produced. In this study, the main criteria that will be examined and used in AHP method is tabulated in Table 1.

Table 1. Framework of Current Research of Causes That Contribute Failure Construction Project.

No.	Category and Sub-category
1	Managerial causes
	i. Lack of experience in handling contract
	ii. Lack in line of work
	iii. Lack of control system
	iv. Lack of commitment
	v. Fraud

2	Financial causes i. Lack of cashflow ii. Lack of capital iii. Low profit margin iv. High interest rate v. Fluctuation in construction material cost
3	Political causes i. High cost material ii. Monopoly iii. Lack of resources iv. Delay collecting debt v. Border closure
4	External causes i. Bank policy ii. Limitation on importing iii. Poor quality of completed works iv. Poor in planning and scheduling v. Major accidents

4. Results and Discussion

A survey was conducted on a randomly selected firms through personal interviews of senior managers of small contractors' companies. Figure 1 shows the frequency of demographic profile.

No	Item	Demographic	Frequency
1	Position	Contractor	20
		Engineer	10
		Project Manager	6
		Others	4
2	Contractor Class	G1	0
		G2	1
		G3	1
		G4	0
		G5	0
		G6	4
		G7	14
3	Gender	Male	35
		Female	5
4	Experience in Construction industry	1 Year	5
		1-5 Years	20
		More than 5 Years	15
5	Type of project	Housing Project	23
		Infrastructure	6
		Road construction	10
		Others	1

Fig. 1. The Demographic Profile of Analyse Factor Affecting Labour Productivity

The design of the questionnaire was based on five sections. The first section is regarding to introduce the purpose of the study to the respondents. The second section is about the list of the main common causes of failure in construction project among small contractor and the assessment their level of significance. The third section presented the sub-causes of the main failure causes.

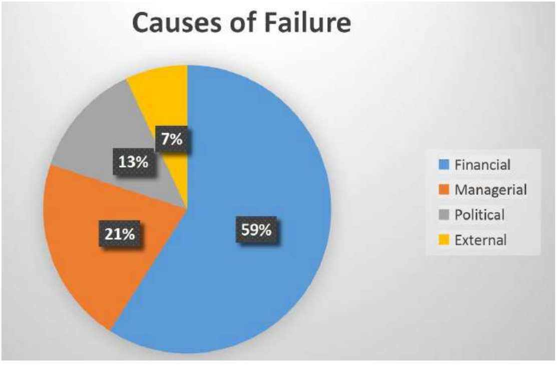

Fig. 2. Pie Chart of Categories of Causes Failure

Figure 2 shows the relative weight of and rank for each causes of failure in descending order. The descriptive results indicate that financial is the top causes which is 59% that contribute to the failure of construction project among small contractors. These are followed by managerial causes, external cause and lastly political causes with 21%, 13% and 7% respectively. Most respondents agreed that financial is the main cause affected the health of construction project. The study that conducted by Assaf et al. (2013) shows that financial is the most important causes and it is common in most of the previous studies conducted in different countries worldwide. The managerial also is one of the crucial causes before starting any project. It involves with many parties to deal in running a project. Political aspect is also one of the factors contributes to the failure of construction project because most of construction projects in Malaysia need to deal with the top management, policies and regulations of any scale of development.

(c) **(d)**

Fig. 3. (a) Sub-Categories for Financial, (b) Sub-Categories for Managerial, (c) Sub-Categories for External and (d) Sub-Categories for Political

Figures 3 (a), (b), (c) and (d) show the rank for each sub causes of financial, managerial, external and political respectively. From Fig. 3(a), the descriptive results indicate that fluctuation in construction material cost is the top causes that contribute to the construction project failure among small contractors. From the interviews, projects under authority supervision, mostly the payment will be processed based on the progress. As an example, if the progress is 60% complete, owners will pay 60% from the full payment to the contractor. The contract work done is usually paid for valuing the quantity of work that they carried out. Problem will occur when owner failed to fulfil the payment on time. The contractor needs money to rolling their capital, if they don't have enough capital the project may face problems or fails. Contractor need to have a systematic cash flow, to avoid from problems affected due to delayed payment. Rate of interest may also affect the financial of the contractor in term of their capital and relate with the profit margin. Cost of materials are depending on the country economics' condition. The fluctuation in construction material cost may change the budget or the cashflow.

From Fig. 3(b), lack of experience in construction work is the top causes that contribute to the construction project failure. As examples to the lack of experience in line of work are lack of commitment, lack of control system and fraud. It is expected that the small contractors should have qualifications in construction in order to run the project. In all industry it is important to have experience in line of working order for the role to be performed to excel. Most of the small contractors are lack in experience in line of work and in contract. It is related when bidding contract. In this context fraud happened when lack in experience. The presence of fraud in a contract is usually grounds for voiding the contract and making it unenforceable. Commitment of the contractors at the early stages is important. If the commitment at this stage is not substantial, the organization will break up at first sign of rough times. The commitment can create a barrier for the contractor with others and without the proper control system it may lead the projects fails.

From Fig. 3(c), the relative weight and rank for each sub causes of external in a descending order. The descriptive results indicate bank policy is the top causes that contribute of failure construction project among small contractors. These followed by limitation on importing, poor quality of completed works, poorly done planning and scheduling, and major accidents. Construction project may lead to fails with others causes that we never know. Other condition if the contractor cannot supervise it will give a bad impression to the client. The major accidents, limitation on importing, poor completed works may cause the construction project fail. It will be worst if have a bad record with banks or others that related. External causes that suddenly appear may give the bad effect to the project.

From Fig. 3(d), shows the relative weight and rank for each sub causes of political in a descending order. The descriptive results indicate that high cost material is the top causes that contribute of failure construction project among small contractors which is 29.58%. These followed by lack of resources, monopoly, delay collecting debt, and border closure and each is 23.25%, 18.22%, 16.27% and 15.18%. High cost material is the top ranking that affect the failure of construction projects in Gaza (Enshassi et al., 2006). It is common that material cost will affect financial. It is because the material cost it depends on the economy country.

5. Conclusions

It is concluded that the most crucial causes of construction project failures among small contractors are financial, managerial, external and political. The respondents agree that financial is the most causes of failure. Managerial category was considered as the second most severe causes of failure construction projects followed by external and political causes. Financial related reasons such as lack of cash flow, lack of capital, low profit margin, high interest rate, and fluctuation in construction material are crucial causes of failure construction project among small contractors. Contractor should have enough capital to start works or projects because financial is the most importance in construction. The cash flow should be systematic and well manage to prevent or avoid delay in the middle of the activities at site cause from insufficient cash to invest. Therefore, small contractors should seek the advice of financial consultants as well as experienced accountants.

Acknowledgments

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Colour Removal using Rubber Seed Pod Carbon

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Abstract

Malaysia is a country facing a massive physical development for a brighter economic growth. However, at the same time Malaysia also having issues in managing massive industrial effluents discharges to the water body instantaneously that cause pollution to the water sources. Dyes are used extensively in various industries such as textile, paper, rubber, plastics, leather, cosmetics, pharmaceutical and food. Dye is a colour pollutant that can be removed from wastewater by using adsorption because of the simplicity and economic feasibility. This study used a low-cost adsorbent namely rubber seed pod (RSP) in removing Methylene blue (MB as a synthetic industry waste water. A series of batch equilibrium adsorption study was conducted to determine the effect of varied dosage from 0.5, 1.0, 1.5, 2.0, 2.5 and 3 grams, contact time at 30, 60, 90, 120, 150 and 180 minutes at an agitation speed of 150 rpm. Atomic Absorption Spectrometer was used to analyse the concentration of Methylene Blue (MB) in the sample. As a result, RSP in a form of carbon is capable to remove more than 90% of coloured pollution at optimum dosage of 0.6 g and contact time of 60 minutes. Thus, RSP has a potential in removing coloured pollution.

Keywords: Methylene blue, Adsorption study, Rubber seed pod carbon, Colour removal.

1. Introduction

Malaysia is a country going through massive development especially in industrial sectors. These massive developments have prone to produces tonnes of effluent that is harm to human health and natures. One of the major problems concerning industrial wastewater in Malaysia is colour effluent. Colour is pollution in wastewater that needs to be treated using suitable method.

Dyes are used extensively in various industries such as textiles, rubber, plastics, printing, leather, cosmetics, production of coloured products etc. In the textile industry as an example, the main sources of wastewater are the dyeing and finishing operations. About 7 x 10^5 dyes are produced annually in the global market. It is estimated that about 2% of these dyes are discharged into the water system with most of the sources generated from textile industries (Samal, 2014). The result of it, they generate from 40,000 to 50,000 tonnes of dye discharged to surface water every year. The presence of of dyes in water (less than 1 mg/L for some dyes) is highly visible and undesirable (Tahir & Majid, 2013).

A total of 9,027 water pollution point sources from 18,956 have proven successful on lowering dye concentration from industrial effluents by using adsorbents such as activated carbon, peat, chitin, clay, and others (Tahir & Rauf, 2006). Activated carbon is a material that has been widely used in many industrial fields of applications due to its excellent pore structure, high surface area and temperature stability (Anis et al., 2014). Activated carbon can be used for colour removal that comes from various sources. One of the low-cost adsorbents that has potential to be use as carbon is rubber seed pod (RSP). This study will focus on the effectiveness of rubber seed pod (RSP) as carbon to adsorb colour in different variable conditions.

2.1. Rubber seed pod

Rubber seed pod (RSP) is the outer part of the rubber seed. These pericarps can be act as an activated carbon once after the burning process via furnace. RSP can be find in Malaysia since numerous plantations of rubber tree for the use in rubber industry. For north country, it can be found around Kedah, Penang and Perlis. Malaysia planted more than 1000 ha of *Hevea Brasiliensis* or rubber tree throughout the land. This massive plantation showed that, the waste of rubber seed generated is numerous as the plantation of rubber is only for the natural rubber produce by the trees not the rubber seed. In Malaysia RSP, is utilized as fuel and manure. To produce a value-added product from waste agricultural by-product, it is proposed to convert rubber seed coat into activated carbon (Abilasha & Lisy, 2016). Activated carbon prepared from rubber seed coat is 2.25 timer move efficient compared to commercial activated carbon (Abilasha & Lisy, 2016).

2.2. Methylene blue

Methylene blue (MB) is a basic dye mostly used by industries involve in textile, paper, rubber, plastics, leather, cosmetics, pharmaceutical and food industries. Effluents discharged from such industries contain residues of dyes (Mohammed et al., 2014). MB is used in a wide variety of application. It was known as a common substance used in a dying process due to its potential risk towards the survival aquatic compartment, ecosystem and environmental pollution (Anis et al., 2014). MB is a heterocyclic aromatic chemical component with a chemical formula of C16H18N3 and a molecular weight of 319.85g mol-1. According to Anis et al. (2014), MB is a relatively large molecule and often employed as adsorbates to evaluate the efficiency of activated carbon for removal of dyes. Methylene blue is highly stable in the human body, and if ingested, it resists the acidic environment of the stomach as well as the many hydrolytic enzymes present. It is not significantly metabolized by the liver, instead quickly filtered out by the kidneys. Therefore, it is necessary to make sure the effluent contained methylene blue was treated first before released it to the environment.

2.3. Adsorption

Adsorption is one of the preferred processes for dye removal over conventional methods due to high efficiency, fast and easy operation and simple and flexible design (Toor, 2010). The adsorption process may generate little or no toxic pollutants and has low initial capital and operating costs. These methods also safe from the environmental point of view as no sludge is produced (Toor, 2010). The adsorption efficiency is controlled by different types of parameter such as particle size, dosage of adsorbent, pH value, agitation rate, contact time and concentration of adsorbate. To achieve good adsorbent removal, optimum value for each of the parameter need to be determine. Batch study is the easiest way to achieve all the optimum value and easy to handle to run the experiments. It is also easy for us to understand the experiments flow.

3. Methodology

3.1. Preparation of adsorbent and synthetic waste water

3.1.1. Rubber seed pod carbon

Rubber seed pod (RSP) were obtained from Kampung Asam Jawa, Baling, Kedah. The rubber seed with its pod then were dried under the sun shine. The pods then were removed from the seed shell. In the laboratory, RSP were rinsed with distilled water until it discoloured (Abilasha & Lisy, 2016). Then, RSP were dried at temperature between 105˚C-104˚C for 1 day. The next day, RSP were heated in the furnace at Heavy Structure Laboratory, UiTM Penang at 600˚C for three hours (Ekebafe et al., 2010). Due to a very high temperature, the furnace needs to be freed at least for 1 hour after burning process to be cool down. Then, RSP were rested in room temperature for 1 hour at Environmental Laboratory. At this point, RSP were turn into carbon. Only half of the total burning volume could be used since the rest of RSP turn into ash. The remaining rubber seed pod carbon then were crushed using pestle mortar. The crushing process took only at a medium rate to avoid RSP become flour. The size of the RSP is crushed into size between 0.02mm – 0.1mm.

3.1.2. Methylene blue

The synthetic water sample used Methylene blue (MB) in form of powder mixed with distilled water in volumetric flask. The amount of MB used is 0.1 g was mixed with 1 litre of distilled water. Poured and inverted the mix in 1000 ml of volumetric flask carefully while tightly holds the cap. Eq. 1 is used to measure the concentration of Methylene Blue powder for the preparation of MB stock:

$$M_1V_1 = M_2V_2 \qquad (1)$$

where M_1 is the concentration in molarity (moles/ liters) of the concentrated solution, V_1 is the volume of the concentrated solution, M_2 is the concentration in molarity of the dilute solution (moles/ liters), and V_2 is the volume of the dilute solution.

3.2. Batch study

Adsorption capacity of RSPAC to remove MB from the waste water sample was carried out using batch adsorption study. The effect of dosage is ranging from 0.5 to 3 g, contact time is ranging from 0 to 180 min at speed of 150 rpm was investigated in this method.

3.2.1. Varied dosage

Different amounts of adsorbent (i.e.: 0.5, 1.0, 1.5, 2.0, 2.5, and 3 gram) were mixed with 100 ml of Methylene Blue solution in 250 ml closed conical flasks. The conical flasks were placed in orbital shaker and agitated for 30 minutes at speed of 150 rpm in a room temperature. The water sample then can rest for 60 minutes before the final colour concentration value is determined by using HACH DR2800 spectrophotometer. Graph of % MB removal or removal efficiency of the adsorbent versus varied dosage is plot and value of optimum dosage is determined.

The removal efficiency of the adsorbent can be expressed in Eq. 2.

$$\%removal = \left(\frac{C_i - C_t}{C_i}\right) \times 100 \quad (2)$$

The adsorption capacity of adsorbent can be expressed in Eq. 3.

$$q_e = \frac{(C_i - C_t)V}{m} \quad (3)$$

where C_i and C_t is the initial and final concentration of MB solution (mg/L), V is the volume of sample (L) and m is the mass of adsorbent (g).

3.2.2. Varied contact time

After the optimum dosage is determined from previous method stated in section 3.2.1., 8 numbers of conical flask are placed in the orbital shaker and agitated for different contact time (i.e.: 30 minutes, 60 minutes, 90 minutes, 120 minutes, 150 minutes, and 180 minutes) at speed of 150 rpm in a room temperature. After shaking process ceased, the water sample then can rest for 60 minutes before the final colour concentration value is determined by using HACH DR2800 spectrophotometer. Graph of % MB removal versus varied contact time is plot and value of optimum contact time is determined.

4. Results and Discussion

4.1. Effect of varied dosage on adsorption

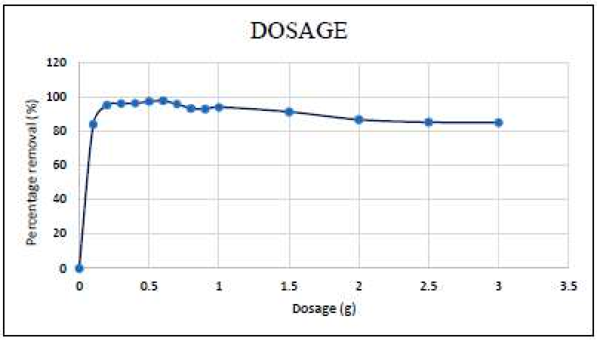

Fig. 1. Graph of percentage removal versus dosage.

Adsorbent dosage is a very important parameter to determine the capability of an adsorbent to remove MB for given amount. Figure 1 shows the amount of percentage removal of the rubber seed pod carbon (RSPC) over a fixed contact time, constant agitation rate and same value of initial concentration. The initial value for this test is 0.1 g/L and the value for the percentage showed that rubber seed pod activated carbon (RSPAC) was very capable in adsorbing dyes because most of the value is more than 80 %. As the dosage is increase, the value of percentage removal also increasing. The increasing value of the percentage removal is fluctuating due to the unstable adsorption capacity of the RSPC. The starting value of the graph is quite low because of the very small amount of dose is used 0.1g. The higher the dose the better the adsorption removal due to increasing number of porosities in the RSPC. But it starts to drop at the amount of 2 g. This may be due to the fact that as the amount in grams of adsorbent is increased the total surface area available for the adsorption of methylene blue reduces as a result of overlapping or aggregation of adsorption sites (Nsami & Mbadcam, 2013). Between dosage 1 - 3 g, the percentage of removal is decreasing. This decreasing graph is because due to the optimum value of the RSPC located at lesser amount of dosage. The amount between 1 - 3 g, there might happen a discolouring process of PSPAC in the adsorbate during the shaking process. As the amount of dosage increasing, the percentage removal is decreasing and start to achieve same value of removal at the amount of 2.5 g – 3 g. While, the optimum dosage that remove higher MB is 0.5 g at 97.4 %. Thus, this study will look detail at dosage between 0.1 g to 0.9 g to check for optimum value because of 0.5 g result is suddenly at the highest percentage removal. The optimum value might be lies between the 0.1 – 0.9 g. The result for the highest removal after the detailed experimental work, the optimum value is 0.6 g at 97.8 %.

4.2. Effect of varied contact time on adsorption

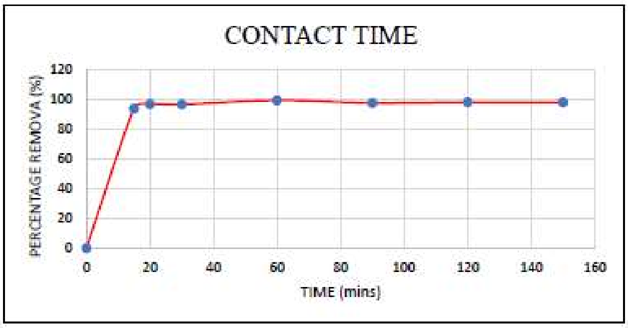

Fig. 2. Graph of percentage removal versus time.

The time for contact hour effected the removal of MB. The amount of dyes removal is increasing over time but in a very small different value between them. The value of percentage removal is increasing with more than 90% over time which is considerably good. The highest amount of removal is between 30 to 60 minutes. Figure 2 shows the graph of percentage removal over time. According to (Sundari et al., 2015),the colour removal increases with increase in time. But contrast with the result gained, the percentage removal tends to achieve the same value of removal as the time increasing. Apart from that, the fast adsorption at the initial stage also may be due to the fact that a large number of surface sites are available for adsorption but after a lapse of time, the remaining surface sites are difficult to be occupied. This is because of the repulsion between the solute molecules of the solid and bulk phases, thus, make it take long time to reach equilibrium (Idris et al., 2011). The optimum contact time for RSPC is 99.23% at 60 minutes of contact time.

5. Conclusions

It is concluded that the removal percentage of Methylene Blue increase with the increment amount of adsorbent dosage. As the adsorption increase, the adsorption mechanism will become saturated and less efficient. In this study, the optimum percentage removal of Methylene Blue is 97.8% for varied in dosage where optimum dosage is 0.6 g and 99.23% for varied in contact time where optimum contact time is 60 minutes. RSPC is environmentally friendly, cost effective and locally available has a potential to be used as a natural waste adsorbent to remove Methylene Blue in the waste water.

Acknowledgments

The authors would like to express their sincere gratitude to Research Management Institute and Faculty of Civil Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang (UiTMPP) for providing facilities and guidance that helped this study until it completed. We thank also to our colleagues from UiTMPP who provided insight and expertise that greatly assisted throughout the time in completing this study, although they may not agree with all the interpretation or conclusions of this paper.

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Properties of Pervious Concrete Modified with Latex

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Abstract

Pervious concrete is a porous concrete that are widely used in making the sidewalks, pavements and many are used in storm water management due to its ability to channel water through it. Making the pervious concrete is the same as the normal concrete but it is only lack of fine aggregate. As from its name, the pervious concrete are known as porous concrete having the low strength and durability. In this study, the pervious concrete were modified with synthetic latex to help in improving its compressive strength. The percentage of latex were 0%, 2%, 4%, 6%, 8% and 10% based on the cement weight. The mix design of cement, aggregate and water of 1:4.5:0.35 in ratio used in this study and only 10mm aggregate size were used. The specimens were cured and tested their compression test and permeability test. The effect of latex that gives the most enhancing effect in compressive strength of the pervious concrete were found at 4% concentration that enhanced almost 17% of compressive strength.

Keywords: Pervious concrete, Latex, Compressive strength, permeability.

1. Introduction

Concrete is a mixture of aggregate, cement, and water. This combination of these three elements will produce a strong bond between cement aggregate and water thus, concrete become durable and can hold a large forces and stress. Concrete are common in modern day construction practice. It is a commonly used material in construction and impermeable. Therefore, permeable or pervious concrete are required.

According to Tabatabaeian et al. (2019), pervious concrete main advantages are: materials saving, lower shrinkage and excellent drainage property. Indeed, many pores in this type of concrete cause the better feature compared with conventional cement concrete. The main drawback of this type of concrete however it is low strength and durability (Rasiah, 2010; Eisenberg et al., 2015; Lu et al., 2019; Saboo et al., 2019; Tabatabaeian et al., 2019; Adil et al., 2020; Borhan & Al Karawi, 2020; Lederle et al., 2020; Wang et al., 2020; Yang et al., 2020).

Optimizing water to cement ratio will achieve an enhancement in strength. The use of polymeric composites can also be seen to be beneficial. Huang et al. (2010) pointed out that SBR latex polymer are capable to improve pervious concrete performance, particularly for low cement content.

Different polymers such as cationic SBR latex, polyvinyl acetate latex, ethylene vinyl acetate powder and anionic SBR latex have also been used in concrete and have been compared with their roles on the properties of concrete (Zhang et al., 2011; Giustozzi, 2016; Lang et al., 2020). Latex is a stable dispersion of polymer micro particles in an aqueous medium. It is commonly found in nature, but synthetic latex was manufactured. Nowadays, synthetic rubber mostly used and made from the petroleum by products. Synthetic rubbers that used in this study are Styrene Butadiene Rubber (SBR) latex. The purpose of conducting this research is to explore the properties of pervious concrete when it was modified with latex. The optimum percentage of latex were determined.

2. Materials and Methods

2.1. Materials

The materials used in this study comprised of Ordinary Portland Cement (OPC), water, aggregates and additives. OPC manufactured by Tasek cement was used in this study. Single size aggregates were used specifically 10 mm in size. Additive, namely Styrene Butadiene Rubber (SBR) Latex were used as an additive in this research as shown in Fig. 1. The proportions of the pervious concrete were adopted from Huang et al. (2010) and the ratio of cement, aggregates and water cement ratio (w/c) are 1:4.5:0.35 respectively. The concentration of SBR latex were 0%, 2%, 4%, 6%, 8% and 10% based on the cement weight.

.

Fig. 1. Styrene Butadiene Rubber (SBR) Latex

2.2. Methods

Pervious concrete samples were cast into 2 shapes which are 100 mm x 100 mm x 100 mm cube and 100 mm diameter x 200 mm height cylinder for compression test and permeability respectively. There were 9 cubes and 9 cylinders for each series. After 24 hours, pervious concrete specimens were demoulded and cured for 7, 14 and 28 days. Pervious concrete samples were tested their compressive strength and permeability. Compression test were conducted using compression machine in accordance to BS EN 12390-3 (2009). Meanwhile, the permeability test of the pervious concrete specimens were conducted using flow meter as shown in Fig. 2. Testing method for measuring pavement texture drainage was referred to EN 12697-40:2011. This method is adopted from Test Method of Hot Mix Asphalt – Part 40 (In situ Drain ability). The time taken for the specific volume of water to pass through the voids of the pervious concrete specimens under the gravitational pull were recorded.

Fig.2. Flow Meter Test

3. Result and Discussions

The compressive strength of the pervious increased regardless SBR latex concentrations. Figure 3 shows the compressive strength of the pervious concrete specimens from 0% to 10 % concentration of latex for 7, 14 and 28 days of curing. The compressive strength increase linearly for the first three percentage of latex which are 0%, 2% and 4%. This is due to the mix of latex and cement hydration work as matrices resulting in higher compressive strength of pervious concrete. Beyond that, the compressive strength falls until 10% of latex composition. It can be clearly seen that the compressive strength of the pervious concrete specimens are reaching its peak at 4% of latex percentage and then slowly decline until it reach the lowest strength at 10%. At the age of 28 days of curing, the strength of the pervious concrete greater than 10 MPa for all specimens regardless their concentrations. The inclusion of 4% of latex contributed to the compressive strength enhancement about 17% compare to control. This trend is in line with Huang et al. (2010).

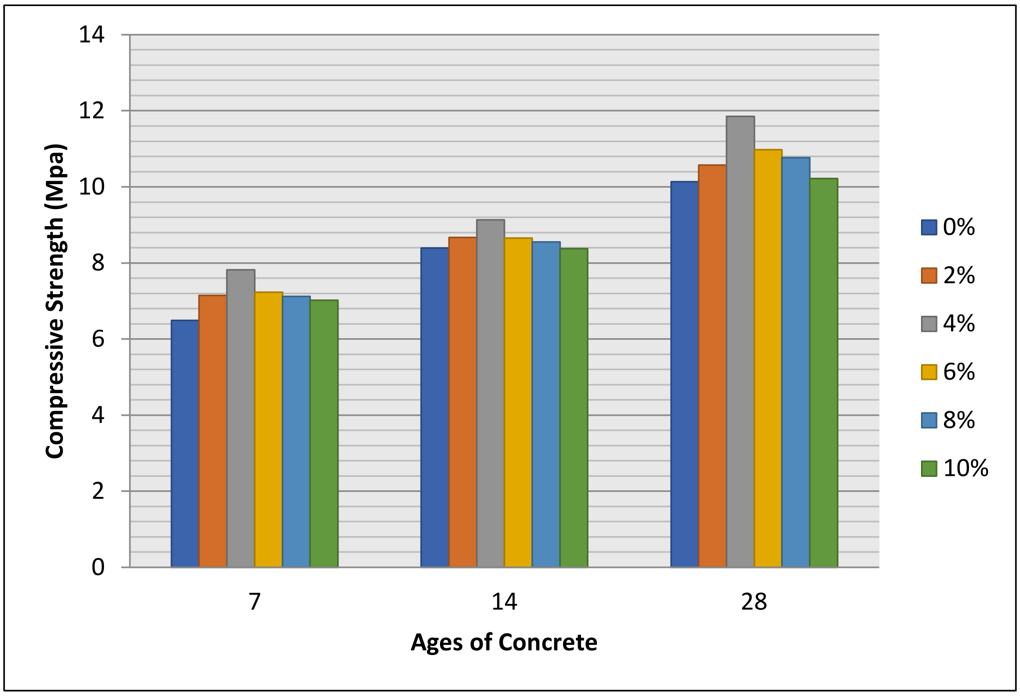

Fig.3. Compressive Strength of Pervious Concrete

Figure 4 shows the permeability of concrete at 28 days of ages with different percentage of latex. It can be clearly seen that the permeability of pervious concrete gradually decreased as the higher concentration of latex included into the concrete mixes. The rates of permeability between each concentration are not much differ. Without any latex the permeability of the pervious concrete is 0.47 l/s while 10% concentration has reduced to 0.355 l/s but still within acceptable range. Reflecting to compressive strength, the permeability of 0.4% latex is 0.434 l/s which reduced about 8% compare to control. The higher percentage of latex induced lower permeability rate of the pervious concrete but could still achieve acceptable permeability. The latex cement bonding was formed and the arrangement of particles in the pervious concrete has reduced the interconnected pores. Subsequently lower permeability (Huang et al., 2010).

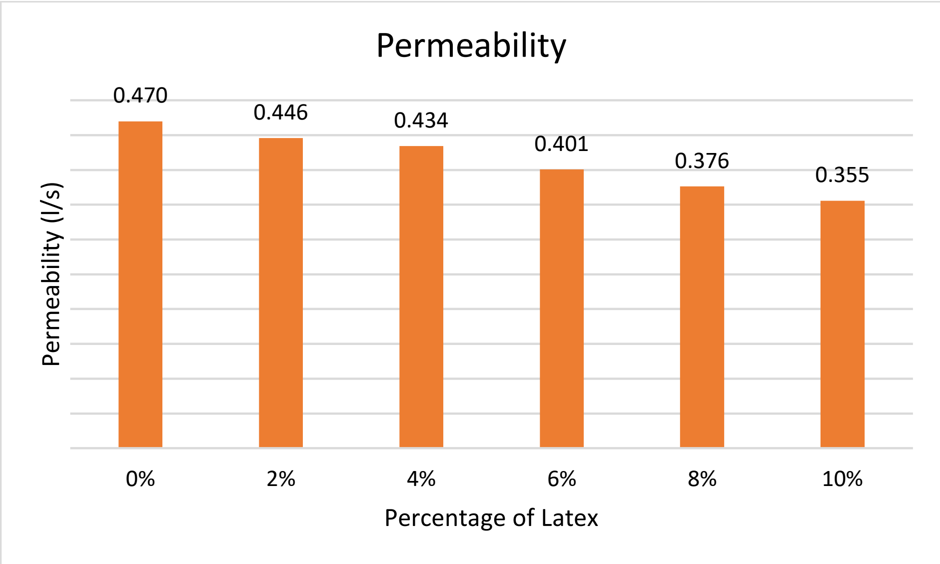

Fig. 4. Permeability of pervious concrete

4. Conclusions

The objective of this study is to assess the performance of pervious concrete added with latex in terms of compressive strength and permeability of the pervious concrete. Adding latex to the pervious concrete increased the compressive strength of the pervious concrete. The optimum percentage of latex that give the most enhancing effect is 4%. The increment about 17% compare to control. The permeability of the pervious concrete decreased when the latex is added into pervious concrete mixes. But the reduction is still within the acceptable range.

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Development of Computer Algorithm for Traffic Volume Study

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Abstract

The term traffic volume study can be termed as traffic flow survey or simply traffic survey. Traffic volume study is very important to perform because it can increase efficiency of the road, reduce traffic congestion etc. This is an efficient method for gathering information to be utilized for different traffic designing purposes. Generally, there are two methods that can determine traffic volume which are manual count method and automatic count method. Manual count method is conventional method that been using widely around the globe to obtain traffic survey data. Automatic count method is the improvement from manual count method which decrease the manpower and time consume in traffic survey collection data. The objectives of this study are to modify computer algorithm using Python and compare the results between traditional count method. For calibration purposes, manual count method from video was used. Manual counts from the video were conducted several times to ensure its accuracy for calibration purposes. Then, the results processed by computer algorithm also has been compared with the results obtained from manual count method. Based on the analysis, it can be concluded that computer algorithm is capable to produce good results in determination of traffic count and traffic composition compared to manual count method. Automatic count method based on computer algorithm produce lower percentage of error toward counting and classification purposes in determining traffic count and traffic composition.

Keywords: Traffic volume study, vehicle detection, image processing, object tracking, video surveillance.

1. Introduction

Traffic volume is essentially the number of vehicles passing a segment of a roadway. Traffic volume study is very important to perform because it can increase efficiency of the road, reduce traffic congestion etc. Meanwhile, expressing traffic volume as a number of vehicles passing a traffic lane per unit time will be inappropriate when several types of vehicles with widely varying static and dynamic characteristics were comprised in the traffic (Hoque, et al., 2013).

These problems of measuring volume can be encounter by converting the different types of vehicles into equivalent passenger cars and expressing the volume in terms of Passenger Car Unit (PCU) per hour. Thus, vehicle classification from a traffic volume count is necessary.

Traffic volume counting techniques are divided into two; which are manual method and automatic method. Manual counts are typically used to gather data for the determination of vehicle classification, turning movements, direction of travel, and vehicle occupancy. Numbers and types of vehicles are manually determined by the person, either by manual counter, mechanical counter or application of video. This method allows determination of vehicles count and classification, but enumerators tends to miscount the number of vehicles, especially heavy traffic roads. In Malaysia, normally engineers use manual method to obtain traffic data as this method was the simplest compared to the others and this method was commonly used by the others.

Automatic count method is used in cases where the manual method of counting is not practical. Different automatic counting instruments are available with their own pros and cons. Pneumatic tubes, inductive loops, weight-in-motion sensor, micromillimeter wave radar detectors and video camera are some of the widely used instruments. Classified traffic volume count provides a better understanding of the vehicle types that use the road and can be used for numerous other purposes apart from transportation surveys. It can also be used to calculate on-road vehicle modal splitting. This method gives more advantages in traffic data survey compare to manual method, especially in terms of data accuracy and long-term costs.

The traffic surveillance camera is one of the automatic count methods. Traffic survey using camera provides a lot of traffic information. With proper computer programming of image processing, it could provide number of vehicles, identification of vehicle classification, vehicle occupancy, gap, travel time and delays. These data can be used as a basis for a good traffic management plan to increase traffic efficiency.

Therefore, this research focused on adopting computer algorithm to extract traffic volume and traffic composition data from traffic surveillance camera. It provides more accurate traffic data thus contributing to good traffic management.

2. Methodology

In this study, automatic method using surveillance camera was chosen. This method was verified using conventional method which is manual count method. For manual count method, mechanical tally counter and count tally sheet were prepared. Each enumerator was provided with mechanical tally counter for each lane and were observed 3 lanes one-way and counted the traffic using mechanical tally counter for every 15 minutes interval. Each tally counter and a count tally sheet represent for each lane. Counting and classification were determined by enumerator and data collected were recorded in count tally sheet. Observation for peak hour was conducted from 7am until 9am and 9am until 10am for off-peak hour.

Data were collected at the same location as in manual count method. Surveillance camera were put in between 2 lanes and recorded at the same duration of time as manual counting activities. The camera was being supervised to prevent from equipment failure due to battery capacity, vandalism and weather condition. Then, video recorded was executed in the Phyton script for counting and classification purposes.

The first step is to extract data from video by background subtraction. Background subtraction was used to extract moving objects from the video by using background segmentation algorithm. Then vehicle detection and counting can be performed by vehicle detection and counting algorithm. It detects each vehicle and track it until it crosses region of interest and counter will increase depend on the area. Background subtraction is a key module of the whole system and the performance obtained at this step significantly affects the subsequent stages. The module of *BackgroundSubtractorMOG2* developed by Zivkovic & Van Der Heijden (2006) was adopted. It was selected because it is proven to be robust and effective by outperforming all other available algorithms used on the *OpenCV* dataset. One important feature of this algorithm is that it selects the appropriate number of gaussian distribution for each pixel. A sample of the background subtraction module output can be seen in Fig. 1. Figure 1 represents respectively the correspondent input frame and the reconstructed background model.

(a) (b)

Fig. 1. (a) Input Frame and (b) Reconstructed Background Model in Background Subtraction Module

Vehicle counting can be done by checking if the centroid of a vehicle has touched or crossed the imaginary line in region of interest (ROI). An imaginary line is the line that diagonally appears by connecting two ROI points. Once the centroid of a vehicle in ROI crosses the imaginary line, the computer algorithm counts the vehicle (Memon et al., 2018). From Fig. 2, it is noticeable that when centroid of vehicle touches the imaginary line in ROI, the number of a respective traffic classification increase.

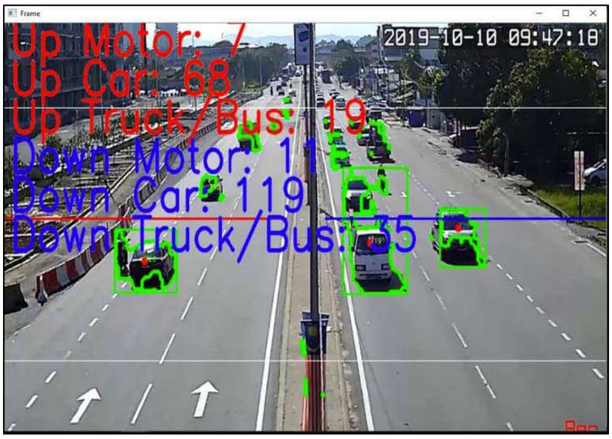


Fig. 2. Variables Showing Classification of Vehicles When Vehicle Touching ROI.

Count and classification using Contour Comparisons is defined as the contour properties such as perimeter of the contour are extracted and compared with assumed values to determine whether the objects are car, van or lorry. Perimeter between 0 and 250 are defined as motorcycle or scooter. Perimeter between 250 and 500 area define as car and perimeter greater than 700 are define as lorry. Foreground object was used to detect the contour by using the *findContour* in *OpenCV* dataset.

3. Results and Discussions

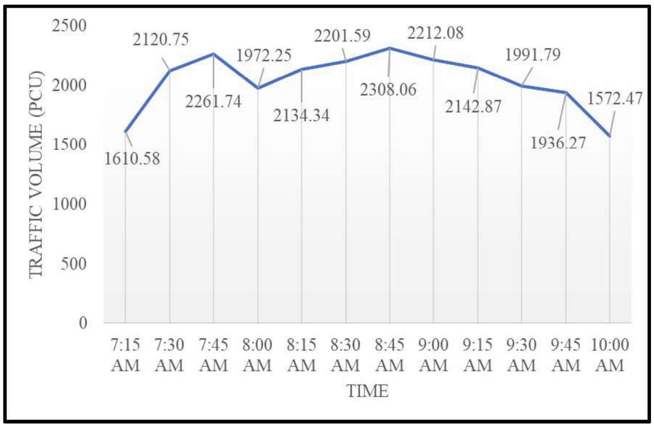
3.1. Data analysis

Before analysis had been made, all the data must be converted into Passenger Car Unit (PCU) for easy data analysis. According to Public Works Department Malaysia (1986), the value of PCU for different vehicles are listed in Table 1. Figure 3 shows data for traffic volume from manual count at site, automatic count method using computer algorithm, and manual count from video respectively.

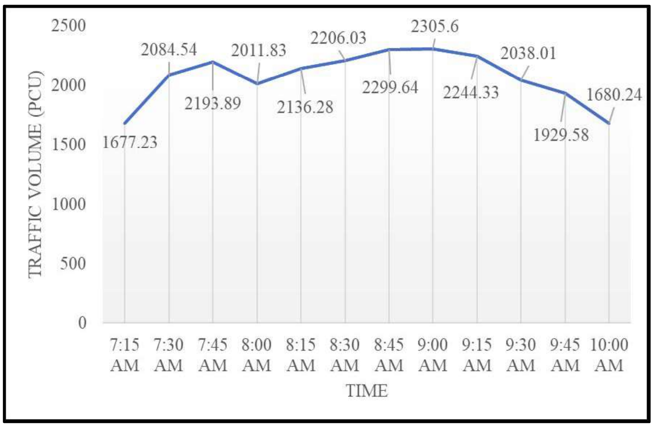
Table 1. PCU for Each Vehicle Type.

No.	Vehicle Type	PCU Value
1	Passenger Cars	1.00
2	Motorcycles	0.33
3	Heavy Lorries	2.25
4	Buses	2.25

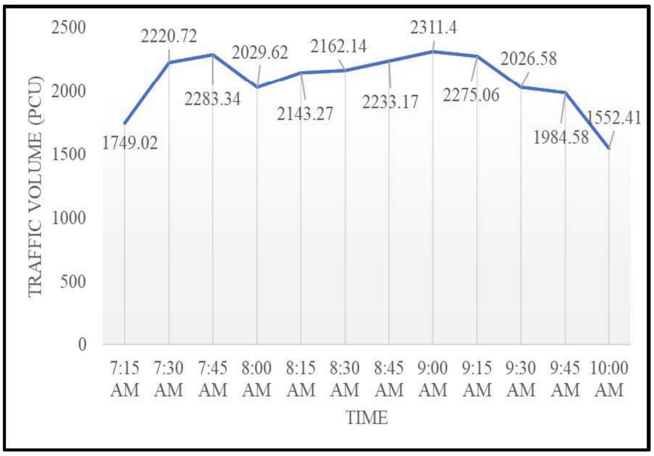
From the graph plotted, the highest number of vehicle (PCU) is at 9:00 a.m. and the lowest number of vehicle (PCU) is at 10:00 a.m. From the graph plotted, it shows increment number of vehicles start from 7:00 a.m. until 7:45 a.m. since this time is where road user tends to use the road to go to work. It shows a decrement at 8:00 a.m. and start increasing until 9:00 a.m. This probably because most of the corporates start at 8:30 a.m. to 9 a.m. All the three methods show a similar pattern of traffic flow; which indicated that 7:00 a.m. until 9:00 a.m. is the peak hour and traffic flow started to decrease from 9:15 a.m. However, the accuracy of results from manual and auto methods are of interest, which is discussed in the next section.



(a)



(b)



(c)

Fig. 3. Traffic Volume by (a) Maanual Count At Site, (b) Automatic Count Using Computer Algorithm and (c) Manual Count From Video Records.

3.2. Comparison of data

Table 2 shows the percentage of error in manual count method at site compared with the method of manual count on video records. From Table 2, the highest percentage of error is 7.92% at interval 1 which is from 7:00 a.m. until 7:15 a.m. due to peak hour on this road and lowest percentage errors is 0.42% at interval 5 which is from 8:00 a.m. until 8:15 a.m. High percentage of error obtained is due to difficulties of enumerators to count exact number of vehicles passing through this road since this road has high number of vehicles. Nevertheless, the percentage of error depends greatly on many other factors such as alertness and numbers of the enumerators.

Table 2. Percentage of Error Between Manual Count Method at Site and Manual Count on Video

Interval	Time (a.m.)	Manual count method at site (pcu)	Manual count from video (pcu)	Percentage error (%)
1	7:00 – 7:15	1610.58	1749.02	7.92
2	7:15 – 7:30	2120.75	2220.72	4.50
3	7:30 – 7:45	2261.74	2283.34	0.95
4	7:45 – 8:00	1972.25	2029.62	2.83
5	8:00 – 8:15	2134.34	2143.27	0.42
6	8:15 – 8:30	2201.59	2162.14	1.82
7	8:30 – 8:45	2308.06	2233.17	3.35
8	8:45 – 9:00	2212.08	2311.40	4.30
9	9:00 – 9:15	2142.87	2275.06	5.81
10	9:15 – 9:30	1991.79	2026.58	1.72
11	9:30 – 9:45	1936.27	1984.58	2.43
12	9:45 – 10:00	1572.47	1552.41	1.29
			Average	3.11

Table 3 shows the percentage of error in automatic count method based on modified computer algorithm. From Table 3 the highest percentage of error is 8.23% at interval 12 which is from 9:45 a.m. until 10:00 a.m. It is because some vehicle cannot be detected by computer algorithm due to vehicle occlusion. The lowest percentage of error is 0.25% at interval 8 which is from 8:45 a.m. until 9:00 a.m. due to a smaller number of vehicle occlusion.

Table 3. Percentage of Error Between Auto Count Method and Manual Count on Video

Interval	Time (a.m.)	Automatic count method by using computer algorithm (pcu)	Manual count from video (pcu)	Percentage error (%)
1	7:00 – 7:15	1677.23	1749.02	4.10
2	7:15 – 7:30	2084.54	2220.72	6.13
3	7:30 – 7:45	2193.89	2283.34	3.92
4	7:45 – 8:00	2011.83	2029.62	0.88
5	8:00 – 8:15	2136.28	2143.27	0.33
6	8:15 – 8:30	2206.03	2162.14	2.03
7	8:30 – 8:45	2299.64	2233.17	2.98
8	8:45 – 9:00	2305.60	2311.40	0.25
9	9:00 – 9:15	2244.33	2275.06	1.35
10	9:15 – 9:30	2038.01	2026.58	0.56
11	9:30 – 9:45	1929.58	1984.58	2.77
12	9:45 – 10:00	1680.24	1552.41	8.23
			Average	2.79

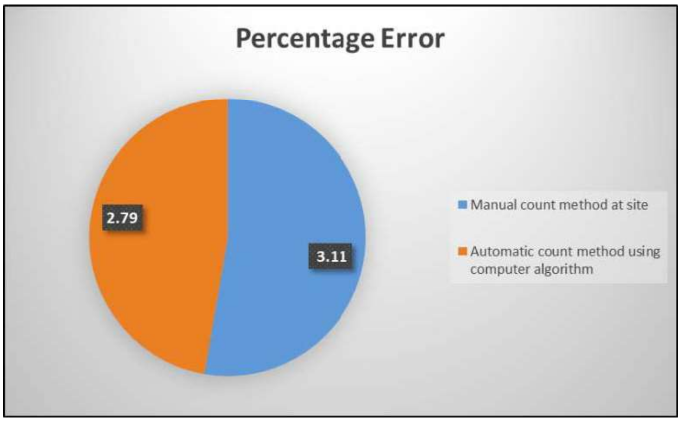


Fig. 6. Comparison Percentage of Error Between Manual Count Method at Site and Automatic Count Method Using Computer Algorithm

Figure 6 show comparison of average percentage error of both methods against manual count from video. From the figure above manual count method at site has high percentage error which is 3.11% compared to automatic count method using computer algorithm which is 2.79%. The modified computer algorithm is slightly more efficient compared to manual count method in term of counting and classification.

4. Conclusion & Recommendation

Based on the results of analysis obtained, it can be concluded that computer algorithm that been modified is capable to produce good results in determination of traffic counts and traffic compositions compared to manual count method. Automatic count method based on computer algorithm produce lower percentage error toward counting and classification purposes. Modified computer algorithm also has more advantages which are decrease number of manpower needed. Limitation of this modified computer algorithm is that this system cannot detect occlusion of vehicles thus affects count and classification accuracy due to the width of camera angle. This can be improved by providing each camera for each road or each camera for each lane. However, this is not cost effective. Thus, the computer program could be further refined in the future. Another limitation on this computer algorithm is it needs human supervision on determination of region of interest and area for each type of vehicles. So, it prone to human error in classification of vehicles.

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Optimal Work Pattern Analysis for Construction Workers in Malaysia

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Abstract

Currently the unpredictable temperature of the country is a serious concern. As this factor can be impact to the worker productivity, therefore the study on both working time and temperature is one of the great interests. Other than that, due to heat stress, each of the factor study will establish the optimal pattern of work for construction workers. The study's purpose is to assess the worker efficiency parameters to the project's performance and to determine an acceptable job pattern due to heat stress for the construction staff. Two approaches which are interview process and site assessment used to complete the analysis. From the survey, the strongest staff efficiency strategy discovered in a survey with the web specialist. When the correct formula had been collected, site evaluation was performed. In conducted site observation several of reported variable such as ambient temperature, working period and worker performance for three specific forms of job which are bar bender, rebar wall construction and installation tiles. The heat stress impact study is produced to three forms of this research. Then the job efficiency relation of two kinds of work completed. The optimum working method from the study adds most to the received job efficiency. Ultimately, both the goal reached by achieving the parameters of productive project and optimal style of operation.

Keywords: Optimal work pattern, Productivity, Construction workers.

1. Introduction

The effect of climate change has contributed to a rise in the incidence and severity of excessive temperatures over the last decade. Construction staff typically operate in a humid atmosphere with access to these rising temperature levels. Working in hot temperatures can raise the discomfort and exhaustion that can contribute to severe workplace health conditions. Dehydration and exhaustion may contribute to destruction of the body when this tension is coupled with physical exercise. This condition is attributed to work in hot conditions or heat exposure in the weather being high. Heat stress is physical danger which may directly or indirectly affect health effects workers. Furthermore, the heat waves also significantly affect the safety and efficiency of employees (Lundgree et al, 2013). This topic is linked to the research to analyse the association between heat stress and efficiency of the worker during working hours. This research is one of the analyses for calculating the impact of heat stress on the efficiency of employees. Fresh working time can be regenerated from the analysis.

2. Methodology

In this report, the scale of the analysis refers to the construction site at Evoke @ Gravitas, Seberang Prai, Pulau Pinang where one of the 300 condominium units built by the development project. Most of them are project manager, project designer, construction technician, construction controller, and quality management designer / quantity assurance. Owing to much of their time, the justification for selecting them as the interviewees is on the site to monitor the practices of the workers. So, they can also see how the worker is exposed to the stress of heat. The interviewees converted all the question answer to the quantitative data to simplify the opinion measurement. Next, all data will be analysed, and the most suitable criteria generated. The data collection then proceeded with evaluation of the site about the impact of heat stress on the efficiency of the staff. To quantify the efficiency of the worker the output of the worker was calculated at four intervals of time every day. The data collection phase extends for a month from August 1 to August 31, 2018. Other than calculating worker efficiency, each time is reported with the current ambient temperature. Then, the line graph analysis of the relation between the built temperature and worker productivity after collecting the results.

2.1. Literature review

Analysis of literature is one of the analyses for obtaining the study knowledge. The understanding regarding the relevant word to be used in the analysis before performing the study is essential. Therefore, literature review was undertaken to examine the previous work, books, papers, dissertation, and thesis for further comprehension.

2.2. Site expert interview

An interview recognized as the Knowledge Collection Process. The interviewees, for example Project Director, Construction Administrator, Site Technician, Site Supervisor, Security and Health Officer, and Quality Assurance / Quality Management Specialist, picked from business expertise and trained staff. In fact, the interview was performed to determine the most acceptable method for measuring the efficiency of the worker depending on the prior knowledge of each of the interviewees. The theory given to the interviewees is gathered from the previous work and journals' literature analysis.

2.3. Site observation

The method of performing site assessment started after receiving the description of the worker's output from the interview. Observation of the site undertaken to see the impact of heat stress on staff efficiency. Few variables needed to establish the relationship between heat stress and productivity of the worker, for example heat stress (temperature), working period, and efficiency of the job. There are three types of work to be observed as shown in the Fig. 1, Fig. 2 and Fig. 3 which are bar bender work, rebar wall installation work and tiles installation work.

Fig. 1. Bar Bender Work

Fig. 2. Installation Rebar Wall

Fig. 3. Installation Tiles Work

2.4. Data analysis

The research data analysis was divided into two methods which are analysed for all of the interviewee's outcome by the excel tools analysis. From this analysis, the interviewee has chosen to fulfil the objective of one of the research which is the criteria of worker productivity based on the result. First, after receiving the worker efficiency method, monitoring of the site was conducted to determine the period, temperature, worker numbers and worker production at the site. The efficiency of the worker was determined for three specific forms of jobs, depending on the results observed.

Research started with the study line graph intended to see the impact of heat stress on three specific forms of staff: construction tile staff, implementation of wall reinforcement bar and bender bar. This method of research was performed to establish the connection between heat stress and worker efficiency in the excel software. Finally, the suggestion of an optimal job pattern produced to enhance and reduce the impact of heat stress on the worker, which would at once maximize the efficiency of the worker and the project results. The recommendation of optimal working pattern will be provided to the nearest site to boost the project efficiency while maximizing the productivity of the staff. The prediction of the aerodynamic coefficients of the investigated projectiles shown in Fig. 1, Fig. 2 and Fig. 3 was carried using the methods and the computer programme described above. The effects of forebody and afterbody shapes on the aerodynamics at supersonic speeds are analysed in this paper.

3. Result and Discussion

3.1. Criteria of worker productivity

The culmination of the interview process is the last two issues that are the criterion for a productive job, whether to calculate the cost-based efficiency of the worker or the period to assess the quality of the efficiency of the worker. The climax of the interview is the last question which is the criteria of successful project whether to measure the worker productivity based of the cost or the time in order to get the accuracy in measure the worker productivity.

From the Fig. 4, the 33.33% respondent agreed to measure the worker productivity with respect to time based of the output the worker, but another 16.67% respondent prefer to measure productivity based of the cost of labours. According to Tran & Tookey, (2011), interviews were carried out to obtain experience and attitude of people. They also mention that the questions were prepared with the objectives of obtaining information. Therefore, the same procedure implemented in this study which is an interview conducted with the site expert to obtain their experience opinion.

After obtained the criteria of worker productivity, the site observation is conducted to measure the worker productivity. Three type of work will be analysed based on the current progress of the site which are bar bender work, installation of rebar wall work and installation tiles work. The average temperature of the current time also recorded to analyse the effect of the heat stress to the worker productivity.

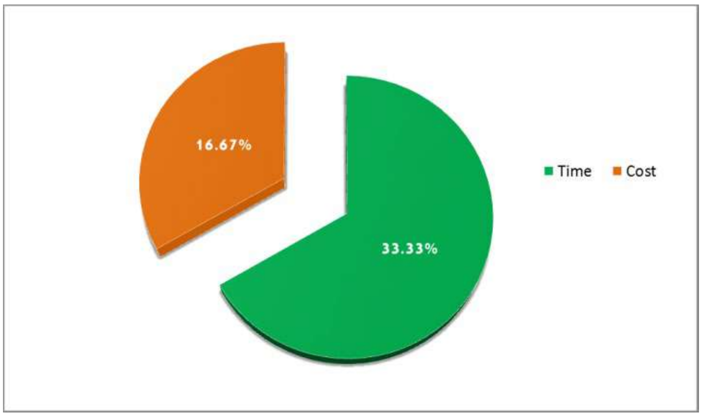

Fig. 4. Percentage Criteria of Worker Productivity

3.2. Effect of heat stress to worker productivity

Three forms of work will be evaluated based on the site's recent development, which is bar bender service, rebar wall job construction and tiles construction function. The average current-time temperature was also reported to examine the influence of heat stress on the efficiency of the worker (Thiyagu, 2015). In analysis three types of work above, the effect of heat stress can be seen based on the reducing of worker productivity when the temperature increase. The higher the amount of heat stress the lower the worker productivity. As the temperature achieved maximum observed, the worker productivity of installation rebar wall worker is 5.04m²/hour and installation tiles worker is 5.28 m²/hour. Therefore, this may be due to the exposure to the heat stress outsider is more compared to in the buildings.

Most of developed country aware about the heat stress but in Malaysia heat stress is not emphasized by the employers. The employers also ignored this condition, but it is also contribution factors affecting the worker productivity.

3.3. Optimum work pattern

The best time interval in site observation is 8:30am to 10:00am based on the analysis done. Due to higher worker productivity compared with other time intervals, this time interval was counted as the optimum working pattern. That style of work does not show the heat tension as much as job cycle 11:00am to 12:30pm.

The most important attribute of staff efficiency is the time 11:00am to 12:30pm. The worker becomes fatigue because of the high temperature and reduces their productivity. Finally, a certain two-time period makes staff efficiency moderate (Abdul Aziz and Rajendranath, 2015). In addition, the working pattern will begin earlier to avoid exposure to heat stress.

4. Conclusions

The goal of this research was to calculate the parameters of worker efficiency for the project's progress and to determine an acceptable work pattern due to heat stress for the construction workers. The overall conclusion of the outcome in the early part of the study achieved the research objective.

To be successful in any project, all the consideration that affects productivity must be considered based on previous research. Worker productivity is an integral component of overall project productivity. The worker productivity criteria are found in the literature review being analysed to get the most suitable one. Employers should be taking control of heat stress. That condition can reduce the project's time and cost at once.

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Development of Building Information Modelling (BIM) for Malaysia Construction Safety

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Abstract

The purpose of this study is to develop a Building Information Modelling (BIM0 framework for Malaysia construction safety. The objective of the study is to identify the safety parameter and safety process in construction. The framework of BIM is developed based on the data collected which is from questionnaire and interview. Data collection for the framework are from the literature review, questionnaire and interview. As a result, the implementation of BIM towards construction safety can reduce the accidents rate that occur. Where the framework helps in determine the problem that might occur during the construction using Prevention through Design (PtD).

Keywords: Building Information Modelling (BIM), Prevention through Design (PtD), framework, safety element.

1. Introduction

The construction industry has always played a huge role in the development process of a country as where a successful development would contribute in the economic growth generating additional demands for construction activities. However, the construction industry always recorded a high number of accidents. This is a very concerning issues as the rates of accidents is very high that also include death and permanent disability. Malaysia, recorded a worrying increase in the numbers of accidents occurring at the construction sites by the Social Security Organization (SOCSO) indicating the number of permanent disabilities and fatalities from year 1996 to 2008 (Abang Abdullah & Wern, 2010). Also supported by Lily et al. (2016), where statistics from Occupational Safety and Health Act 1994 has shown that the number of fatality in the construction industry is 5 times more than in other sectors. The total fatalities in construction are 796 in year 2013 and out of this 796, there were 294 fall fatalities. Hence, the urgency to eliminate this problem need to be prioritize.

In order to prevent accidents, one must know the causes of accident, more specifically the root cause of accidents and the approaches to reduce the falls (Rahim et al., 2008). Factors that can lead to accidents in construction site are unsafe method, human element, unsafe equipment, job site conditions, management, and unique nature of the industry. The main cause of construction accidents found are the workers' negligence, failure of workers to obey work procedures, work at high elevation, operating equipment without safety devices, poor site management, harsh work operation, low knowledge and skill level of workers, failure to use personal protective equipment and poor worker's attitude about safety (Rahim et al., 2008).

2. Methodology

This study started with gathering information through literatures review, where the safety parameter and safety process in construction is determined. BIM uses can be classified primarily based on the purpose for implementing BIM throughout the life of a facility (Kreider & Messner, 2013). Where based on the research conducted by Kreider and Messner (2013), the BIM use purpose is divided into two main categories which is characterise and purpose of the BIM. Then further divided into primary category which is Gather, Generate, Analyze, Communication and Realize.

Using safety at the earlier phase of the project which is the design process are important because it can help prevent accident from occur starting for the design or a system called Accident Prevention Through Design (PTD). By definition, prevention through design is a methodology applied to the various phases of the design process for identifying and mitigating risks and hazards that will be encountered by construction workers during the construction of the facility on site (Kamardeen, 2010). This involves systematically identifying hazards and risks and introducing mitigating design solutions that will meet the design requirements as well as create a safe work environment for the workers (Kamardeen, 2010).

Next, a study questionnaire was prepared based on safety element that has been find. The questionnaire is then sent to various construction company to review and comment. The data collected from the questionnaire is then analyses using SPSS software where the test used based on Pearson correlation test level of significance was set to 0.01. The population size for the test is set to 30. Furthermore, the framework created from the questionnaire then being analyse further during the interview. By doing so, any additional safety elements can be added or any changes can be implemented for better safety framework can be made.

3. Data Analysis and Discussion

3.1. Implementation of BIM towards construction safety

Table 1 shows the result of the implementation of BIM towards safety is statically significant which is 0.00 (p-value<0.01). Since the BIM innovative technologies that is broadly use in the construction industry thus the result is expected as BIM can be implemented in safety. Since the BIM implemented in safety are focus at PtD where the safety can be easier to be improve at construction sites. Prevention through Design (PtD) is therefore recognised by the construction industry and researchers as an effective means to improve site safety as it helps to eliminate hazards at source (Kamardeen, 2015).

Table 1. Result of BIM Implement Towards Construction Safety.

	Test Value=0					
	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**99% Confidence Interval of the Difference**	
					Lower	**Upper**
Implementation of BIM will increase safety at construction site.	15.452	29	0.000	1.267	1.04	1.49

3.2. Critical stage to influence safety

Based on the data collected in Table 2, 24 respondents (84%) choose Design Development stage as the critical stage that contribute the most in increasing the safety at construction site. In this study, the correlation between PtD and Design Stage in Table 3 was statically significant (p-value<0.01) as the p-value for Design Development stage with PtD effect in giving Better Planning is 0.003 while for Better Visualisation is 0.001. This result shows that design stage actually gives a better safety implementation, thus showing the most influence stage towards safety implementation is Design Development stage.

Design stage prove to have better influence towards safety on construction site because as during that stage a better visualization towards the site condition can be seen thus better visualization towards safety on construction site can be seen. Thus, any safety problem can be prevented easier. This involves systematically identifying hazards and risks and introducing mitigating design solutions that will meet the design requirements as well as create a safe work environment for the workers (Kamardeen, 2010).

Table 2. Frequency of Critical Stage.

Stage	Frequency	Percentage, %	Cumulative
Design Development	24	80	24(80%)
Construction Preparation	6	20	6(100%)
Total	30	100	

Table 3. Correlation of PtD Towards Design Stage.

		Paired Differences		
		Mean	**Std. Deviation**	**P-Value**
Pair 1	PtD effects (Better Planning) – Design Development Stage	-0.400	0.621	0.001
Pair 2	PtD effects (Better Visualization) – Design Development Stage	-0.367	0.615	0.003

3.3. Construction preparation stage

Table 4 shows that the relation for both elements are 0 showing that the data is statically significant (p-value<0.01). Thus, showing that the data suitable to be put inside the Construction Preparation Stage. The most recent studies on health and safety have been on the way visualisation can be used to integrate some of the problems encountered in managing by regulations and enforcement alone (Godfaurd & Abdulkadir, 2011).

In addition, in the study by Ku and Mills (2008) stated that Construction Safety Toolbox allows user to access hazard information related to specific activities, design features or project systems.

Table 4. Correlation of PtD Towards Design Stage.

	Test Value=0					
	t	df	Sig. (2-tailed)	Mean Difference	99% Confidence Interval of the Difference	
					Lower	Upper
Enforce Safety Guideline.	13.730	29	0.000	0.867	0.69	1.04
Provide Toolbox Meeting with Safety Officer	5.385	29	0.000	0.500	0.24	0.76

3.4. Construction preparation stage

Table 5 shows the relation between different component of construction stage towards reducing accidents. For the first pair (Safety Guideline – Prevent or reduce mishaps) and the second pair (Daily Report – Prevent or reduce mishaps) the result also show that the correlation is statically significant with p-value of 0.00 (p-value<0.01). Daily report is very important as it can help to keep track of all the accidents that occur and can increase awareness of workers towards safety. It can draw attention of the workers to the possible hazards that will happens when works and take precaution on it before the accidents happens (Liy et al., 2016).

In the third pair (Toolbox Meeting – Prevent or reduce mishaps) the result also shows that the correlation is statistically significant with p-value of 0.00 (pvalue< 0.01). Toolbox is a very important tool to provide a better safety implementation on construction site. In a study conducted by Liy et al., (2016), stated that most of the respondents in their research strongly agreed that commitment of management and supervisor and tool box safety meeting are effective to reduce fall accidents.

Table 5. Correlation of Different Variable Towards Reducing or Prevent Accidents.

		Paired Differences		
		Mean	Std. Deviation	P-Value
Pair 1	Daily Report – Prevent or reduce accidents or mishaps	-3.433	0.568	0.000
Pair 2	Safety Guideline – Prevent or reduce accidents or mishaps	-3.533	0.571	0.000
Pair 1	Toolbox meeting – Prevent or reduce accidents or mishaps	-3.600	0.498	0.000

4. Conclusion

Construction industry has always been one of the most industries that give a high rate of accidents. By using Prevention through Design (PtD), the safety on construction can help to reduce the accidents rates at construction site. From the benefit form using BIM, it shows that BIM also can help increase the safety on construction site thus reducing the accident that occur at site. By using PtD and BIM, the framework that being develop can help further increase the safety in Malaysia construction site. The framework develop can also help in identifying problems at construction site earlier, at such prevention towards accidents can be implemented. This will help the safety of the worker are ensured making the accidents rate to decrease.

BIM also hard to be implemented especially towards local contracted that are not ready to apply BIM that need additional training added with the software need substantial amount of money to purchase. With majorities worker in construction industry that not understand BIM has also caused the data collection to be hard as most of them also avoid to answer it.

The framework is still in early development due to most of the respondent is lack in knowledge toward BIM itself. Further study needs to be done to see the difference in accidents that occur in construction site and how to best to provide solutions in order the safety can be guaranteed

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QLASSIC as An Improvement Tools for IBS Project in Northern Malaysia

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Abstract

Quality Assessment System in Construction (QLASSIC) has been introduced by Construction Industry Development Board (CIDB) in 2006 in order to improve and maintain the quality performance in construction industry by assessing the quality of workmanship in construction project. Meanwhile in the context of quality, the Industrialized Building System (IBS) is highlighted to be the best method of construction system that providing a better quality performance comparing to conventional system. As both systems are link towards a better quality construction, the implementation on QLASSIC in IBS projects are expected to raise the quality in all aspect. Hence this study is intended to study on the implementation of QLASSIC as improvement tools for IBS projects in northern areas in Malaysia. IBS projects that has been assessed by the QLASSIC assessor were selected as the sample of study. Based on the findings, the respondents are satisfied with the implementation of the QLASSIC systems towards IBS project thus it can be concluded that the QLASSIC system is suitable to be used as improvement tools in IBS project.

Keywords: Industrialized Building System (IBS), Quality management, Quality Assessment System in Construction (QLASSIC)

1. Introduction

Quality Assessment System in Construction (QLASSIC) was introduced by Construction Industry Development Board (CIDB) in 2006 in order to assess the workmanship's quality of the construction project by using Construction Industry Standard, Quality Assessment For Building Construction Works (CIS 7: 2014) as a guideline. The workmanship's quality performance is determine based on QLASSIC Scoring that are assess by the qualified assessor appointed by CIDB. In the International Organization for Standardization (ISO), the management of quality is stated in ISO 9001 QMS which is consists of important standard that can help in producing an adequate and establish a quality system in producing a product or services (Keng & Zainul Kamal, 2016). The adaptation of IBS in construction has been proven to help promoting the efficient, safe, clean and cost-effective work environment (CIMP, 2007). Hence, promoting the QLASSIC in IBS projects is important to encouraging this initiative. As the IBS are known as one of the construction systems that provide high quality of construction product, the application of QLASSIC are realistic in order to assess the quality of workmanship. This has been generally agreed by (Che Ali et al., 2012) where the QLASSIC can be classified as one of the improvement tools to improve and maintain the IBS quality management. In some circumstances, there are also a risk in IBS such as technical risk and quality risk that can cause aesthetic and functional defects such as cracks, blemishes of moisture penetration and poor thermal insulation in completed buildings. (Hassim et al., 2009). Therefor this study has been carried out in order to study the QLASSIC implementation in IBS project in northern areas.

2. QLASSIC Assessment

In this modern era, the sustainability and quality of product and services become an important and concern factor to be considered for development in construction industry. The sustainability in construction consist a few of element which are protecting environment included social, economy and quality (Che Ali et al., 2012). In order to produce an excellent quality of output, the systematic quality management need to be applied in construction project. CIDB has develop a few programs that promoting a quality in construction industry which is QLASSIC and IBS (Che Ali et al., 2012).

The QLASSIC assessment is based on the rating system and is conducted by trained invidu alswho are also known as QLASSIC assessors. During the QLASSIC evaluation, there are ma ny elements in the design of the building which these assessors may examine or evaluate by using specifics tools. The developer must ensure that the building workmanship is on a good quality as the first assessment will be the final QLASSIC score. This is to highlight the motto of QLASSIC which is "Doing things right the first time and every time". Thus, in this assessment involved four categories of building which is stated as Table 1.

Table 1. Four categories of building assessed by QLASSIC. (CIDB, 2014)

Category	**Description**
Category A (Landed Housing) Category B (Stratified Housing) Category C (Public/ Commercial/ Industrial Building without Centralized Cooling System) Category D (Public/ Commercial/ Industrial Building with Centralized Cooling System)	Detached, Semi-Detached, Terrace and Cluster House Flats, Apartment, Condominiums, Service Apartments, Small Office Home Office (SOHO), and Town Houses. Office Building, Schools, Factories, Warehouse, Workshop, Hangers, Small Office Flexible Office (SOFO), Small Office Virtual Office (SOVO), Religious Buildings, Stadiums, community Halls, Hospitals, Airports, Universities, Colleges, Police Stations etc.

2.1 Relationship between Quality Assessment System in Construction QLASSIC and Quality Management System in Construction (QMS)

Based on the CIS 7:2004, the Quality Assessment System for Building Construction Works (QLASSIC) is an assessment system that measures and evaluates the workmanship quality of a building construction work. It was an assessment that evaluate the performance of contractor based on their quality of workmanship in construction project. (CIDB, 2014.)

From CIS 7:2004, QLASSIC is produced and develop objective of QLASSIC to enable user to achieve it, which is:

i. To benchmark the level of quality of the construction industry in Malaysia
ii. To have a standard quality assessment system for quality of workmanship of
iii. building projects
iv. To assess the quality of workmanship of a construction project based on CIS 7 Standard
v. To evaluate the performance of contractor based on quality of workmanship
vi. To compile data for statistical analysis

Basically, the Quality Assessment System for Building Construction Work cover four (4) main components that is stated as Table 2.

Table 2. Four Main Components in Quality Assessment System. (CIDB, 2014.)

Structural Work	**Structural Work Architectural Works**	**Mechanical &Engineering (M&E) Works**	**External Works**
Reinforced concrete structure (carried out during construction of the building project	Internal finishes -floor, internal wall, ceiling, door, window and fixtures. External finishes -roof, external wall, apron and perimeter drain and car park	Electrical works Air conditioning and mechanical ventilation Plumbing and sanitary works Basic M&E fittings Fire protection	Link-ways External drains Roadwork and parking bays on the ground Footpaths

Based on this standard, the best workmanship quality performed by developers and contractors in quality of workmanship will be awarded with QLASSIC performance score which is the total summed up of marks to give a total quality score (%) (CIDB, 2014). The weightage for the overall component that stated before allocated in accordance to four categories of buildings as in Table 3.

Table 3. Allocated of Weightage for Components of Building Construction Works According to Building Category. (CIDB, 2014)

	Residential Building		*Non-Residential Building*	
Component	Category A (Landed Housing) (%)	Category B (Stratified Housing) (%)	Category C (Public/Commercial/ Industrial Building) (%)	Category D (Public/ Commercial/ Industry Building) (%)
Structural Works	15	20	20	20
Architectural Works	70	60	55	50
M&E Works	5	10	15	20
External Works	10	10	10	10
Total score	100	100	100	100

3. Methodology

The scope of study for this research are limited on the IBS projects that already being assessed by the QLASSIC assessor. There are two types of building categories include in this samples; Type A is landed housing and type B is stratified housing. These IBS projects varies in different IBS components. The QLASSIC score achieved by the projects are between 67 to 78 as shown in Table 4. All contractors involved in this project are in G7 class.

Table 4. IBS Projects in Northern Area.

No.	*Building category*	*IBS Component*	*Contractor gred*	*Gross Floor Area*	*QLASSIC Score*
1	A	Conventional & IBS	G7	63,323.37 m2	67
2	B	IBS (80% IBS Component)	G7	49,943.00 m²	78
3	A	IBS (50% IBS Component)	G7	10,481.00 m2	72
4	A	IBS (20% IBS Component)	G7	14,840.00 m2	71
5	A	IBS (28.5% IBS Component)	G7	14,731.20 m2	78
6	A	IBS (50% IBS Component)	G7	24,216.02 m2	68

There are 2 sets of questionnaires which are different in terms of type of respondents. First set is given to contractors and Developer involved in the IBS projects mention in Table 4. The questions include three sections:

i. Section A - Respondent’s Background
ii. Section B - Level of knowledge and practice of QLASSIC
iii. Section C – The implementation of QLASSIC in IBS project

The second sets are given to Panel expert and QLASSIC Assessors. This sets questions consist of two sections:

i. Section A - Respondent’s Background
ii. Section B - The implementation of QLASSIC in IBS project

4. Result and Discussion

4.1 Implementation of QLASSIC in IBS project by Developer and Contractors

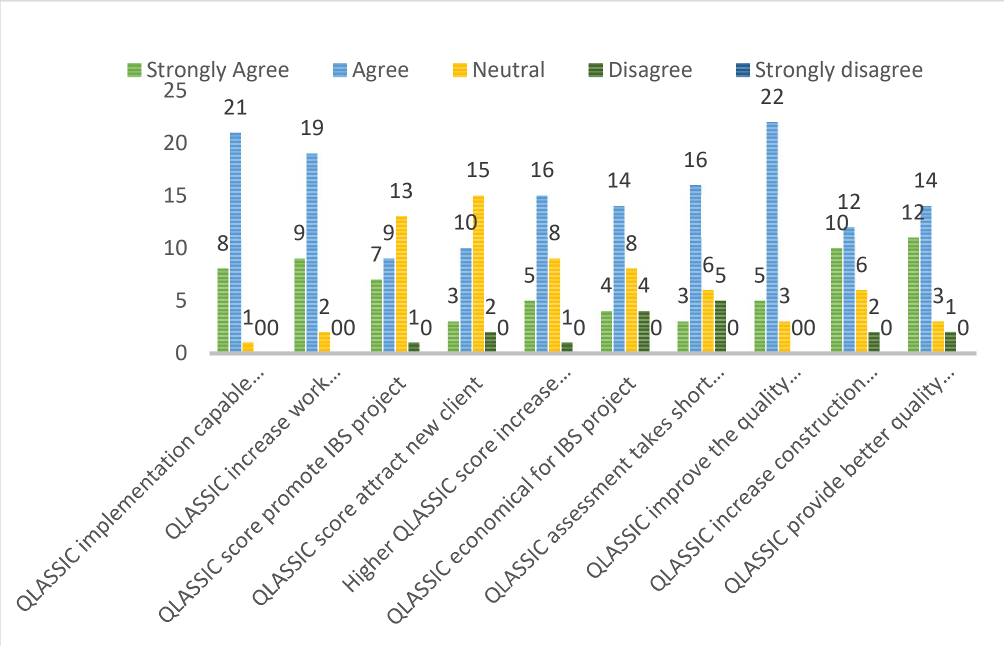

Fig. 1. QLASSIC Implementation in IBS Project by Developer and Contractors.

Figure 1 shows the overall results regarding the developers' and contractors' feedback on QLASSIC implementation. 70% of the respondents has agree about the capability of the QLASSIC implementation to evaluate the workmanship performance of the contractor and developer in IBS projects.

63.3% of the respondent also agree with the implementation of QLASSIC assessment helps to increase work productivity in IBS project. The productivity of work in IBS project is an important element since the IBS is the system that offers a quicker project completion compare to conventional system. However, 43.3% of the respondents indicates the 'Neutral' answer on the QLASSIC score helps in promoting IBS project. There is a possibility that this feedback may came from the perception of the respondents about the high quality production of IBS projects is already enough to promote IBS system.

50% of the respondents respond 'Neutral' regarding the QLASSIC score can helps in attracting new client. The low awareness and knowledge of the customer about the implementation of QLASSIC system in Malaysia may leads to this result. Some clients are unaware on the QLASSIC assessment especially for those who have lack of knowledge in construction issues. 53.3% of respondents has agree on the statement that the higher QLASSIC score increase the client's satisfaction. Based on this result, it reflects that most respondent has agreed that QLASSIC score can be used as a medium to investigate the level of client's satisfaction.

46.6% of respondents has agree that QLASSIC is economical for IBS project. 53.3% of the respondent also agree that QLASSIC assessment takes less time since the assessment of QLASSIC was conducted by qualified and trained assessor.

From Fig. 1, it states that 73.3% of the respondents has agree about the implementation of the QLASSIC system will improve the quality performance of the IBS project. The IBS system was a system that always prioritized a higher quality of product. However, there are also a potential of minor defect to be occur, especially during the assembled of components. The joints and connections of the components are sensitive towards an error and sloppy work, thus the implementation of QLASSIC system can helps to improve the quality performance of IBS project especially in finishing work. 40% of the respondents was agree on the QLASSIC will increasing construction build rate and 46.7% of them also agree on QLASSIC provides a better quality management in IBS project.

4.2 Implementation of QLASSIC in IBS project by Panel experts and Assessors

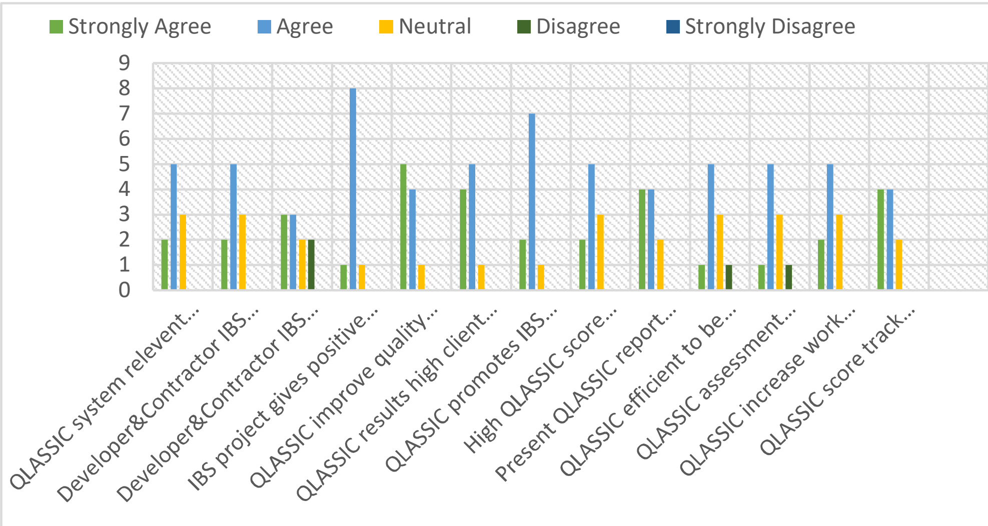

Fig 2. QLASSIC implementation in IBS Project by Experts Panel and Assessors

Figure 2 shows the overall results on the Experts Panel and Assessor feedbacks regarding the QLASSIC implementation in IBS project. 80% of the respondents agree that previous IBS project gives a positive outcome towards QLASSIC implementation. Through this result it can be seen that implementation of QLASSIC system was gradually being accepted among construction practitioners.

In perspective of an Assessor and Expert Panel, the QLASSIC system do helps in promoting the IBS project. This can be seen from Figure 2 that stated 70% of the respondent is agree on this statement. 70% of respondents agree that high QLASSIC score increase the marketability of building in IBS projects. The high quality of the product is the main elements that client needed. In addition, most of the client will include the QLASSIC score as the criteria of building's selection. 50% of the respondents agree that QLASSIC score track records is used as the criteria in selection of potential contractor. The high QLASSIC score of contractors from previous project, may broaden the opportunity of the contractor in gaining new projects.

80% of respondents has agree that the present QLASSIC report assist industry players to identify the area improvement in IBS project. From this result, it can be seen that QLASSIC assessment give an opportunity for the industry players to review and improve their quality of workmanship.

5. Conclusions

As for the conclusion, both developer and contractors are satisfied with the implementation of QLASSIC in IBS projects. While both assessors and panel experts agree that previous IBS project gives a positive outcome towards QLASSIC implementation. With this outcome, the implementations of QLASSIC and IBS projects has also helped to increase the marketability of IBS projects.

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