

The efficiency testing of Shoulder Rumble Strips (SRS) on noise for alerting drivers in Thailand: a comparison among three types of SRS

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Abstract

Long distance driving exposes drivers to microsleep or drowsiness that can possibly cause run-off-road accidents. It is therefore, crucial to install safety devices for alerting drivers in order to prevent accidents. This study aimed to test the efficiency of shoulder rumble strips (SRS), which is renowned as a safety device, designed for preventing accidents. The study determines if SRS are statistically significant in creating high alarm levels to warn unmindful or drowsy drivers. It also examines the efficiency differences among the three types of SRS: profiled; milled-in; and transverse. The study findings showed that the three types of SRS can increase noise levels, ranging from 9.97 dBA to 17.47 dBA, which are enough to alert the drivers. Results revealed that efficiencies of both profiled and transverse SRS were significantly similar, whereas milled-in SRS showed efficiency differences at all speeds and reported the lowest increase in noise level.

Keywords – Shoulder Rumble Strip, run-off-road accident, microsleep, ANOVA

1. Introduction

In 2009, Thailand encountered massive losses caused by road accidents (per 100000 population) that 16.8 fatalities and 178.2 injuries were reported. This resulted in total economic losses of almost US\$ 7990 millions or approximately 2.97% of GDP (Gross Domestic Product) [3]. When considering the accidents that occurred on National Highways (NH), driver drowsiness or microsleep is one of the most common causes of road accidents [27]. It generally poses a very high accidental risk for drivers [12, 20, 31]. A telephonic survey of 1,000 licensed drivers in New York, United States, showed that 22.6% of them had experienced drowsy driving but no crashes, whereas 2.8% experienced microsleep crashes [18]. Additionally, the results of 4,600 interviewed drivers indicated that 29% of them had experienced microsleeps while driving [17]. Face-to-face interviews of 593 long-distance truck drivers showed that 47.1% of them had experienced behavioral microsleeps [19]. A survey on 154 truck and bus drivers in Sweden showed that 14%

of them usually drive sleepily, 33% drowse while driving but force themselves on the road, and 8% had even nodded-off while driving [32].

Based on the evidence, microsleep episodes usually reduce efficient driving, depending on time periods of microsleep: short period ($3 \leq t < 4.74$ s); medium period ($4.74 \leq t < 7.00$ s); and long period ($t \geq 7.00$ s) [2, 8, 12, 17] long hours of night driving is an influential factor that affect microsleep conditions. Generally, microsleep is associated with driver fatigue that is primarily derived from two factors including sleep and work conditions. The common causes of sleep factor involve time of day (circadian rhythm effects), sleep deprivation, sleep restriction, and untreated sleep disorders; while work factor is induced by increased task load, high density traffic, poor visibility, need to complete secondary task, underload conditions, monotonous drive, extended driving periods, and automated systems [16]. Furthermore, Papadakaki et al. [22] found drowsy driving behavior is related to gender, daytime sleepiness, sleep quality and the lifestyle.

Prevention of accidents caused by microsleep encompasses several ways for overcoming drowsiness. Besides common practices such as resting at stops and walking around, opening windows, chatting, drinking tea or coffee, etc. [17, 20] some devices related to detection and warning technology (e.g. eye closure, head-nodding technology, and deadman switch technology) and crash prevention technology (e.g. rumble strips, lane departure warnings system, and collision avoidance system warnings [16] are also important, especially, the use of rumble strips on the road surfaces as a countermeasure to prevent accidents [13, 16, 24]. In this regard, rumble strips are practically installed, perpendicular or parallel to the traffic direction. The noises generated by these devices alert drivers to reduce speeds when they pass over them, and in particular, warn them of accidents that can occur due to changes in road and environmental conditions. In general, there are three types of rumble strips comprising centerline rumble strips (CRS), shoulder rumble strips (SRS), and traverse rumble strip (TRS) which are installed in different objectives. Installing CRS aims to prevent head-on and side impact collisions; while SRS is effective to prevent single-vehicle run-off-road (SVROR) accidents. For TRS, it has been used to warn drivers to reduce speeds when approaching community zones, railway crossing, curves or hazardous points [26, 30]. An example of the application of rumble strips includes over-speed problem fixation by the installation of transverse rumble strips on cross-streets to deter excessive speeds. As reported in prior literature reviews, these strips are capable of decreasing vehicular speeds by 9.2 -12.0 km/h and thus, also reduce 25% of accidents [14]. Moreover, the use of centerline rumble strips can lessen the number of head-on collisions on two-lane roads by about 25% [23]. According to different kinds of rumble strips, it can be noticed that the design and management of shoulder rumble strip (SRS) are provided for alerting microsleep drivers from run-off road crashes as effective way to do before trying to solve situation. When passing over SRS, it begins to vibrate and make sound to awake sleeping drivers.

Based on previous studies, SRS enables a statistically significant reduction in the total number of crashes [33] and SVROR accidents about 14-88% [9, 15] and provides benefit/cost ratio ranging from 66:1 to a high of 182:1 on New York State Thruway [9]; thus resulting in the widespread use of such device. However, three basic types of SRS are identified - profiled, milled-in, and transverse, in which their efficiency on noise generation were rarely examined in previous studies.

The study comprises the following three objectives: (1) to test main effects and interactions of factors related to SRS types and speeds affecting increasing noise levels; (2) to test the efficiency on noise levels of each type of SRS in preventing run-off road accidents using comparisons among means of three types SRS and benchmark.

The research question is drawn on whether three types of SRS are statistically significant to generate sufficiently high noise levels for awakening unmindful, drowsy, or microsleep drivers, (3) to test the efficiency differences between three types of SRS on noise production regarding different speeds.

The outcomes of this study can be further applied as indicator in deciding on the appropriate use of SRS.

2. Methodology

2.1. Design and installation of SRS

Shoulder Rumble Strips in this study have three patterns including profiled, milled-in, and transverse that can be more described as follows:

(1) Profiled Raised SRS has a convex shape with two Thermoplastic Profiled Markings above the edge line. The installation of this type of SRS involves placing thermoplastic marking in strips along the edge line. The size of each Thermoplastic is 50 mm. wide and 80 mm. long with 5 mm. thick. In the same strip, the Thermoplastic is offset from the edge line with a distance of 10 mm with 20 mm spacing. Each strip has a regular pattern of gaps at 200 mm. Installation of Profiled Raised SRS is fitted with warm climatic zones rather than cold climatic zones due to the maintenance problems related to snow removal [1, 30].

(2) Milled-in SRS can be appropriately installed in new or existing shoulders in which rotomilling machine can be easily cut or grinded [1, 30]. Milled-in is a pattern of SRS having gaps at regular intervals resulting in wheel impact with high intensity of sound. Key features of milled-in SRS related to dimension exemplify a width of 200 mm, a length 500 mm and a depth of 13 mm with spacing 150 mm. It is offset from the edge line with a distance of 100 mm. Milled in SRS can be installed in groups that each group has 11.25 m long with 2 m spacing as illustrated in Figure 1(b).

(3) Transverse Raised SRS can be made from various materials with different ways of installation. However, the material mostly used for constructing Transverse Raised SRS is raised pavement markers which have limitation on installing according to weather conditions [1, 30]. Transverse Raised SRS is 400 mm long and 150 mm wide that is offset from the edge line around 200 mm with 300 mm spacing between strips. The thickness of each strip is 10 mm above the road surface. Transverse Raised SRS can be placed along the road segments as demonstrated in Figure 1(c). When considering the SRS installation position, Profiled Raised SRS is normally placed furthest from edge line thus meaning that this type of SRS can alert drivers earlier than other SRS types. However, regarding the width of SRS, Profiled Raised SRS has the minimum width when compared to other types of SRS causing lower noise levels in warning drivers. The design of each type of SRS was complied with the OTP (Office of Transport and Traffic Policy and Planning) standards to determine the most common SRS type used in Thailand. Then, SRS was installed along the studied roadway, NH-7, that had substantial evidences of potential hazard points and accidental risks with 28 accidents already been reported. The SRS was installed on NH-7, in the section between Bangpakong Interchange and Phanthong Interchange from KM 46+691 to KM 65+326 that are 8-lane roads with 2 directions(4 lanes in each direction), barrier median, and 1.2 m wide shoulder. The speed limit on this roadway is 120 km/hr. The installation position of profiled SRS on edge line on NH-7 fell in the range of KM 54+850 to KM 54+900 covering a distance of 50 m; while the installation location of transverse raised SRS on surface shoulder on NH-7 was between KM 55+100 and KM 55+150 covering 50 m distance located in level terrain, as illustrated in Figure 2.

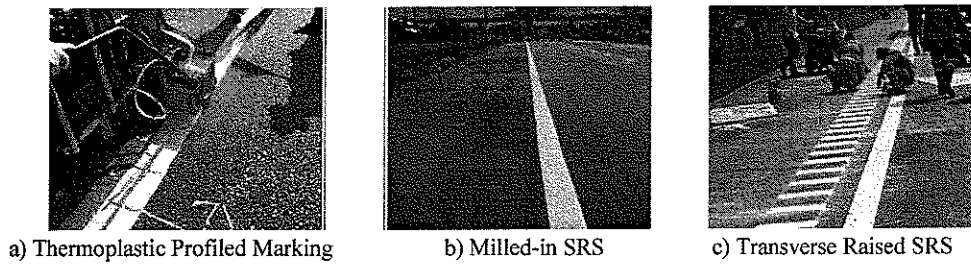


Fig. 1 - Installation of three types of SRS

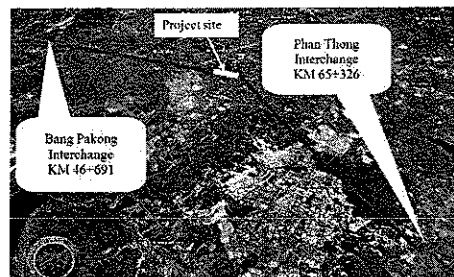


Fig. 2 - Project site

2.2. Data collection

After installing the three types of SRS, the study subsequently collected the effect of SRS on noise level, generated by the SRSs, in vehicles passing over each type of SRS. Survey on vibration inside vehicles was conducted using noise meter (RION-NL21) during daytime with dry condition by keeping the windows closed without turning off the air conditioner. In this case, only one driver was used along the test. The experiment was carried out through ten times of driving over the SRS under each speed level of 40, 60, 80, 100, and 120 kph (a total of 50 times). In this regard, a comparison of noise levels between before and after SRS installation was conducted with only one vehicle along the test by using a Rion NL-21 sound level meter. The measurement of SRS performance in alerting drivers at different speeds aims to answer the research question on whether SRS performance brought by an increase in noise levels from ambient condition is associated with speeds. The test results indicated no linear relationship between two parameters. The study also examined that at different speeds, which type of SRS generates a higher noise level than the other. So, the results can be applied for various road types where different speeds are determined.

2.3. Data analysis

Two-Factors Analysis of Variance (2-Way ANOVA) was used to analyze main effects and interactions of SRS types and speeds that affect increasing noise levels. Simultaneously, pairwise comparison test was applied to compare the efficiency differences on noise among different SRSs at all speeds. For the test, dependent variable is increasing noise levels of SRS; while independent variables are three types of SRS (profiled, milled-in, and transverse) and speeds (40, 60, 80, 100, and 120 kph). As well, SPSS V.16 is a software package used for statistical analysis. In general, the pairwise comparisons in SPSS by 2-way ANOVA test can't illustrate mutual effects of two factors; then a set of codes must be created (see Appendix1). Multiple comparisons from ANOVA

were performed to examine the potential of each type of SRS in alerting unmindful or microsleep drivers according to a comparison of average increase in noise levels between each SRS type and benchmark (10 dBA). For the test, the dependent variable is increasing noise levels of SRS; while independent variables are four conditions (profiled, milled-in, transverse, and benchmark). The reason why we don't use t-test is to avoid the probability of a type I error [4, 7, 10].

3. Results

3.1. Performance of SRS

The efficiency test on noise level of each type of SRS is shown in Table 1. The test results before SRS installation showed the average noise level was between 58.6 – 71.15 dBA. For post installation, the experiment results indicated that profiled, milled-in, and transverse SRS generated noise levels in the range of 76.36 - 83.93, 72.95 - 81.90, and 80.35 – 83.18 dBA, respectively. The average increment of noise levels by profiled SRS under each speed of 40, 60, 80, 100, and 120 kph was 13.47 dBA (SD=1.15), 11.11 dBA (SD=0.60), 16.78 dBA (SD=2.85), 14.88 dBA (SD=1.30), and 15.48 dBA (SD=3.07), respectively; while milled-in SRS produced the average noise levels of 16.01 dBA (SD=2.14), 11.45 dBA (SD=0.75), 14.95 dBA (SD=1.68), 12.80 dBA (SD=0.26), and 9.97 dBA (SD=0.40). For transverse SRS, average increase in noise levels under each speed as the same to profiled SRS was 13.10 dBA (SD=2.20), 17.47 dBA (SD=0.65), 17.35 dBA (SD=1.23), 15.05 dBA (SD=0.49), and 14.73 dBA (SD=0.57). The test compared the pre- and post-installation results of each type of SRS to determine whether it can alert drivers by increasing the noise levels to a perceived sound level, equivalent to 10 dBA [21, 30] that can noticeably awaken microsleep or unmindful drivers. The efficiency test applied multiple comparisons of Bonferroni between noise critical point of 10 dBA and three types of SRS, as shown in figure 3. The test results in Table 2 illustrate that with a *p*-value less than 0.05, the mean differences between benchmark and all types of SRS are negative; thus indicating noise levels of all types of SRS are greater than the benchmark at a significance level of 0.05 ($\alpha=0.05$) that can effectively alert drivers.

3.2. The main effect and interaction effect

The differences in noise levels, derived from cars passing over each type of SRS, were statistically examined by the ANOVA test. However, this test would be functional if the prepared data showed homogeneous variances, so the test of homogeneity of variances was required by setting the confidence level to 95%.

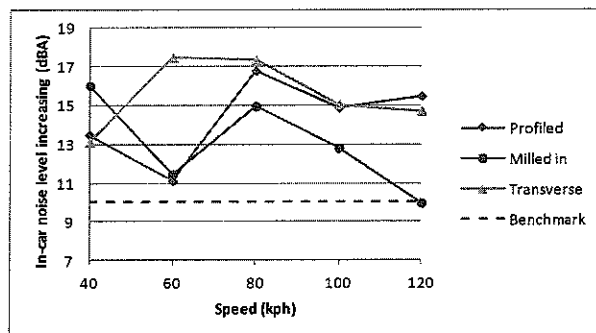


Fig. 3 - Comparison of the average increase in noise levels between each type of SRS and benchmark

Tab. 1 - Average noise level (dBA) of indoor passenger car

SRS Type	Condition	Speed (kph)				
		40	60	80	100	120
Profiled	Before	67.25	65.25	65.25	67.45	68.45
	After	80.72	76.36	82.03	82.33	83.93
	Increment	13.47	11.11	16.78	14.88	15.48
		(1.15*)	(0.60*)	(2.85*)	(1.30*)	(3.07*)
Milled in	Before	58.60	61.50	63.95	69.10	71.15
	After	74.61	72.95	78.90	81.90	81.12
	Increment	16.01	11.45	14.95	12.80	9.97
		(2.14*)	(0.75*)	(1.68*)	(0.26*)	(0.40*)
Transverse	Before	67.25	65.25	65.25	67.45	68.45
	After	80.35	82.72	82.60	82.50	83.18
	Increment	13.10	17.47	17.35	15.05	14.73
		(2.20*)	(0.65*)	(1.23*)	(0.49*)	(0.57*)

(*) Standard Deviation

Tab. 2 - Testing difference in means between benchmark and SRS

Benchmark (I)	SRS (J)	Mean Difference (I-J)	p-value ^b	95% Confidence Interval ^b	
				Lower Bound	Upper Bound
10 dBA	Profiled	-4.344*	<0.001**	-5.769	-2.919
	Milled-in	-3.094*	<0.001**	-4.517	-1.672
	Transverse	-5.520*	<0.001**	-6.936	-4.104

Note: **The mean difference is significant at the 0.05 level. ^aAdjustment for multiple comparisons: Bonferroni.

The study tested the null hypothesis that the error variance of the dependent variable is equal across groups. Levene's test of equality of error variances provided $F=7.528$, $df_1 = 14$, $df_2 = 140$, and $p\text{-value} < 0.001$. So, the findings showed heterogeneous variances. After variance examination, hypothesis testing for population mean was performed as the following equation 1 for speed, equation 2 for SRS types, and equation 3 for interaction:

$$H_0 = \mu_{40} = \mu_{60} = \mu_{80} = \mu_{100} = \mu_{120} \quad (1)$$

H_a : At least one pair of means of increasing noise levels of speed is not equal

$$H_0 = \mu_{\text{profiled}} = \mu_{\text{milled}} = \mu_{\text{transverse}} \quad (2)$$

H_a : At least one pair of means of increasing noise levels of SRS is not equal

$$H_0: \text{There is no significant interaction between the effects of speed and SRS} \quad (3)$$

H_a : There is a significant interaction between the effects of speed and SRS

Table 3 illustrates the results of a two-way ANOVA that found speed has a mainly significant effect on increasing noise levels ($F = 18.54$, $p < 0.001$). Also, SRS factor mainly and significantly affects increasing noise levels ($F = 33.41$, $p < 0.001$). Furthermore, the findings showed both speed and SRS have significant interaction effects on increasing noise levels ($F = 21.76$, $p < 0.001$); thus exemplifying differences in noise levels for all SRS types in each speed in section 3.3.

3.3. Differences in noise levels for each SRS type

Table 4 illustrates the results of comparison among all pairs, at speed levels of 40, 60, 80, 100, and 120 kph. It, thus, questions whether each pair of SRS has increasing noise levels owing to the differences in SRS installation. The hypothesis is expressed as following:

Tab. 3 - Test of between speed-SRS effects

Source	Sum squares	df	Mean square	F	p-value	Partial Eta Squared
Corrected Model	752.843 ^a	14	53.775	21.959	<0.001**	.687
Intercept	31594.474	1	31594.474	12901.882	<0.001**	.989
Speed	181.573	4	45.393	18.537	<0.001**	.346
SRS	163.652	2	81.826	33.414	<0.001**	.323
speed × SRS	426.389	8	53.299	21.765	<0.001**	.554
Error	342.836	140	2.449			
Total	32980.670	155				
Corrected Total	1095.679	154				

Note: Dependent variable is increasing noise levels of SRS. ^aR Squared = 0.687 (Adjusted R Squared = 0.656)

** Statistically significant at 5%

Tab. 4 - Testing difference in means between SRS types for each speed

Speed	SRS (I)	SRS (J)	Mean Difference (I-J)	p-value ^b	95% Confidence Interval ^b	
					Lower Bound	Upper Bound
40	Profiled	Milled-in	-2.539	0.001**	-4.196	-.882
	Milled-in	Transverse	2.909	<0.001**	1.326	4.492
	Transverse	Profiled	-0.370	1.000	-1.994	1.254
60	Profiled	Milled-in	-0.340	1.000	-2.036	1.356
	Milled-in	Transverse	-6.017	<0.001**	-7.640	-4.393
	Transverse	Profiled	6.357	<0.001**	4.733	7.980
80	Profiled	Milled-in	1.830	0.030**	.134	3.526
	Milled-in	Transverse	-2.400	0.002**	-4.096	-.704
	Transverse	Profiled	0.570	1.000	-1.126	2.266
100	Profiled	Milled-in	2.080	0.010**	.384	3.776
	Milled-in	Transverse	-2.250	0.005**	-3.946	-.554
	Transverse	Profiled	0.170	1.000	-1.526	1.866
120	Profiled	Milled-in	5.510	<0.001**	3.814	7.206
	Milled-in	Transverse	-4.760	<0.001**	-6.456	-3.064
	Transverse	Profiled	-0.750	0.857	-2.446	.946

Note: Based on estimated marginal means. **The mean difference is significant at the 0.05 level.

^b Adjustment for multiple comparisons: Bonferroni.

$$H_0 = \mu_i = \mu_j; i, j = \text{profiled, milled in, transverse} \quad (4)$$

$$H_a = \mu_i \neq \mu_j; i \neq j$$

According to the test, at speed of 40 kph, milled-in has the maximum average increasing noise level that was significantly greater than the average score of profiled SRS and transverse SRS of 2.539 dBA ($p=0.001$) and 2.909 dBA ($p<0.001$), respectively. When comparing transverse SRS with profiled SRS, the former represented an average increasing noise level of 0.37 dBA ($p=1.000$) indicating no significant difference.

At the speed of 60 kph, the findings exemplified the highest average increasing noise level of transverse SRS which significantly exceeded the average score of milled-in SRS of 6.017 dBA ($p<0.001$) and profiled SRS of 6.357 dBA ($p<0.001$). Profiled SRS obtained the lower average increasing noise level than milled-in SRS of 0.340 dBA ($p=1.000$), identified as a statistically insignificant difference. At the speed of 80 kph, transverse SRS acquired the highest average increasing noise level over profiled SRS of 0.570 dBA ($p=1.000$).

No significant difference was found among both types. The average increasing noise level of transverse SRS was 2.400 dBA more than milled-in SRS ($p=0.002$), identified as a statistically significant difference. The profiled SRS generated an average increasing noise level of 1.83 dBA over milled-in SRS, with p -value of 0.030, considered to be statistically significant. At the speed of 100 kph, transverse SRS also gained the maximum average increasing noise level that was 0.170 dBA greater than profiled SRS ($p=1.000$), indicating no significant difference. Score difference between transverse SRS and milled-in SRS was 2.25 dBA that the value of the milled-in SRS was lower. In this case, p -value was 0.005 resulting in the rejection of the null hypothesis. Profiled SRS has the greater average increasing noise level than milled-in of 2.080 dBA with p -value of 0.010 that showed significant difference. At the speed of 120 kph, profiled SRS obtained the highest average increasing noise level greater than transverse SRS of 0.750 dBA ($p=0.857$), indicating statistically non-significant between both SRS types. For profiled SRS and milled-in SRS, the average increasing noise level of milled-in SRS was 5.510 dBA lower than profiled SRS ($p<0.001$) that can be denoted as a statistically significant difference.

Considering the noise levels between milled-in SRS and transverse SRS, it found the average increasing noise level of milled-in SRS was slightly lower than transverse SRS of 4.760 dBA, which were statistically significant (p -value < 0.001).

4. Discussion and conclusion

The study, for the first time, provides efficiency tests on the three types of SRS for its possible application in Thailand. The methodology framework incorporates the efficiency measurements of each type of SRS based on the increasing noise levels when a car passes over it at speeds of 40, 60, 80, 100, and 120 kph. The test results, interestingly, showed that when a vehicle passes over SRS, the average increasing noise level of profiled SRS, milled-in, and transverse SRS ranged from 11.11 to 16.78 dBA, 9.97 to 16.01 dBA, and 13.10 to 17.47 dBA, respectively. This reveals that the noise levels generated by this experiment are lower than those observed in prior studies, which indicates that profiled SRS produces increasing noise levels in the range of 8 to 16 dBA [11]. For milled-in SRS, Pigman and Barclay [25] found noise level inside the vehicle was increased by 5 to 15 dBA. Also, Chen [5] found the average noise level increased from ambient noise was 10.87 dBA [6]. The findings of efficiency tests of each type of SRS when compared to the benchmark at 10 dBA indicated that all types of SRS generate noise levels above benchmark at all speeds. The next step involves the measurement of main and interaction effects of SRS types and vehicle speeds by using two-way ANOVA. The test results showed that, both vehicle speeds and SRS types are factors having main and interaction effects on increasing noise levels at a significance level of 0.05 ($\alpha=0.05$). Continuous examinations were performed to determine those differences and the case of no differences, in which such pairs were substituted. According to the test results, milled-in SRS gained the maximum average increasing noise level at the speed of 40 kph; while transverse SRS obtained the highest average score at the speed level of 60, 80 and 100 kph.

With regard to milled-in SRS, the maximum average score was existed at the speed level of 120 kph. When considering the paired comparison between SRS types, the findings of statistical tests at 95% confidence level indicated that at speeds speed level, transverse and profile SRS showed differences in the average increasing noise levels that ranged from 0.17 to 0.57 dBA (p -value > 0.05), except for 60 kph. Hence, it can be assumed that both types of SRS have similar noise-generation efficiency, enabling inter-replacement between the two types. In case of milled-in and transverse SRS, the dissimilarities in average increasing noise levels at all speeds ranged

from 2.25 to 6.02 dBA (p -value <0.05). In addition, at all speed levels, except for 60 kph speeds, the efficiency of milled-in and profiled SRS ranged from 2.08 to 5.51 dBA (p -value <0.05). Therefore, it was concluded that milled-in SRS should not be used for replacing the other two types of SRS. According to the Land Traffic Act, B.E. 2522 (1979), the maximum speed limit for vehicles on urban roads is 80 kph and on other roads, is 90 kph. According to the Highway Act, B.E. 2535 (1992), the vehicle speed on motorways should not exceed 120 kph [28]. Considering the speed enforcement regulations, researchers designed the speed tests according to the speed measurements on each road type: 80 kph (urban road); 100 kph (non-urban road); and 120 kph (motorways). Assumptions based on the statistical results indicated that profiled SRS is the most appropriate for all road types (urban, non-urban, and motorways). The study results prove SRS to be an effective safety device that can potentially alert absent-minded or microsleep drivers. Moreover, it does not produce excessive loud noise if drivers comply within the 90 kph vehicle speed regulation [29]. This study purposely measures the increasing noise levels of SRS at the speed levels of 40, 60, 80, 100, and 120 kph in the context of traffic and climate conditions of Thailand. However, there are a limitation of the study involving the relatively sample size. In order to apply the results of the study in different conditions, it is necessary to conduct more tests by using this study as a model. For further studies, the consideration should be drawn on noise level together with vibration level inside the vehicle. Unlike noise measurement having benchmarks of sound inside vehicle that affects driver's perception, a set of standards or benchmarks for vehicle interior vibration seem to be rarely found and tested in other road types. The outcomes of this study can be applied as indicator for SRS selection combined with other factors such as vibration generation, slippery surface, opportunity to pass over SRS, and construction and maintenance cost, etc.

Appendix 1

Code for illustrating pairwise comparisons of both factors in a two-way AVOVA by SPSS:

```
UNIANOVA noise BY speed SRS
/METHOD=SSTYPE(3)
/INTERCEPT=INCLUDE
/POSTHOC=SRS(BONFERRONI)
/EMMEANS=TABLES(Speed*SRS) compare (SRS) adj (BONFERRONI)
/CRITERIA=ALPHA(.05)
/DESIGN=speed SRS speed*SRS.
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**แบบเสนอขอรับรางวัลการเผยแพร่ผลงานวิจัย
มหาวิทยาลัยราชภัฏพิบูลสงคราม**

1. ชื่อผู้ขอรับทุน นายสังจากาจ จอมโนนเขว.....ตำแหน่งทางวิชาการ.....อาจารย์.....
สังกัดภาควิชา/หน่วยงาน.....สาขาวิชาวิศวกรรมโลจิสติกส์ คณะเทคโนโลยีอุตสาหกรรม.....
2. ชื่อผลงานที่ขอรับรางวัล Jomnonkwao, S., Siridhara, S., & Ratanavaraha, V. (2015). Awareness status of sightseeing bus entrepreneurs: A case study in rural areas of Thailand. Lowland Technology International, 17(1), 47-52.
3. สถานะผลงานที่ขอรับรางวัล
 - ☐ 3.1 เจ้าของผลงานเพียงผู้เดียว
 - ☐ 3.2 ร่วมทำกับหน่วยงานภายใน (กรุณาระบุ หนังสือแบ่งสัดส่วน)
 - ☒ 3.3 ร่วมทำกับหน่วยงานภายนอก (กรุณาระบุ หนังสือแบ่งสัดส่วน)
4. มีความประสงค์จะขอรับเงินรางวัลเผยแพร่ผลงานวิจัย ดังต่อไปนี้
 - ☒ 4.4 บทความที่ตีพิมพ์ในวารสารวิชาการระดับนานาชาติที่อยู่ในฐานข้อมูล SCImago Journal Rank (SJR) Quartile 3 ให้รางวัล 15,000 บาท และเงินรางวัลเพิ่มเติมเพื่อสร้างแรงจูงใจ 5,000 บาท รวม 20,000 บาท
ขอเบิก: $(0.5 \times 15,000) + 5,000 = 12,500$ บาท

ข้าพเจ้าขอรับรองว่า

บทความที่เสนอขอรับทุนนี้ไม่เคยได้รับทุนอุดหนุนการทำบทความจากวิทยานิพนธ์ จากโครงการบัณฑิตศึกษาของคณะ หรือ หน่วยงานภายในมหาวิทยาลัยราชภัฏพิบูลสงคราม หรือหน่วยงานอื่นมาก่อน

ลงชื่อ
(.....อาจารย์สังจากาจ จอมโนนเขว.....)

ผู้ขอรับการสนับสนุน

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หนังสือแนบสัดส่วน

ชื่อผลงาน: Jomnonkwao, S., Siridhara, S., & Ratanavaraha, V. (2015). Awareness status of sightseeing bus entrepreneurs: A case study in rural areas of Thailand. Lowland Technology International, 17(1), 47-52.

จำนวนผู้ร่วมวิจัย ทั้งหมด 3 คน (โปรดระบุสัดส่วนการทำวิจัยของผู้เสนอขอรับทุน พร้อมทั้งลงนามของผู้ร่วมวิจัย)

ชื่อ-สกุล	หน่วยงานต้นสังกัด	สัดส่วนที่ ทำงานวิจัย (%)	ลงนาม
1. อ. ศัจจากาจ จอมโนนเขวา	มหาวิทยาลัยราชภัฏพิบูลสงคราม	50	
2. อ. ดร. ศิรดล ศิริธร	มหาวิทยาลัยเทคโนโลยีสุรนารี	25	
3. รศ.ดร.วัฒนวงศ์ รัตนวราห	มหาวิทยาลัยเทคโนโลยีสุรนารี	25	
4.			

หมายเหตุ : กรุณาแนบบแบบเสนอขอรับรางวัลการเผยแพร่ผลงานวิจัยและหนังสือแนบสัดส่วน 1 ฉบับต่อ 1 ผลงานวิจัยที่ขอรับรางวัล



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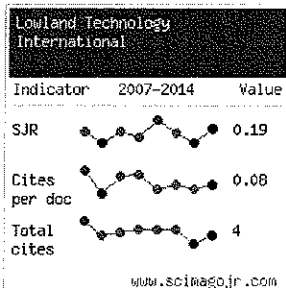
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