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Impact of speed humps of bicyclists

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ABSTRACT

Speed hump is one of the most popular and economical traffic calming measures used globally. It induces shocks and vibrations in the vehicles passing over it. Hump aims to force the driver to reduce the vehicle speed to an optimum speed at which the discomfort is minimum. Extensive studies have been conducted to understand the vibration effect. In developing countries such as India, a large percentage of population uses bicycle or other non-motorized vehicles routinely. This study aims to understand the effects speed humps on bicycle riders. Variables such as geometry of the hump, speed of the vehicle, and riding posture of the driver are considered to understand the discomfort levels in detail. A set of volunteers in bicycles were asked to go over speed humps of different geometry at varying speeds and report the level of discomfort they felt. The vibrations were recorded by accelerometers installed on the handle bar, seat, and neck of the rider for measuring vibrations. These readings from accelerometers were converted to vibration dose values for evaluation. The same procedure was carried out for motorized two-wheeler riders also. The result shows that the bike riders experience the same level of discomfort as that of riders of motorized two-wheelers at a much low speeds. This study shows that unless proper considerations for bicycle riders are made, speed humps which is the most popular speed calming device used across the world could harm the bicyclists, which in turn could negatively impact the bicycling level of the region.

1. Introduction

Speed humps, like most of the other traffic calming devices, are aimed at reducing speed of motorized vehicles to improve overall safety of an urban area or a residential area. They are mainly intended to increase safety for pedestrians and non-motorized vehicles. Speed hump is one of the most commonly used traffic calming measures used globally, mainly because it is economical and efficient. The primary objective of installing speed hump is to introduce discomfort, through shocks and vibrations, to driver and passengers, while their vehicle passes over it with the speed greater than the designed speed. The levels of vibration and shocks and ideal operating speeds depend majorly on the hump geometry. Vibrations are defined as mechanical oscillations of an object or body about a reference position with certain amplitude and frequency. The human body can accept vibration energy to a certain level above which it is hazardous to health in repeated exposures. Vibration transmission to passengers greatly influences the comfort, performance and health (Griffin, 1996). The vibration energy waves caused by speed humps are transmitted into body of passengers causing various effects on the body structure internally. Human body is exposed to whole–body vibrations during commute and posture determines the level of discomfort felt by passengers (Adams et al., 1985).

There have been several studies conducted in understanding the relationship of geometry of speed humps and level of discomfort they induce for various vehicle types, mainly four-wheelers. Watts (1973) compares two types of humps: long humps and short humps. The results show that as the breadth of speed humps increased, the health hazard to car drivers is reduced. Bjarnason (2004) analyzes the effect of different types of speed humps (different geometry) on the comfort levels experienced by drivers. The result of this study shows that peak vertical acceleration is steady up to 30 km/h, but increases very rapidly after that. This study also finds out that round humps have greater peak acceleration as compared to that of long flat humps, thus causing more discomfort to drivers. This study shows that geometry of speed hump (breadth and height) affects the vertical acceleration and hence the ideal passing speed.

Paddan and Griffin (1988) present the transmissibility of vibrations in human body, between the points at which vibrations enter the body and the point at which the vibration is measured on the body, to understand the biodynamic response of human body. Transmission associated with dynamic system depends on the

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frequency, the point of contact between the human body and the source of vibrations. Hostens et al. (2003) report that vibration up to 12 Hz affect all human organs, while those above 12 Hz have local effects (Hostens et al., 2003). The vibrations affecting drivers are divided into two categories: whole-body vibration and hand-arm vibration.

Nahvi et al. (2009) presents the effect of road condition parameters such as International Roughness Index (IRI) on vibration dose value (VDV) discomfort faced by passengers of vehicles. Speed humps usually have a critical speed limit beyond which the passengers are expected to experience extreme discomfort. This critical speed limit is generally defined for motorized vehicles. Khorshid et al. (2007) illustrate the effect of different speed hump geometry on passenger's health as function of speed, seat features, and vehicle type. The result of this study shows that the whole-body vibration of driver is greatly dependent on speed hump geometry (mainly the height). This study finds that certain commonly used speed humps induce the mechanical shocks beyond the health-risk zone, even when the driver passes below the prescribed speed limit. The authors also report that circular speed humps, which are popular among transportation professionals, need to be modified to reduce the health hazard. In this paper, the authors introduce two new geometries of speed hump that are reported to be less hazardous than the circular speed hump.

Chen et al. (2009) compare the whole-body vibrations experienced by motorcycle riders and car drivers while riding on urban routes. The results, based on the vibrations measured at seat pad, show that whole-body vibration exposure levels of motorcycle riders are distinctively higher than those of drivers of sedans. Several studies (Okunribido et al., 2006; Blood et al., 2010; Smets et al., 2010; Nastac and Picu, 2010; and Velmurugan et al., 2014) have been done exclusively on different categories of vehicle such as buses, trucks, delivery vans, tractors and trains respectively to study the whole-body vibrations on drivers and passengers.

The literature review shows that there have been several studies conducted in the area of speed humps and their impact on traffic safety and on discomfort to drivers. However, all the previous studies focused on motorized vehicles, and none on non-motorized vehicles. Urban areas and residential areas, where installation of speed humps are predominant, are also shared by non-motorized users. Unfortunately, the discomfort caused to the non-motorized road users such as bicyclists are not taken into consideration while installing speed humps. The rigid structure of bicycle can accentuate the discomfort experienced by the rider. Most of the bicycles used for daily commute in developing countries such as India, have no shock-absorbers. Hence, it is extremely important to study the effect of speed hump on non-motorized users, as the exposure of these daily shocks to bicyclists gets unaccounted which may cause some serious health issues at later stages. This study is an attempt to understand the effect of speed humps on bicyclists.

2. Objective

The objective of this study is to understand the discomfort experienced by bicyclists while going over speed humps. Since the speed humps are designed primarily keeping motorized vehicles into consideration, this study aims to compare the discomfort felt by bicyclists and motorized two wheeler users.

3. Data collection

The first step of the study consists of collecting data on discomfort. To start with, speed humps inside Indian Institute of Technology Kanpur campus were selected. Although there were about 10 speed humps on campus, several of them were of same geometry. The geometries of all the speed humps were determined. All the speed humps had parabolic profiles. The process is explained in the following sub-section. Then four speed humps with different geometries were shortlisted for detailed data collection.

3.1. Speed hump geometry

Based on Indian Roads Congress guidelines (IRC 99-1988, 1996), the recommended dimension of speed humps for a speed of 25 km/h is 3.7 m broad and 0.10 m high. However, these guidelines were not followed in most of the cases as speed humps were made on-site (as opposed to precast) without proper quality control and hence their sizes varied significantly. Digital level Leica NA 2002 was used to measure the geometry. Since the speed humps were installed several years back, their shapes were not consistent throughout the cross-section. Therefore, measurements were taken at three locations (left end, center, and right end) and the average value was reported. Table 1 summarizes geometries of four different speed humps used for experimental testing. When compared with the dimensions of standard speed humps used across the world, the dimensions of these humps were observed to be somewhere in between speed humps and speed bumps. However, these are the typical ranges of dimensions of speed humps used in India.

3.2. Rider comfort

The data collection on bicyclists was conducted using nine male subjects at the four selected sites. Bean device Ax-3d accelerometers were used to measure Hand Arm Vibration (HAV), Whole Body Vibration (WBV) and Neck Vibration (NV). Three accelerometers were installed as follows:

(1) on handle to measure HAV,
(2) at seat of bicycle to measure WBV, and
(3) on neck of rider to measure NV.

Table 1
Dimensions of speed humps used in study.

Site	Height (in m)	Breadth (in m)	h/b
Site 1	0.08	2.76	0.029
Site 2	0.07	1.95	0.037
Site 3	0.05	1.24	0.040
Site 4	0.04	0.72	0.056

Fig. 1. Accelerometers installed on Bicycle.