International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

PAPER ID: 10A14D

AN EXPERIMENT ON SPEED BUMPS BUILT WITH USED PNEUMATIC RUBBER TIRES

Boonsap Witchayangkoon [a*], Sayan Sirimontree [a], Krittiya Leartpocasombut [a], and Sanya Namee [b]

[a] *Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, Pathumtani, 12120, THAILAND*

[b] *Department of Disaster Prevention and Mitigation, Ministry of Interior, Royal Thai Government, Bangkok, THAILAND*

ARTICLEINFO

Article history:
Received 27 March 2019
Received in revised form 03 July 2019
Accepted 24 July 2019
Available online 19 August 2019

Keywords:
Sustainability traffic engineering; Low-cost speed bump; Waste management; Tire recycling; Speed control; Traffic calming device; Vehicle maneuver; Tire reuse.

ABSTRACT

Having a sustainability concept, used car pneumatic rubber tires are employed to build simple speed bumps to be placed on a local roadway to reduce passing speeds of vehicles. This study demonstrates a way to build low-cost speed bump. In this experiment, bumps are made with different used tire sizes (of a sedan, a six-wheel lorry, and a ten-wheel lorry). The effects on vehicles passing the bumps are observed. Traffic audits and investigation on vehicles passing the used rubber tires bump are investigated, at 85th percentile speeds. With an installation of cheap bump built with used pneumatic rubber tires, it can increase safety to the local community in the roadway neighborhood.

1. INTRODUCTION

Over 1 billion pneumatic car tires are annually manufactured worldwide (Wikipedia, 2018). In 2018, it is estimated that Thailand manufactures more than 30 million car pneumatic rubber tires with which about two-thirds are consumed inside the country. Therefore, a million old car tires are needed to be managed and get rid of. The better way is to reuse and recycle them in an environmentally friendly way as recycling and reuses are vital to sustainable consumption and development. Old standard car tires can be seen using as flowerpots, tire swings, and furniture seats and tables. Bigger sizes of tires are even far more difficult to apply for reuses and recycling.

1.1 SPEEDY DRIVING

From the record, driving behaviors that cause accident involve speedy driving. Speedy driving

*Corresponding author (B. Witchayangkoon) E-mail: drboonsap@gmail.com

can occur not only on the highways but also on local roads. Table 1 shows death tolls and injuries record from accidents in Thailand during 2015-2017.

Table 1: Death tolls and injuries record from accidents in Thailand during 2015-2017

Year	Death Toll	Injuries
2017	15,256	1,002,193
2016	9,815	831,118
2015	11,389	660,888

Recent highway accident record from Department of Highways of Thailand in the first six months (1 January to 30 June 2018) showed a total 8839 accidents with death toll risen to 1449, and 8141 people got injured, with involved 13271 vehicles and highway damages cost US$4.7millions. This accident figure is increased from the previous year 6%, the death toll climbed 7%, and a number of vehicles involved in the accidents soared 7% (DOH, 2018). The Asia Injuries Prevention (AIP) Foundation has reported that during 2001-2013 the arrested speedy driving cases in the Bangkok metro area were 4424 cases, higher than drunk driving cases 66%, even though in crowded areas that could not use speed (Isaranews, 2017).

Many traffic instruments have been built to control the speed. This work thus builds and experiments low-cost speed bumps with used pneumatic rubber tires of multiple sizes. The experimentation simply observes driving behaviors through monitoring vehicular passing speeds. Traffic audits and investigation on vehicles passing the used rubber tires bump are investigated, as well.

2. LITERATURE REVIEW

Namee and Witchayangkoon (2011) investigated the speed bump installed at all legs of the crossroad. Traffic audit at 85th percentile speed was observed on four types of vehicles: passenger cars, pickup trucks, motorbikes, and passenger buses and lorries (i.e., more than four wheels vehicles). The study suggested the traffic calming devices should be re-shaped to have hump profile. The devices should also be repositioned to the intersection corners. The study also introduced crossroad speed tables.

Zainuddin et al. (2012) reported the optimization of speed hump design for Malaysia residential streets. The study applied geometric parameters including speed hump height, length, and width, to ascertain the effect of 85th percentile speed reduction. With several analyses, a model with R-Sq value of 80.6% was developed using multiple linear regressions.

Witchayangkoon (2015) presents combined traffic calming devices of humps into bumps, which had been installed in a local village community. This innovative device gave more comfort to drivers and passengers but needing drivers' attention in aiming wheels' positions at the hump areas. The invented device thus effectively reduced vehicular driving speeds and helped reduce noise and damage of vehicle passing the devices. This device also saved construction cost, compared to hump, however, frequent maintenance for worn out hump areas was needed.

Lav et al. (2018) study a fundamental experimental approach for optimal design of speed bumps, that the wheel speed and the vertical acceleration at the speed bump were observed via a Vernier

Motion Detector. The optimal dimensions of a speed bump were found with 5.0 cm in width and 2.8 cm in height.

Interestingly, Pau (2002) reported that speed bumps may induce improper drivers' behavior in Italy, due to sudden slow down before the bump and acceleration after passing the bump. When approaching the undulation, drivers were likely to perform all sorts of maneuvers, in order to reduce their discomfort, particularly where the bumps do not extend over the entire street. Where speed bumps were not properly installed, car and motorbike drivers tried to avoid the bumps to reduce noise and vibrations of the vehicle.

Speed bumps induced traffic noise was reported by Wewalwala & Sonnadara (2011). The noise was measured before and after the vehicles passing the bumps. For lorries and three-wheelers, speed bumps caused the maximum noise level increased by over 5 dB (A). The results indicated that there is a considerable effect on the noise levels at a short distance from the speed bump as drivers increased the speed after passing the bumps. The equivalent noise level at 20 m from the speed bump was found to be on average 1.2dB(A) higher than at the speed bump.

In Thailand, local roadways (roads with concrete and asphaltic pavement, and dirt roads) are the key transportation mode to access all areas. Roadways users include pedestrians, bicycles, motorcycles, personal cars, public buses and vans, and some lorries. Road safety concerns have raised awareness to all involved government and public agencies as well as to road users. Cheap bumps are installed in residential areas in order to slow traffic, expecting to reduce the danger to people in the neighborhood, particularly children. This work explores technology-based sustainable development with used pneumatic rubber tires to build sustainability speed bumps.

3. METHODOLOGY

3.1 SPEED BUMP AND BUMP PROFILES

Bump is a speed self-control device applied vertical deflection to the vehicle passing the bump. Bumps normally are installed in local or private roads, thus sizes of bumps may vary. Bumps may have height 7-15cm with width 30cm or more (Elizer Jr, 1993). Some vehicle drivers feel unhappy due to the immediate and specific hazard of the bumps (Namee and Witchayangkoon, 2011).

In Thailand, commercialized vulcanized (caoutchouc/cinnamene-butadiene) rubbers bumps have varied width 27.5–50cm with height 4.5–7cm, with color black and white. These synthetic rubber bumps are quite hard and more difficult to get through. These bumps are installed in private areas such as hotels, schools, and shopping malls.

3.2 TRIAL AND ERROR

This study experiments on bumps produced from used pneumatic rubber tires with varied sizes. Old tires used in this study are bias tires (tubeless tires). A bias tire is made up of several overlapping plies of different materials (such as rubber, steel, nylon, fiberglass or combination of these materials) (Dealer tire, 2018; Michelin, 2018). Details and prices are given in Table 2.

Table 2: Types of vehicle tires

Type of tire	Price per old tire	Width
Sedan	20Baht (US$0.67)	16cm
Six-wheel lorry	40Baht (US$1.34)	19cm
Ten-wheel lorry	50Baht (US$1.67)	24cm

Figure 1: Cut Tires

Figure 2: Installation process of bumps built with used pneumatic rubber tires on a local road

3.3 INSTALLATION OF TESTED BUMPS

Installations of multiple bumps built with used pneumatic rubber tires on a road have been made to test with actual vehicle maneuver passing the bumps. Cut tires are stretch and placed across the width of a local road. Drills are made to the road. Flathead socket cap screws (or hexagonal bolts) with full thread, together with double expansion anchors, are used to fix the rubber tires to the road. It is important to make sure that while vehicles passing the bump will not rub over the bolt. Yellow paint is applied to the rubber tires bumps, to give better visibility of the bumps to road drivers to reduce their speeds. The "Caution Speed Bumps Ahead" signs are put at 65m ahead of the bump.

4. TESTING, RESULT, AND DISCUSSION

This study observes four types of vehicles passing the bumps built with used pneumatic rubber tires, *see* Figure 3. The experiment is conducted on bumps made from different used tires of a sedan, a six-wheel lorry, and a ten-wheel lorry. For sedan tires bump, it finds that bump has a too narrow width. In addition, the thin thickness of sedan tires bump makes it difficult to slow down big vehicles' speeds.

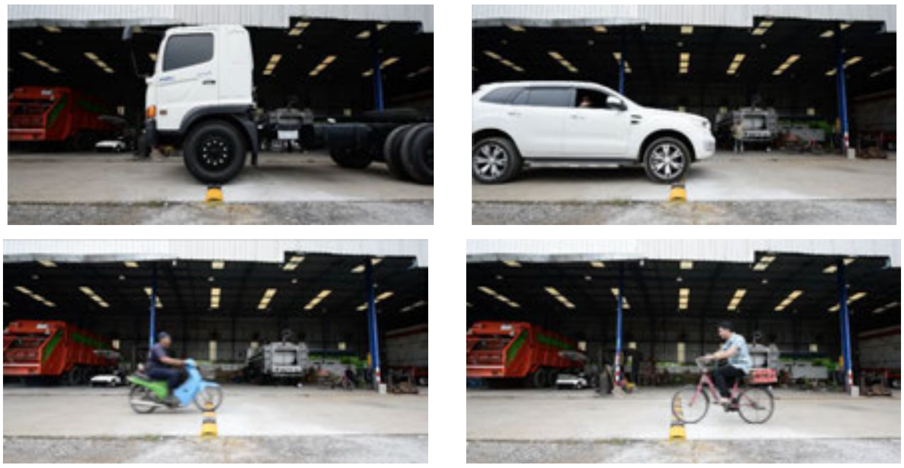

Figure 3: investigation on vehicles passing the bump.

The testing finds that used tires from six-wheel lorry is the most appropriate materials to make up the bump. This is due to the fact that thickness from six-wheel lorry tires is the right thickness as it is not too thick. Also, the width of six-wheel lorry tires is considered suitable, as the width is not too long for small vehicles to get through. More importantly, bump made with six-wheel lorry tires can get the impact better from the passing big vehicles.

Testing the bump made with ten-wheel lorry tires as pneumatic rubber tires, it is learned that the rubber is too hard. This causes great discomfort from road-holding to bicycles and motorcycles to maneuver across the bump.

5. TRAFFIC AUDITS

Traffic audits and investigation on vehicles passing the bump made of used rubber tires (from a

*Corresponding author (B. Witchayangkoon) E-mail: drboonsap@gmail.com Volume 10 No.14 ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8 Paper ID:10A14D http://TUENGR.COM/V10A/10A14D.pdf DOI: 10.14456/ITJEMAST.2019.182

six-wheel lorry) are investigated. Four types of vehicles speeds are observed and graphs are plotted at 85 percentile speed, see Figures 3 and 4. From the investigation, the bump seems to work well, as speeds go down to 25-30km/hr, especially at distance about 20m before and after passing the bump, see Figure 4. It is therefore recommended these low-cost bumps can be put every 50-60meters apart to slow down traffic speed.

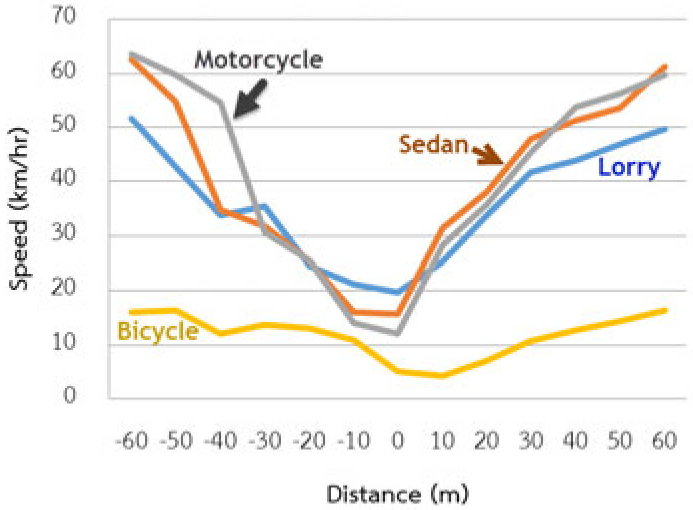

Figure 4: 85th percentile speeds passing through used tires of six-wheel lorry.

6. CONCLUSION

This study applies sustainability concept, with utilizing used car pneumatic rubber tires to build simple speed bumps to be placed on a local roadway to reduce passing speeds of vehicles, expecting to increase safety to the neighborhoods. This study demonstrates a way to build low-cost speed bump. In this experiment, bumps are made with different tire sizes, to observe the effect on a vehicle passing the bumps. The best low-cost bump is made of used tires from six-wheel lorry. Traffic audits and investigation on vehicles passing the old rubber tires bump are investigated, at 85 percentile. With an installation of bump built with used pneumatic rubber tires, it can decrease vehicular speeds to increase safety to the local community in the roadway neighborhood.

7. AVAILABILITY OF DATA AND MATERIAL

All used and generated data detail is already given in this work.

8. ACKNOWLEDGEMENT

This work is executed with the helps of Mr. Naphot Chanma and Mr. Parinya Bangchuad.

9. REFERENCES

Dealer tire. 2018. Bias Tires: Tires Facts. Available from https://www.rightturn.com/tire-guide/bias-tires Accessed September 2018.

DOH. (2018). Accident Report: Half Year 2018. Department of Highways, Royal Thai Government, August 2018.

Isranews. (2017). Bangkokians speed driving more than four thousand arrest cases. Isranews Agency. https://www.isranews.org/isranews-news/56274-news-562741.html Accessed October 2018.

Lav, A. H., Bilgin, E., & Lav, A. H. (2018). A fundamental experimental approach for optimal design of speed bumps. *Accident Analysis & Prevention*, *116*, 53-68.

Michelin. 2018. Radial or bias, the right choice. https://agricultural.michelinman.com/us/Properly-use-your-tires/Radial-or-bias-the-right-choice Accessed September 2018.

Namee, S., & Witchayangkoon, B. (2011). Crossroads vertical speed control devices: Suggestion from observation. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, 2(2), 161-171.

Namee, S., & Witchayangkoon, B. (2011). Crossroads Vertical Speed Control Devices: Suggestion from Observation. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, *2*(2), 161-171. http://tuengr.com/V02/161-171.pdf Accessed October 2018.

Pau, M. (2002). Speed bumps may induce improper drivers' behavior: Case study in Italy. *Journal of transportation engineering*, *128*(5), 472-478.

Wewalwala, S. N., & Sonnadara, D. U. J. (2011). Traffic noise enhancement due to speed bumps. *Sri Lankan Journal of Physics*, *12*, 1-6.

Wikipedia. 2018. Tire manufacturing. Available from https://en.wikipedia.org/wiki/Tire_manufacturing Accessed September 2018.

Witchayangkoon, B. (2015). Observation on Innovative Speed Bumps with Humps. *American Transactions on Engineering & Applied Sciences*, 4(4), 213-218. http://tuengr.com/ATEAS/V04/213.pdf Accessed October 2018.

Zainuddin, N. I., Diah, J. M., Adnan, M. A., & Sulaiman, N. (2012, December). The optimization of speed hump design: A case study in Malaysia residential streets. In *Humanities, Science and Engineering (CHUSER), 2012 IEEE Colloquium on* (pp. 368-373). IEEE.

Dr. Boonsap Witchayangkoon is an Associate Professor at Department of Civil Engineering, Thammasat University. He received his B.Eng. from the King Mongkut's University of Technology Thonburi with Honors in 1991. He continued his Ph.D. study at University of Maine, USA, where he obtained his Ph.D. in Spatial Information Science & Engineering. Dr. Witchayangkoon current interests involve Applications of Emerging Technologies to Engineering.

Dr. Sayan Sirimontree earned his bachelor degree from Khonkaen University Thailand, master degree in Structural Engineering from Chulalongkorn University Thailand and Ph.D. in Structural Engineering from Khonkaen University Thailand. He is an Associate Professor at Thammasat University Thailand. He is interested in the Durability of Concrete, Repair, and Strengthening of Reinforced and Prestressed Concrete Structures.

Dr. Krittiya Lertpocasombut is an Associate Professor in the Department of Civil Engineering, Faculty of Engineering, Thammasat University, Thailand. She received a B.Sc. from Chulalongkorn University, Thailand, an M.Sc. from Asian Institute of Technology, D.E.A. Diplome d'Etudes Approfondies in Water Purification and Treatment Engineering from INSA de Toulouse, France, and a Ph.D. in Water Purification and Treatment Engineering, Institut National des Sciences Appliquees (INSA), Toulouse, France. Dr. Lertpocasombut is interested in Water and Wastewater Treatment; Wastewater Recycled by Membrane Technology; Water Supply Sludge Treatment and its Reuse/Recycle.

Dr. Sanya Namee works at the Department of Disaster Prevention and Mitigation, Ministry of Interior, Thailand. He holds a Bachelor of Engineering from King Mongkut's Institute of Technology Ladkrabang, a Master of Engineering degree from Prince of Songkhla University and a Ph.D. degree in Civil Engineering from Thammasat University, Thailand. His research interests encompass Hazardous Material Transport.