Green and sustainable median on a divided multilane highway

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Abstract. The road system in Malaysia showed good growth with increasing number of vehicles on the road. However, statistic of road accident is still at an alarming rate. There are many factor can contribute to the occurrence of an accident. If the accident was caused by road facilities such as street furniture, it is shown that the street furniture was failed to improve the safety of the road users. In this study, a new concept of materials for the construction of road dividers was purpose. The sustainable materials such as laterite soil, Cow Grass, tires and PVC pipes was used to replace the cement and iron guardrails in road divider construction. The main objectives of this study is to design characteristics of a road divider using natural material such as laterite soil, sand, grass and recycle material like used a tyre. A series of experiments such as test liquid limit, plastic limit test, standard proctor test and observations of root growth in 30 days were conducted. The result shows that the plastic index value of 35% was obtained. From the proctor compaction test, the optimum water content was 23% and maximum dry density at 15.3 kN/m^3. This value was used to build a prototype of green and sustainable raised road median. The suitability of sand used as the medium in irrigation system was approved. Permeability of sand is 10^{-2} mm/s to 10 mm/s which is having a high rate of flow. The growth of Cow Grass roots was increased by 4.9 cm in 30 days. This shows that, the grass is suitable to grow in laterite soil and can be used as vegetation material. Through the impact test conducted on a model with a scale of 1:7.5, indicate the initial damage occurred when a force reaches 10N. However, the condition of the model is still stable. From the impact test conducted, the prototype of green and sustainable raised road median has a good potential to be used as existing road divider as it can absorb the impact of an accident.

1. Introduction

There are a many causes of accidents such as negligence of drivers, slippery road surfaces, weather factors and there are also some accidents due to the roadblocks. Road barrier function of protecting the driver is in an unsatisfactory level [1]. In the event of road accidents occur on the existing road divider, it will help reduce the acceleration of the vehicle is either slowly (rubbing) or dramatically, which will result in greater impact [2]. Therefore, the study of innovation on green and sustainable raised road median at multi-lane highway is conducted to determine the effectiveness in replacing the existing road divider.

Innovation on the material used to build a road median is to reduce the level of accidents and injuries. The use of cement and guardrails are replaced with laterite soil. A rigid surface such as concrete dissipate almost no kinetic energy than a soft surface such as plastic is ground to dissipate the kinetic energy [3]. The use of concrete and steel in building a road divider rail will not only have a

negative impact on the environment [4], but it does not have the aesthetics. Green landscape on the road would reduce pressure on road users [5].

This study is expected to help reduce maintenance costs. The material is made up of laterite soil. Laterite soil easily found in Malaysia and the tropical region. Furthermore, the use of laterite soil could also reduce the use of cement and steel. In the process of cement preparation, cement dust and gas that contribute by cement factories that cause pollution and ultimately affect human health [4].

2. Materials and methods

In this study, the existence of road divider was studied in terms of material and structure. This information is obtained from the Public Work Department Guidelines *Arahan Teknik (Jalan)* 1/85. There were no such type of sustainable for road median and barrier to be referred. Therefore, the green and sustainable raised road median is proposed and to be designed.

2.1. Green median conceptual design

Height of guardrails that commonly applied in Malaysia is about 600mm to 800mm according to *Arahan Teknik (Jalan)* 1/85. This range of height is applied in the design of green and sustainable raised road median. The vertical drainage system is 12 feet help to channel the water directly into the subgrade. The most suitable diameter is between 150 mm to 200 mm. The pipe is placed at a distance of 900 mm between each other (see figure 1). The use of sand in irrigation systems is a good choice because sand can be a separation medium by eliminating unwanted particle or material with good flow rate. The permeability of the sand is 10^{-2} mm/s to 10 mm/s. This value indicates that the sand has good water flow properties [6].

The focus of this study is to investigate suitable design to build raised road median using laterite soil. Some of the tests carried out on the laterite soil characteristics and the extent of soil suitability for the construction of this road divider. Type of grass that used was a Cow Grass and it has strong root suitability. The Cow Grass as vegetative material is durable and has a strong grip to avoid the grass from out rooted if an accident occurs at the raised road median. The function of grass is also to help maintaining the shape of the raised road median.

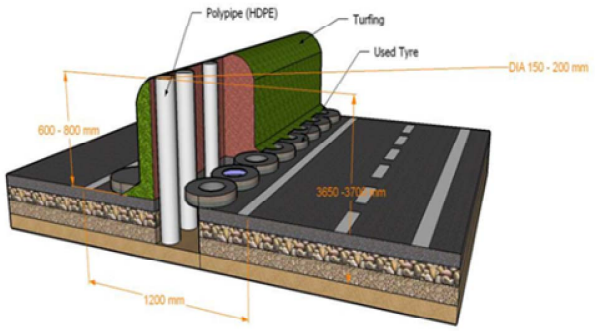

Figure 1. The design concept of the green and sustainable raised road median.

2.2. Testing the suitability of laterite soils

In order to determine the suitability of laterite soil that are used to construct the green median, a few experiments are conducted. To know the plasticity characteristic of the laterite soil, atterberg test was conducted according to the British Standard 1377: Part 2: 1990. The value of plastic index will indicate the characteristic of laterite soil. Other than that, standard compacted are conducted based on

BS 1377: Part 4: 1990 to know the optimum water content. The optimum water content will be used in the construction of green and sustainable raised road median prototype.

2.3. Impact test on the median

To determine the effectiveness of green and sustainable raised median, an impact test is designed by using the pendulum swing theory as applied by Virginia Technology [7] as shown in figure 2. In the impact test, the median strip of the green model and sustainable was built in scale 1: 7.5 to facilitate the impact test are conducted. A small scale model was built due to lack of equipment to conduct impact tests on prototypes and sustainable green median strip in figure 3. Heavy pendulum that is released is equivalent to the power provided by a train at a certain velocity, in this test which used the pendulum weight was calculated using the following formula.

Figure 2. Impact test conducted by Virginia Technology [7].

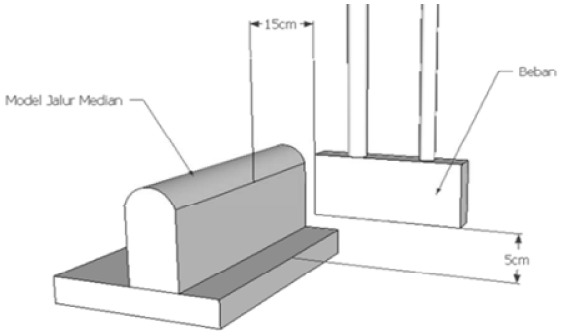

Figure 3. Impact test on small scale model.

2.4. Observation on the growth of cow grass

Suitability of grass that used as vegetative in the construction of green and sustainable raised road median are determined by observing the growth of the Cow Grass's root in 30 days. Previous studies done by planting grass type Axonopus Compressus in a cylindrical container which has a diameter of 18cm and height 40cm. In this study, the grass is planted in sandy loam soil (see figure 4). The length of the root measure and observe in 360 days. The growth of root at the end of this experiment of the previous study is 35cm [8].

The same observation is made for the development of grass roots within 30 days. The grass was planted in the laterite soil, in a cylinder container which has a diameter of 7.5cm and a height of 15cm. According to previous studies, the length of the Cow Grass root within 30 days can reach 5cm to 10cm. At the end of this experiment, the pattern of growth of grass can be observed. In addition, the level of suitability of Cow Grass grown using laterite soil can be determined.

Figure 4. Cow Grass is planted in a container.

3. Results and discussions

The results of laboratory analysis have been derived from the liquid limit test, plastic limit test and soil compaction test. Each experiment was carried out to determine the properties of laterite soil that will be used to build a prototype of a sustainable road divider and sustainable. In addition, the results of crash tests conducted on prototypes divider are discussed. Subsequently, the observation of the Cow Grass root growth is conducted.

3.1 Atterberg limit test

This study is to design a raised road median using laterite soil. Therefore, plastic limit and liquid limit test are conducted to determine the laterite soil plastic index. The cone penetration method, the water content in the cone penetration depth of 20 mm was taken as the liquid limit. Based on the graph that has been plotted, the liquid limit obtained is 60%. From the plastic limit test, the water content of each sample was recorded and the value of plastic is the limit is 25%. Then, the value of the Plasticity index obtained is 35%. In addition, the proctor test on soil is conducted to obtain the optimum moisture content of 23% and maximum dry density at 15.3 kN/m^3. The percentage content of water is used in the construction of this prototype green and sustainable raised road median.

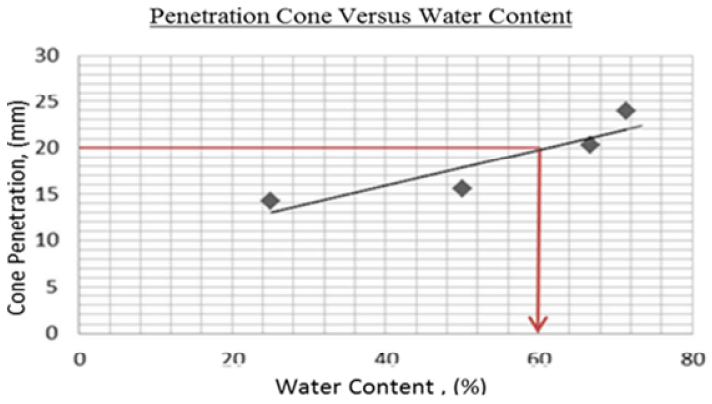

Figure 5. Graph of penetration versus water content.

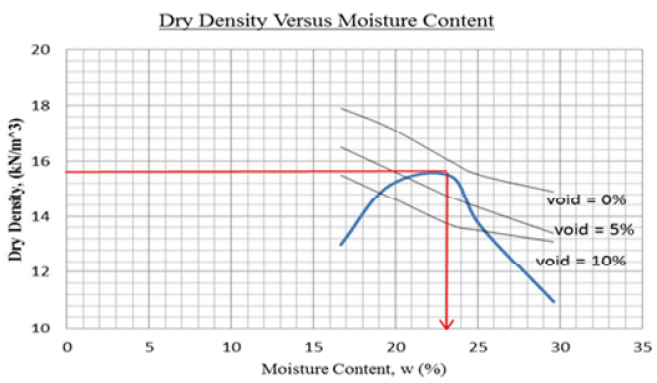

Figure 6. Graph of dry density versus moisture content.

3.2 Impact test on model (1:7.5)

From observation of the impact test, the smallest impact of 2.5kN did not show any damage to the surface of the model. Table 1 shows the damage occurs when the force of 10N imposed on the model (1:7.5). Damage that occurs at the third layer which is the layer compacted at a percentage of 19% water. Weight 20 kg, which is used on a small scale model (1:7.5) is equivalent to the weight of the pendulum 150kg levied on the real size raised road median (1:1). Therefore, it can be estimated at 150 kg weight resulting is 10N. The initial damage occurs at the green and sustainable raised road median when the force of 10N imposed on the model (1:7.5) in Figure 7. This damage is not serious and can be treated with appropriate because planting grass vegetative material, can help to protect the soil surface.

Table 1. Result of impact test.

Weight, (kg)	Accelaration (m/s^2)	Force (kN)	Condition of Model
5	0.5	2.5	Stable
10	0.5	5	Stable
15	0.5	7.5	Stable
20	0.5	10	Small Damage

Figure 7. Damage on the model (1:7.5).

3.3 Observation on cow grass growth

The grass is allowed to grow in a plastic container. After 14 days, the lawn is fertilized in order to speed up the grass growth. On day 30, the grass is removed and the length of the root length is

recorded. Figure 8 shows the grass roots have grown up to 12.3 cm on the 30th day. The grass roots growth increased by 4.8cm from the initial day.

(a) Initial day (b) After 30 days

Figure 8. The root pattern on first day (a) and after 30 days (b).

Referring to previous studies, on day 30, the length of the roots of Cow Grass is 5cm [8]. The length of Cow Grass roots that planted in sandy loam soil in this previous study is similar to the growth of the grass on laterite soils. Therefore, the length of the roots of the Cow Grass planted in the laterite soil has potential to grow up to 35cm in a year as has been stated in previous studies. Furthermore, after 30 days, the roots patterns of the Cow Grass (b) have extended compare with the roots pattern on the initial day (a). This helps the grass to the ground with a stronger grip [8].

4. Conclusion

In conclusion, the objective of this study was achieved. Material such as laterite soil is a suitable material to build Green and sustainable raised road median. The structure of the green and sustainable raised road median is stronger by using PVC pipe and tire as additional material. In addition, Cow Grass is a suitable for as covering material to maintain the shape of the raised road median this kind of grass has a good pattern of growth. Based on the impact test was conducted on the model, this study has a high potential in achieving the objectives of the study. While medium irrigation bleak sand can serve to isolate unwanted substances.

5. References

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