DEVELOPMENT OF SPEED HUMPS MODEL ON FLEXIBLE PAVEMENT USING PAVEMENT CONDITION INDEX (PCI): A CASE STUDY OF ARTERIAL ROAD VADODARA CITY

[1]Tewodros Kassahun, [2]Jayesh Juremalani,[3]Siddharth Gupte

[1]M. Tech Student, [2]Assistant Professor,[3]Assistance Professor

[1]Transportation Engineering

[1]Parul institute of Engineering and Technology Vadodara India

Abstract: Road accidents are common in India, often due to poor driving or poor traffic calming. One of the most common types of traffic calming devices is Speed humps due to enforce slow down speed limit, having low cost and easy installation. Howeve r, in Vadodara city, many speed humps characteristic improperly designed. This makes pavement condition poor near to these humps and reduces smooth vehicles flow over speed humps. This paper Aim to develop speed humps model on flexible pavement using visual inspection method. Total 32-speed humps considered for the study on a stretch from Airport Circle to Soma Talav Cross Road both side. Pavement condition index (PCI), in road sections, near speed humps in the two directions of the road is calculated by the visual inspection measurements. The characteristics of each speed hump (height and width humps) for two directions recorded. Using linear regression correlations method developed best suitable mode between the pavement conditions index and speed hump characteristics. The width of speed humps less than 120cm From Airport Circle to Soma Talav Cross Road and From Soma Talav Cross Road to Airport Circle both direction Pavement Condition Index (PCI) was found between 25 to 40 which means pavement condition is poor. Generally, the results proved that the pavement conditions and Impact of speed humps on environmental pollution, safety, travel time, fuel consumptions, comfort for drivers and passengers and other factors are greatly influenced by the presence of improper design ofspeed humps and hump characteristics.

Index Terms – PCI, Speed Humps

I. INTRODUCTION

GENERAL

According to IRC's 1987 guidelines, a speed breaker should have a radius of 17m with a width of 3.7m and a heigh t of 0.1m. This is calculated to reduce the speed of the vehicle to 25kmph. It is mentioned that more humps be constructed at regular intervals depending on desired speed and acceleration/deceleration characteristics of vehicles and that the distance betwe en one hump to another can vary from 100 to 120 metres centre to centre. Speed breakers have sprung up all over the city, making driving quite hazardous. What's described as a traffic calming measure by the traffic police is a source of great agitation f or most drivers. Essentially a pedestrian-friendly measure, these have become a nuisance because they are not built or installed according to guidelines and the choice of spots is arbitrary. This causes damage to vehicles and also poses a threat to people. Speed humps (or speed breakers) are the common name for a family of traffic calming devices that use vertical deflection to slow motor -vehicle traffic in order to improve safety conditions. Variations include the speed hump, speed cushion, and speed table. The use of vertical deflection devices is widespread around the world, and they are most commonly found to enforce low speed limit, unde r 40 km/h (25 mph) or lower.

II CITY PROFILE

Vadodara also known as Baroda is the third largest city in the western Indian state of Gujarat after Ahmedabad and Surat. It is located on the banks of the Vishwamitri River. The railway line and NH 8 that connect Delhi and Mumbai pass through Vadodara. As per census 2011, the population of Vadodara is 16,70,806 of which male and female are 8,69,647 and 8,01,159 respectively. Average literacy rate is 90.63% and gender ratio is 921 male per 1000 females.

STUDY CORRIDOR

The study used two-lane road from Airport Circle to Soma Talav Cross Road which having 32 speed humps both direction and 13.7 km total length and the road has five main intersection. All of these humps are made of asphaltic concrete and have conv ex shapes with variable heights and widths. A meter was used on site to measure the speed humps length, heigh t and width where as Two wheeler for measure distance from preceding hump. The scale was used to measure the width and height of each

speed hump.

Fig 1 Snap shot of study road stretch city satellite from Airport Circle to Soma Talav Cross Road map (Source: Google map)

STUDY DESIGN

The main purpose of the study is developing speed hump model on flexible pavement condition using pavement condition index (PCI). The study design included survey type. The tasks will involve in this study inclu de selection of stud y area, survey of traffic flow, road geometry characteristic and pavement condition.

III OBSERVATIONS, RESULTS AND DISCUSSION

Under this section incorporates only observations 13.7 km road stretch from Airport Circle to Soma Talav Cross Road both side. In addition to this section measured chain age and Distance from preceding humps as well as counted number of speed humps

Table 1 Magnitudes of speed humps characteristic from Airport Circle to Soma Talav Cross Road

From Airport Circle to Soma Talav Cross Road				
Speed humps (SH)	speed humps chain age (m)	Interval between speed humps (m)	Width of speed humps(cm) (X)	Height of speed humps (Z)
SH1	0	0	130	14
SH2	437	437	120	14
SH3	1595	1158	150	13.5
SH4	1905	310	300	10
SH 5	2117	212	200	12
SH6	2885	568	130	14
SH7	3511	826	140	13.5
SH8	3887	376	90	15
SH9	4713	826	105	14
SH10	4912	199	93	14.5
SH11	5415	503	90	14
SH12	5911	496	120	14
SH13	6300	389	140	14
SH14	6528	328	105	10
SH15	6687	159	145	14

Pavement condition data

The process of data collection for pavement condition includes visual inspection of distresses, then measurement of the extent and severity of these distresses and finally calculation of the coefficient of pavement condition index (PCI). The PCI values were calculated over the distressed sections before and after the speed humps (in both directions of travel) .During the insp ection task for each before and after near of speed humps, the inspector measured each distress type and severity, and recorded these data on an asphalt-surfaced pavement inspection sheet. After recording the inspection data into the sheets, surface distresses evaluation was calculated based on a numerical rating from 0 to 100.

Steps for performing the condition survey and determining the PCI rating are conducted as per literature (PAVER 1982; ASTM D6433-09 2009; Shahin 1997):

1. Inspect sample unit, determine distress type and severity level and then measure the density
2. The deduct values are determined from the deduct value curves for each distress type and severity.
3. A total deduct value (TDV) is computed by summing all individual deduct values.
4. Once the TDV is computed, the corrected deduct value (CDV) can be determined from the correction curves. When determining the CDV, if any individual deduct value is higher than the CDV, the CDV is set equal to the highest individual deduct value.

5. The PCI is computed using the relation PCI = 100 − CDV.

Table 2 PCI rating

PCI rate	**Rating**
85–100	Excellent
70–85	Very good
55–70	Good
40–55	Fair
25–40	Poor
10–25	Very poor
00–10	Failed

Table 3 Magnitudes of speed humps characteristic from Soma Talav Cross Road to Airport Circle

From Soma Talav Cross Road to Airport Circle				
Speed humps (SH)	speed humps chain age (m)	Interval between speed humps (m)	Width of speed humps (cm)	Height of speed humps (cm)
SH1	0	0	90	11
SH2	211	211	120	11.7
SH3	524	313	117	11.5
SH4	606	82	118	11
SH5	922	316	150	13
SH6	1309	387	148	13.5
SH7	1961	652	130	11
SH8	2033	72	100	10
SH9	2812	779	140	12
SH10	3206	394	130	11.5
SH11	3962	756	240	14.5
SH12	4525	563	120	11
SH13	4610	85	2.9	15
SH14	4909	299	125	10.5
SH15	5122	213	127	11
SH16	5605	483	115	11
SH17	6606	1001	117	11.5

Table 4 Pavement condition index of the road near speed h umps both directions

From Airport Circle to Soma Talav Cross Road		From Soma Talav Cross Road to Airport Circle	
Speed humps (SH)	PCI value near to speed humps (Y)	Speed humps (SH)	PCI value near to speed humps (Y)
SH1	61	SH1	38
SH2	60	SH2	60
SH3	65	SH3	40
SH4	87	SH4	40
SH5	75	SH5	76
SH6	59	SH6	75
SH7	63	SH7	70
SH8	39	SH8	65
SH9	57	SH9	71
SH10	40	SH10	69
SH11	40	SH11	89
SH12	52	SH12	68
SH13	65	SH13	90
SH14	40	SH14	66
SH15	63	SH15	67
SH16	No	SH16	39
SH17	No	SH17	40

Statistical *Correlation Analysis*

This section is devoted to describe the correlations between PCI and speed hump characteristics of both direction

of the road using fit line plot and residual plot. This could help for better understanding of the associatio n between pavement condition and variables representing speed hump characteristics. All figures show the correlation coefficients between PCI and speed hu mps characteristics. According to all figure the signs of the correlation coefficients are in the expe cted direction. For example, the

width of hump and distance from preceding speed hump showed positive correlations with PCI for both directions. This means that the PCI tend to increase as width of speed hump and distance between speed humps increase. Alte rnatively, height of speed hump showed negative correlation with PCI, meaning the higher the height of speed hump the lower the PCI. The major observation is that all speed hump characteristics have significant correlations at the 0.01 level with PCI. More over all correlation coefficients between speed hump characteristics and PCI have approximately very close values.
Line fitting is the process of constructing a straight line that has the best fit to a series of data points

Table 5 statically analysis of speed humps characteristic and PCI

From Airport Circle to Soma Talav Cross Road			
Speed humps	value(PCI Value) Y	X(cm) width of speed humps	Z(cm) height of speed humps
SH1	61	130	14
SH2	60	120	14
SH3	65	150	13.5
SH4	87	300	10
SH5	75	200	12
SH6	59	130	14
SH7	63	140	13.5
SH8	39	90	15
SH9	57	105	14
SH10	40	93	14.5
SH11	40	90	14
SH12	52	120	14
SH13	65	140	14
SH14	40	105	10
SH15	63	145	14
AVARAGE	57.7	137.2	13.4
STDDEV	8.6	53.4	1.5
MAX	87.0	300.0	15.0
MIN	39	90.0	10.0

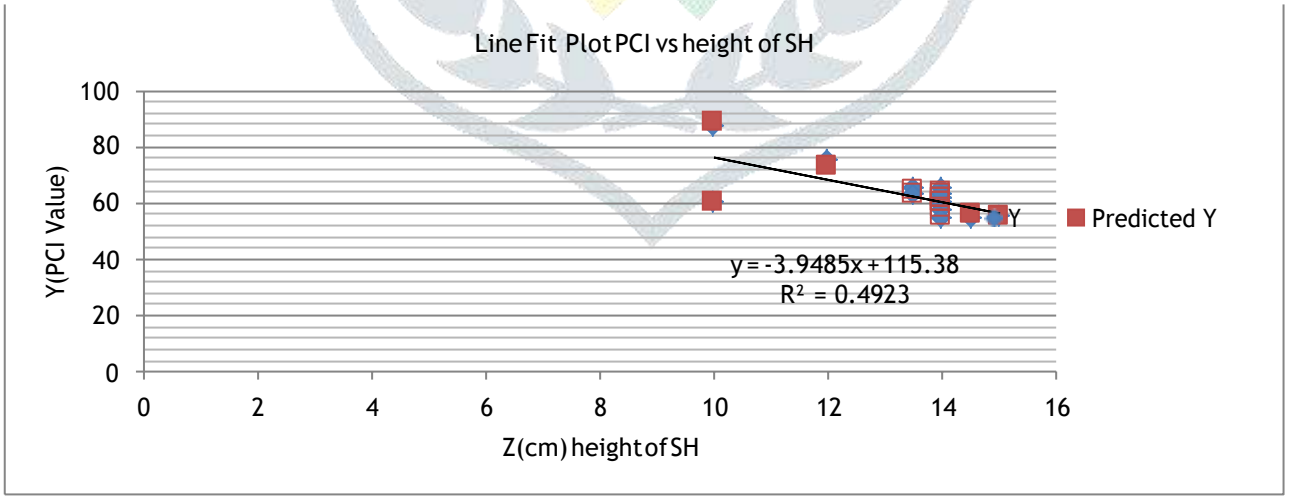

Fig 2 PCI vs Height of speed humps From Airport Circle to Soma Talav Cross Road

According to above line fit plot graph, the signs of the correlation coefficients are in the expected direction. For example, the height of speed hump showed negative correlations with PCI. This means that the PCI tend to increase as height of speed hump decrease. And R-value is 49% which means 51 % PCI and height of speed humps doesn't related .so weak correlation

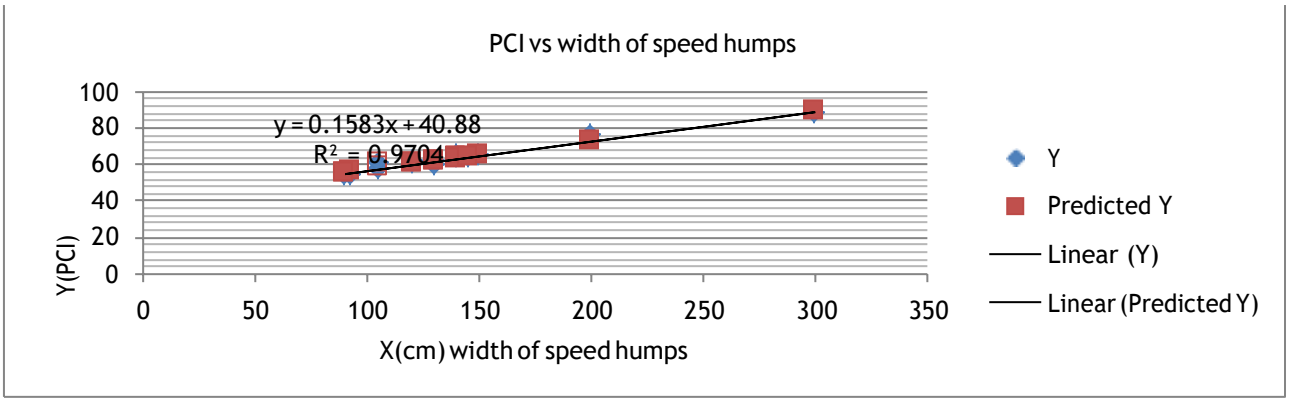

Fig 3 PCI vs. width of speed humps From Airport Circle to Soma Talav Cross Road

According to above line fit plot graph, the signs of the correlation coefficients are in the expected direction. For example, the width of speed hump showed positive correlations with PCI. This means that the PCI tend to increase as width of speed hump increase. And R-value is 97% which means 3% PCI and height of speed humps doesn't relate.

Table 6 statically analysis of speed humps characteristic and PCI value

From Soma Talav Cross Road to Airport Circle			
Speed humps	Y(PCI Value)	X(cm) width of speed humps	Z(cm) height of speed humps
SH1	38	90	14
SH2	60	120	13.5
SH3	40	117	13
SH4	40	118	13.5
SH5	76	150	13
SH6	75	148	10
SH7	70	130	14
SH8	65	100	15
SH9	71	140	13.5
SH10	69	130	13
SH11	89	240	10
SH12	68	120	14
SH13	90	290	10
SH14	66	125	14
SH15	67	127	14
SH16	39	115	13.5
SH17	40	117	14
AVARGE	64.35	139.8	13.1
STDDEV	9.6	50.2	1.5
MAX	90.0	290.0	15.0
MIN	39	90.0	10.0

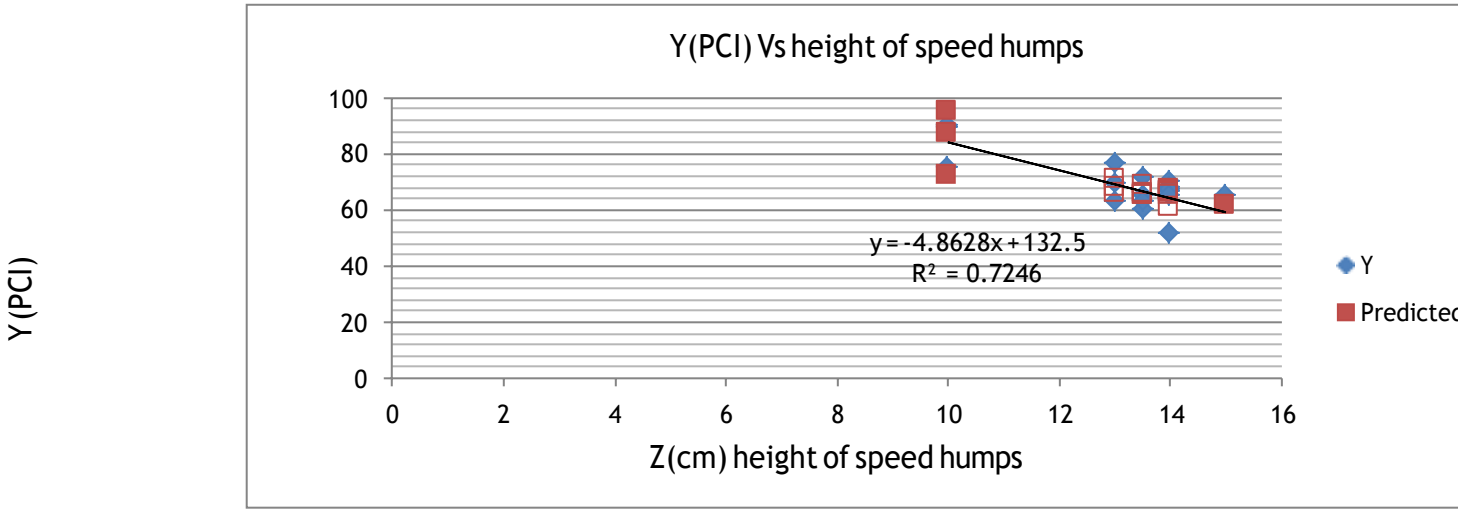

Fig 4 PCI vs. width of speed humps From Soma Talav Cross Road to Airport Circle

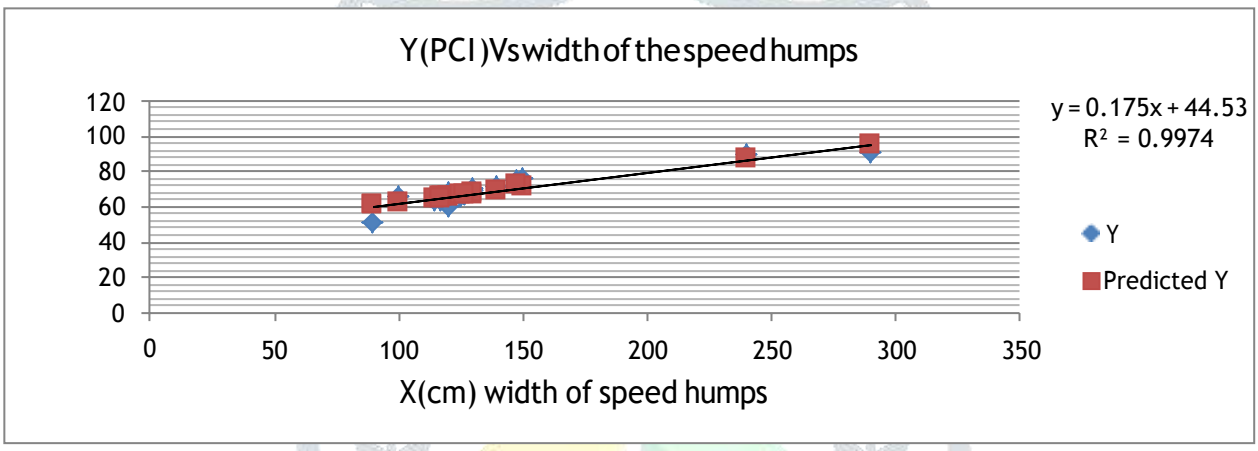

Fig 5 PCI vs. width of speed humps From Soma Talav Cross Road to Airport Circle

According to above line fit plot graph, the signs of the correlation coefficients are in the expected direction. For example, the height of speed hump showed negative correlations with PCI. This means that the PCI tend to increase as height of speed hump decrease. And R-value is 72% which means 28 % PCI and height of speed humps doesn't related

Table 7 Road characteristic Value

Road characteristic value	From Airport Circle to Soma Talav Cross Road	From Soma Talav Cross Road to Airport Circle
Road length (km)	6.87	6.85
Average pavement width (m)	10.8	10.8
Average shoulder width (m)	No	No
No. of speed humps	15	17
Speed humps density (hump/km)	0.904	0.777
Average width of speed humps (m)	137.2	139.1
Average height of speed humps (m)	13.4	13.1
Average PCI value	62.6	69

Indirect Impact of speed humps on environmental pollution, safety, comfort for drivers and passengers and other factors

- **Cause of increase the vehicle fuel consumption and emission rates**

The possible positive and negative impacts of speed humps characteristics have been addressed in this paper. In paper found that traffic calming measures reduced the speed on streets and may contribute to road safety. On the other hand, they may increase the vehicle fuel consumption and emission rates as well as increasing the response times of emergency vehicles while width of speed humps decrease. In video survey show that when the speed humps more than 150cm the vehicle move smoothly and fuel consumption and emission rates relatively lower than the speed humps width having less than 150 cm.

- **increase traffic noise, especially when large goods vehicles pass by**

Several studies investigated the effects of road hump on traffic volume and noise level. The results confirmed the

harmful effects of speed humps. Rosli and Kadar Hamsa (2013) investigated the effects of road hump on traffic volume and noise level in a residential area in Kuala Lumpur. So in this paper during video survey the noise pollution higher when the speed humps widt h less

- **Will cause of damage to the vehicle**

Many vehicles have problem with such speed humps if it doesn't design properly. Speed humps can also pose serious hazards to motorcycle and bicycle if they are not clear visible too. Let take example if the width of speed humps became is wider and wider the vehicle pass easily pass the speed humps smoothly means the vehicle couldn't damage

- **It cause discomfort and back injury to driver and passenger.**

This include those traveling on buss causing them to fall and injure themselves

IV CONCLUSIONS

The study was primarily aimed to develop the speed humps model on flexible pavement condition using Pavement Condition Index (PIC).The three parameter such as Pavement Condition Index (PCI) as dependent variable and speed humps characteristic like width and height of speed humps as independent variable were considered and following are main drawn from study.

1. Strong and weak correlations are found between PCI and examined speed hump characteristics like width and height of speed humps. The signs of the correlation coefficients are the expected direction. The width of speed humps show positive correlation with PCI having strong correlation. On the other hand, height of speed hump showed negative correlation with PCI having weak correlation due to excessive decelerations and accelerations before and after speed humps
2. From Airport Circle to Soma Talav Cross Road and From Soma Talav Cross Road to Airport Circle both width of speed
humps having less than 120 cm Pavement Condition Index (PCI) was found between 25 to 40 means the Pavement Condition is poor
3. When the width of speed humps lesser and lesser cause of increase in travel time and delay, damages to vehicles, discomfort to passengers, and increase in fuel consumption and pollution as well as deterioration in pavement condition.
4. In proper design of speed humps characteristic widespread in Vadodara City which cause damages to vehicles, discomfort to passengers, increase in fuel consumption and pollution, travel time and delay, pavement distresses and consequently in travel costs and waste of money.

REFERENC ES

[1] IRC'S 99-1987 TENTATIVE GUIDELINESON THE PROVISION OF SPEED BREAKERSFOR CONTROL OF VEHICULAR SPEED ON MINOR ROAD

[2] ASTM D6433-09. (2009). American Society for Testing and Materials, "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys", United States

[3] Talaat Ali Abdel-Wahed, Ibrahim Hassan Hashim "effect of speed hump characteristics on pavement condition on pavement condition" Science Direct, Volume, February 2017, Pages 103-110

[4] Prof. Dr Fareed M.A. Karim, Dr Khaled Abdul Haleem Rubasi, and Dr Ali Abd o Saleh "Road Pavement Condition Index (PCI)
evaluation and maintenance: A Case study Yemen". Organization, Technology and Management in Construction 2016; 8: 1446– 1455

[5] Boris Antic , Dalibor Pešic´ , Milan Vujanic , Krsto Lipovac "The influence of speed bumps heights to the decrease of the vehicle speed – Belgrade experience". Safety Science 57 (2013) 303–312

[6] Guidelines for the Design and Application of Speed Humps. Report RP-023A. ITE Traffic Engineering Council Speed Humps Task Force, 1997.

[7] Bekheet, W.. "Short term performance and effect of speed humps on pavement condition of Alexandria Governorate roads ".
2014,Alexandria Engineering Journal 53 (4), 855e8.

[8] Technical Manual TM 5-822-5. (1992). *Pavement Design for Roads, Streets, Walk s, and Open Storage Areas*. AIR FORCE AFM 88-7, Department of the Army, United States.

[9] Ahn, K., Rakha, H., 2009. A field evaluation case study of the environmental and energy impacts of traffic calming. Transportation Research Part D 14, 411–424.

[10] Behzad, M., Hodaei, M., Alimohamnadi, I., 2007. Experimental and numerical investigation of the effect of a speed bump on
car noise emission level. Applied Acoustics 68, 1346–1356.