

A Proposed Study of Using Solar Road Studs for The Improvement of Road Safety at Anao, Mexico Bypass Road

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Abstract: - Road accidents have been a serious issue in the Philippines over the time. As human lives are significant and so are the road, because this is where the economy lies, depends and continue. This study purposely did an extensive and massive search or assessments to find out how people evaluate their safety level on the road. The researchers aimed to propose the use of Solar Road Studs at the chosen location (Anao, Mexico Pampanga) to significantly contribute to the deplete of road accidents due to the different factors—lack of enough lighting during night time and poor weather condition, complexity of the four-lane road with sudden two-lane at both ends. As the research is being processed and assessed the researchers found out the assessment and evaluation of the road users as they are the primary participants of the study. Most of these participants find it uncomfortable and inconvenient to use or pass the road without enough lighting. These participants also prefer the installation of road studs to significantly contribute to the visibility of the road and lanes. The researchers also did a search and assessment of other place where road studs were already being used. Accidents data were gathered, and surveys were conducted to assess if there is a significance between before and after the installation and how it impacted the road users. And on the search, it was found out that road studs significantly contributed to the experience of the road users and to the depletion of road accidents. As a conclusion, the researchers found out that road studs are extensively important for the road users. Also, aside from the fact that it helps, it is also cost-friendly. Cost analysis was also done in this study and was found out that road studs doesn't demand higher expense than the other versions of road lights which are the traditional street lamps and solar street lamps.

Key Words: — *Road Accidents, Solar Road Studs, Visibility, Road Users, Cost Analysis.*

I. INTRODUCTION

Road safety has an important role in the road infrastructure since road safety pertains to minimizing or reducing road accidents. Therefore, the road user should always pay attention to the traffic control and signages in order for them to lessen the risks in traffic accidents and travel in a safe manner. Road

transport is the most complex and the most dangerous transportation system. According to Sethi et al., (2019) road accidents are one of the major causes of death, injury and disability in all over the world both in developed and developing countries. The future of road safety is uncertain and definitely not the same for all regions of the world (Wegman, 2017). Countries with a mature road safety approach and an ambition to make further progress are expected to move in the direction of a pro-active approach: a Safe System approach. There are factors that affect road safety. Most of all is the driver's behavior, it affects the driver such as inappropriate speed and distracted on the road while driving, which can lead to accident. Next is road condition, poor road conditions may impair mobility and cause the vehicle to fail to operate smoothly. And visibility, road visibility is a critical aspect in safe driving.

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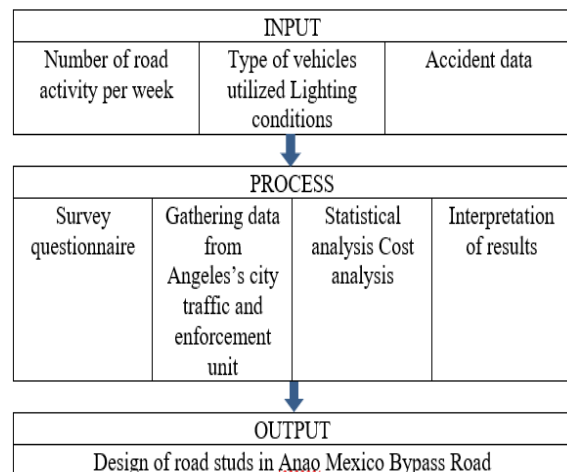
The ability to see the road clearly allows the driver to decide whether to speed up or slow down. Due to the complex environment created by interference lights around urban roads at night, the visual environment of vehicle drivers in a night-time environment is worse, and their recognition ability at night is significantly reduced compared with that in the daytime (Tian et al., 2021). Components to increase the visibility of road at night are streetlamps and road studs, the difference is streetlamps, they attached in the street post that gives light in their specific area where they are attached. While road studs are attached in the road pavement edges that gives pathway of light to the road. LED street lighting is being introduced worldwide to take advantage of the high efficacy, long lifetime, and cost effectiveness of LED light sources. It also provides the opportunity for further lighting infrastructure savings through dimming and adaptive light controls (Isoardi et al., 2018). The researchers have chosen to conduct research around the Anao, Mexico Bypass Road because the road is a four-lane road then suddenly the road will become 2 lanes in each both ends, and the said road has poor visibility at night because it doesn't have enough lighting and there is a possibility of high-risk accidents in that area, Since Anao Mexico is in the top 10 highest vehicular accidents in the Municipality of Mexico.

The Anao Bypass Road does not have enough light to increase the visibility, some option or alternative solution to guide road users at night time is source of light, using road studs as a device to provide path of light to guide. Indeed, the presence of lighting may itself be counterproductive in this respect; drivers may compensate for the presence of road lighting on links in terms of increased speed or reduced concentration (Llewellyn, 2020). There are advantages in using solar road studs compare to streetlamps, road studs are easily installing that does not need a lot of material resources and manpower to use and it can make a path of light in the road pavement that can guide the road user at night. Solar-powered active road studs have been shown to have a positive effect on driver confidence, but their impact on vehicle speed in conjunction with other road features is little understood. In several countries across the world, reflective road studs are used as a measure to assist drivers in low light by highlighting road features, such as lanes, carriageway edges, curvature, and junctions (Llewellyn et al., 2020). The Researchers find an area that has a high level of road safety and higher volume of traffic to get a presumption. The Researchers selected the place of Angeles Balibago, this area is a main entertainment district in Angeles City.

In that case, the said area has a high traffic volume all the time. Since Angeles Balibago has already installed road studs, the researchers select this area as a reference and comparison to conclude the efficiency of using road studs to the local motorists on Angeles Balibago to increase their road safety by comparing the accidents data results when before and after road studs installed and by gathering a data in terms of interviewing on what are the respondents experience when they travel with the presence of the road studs.

Since the road does not have enough light to increase the visibility, some alternative solution to guide road users at night time is source of light, using road studs as a device to provide path of light to guide. Indeed, the presence of lighting may itself be counterproductive in this respect; drivers may compensate for the presence of road lighting on links in terms of increased speed or reduced concentration (Llewellyn, 2020). There are advantages in using solar road studs compare to streetlamps, road studs are easily installing that does not need a lot of material resources and manpower to use and it can make a path of light in the road pavement that can guide the road user at night. Solar-powered active road studs have been shown to have a positive effect on driver confidence, but their impact on vehicle speed in conjunction with other road features is little understood. In several countries across the world, reflective road studs are used as a measure to assist drivers in low light by highlighting road features, such as lanes, carriageway edges, curvature, and junctions (Llewellyn et al., 2020).

II. CONCEPTUAL FRAMEWORK



Solar road studs gained popularity as a sustainable alternative to traditional road marking systems. The proposed study aimed

to investigate the applicability of solar road studs in improving road safety at the Anao, Mexico Bypass Road. The study considered the effectiveness of solar road studs in improving road safety, the behavior and perception of road users, and the cost-effectiveness of the technology. The results of the study provided insights into the potential benefits of using solar road studs as a sustainable solution for road safety at the Anao, Mexico Bypass Road.

III. METHODOLOGY

The researchers used a quantitative data collection method, such as surveys and analysis of documents or records. It included questions about drivers' current use of the Anao, Mexico Bypass Road, their problems in improving the bypass road, and their opinions about implementing solar road studs. In order to get data results, the researchers were able to conduct a convenience sampling method to collect data from the road users of Anao, Mexico Bypass Road and Balibago, Angeles City Road.

IV. ASSESSMENT OF THE STUDY AREA

Anao, Mexico Bypass Road is selected as the main focus of the study. This road was a four-lane way with a sudden two lanes at both ends, which made it complex.



Fig.1. The study area in Anao

V. STATISTICAL TREATMENT

In order to evaluate the opinions and experience of the respondents, the study utilized the formula of frequency % distribution for the questionnaire. The formula used is as follows:

To determine how many people have the knowledge about solar road studs:

- Percentage

$$P = \frac{F}{R} \times 100$$

Where:

P = Percentage

F = Frequency

R = No. Respondents

- Weighted Mean

$$W_m = \frac{F_1 a_1 + F_2 a_2 + F_3 a_3 + F_4 a_4}{R}$$

Where:

W_m = Weighted Mean

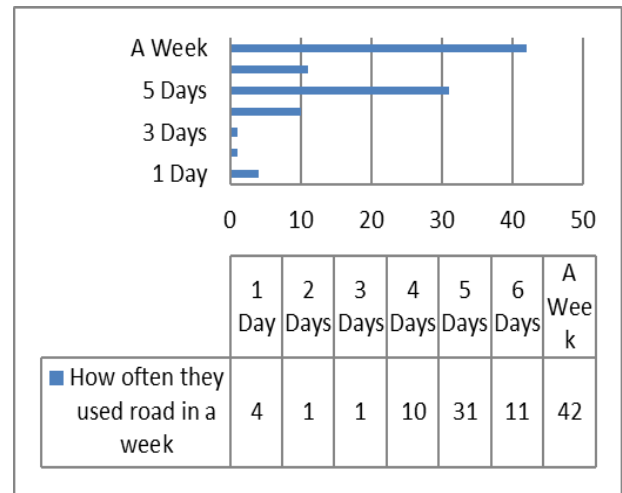
F = Frequency

R = No. Respondents

VI. RESULTS AND DISCUSSION

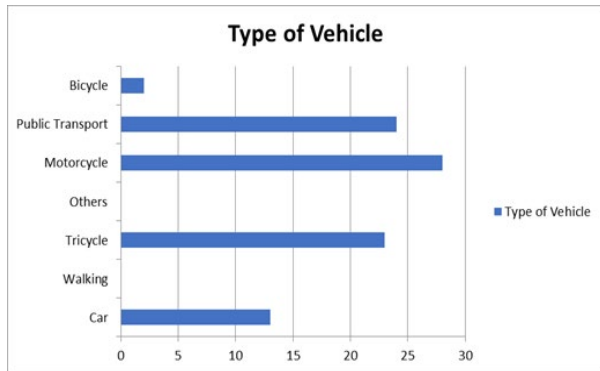
The corresponding analysis and interpretation of data are incorporated in this portion of the study. The road users' satisfaction level in Balibago, Angeles and Anao, Mexico Highway in the presence of road studs.

TABLE.1. HOW OFTEN ROAD USERS TRAVEL IN A WEEK (BALIBAGO)



In the first table, the most frequent is the whole week, with a frequency of 42% and a percentage of 42%. The second most frequent number is 5, which has a frequency of 31% and a percentage of 31%. The least frequent numbers are 2 and 3, which have a frequency of 1 each and a percentage of 1% each.

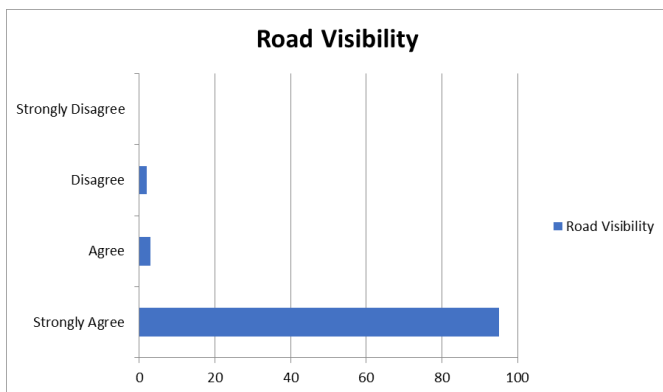
TABLE .2. TYPE OF VEHICLE THEY USED (BALIBAGO)



In the second data set, we can see that the most frequent type of vehicle is Motorcycle, which has a frequency of 38 and a percentage of 38%. The second most frequent type of vehicle is Public Transport, which has a frequency of 24% and a percentage of 24%. In contrast, the third most frequent type of vehicle is Tricycle, which has a frequency of 23% and a percentage of 23%. The least frequent mode of transportation is Bicycle, Walking, and Others, which have a frequency of 2, 0, and 0, respectively, and a percentage of 2%, 0%, and 0%, respectively.

This part presents the results on how the level of satisfaction of road users in Balibago, Angeles City with road studs when they travel, and they rate it in terms of:

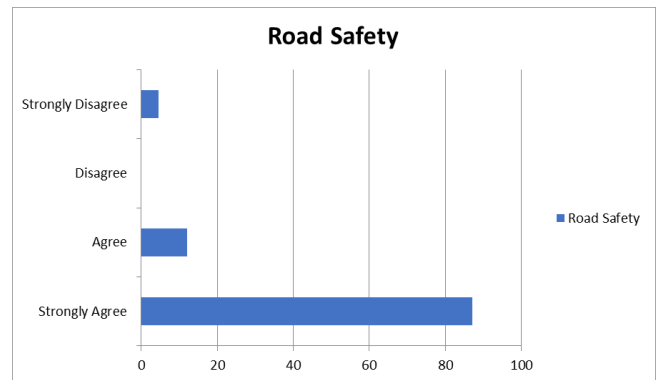
TABLE.3. VISIBILITY



As shown in Table 3. 95% of road users strongly agreed on the impact of road studs for the improvement of visibility, 3% agreed, 2% disagreed, and lastly, none of them answered strongly disagreed. It weighed 3.93. The result in this table is that most road users, or 95% of the respondents in the Angeles

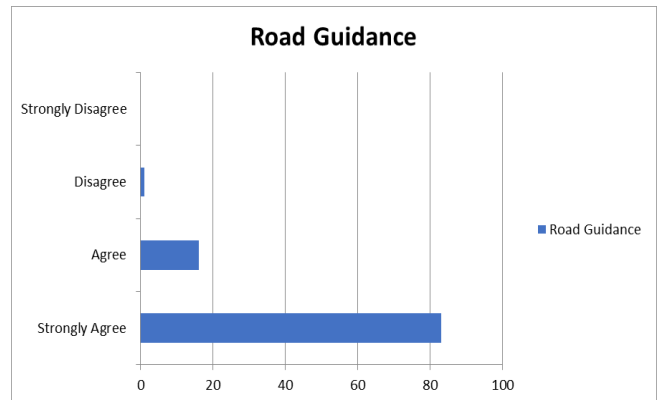
Balibago strongly agree on the effect of the road studs to increase their visibility when they are traveling at night.

TABLE.4. ROAD GUIDANCE



As shown in Table 4. 83% of the respondents strongly agreed to use road studs to guide them while they travel at night. 16% agreed, 1% of them disagreed, and none of them answered strongly disagreed. It weighed 3.82. The conclusion in this table is that most of the Angeles Balibago respondents strongly agree with giving a path of light or guidance using road studs for the drivers.

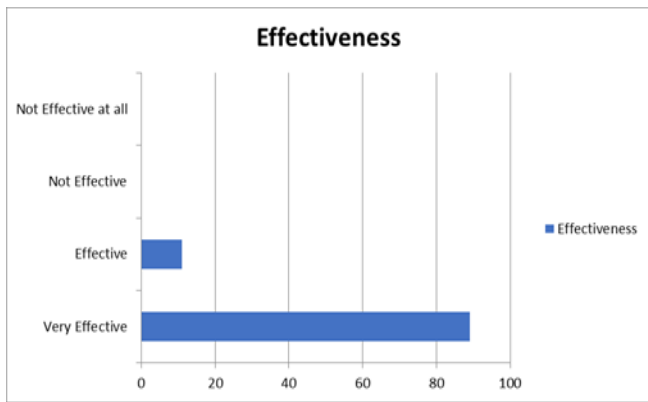
TABLE.5. ROAD SAFETY



As shown in Table.5. 87% of them answered strongly agreed on adding road studs in the road to help or improve road safety, 12% answered agreed, and none disagreed. It weighed 3.88.

As shown in this table, 87% of the respondents from Balibago, Angeles answered strongly agree on the impact of road studs for increasing road safety.

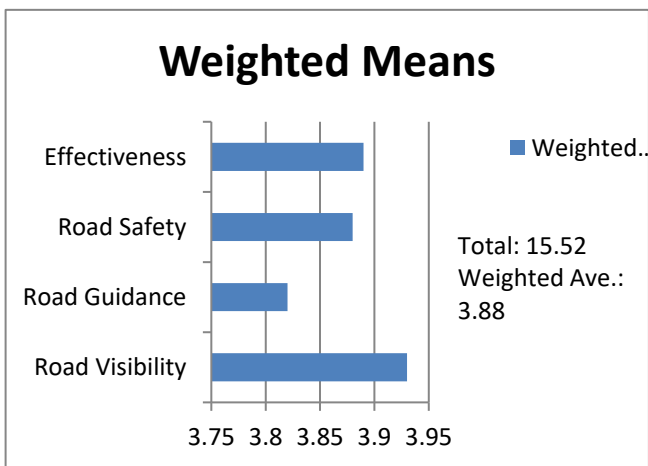
TABLE.6. EFFECTIVENESS



As shown in Table 6. 89% of them strongly agreed on the overall effectiveness of road studs in the road to help or improve road safety, 11% answered agreed, and none disagreed. It weighed 3.88.

As shown in this table, most of the Angeles respondents answered very effectively on the overall performance of road studs for road safety

TABLE .7. WEIGHTED MEAN



The table above shows the weighted means for road studs' overall performance, ranging from 3.93-3.82 from the highest to lowest weighted mean. The highest weighted mean is 3.93, the respondents were satisfied with the effect of road studs in improving visibility, and the least weighted mean is 3.82. The respondents were also satisfied with the effect of road studs in guiding road users. And overall average is 3.88.

TABLE.8. SIGNIFICANT DIFFERENCE IN TERMS OF ACCIDENTS REPORT IN BALIBAGO, ANGELES CITY BETWEEN BEFORE AND AFTER.

	Before	After	
	85	29	114
	44	26	70
Total	129	55	184

Observed

	Before	After	
	79.92	34.08	114
	49.08	20.92	70
Total	129	55	184

Expected

COMPUTED VALUE 2.84

CRITICAL VALUE 3.84

P VALUE 0.09223

COMPUTED VALUE < CRITICAL VALUE

2.84 < 3.84

FAIL TO REJECT NULL HYPOTHESIS

THERE IS NO SIGNIFICANT DIFFERENCE.

This table shows the accidents that occurred from 2019 to 2022.

In 2019 a total of 85 accidents occurred, 44 in 2020, 29 in 2021, and 26 in 2022. Based on this frequency, it is evident that there is a depletion in accident rates but not significant at a 5% significance level.

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The proponents evaluated the effectiveness of solar road studs through survey questions. The majority of the participants answered strongly agree and very effective regarding visibility and effectiveness during the night and poor weather conditions. Mostly the accident happened between 7:00 pm and 4:00 am. Overall, the presence of road studs is important to road users during nighttime.

According to the data gathered from the Angeles City Traffic and Management Unit, the number of accidents in Balibago in 2019 was 85, followed by in 2020 is 44, 2021 29, and 2022 was 26.

To conclude, in the study in Anao, Mexico bypass road in terms of road activity per week, the highest was five times a week with 42%, then comes the second highest was a whole week with 22%, and the third highest was four times a week with a 10%. In terms of mode of transportation, the highest was motorcycle with 41%, the second highest was car and tricycle with 19%, and the third highest was public transport with 13%. The proponents evaluated the road safety condition at night through survey questions. The majority of the participants answered somewhat unsafe, followed by very unsafe regarding road visibility at night and poor weather conditions. Overall, regarding visibility, the road condition is not safe at nighttime.

VIII. RECOMMENDATION

The following recommendations are made considering the results and conclusions of the study. Based on the analysis and interpretation of the results on surveyed data, here are the proponent's recommendations on how to improve road safety in the presence of road studs to reduce the high risk of accidents at night time in the road area of Anao, Mexico Bypass Road.

In light of the results and analysis presented in the study, the researchers recommend the following terms:

- This study will provide DPWH with evidence-based recommendations on the most effective way of using different variations of road studs for different road conditions. They can also use this to propose road studs in different areas.
- The local government may use this study to propose road stud maintenance and additional road signages.
- Future researchers may assess the effectiveness of road studs in improving road safety and the factors that influence their performance.