THE DEVELOPMENT OF SOLAR DELINEATOR FOR ROAD SAFETY IMPROVEMENT

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ABSTRACT

Solar Delineator is an instrument innovated from a current delineator as a tool to assist road user when driving in the dark, heavy rain and haze. This research produce an eco-friendly device for clearer vision of the driver when driving and evaluated the Solar Delineator effectiveness with the normal roadside delineators when in the dark area. It was used the solar concept to store the energy and distribute to light-emitting diode (LED) bulb. The light from the device brightly shows the route of the road. The main material used is an eco-friendly material such as recycled Polyvinyl Chloride (PVC) and LED light for more energy efficiency and solar were convert sunlight into electricity. The test conducted for measuring the light intensity using Thermal Comfort Multi-Station (TCM) at Federal Route 1: 30, Jalan Gopeng, 31610 Gopeng, Perak. In this study, a survey carried out between the road user and Malaysian Public Works Department (PWD) expert on the effectiveness of the Solar Delineator device. The intensity reading from TCM is less than two (2) which is acceptable for human vision. The result of study reveals that respondents agreed 'This device does not interfere with your view while driving (glare)' show by mean score in between 2.34-3.67 that acceptable. These findings appearance that solar delineator more economical and environmental friendly by using recycle material as the body of the device compare to the current delineator.

Keywords: solar delineator, eco-friendly, energy efficiency

1. Introduction

Delineators are tall pylons mounted on the road surface, or along the edge of a road, and are used to channelize traffic. These are a form of raised pavement marker but unlike most such markers, delineators are not supposed to be hit except by out-of-control or drifting vehicles. Delineators are tall enough to influence not only a vehicle's tires but also the vehicle body itself. They usually contain one or more reflective strips around and open in the center or curved of plastic with a reflective strip. They are also used in low reflective markers in an "I" shape. They can also be used to indicate lane closures as in cases where the number of lanes is reduced. The name delineator is also used for reflective devices attached to other objects which are technically not pavement markers.

A road is a thoroughfare, route, or way on land between two places that has been paved or otherwise improved to allow travel by foot or some form of conveyance, including a motor vehicle, cart, bicycle, or horse referred from Organization for Economic Co-operation and Development (OECD), 2004. Nowadays, Road is very important for transporting the goods and people from place to another place. With this, it also need to include a road furniture for road users to reduce the number of accident. The dividing line between minor and serious accident however is blurred. As it has been defined, the accident would rarely give warning although reckless drivers should anticipate the consequences of their recklessness. In general, accidents do not just occur on road furniture only; they are brought by human recklessness, carelessness or negligence (Arafat Suleiman Yero et al., 2015).

The relationship of vision and oculomotor response (visual-motion) is very important. The reaction of braking, cornering or avoiding an oculomotor reaction. The contrast between the object and the background is also important when driving, especially when it is raining or driving at night. Imagine when driving at dark area, suddenly a buffalo crossing. Driver hardly to see the buffalo at dusk because of the contrast between buffalo and lead to a decline dusk buffalo is even difficult to see the big buffalo. Good contrast allows the driver to easily see an object (M. F. Basar et al., 2013).

Moreover, the presence of rain, fog and haze makes the driver's task more difficult. These weather conditions reduce driver perception in several ways and is especially debilitating at night. It both directly affects perception but also produces visibility changes through its action on headlamps, windshields, the road itself and road markings. The impacts of adverse weather conditions on the road network operation have been recognized since the middle of the twentieth century due to the various driver behaviors. These include increased risk of accidents, delays, more hazardous driving conditions and general flow disruptions. In Malaysia, rainfall is a natural phenomenon that occurs nearly every month per year with average recorded rainfall of 2409 mm in a year and 200 mm in a month. The copious rain is influenced by seasonal wind flow patterns coupled with the local topographic features. Rainfall events may begin or end at any time of the day, occurring for a few minutes, hours or at interval for several days. The pouring intensity varies with time and space. The variability gives different impact to the drivers' visibility, driving comfort, pavement friction, and vehicle performance which contribute the speed reduction. Speed reduction caused by rainfall would affect the quality of road service (Nordiana Mashros, 2014).

The increase visibility for motorcyclist detection at night for the purpose of avoiding accidents using a simple circuit road. Referred from International Journal of Applied

Physics and Mathematics, accidents have caused huge losses to the country. It involves an injury, suffering and death but the histories of road accidents in Malaysia seem endless by according to (M. F. Basar 2013). Thus, the desire to travel safely and smoothly remains as the intention of the government and the individual road users. By using the device, researcher propose a visible light communication system so that the warning lights in the corner send appropriate warning information. Visible light communication transmits a signal by blinking the light. One of the characteristics of visible light communication is that it can use existing lighting equipment as a transmitter. This device could help to warn drivers through the road.

Problems often experienced by drivers is the ability to drive at night, have night blindness and severe weather such as heavy rainfall, haze and fog. These cause problems for drivers, especially at sub-urban areas which is lack of street furniture. Therefore, it might be dangerous to the road users. All street furniture has a reflector that bounces back light vehicles to provide clearer vision to the driver. However, when the vehicle lights did not work, it may cause difficulties for the drivers. These weather conditions reduce driver perception in several ways and is especially debilitating at night, haze and heavy rain. It directly affects perception but also produces visibility changes through its action on headlamps, windshields, the road itself and road markings. Therefore, this research is conducted to overcome this problem where by designing Solar Delineator device. The place been taken at Federal Route 1: 30, Jalan Gopeng, 31610 Gopeng, Perak. It involved the people who travel using this road.

*Figure 1.*Test location for Solar Delineator device (google maps)

2. Method

The procedure that applied for constructing this project as shown in Figure 2.

2.1. Design

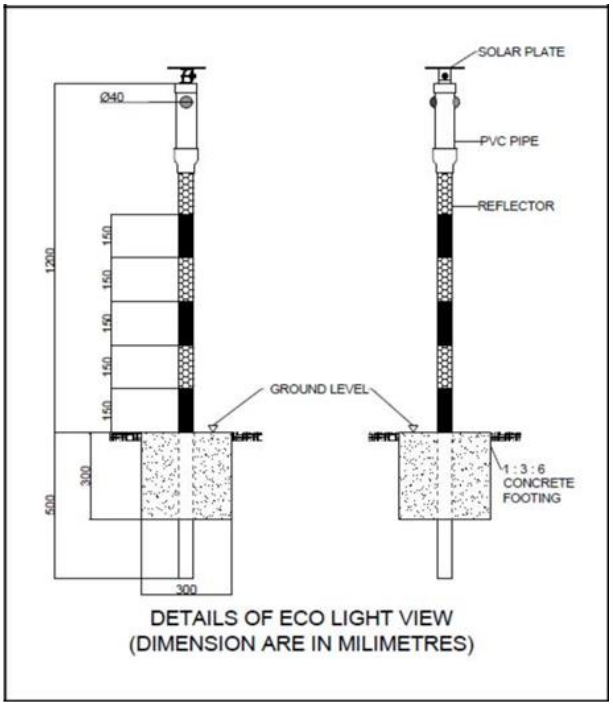

Figure 2. Solar Delineators Design

2.2. Product installations

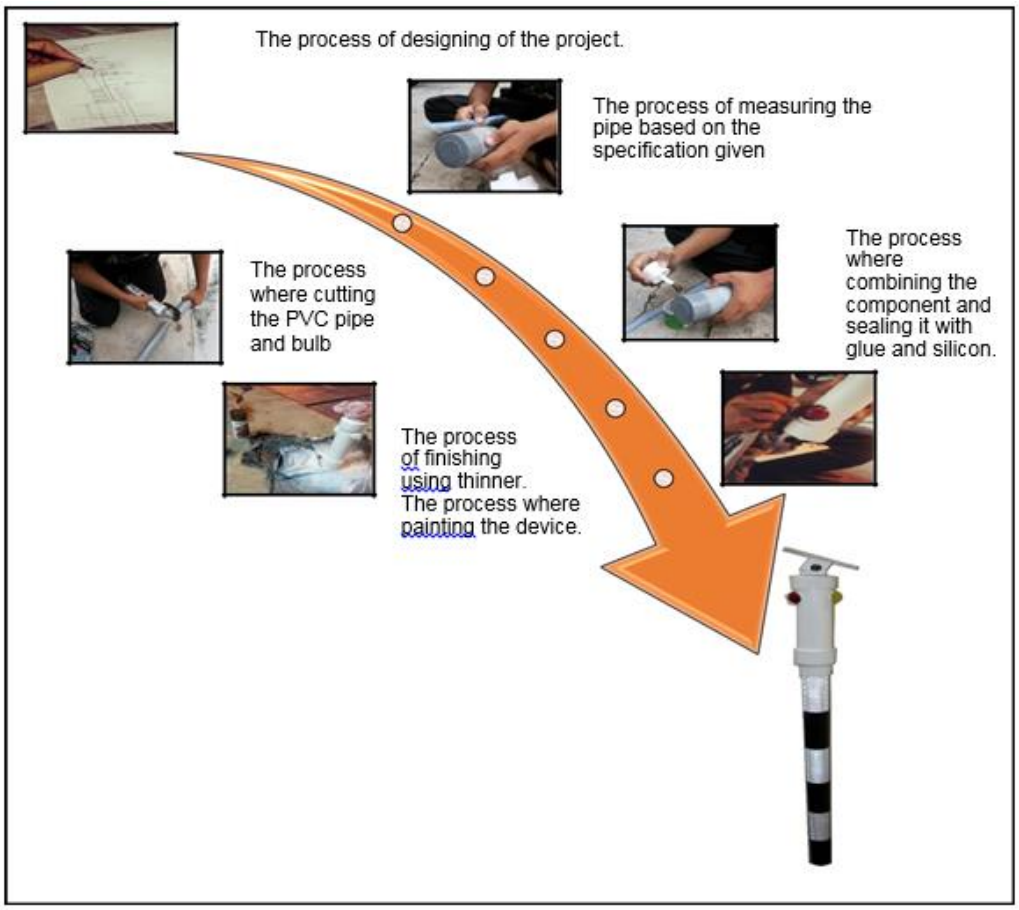

Figure 3. Solar Delineators Installation

Figure 3 show the installation of Solar Delineator process start from design until the prototype done.

2.3. Testing Instruments

In this study, solar delineator is designed and built by affordable and economy materials. Besides that, study were focused on the light transmitted to human eye in giving a clear view while driving. Thermal Comfort Multi Station is a device that consist eight sensors that can test the humidity, pressure, wind speed, ambient temperature, sound, globe temperature and luminance in area. In this study, only one sensor used that is luminance as shown in Figure 4. This is different than measurements of the actual light energy produced by or reflected from an object or light source. The lux is a unit of measurement of brightness, or more accurately, illuminance. It ultimately derives from the candela, the standard unit of measurement for the power of light. A candela is a fixed amount, roughly equivalent to the brightness of one candle. Luminance sensor works by using a photo cell to capture light. The thermal comfort multi station then converts this light to an electrical current, and measuring this current allows the device to calculate the lux value

of the light it captured. The value would be move into a notebook to be collect and analyst.

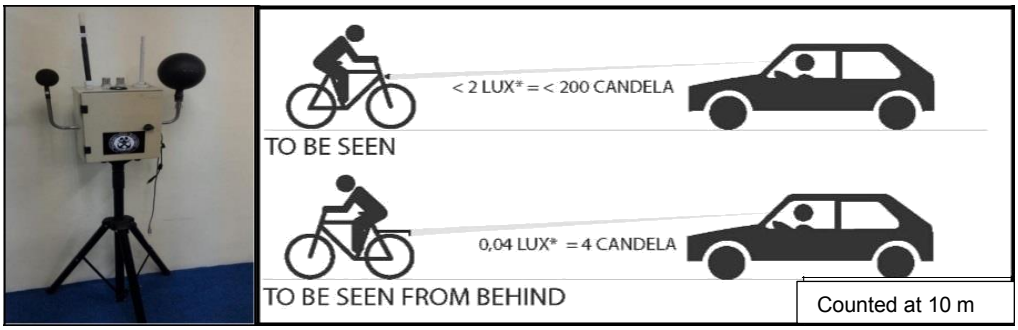

Figure 4. Thermal Comfort Multi-Station and Real Life Situation of Lux Value

2.4. Brightness test

This test was carry out by using Thermal Comfort Multi Station (TCM). The luminance sensor was measured the brightness of light comes from Eco Light View Device then the data should be analyst. This test is done to know the brightness of the device regard to the oversea specification allowed. The procedure of the TCM as shown in Figure 5 and Figure 6.

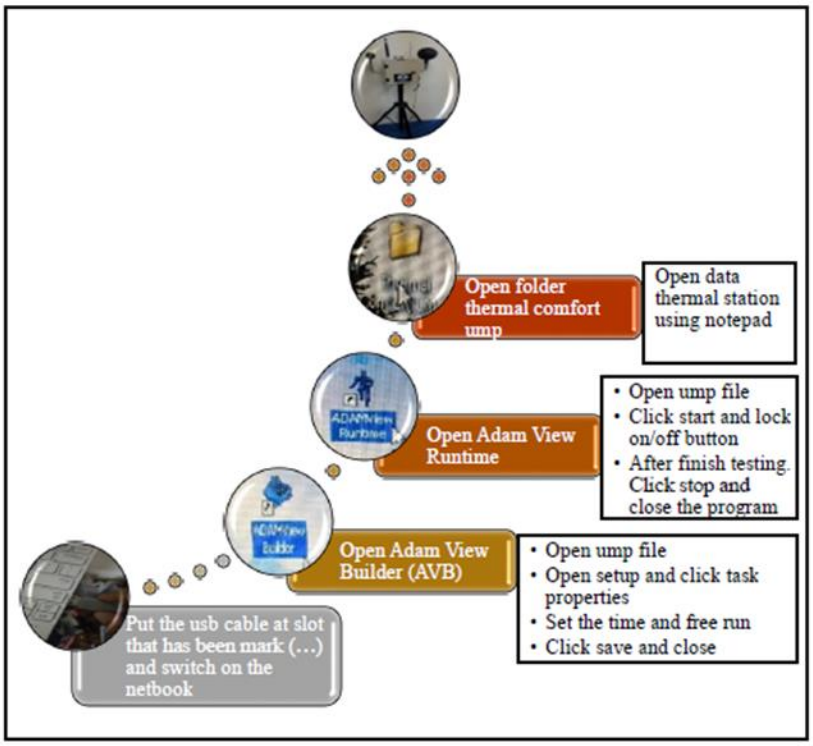

Figure 5. Thermal Comfort Multi-Station Procedure

Date/Time	ppm	RH	kPa	m/s	A Temp	dB	Lux		
Fri Sep 23 03:07:07 2016		868.438	74.371	100.576	0.043	30.256	45.120	-1.100	29.724
Fri Sep 23 03:07:10 2016		868.125	74.329	100.576	0.033	30.269	42.670	-0.600	29.720
Fri Sep 23 03:07:13 2016		867.813	74.755	100.544	0.027	30.294	43.290	3.400	29.712
Fri Sep 23 03:07:16 2016		867.188	75.319	100.544	0.029	30.306	42.800	-0.900	29.724
Fri Sep 23 03:07:19 2016		868.125	75.184	100.544	0.037	30.319	42.780	-1.100	29.728
Fri Sep 23 03:07:22 2016		867.500	74.700	100.576	0.044	30.294	43.380	6.600	29.724
Fri Sep 23 03:07:25 2016		868.125	74.326	100.544	0.046	30.294	42.860	-0.700	29.729
Fri Sep 23 03:07:28 2016		867.813	74.052	100.544	0.056	30.294	42.720	-1.100	29.726
Fri Sep 23 03:07:31 2016		867.500	73.842	100.576	0.089	30.287	42.520	8.200	29.733
Fri Sep 23 03:07:34 2016		867.188	73.910	100.544	0.099	30.281	42.510	-0.500	29.743
Fri Sep 23 03:07:37 2016		867.813	73.735	100.544	0.099	30.294	42.480	-1.000	29.733
Fri Sep 23 03:07:40 2016		868.125	73.687	100.544	0.087	30.287	42.750	-1.000	29.731
Fri Sep 23 03:07:43 2016		867.188	73.710	100.576	0.102	30.287	42.880	9.200	29.745
Fri Sep 23 03:07:46 2016		866.875	73.652	100.576	0.091	30.275	42.770	-0.100	29.750
Fri Sep 23 03:07:49 2016		866.875					43.710	-1.000	29.752
Fri Sep 23 03:07:52 2016		867.500					43.300	3.100	29.750
Fri Sep 23 03:07:55 2016		867.500					42.950	0.500	29.817
Fri Sep 23 03:07:58 2016		867.188					42.860	-1.000	29.769
Fri Sep 23 03:08:01 2016		867.188					42.820	-1.000	29.767
Fri Sep 23 03:08:04 2016		866.875					42.940	-1.100	29.750
Fri Sep 23 03:08:07 2016		866.875	76.145	100.544	0.056	30.294	42.970	1.800	29.746
Fri Sep 23 03:08:10 2016		866.875	74.845	100.576	0.059	30.300	42.600	-1.000	29.754
Fri Sep 23 03:08:13 2016		867.188	74.419	100.544	0.069	30.313	44.350	-1.100	29.752
Fri Sep 23 03:08:16 2016		866.875	74.077	100.576	0.084	30.300	42.960	1.800	29.758
Fri Sep 23 03:08:19 2016		867.188	74.000	100.544	0.095	30.294	43.240	-0.900	29.767
Fri Sep 23 03:08:22 2016		866.875	73.852	100.544	0.091	30.294	43.060	-1.100	29.758
Fri Sep 23 03:08:25 2016		866.875	73.977	100.544	0.087	30.300	43.610	4.800	29.781
Fri Sep 23 03:08:28 2016		866.875	73.842	100.544	0.073	30.294	43.120	-0.800	29.788
Fri Sep 23 03:08:31 2016		866.563	74.113	100.544	0.073	30.306	42.710	-0.800	29.771
Fri Sep 23 03:08:34 2016		866.563	73.935	100.544	0.080	30.306	42.910	-1.100	29.758
Fri Sep 23 03:08:37 2016		865.938	74.342	100.544	0.078	30.325	43.210	4.600	29.781
Fri Sep 23 03:08:40 2016		866.250	74.377	100.544	0.099	30.325	44.090	-0.600	29.784
Fri Sep 23 03:08:43 2016		867.188	74.052	100.576	0.099	30.313	43.100	-1.100	29.792
Fri Sep 23 03:08:46 2016		866.563	73.600	100.544	0.093	30.306	42.860	8.500	29.769

Lux reading are collect and analyse

Figure 6 Data from Thermal Comfort Multi-Station

3. Results

3.1. Product

Figure 7 show the final prototype of Solar Delineator device.

Figure 7: The Prototype of Eco Light View Device

3.2. Measurements result for testing using TCM

Data analysis was based on the experimental results and comparisons undertaken. All of the experimental and comparison was carried out on the Solar Delineator. The data for lux reading that been collect as shown in figure 8 are compared with Table 1 in order to identify the Solar Delineator device are acceptable or not to be seen by driver. The best 10 data from every 3 second have been selected because it does not have any limit of data and based on the apparatus that been used does not have any table or worksheet is based on the situation of the analysis

Date/Time	ppm	RH	kPa	m/s	A Temp	dB	Lux		
Fri Sep 23 03:07:07 2016		868.438	74.371	100.576	0.043	30.256	45.120	-1.100	29.724
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Fri Sep 23 03:07:58 2016		867.188	74.119	100.529	0.074	30.287	42.860	-1.000	29.769
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Fri Sep 23 03:08:46 2016		866.563	73.600	100.544	0.093	30.306	42.860	8.500	29.769

Figure 8: Data from TCM

Lux measurement (lx):

Table 1: LUX value result

Number	Reading(Lux)	
	Yellow	Red
1.	1.7	1.4
2.	1.4	1.3
3.	1.4	1.2
4.	1.4	1.4
5.	1.4	1.3
6.	1.8	1.3
7.	1.9	1.5
8.	0.9	1.4
9.	0.9	1.3
10.	1.5	1.3
Total	14.3	13.4

Result for data:

Average Yellow : 14.3/10 = 1.43

Average Red : 13.4/10 = 1.34

Based on the result that have been taken, the device reading of lux value average of yellow is 1.43 and red is 1.34. The lux value that needed is less than 2 Lux as shown in figure 4.3. Result were accepted because the lux value is below than 2.

3.3. Result from Road User

A questionnaire to the respondent selected to get data information needed and carried out by survey. The survey has been done to the road users at Federal Route 1, 30 Jalan Gopeng, 31610 Gopeng, Perak. Type of sampling techniques using is convenience sampling.

i. Demographic of road user

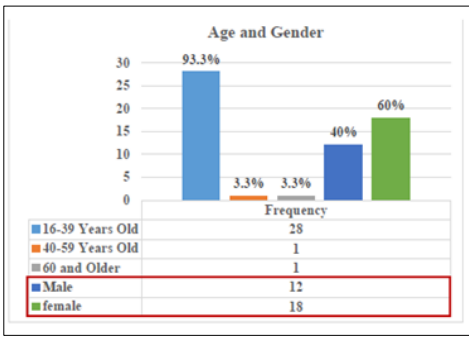


Figure 9: Age and Gender

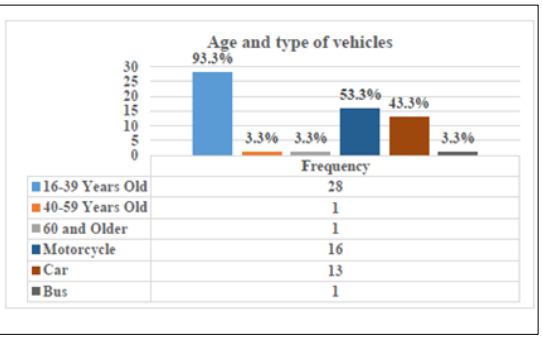


Figure 10: Age and Type of vehicles

The figure 9 show the demographic of road. The total number of respondent involved in the survey is 30 persons. It can be seen clearly the majority of the respondent in this survey is female which are 18 (40%) respondents. However, there is only 12(60%) respondents for male. Figure 10 show the frequency of 'Age and Type of Vehicles' of the respondent. The total number of respondent involved in the survey is 30 persons. The survey was undertaken at Federal Route 1, 30 Jalan Gopeng, 31610 Gopeng, Perak. It can be seen clearly the majority age of the respondent in this survey is 16-39 years old which are 28 respondents. However, there is only 1 respondent for 40-59 years old and 1 respondent for 60 and older. Next, the majority type of vehicle that respondents used in this survey is motorcycle which are 16 respondents. However, there is only 13 respondents that a using the car and one (1) respondent using bus.

3.3.1. Indicator Result and Standard Deviation

The result that has been taken is been valued based on the Table 2 whether the level of satisfaction is Low, Medium or High according to Mohd Salehin (2005), Wiersma (1995).

Table 2: Mean Score Interpretation

Average Mean Score	Level of Satisfaction
1.00 – 2.33	Low
2.34 – 3.67	Medium
3.68 - 5.00	High

Source: Mohd Salehin (2005), Wiersma (1995)

Table 3 and Table 4 shows that the mean and standard deviation by gender and by age, the mean and std. deviation by gender male who answer 'This device does not interfere with your view while driving (glare)' is 3.25, Standard Deviation 0.62. Furthermore, the respondent for female who answer this device meets the needs of road user is 3.39, standard deviation 0.50. Based on the two result that has been taken, the level of satisfaction is medium because it is in the range of 2.34-3.67.

Table 3: Mean and Std. Deviation by Gender

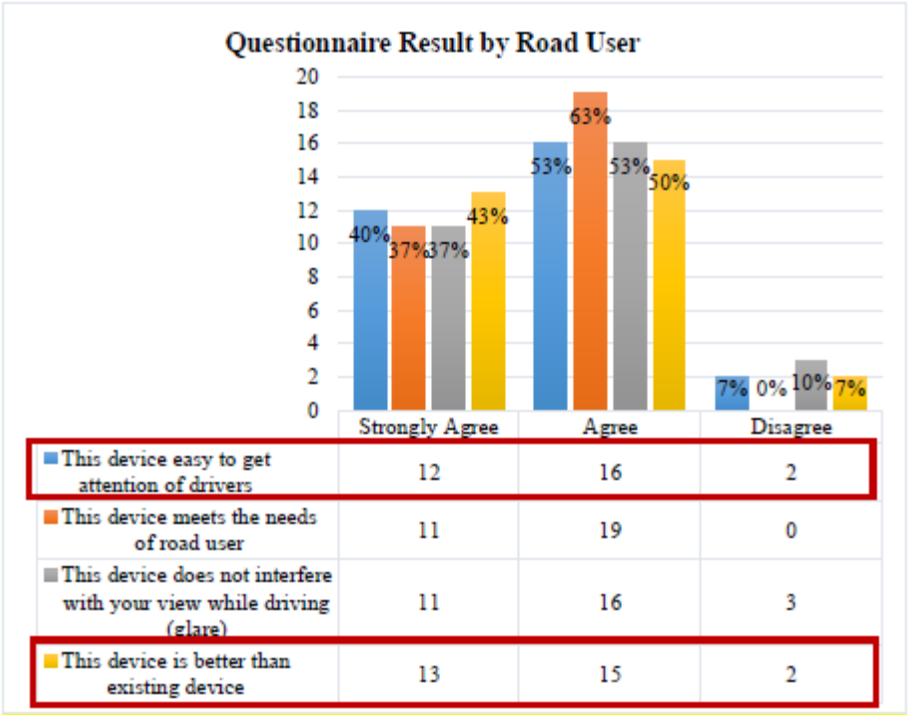
Indicator					
Gender	This device meets the needs of road user		This device easy to get attention of drivers	This device does not interfere with your view while driving (glare)	This device is better than existing device
Male	Mean	3.33	3.08	3.25	3.33
	Std. Deviation	0.49	0.67	0.62	0.65
Female	Mean	3.39	3.50	3.28	3.39
	Std. Deviation	0.50	0.51	0.67	0.61

Next, Table 4 shows that the mean and std. deviation by age 16-39 years old who answer 'This device meets the needs of road user' is 3.32 standard deviation 0.48 and for 40-59 years old who answer 'this device does not interfere with you while you are driving(glare)' is 4.00. Based on the result, the level of satisfaction by age 16-39 years old is medium and 40-59 years old is high. For the conclusion the result is acceptable because it meets the range of medium and high.

Table 4: Mean and Std. Deviation by Age

Indicator					
Age		This device meets the needs of road user	This device easy to get attention of drivers	This device does not interfere with your view while driving (glare)	This device is better than existing device
16-39 Years Old	Mean	3.32	3.36	3.21	3.32
	Std. Deviation	0.48	0.62	0.63	0.61
40-59 Years Old	Mean	4.00	3.00	4.00	4.00
	Std. Deviation	-	-	-	-
60 and Older	Mean	4.00	3.00	4.00	4.00
	Std. Deviation	-	-	-	-

The data in figure 11 shows that the questionnaire results of the respondents. From the data given, the number of respondents who agree for 'this device easy to get attention of drivers' is 16 (53%) and 12 (40%) for 'strongly agree'. Besides that, the number of respondent who answer agree for 'this device is better than existing device is 15(50%) and only 7% who answer disagree. This shows that the result is a positive respond from respondent. The conclusion is the majority say agree to all of the question that has been given.



	Strongly Agree	Agree	Disagree
This device easy to get attention of drivers	12	16	2
This device meets the needs of road user	11	19	0
This device does not interfere with your view while driving (glare)	11	16	3
This device is better than existing device	13	15	2

Figure 11: Result by road user

3.3.2. Result from Expertise

The data information needed were carry out by doing a survey and interview to the expert. The interviewed person that related to this field such as Engineer and Assistant Engineer in road section at Jabatan Kerja Raya (JKR). Type of sampling techniques using is Judgmental Sampling.

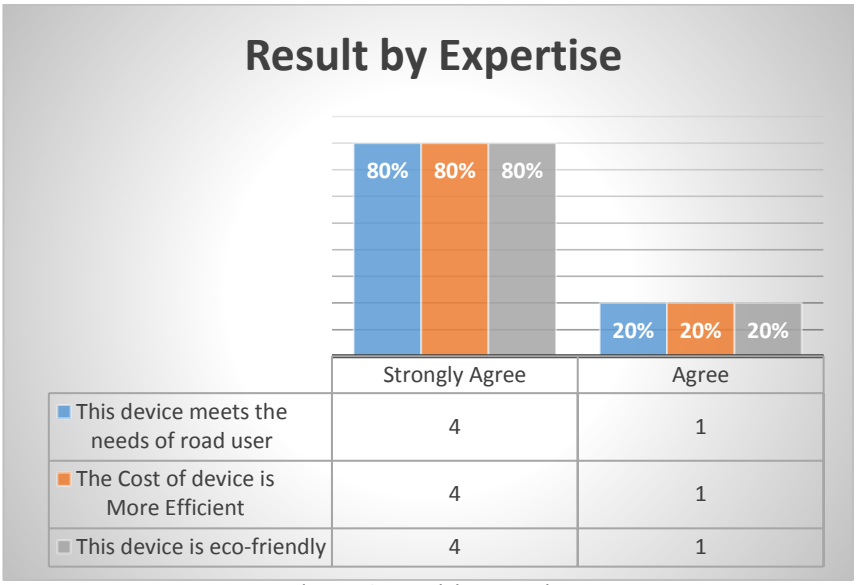


Figure 12: Result by Expertise

The data above shows that the questionnaire results of the respondents from expertise. From Figure 12, its show that the number of respondents who agree for 'this device meets the needs of road user' is one (20%) and four (80%) for 'strongly agree'. Besides that, the number of respondent who answer 'this device is eco-friendly' also four (80%) for strongly agree and one (20%) who agree. For the conclusion majority is answering strongly agree and no disagree. This means that the Solar Delineator device is acceptable.

4. Discussion

Based on the result from the finding, the effectiveness of the product has been shown. Furthermore, Solar Delineator is an environmental friendly product. This innovation also an alternative device designed to raise the ability of existing roadside delineators in improving the durability to reduce hazard among road user. It is modified by using lamp that generate with solar power to charge the battery.

The objectives of this project has been achieved. The data from testing show that luminance value of the product are acceptable. Moreover, it was hope this product outcome be able to give benefits to Jabatan Kerja Raya (JKR) by way of introducing a new modified roadside delineator. Besides that, it can help road users to be more comfortable because if the roadside delineators were unclear, it would cause problem to the visual of the road users. Hence, further research will concern on used materials and sensor with higher quality and widen the bulb cover to improve this product.

5. Conclusion

The result that have been taken for lux value the average of yellow is 1.43 and red is 1.34. The lux value that needed is less than 2 Lux so the analysis is accepted. Besides that, majority of the respondent have agreed in every question that have been asked. This make the conclusion of the device is a success.

In conclusion, through this research has been carried out there is a lot of knowledge has been obtained. There are many challengers against this research but the limitation being cope until this project excel. Moreover, through this study the exchange ideas and knowledge with a discussion beforehand to achieve the required objectives has been done.

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