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# Vibration Impact on Automobile Rider - Review

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**ABSTRACT**

***Now a day's millions of people prefer two wheeler as well as four wheeler as to reach the destination in time due to traffic. The Impact of whole body vibration on health of automobile rider is the main aim of study. The vibration is common in most of the vehicle and it is more in the three wheeler vehicle because of its dynamic nature. Vibration energy waves transferred into the body of the rider are transmitted through the body tissues, vISO 2631 suggests that vibration is measured in the three translational axes on the seat pan but only the axis with the organs and systems of the individual causing various effects on the structures within the body before it is dampened and dissipated. The vehicle vibration produces physiological effect on humans.***

## 1. INTRODUCTION

The majority population in India is depends on three wheeler vehicle for their transportation due to economic reasons. Vibration waves transferred into the body of the rider are transmitted through the body tissues, organs and systems of the individual causing various effects on the structures within thebody before it is dampened and dissipated The vehicle vibration produces physiological effect on humans. The evidence suggest that short time exposure to vibration causes small physiological effects such as increase in heart rate, increase in muscle tension long term exposure to vibration causes effects such as disk tospine & effects on digestive system. the health problems are also increasing and it is essential to identify whether there is any relation between the health problems of the driverVibration within the frequency range up to 12 Hz affects the whole human organs, while the vibrations above 12 Hz will have a local effect. Low frequencies (4-6 Hz) cyclic motions like those caused by tires rolling over an uneven road can put the body into resonance. Just one hour of seated vibration exposure can cause muscle fatigue and make a user more susceptible to back injury.

Currently, there are two main standards for evaluating vibration with respect to the human responses to whole body vibration; British Standard BS 6841 (1987) and International Standard ISO 2631 (1997). BS 6841 considers a frequency range of 0.5-80 Hz . This standard recommends the measurement of four axes of vibration on the seat (fore- aft, lateral and vertical vibration on the seat surface and fore- aft vibration at the backrest) and combining these in an evaluation procedure before assessing the vibration severity.most severe vibration is used to assess vibration severity. Therefore it is necessary to evaluate the influence of vibration to the human body and to make up appropriate guidelines for the three wheeler design and selection parts. The intensity of these harmful vibrations is reduced by providing a standard type of seat, front and rear suspension.

## 2. LITERATURE REVIEW

GOURAV.P.SINHAet al. [1] examined Whole-body vibration occurs when man/women or any kid is supported by a surface that is shaking andthe vibration affects body parts remote from the site of exposure. For example, when a forklift truck drives over a bumpy surface, vibration is transmitted through the vehicle to the seat and footrest, and also to the body which are the surfaces that support the driver. The vibration is then transmitted through the body of the driver to the head, which will move. This transmission path includes the seat; the surface of the driver in contact with the vehicle including the driver's nervous system; the skeleton, including the spine where an injury might occur; and ultimately the skull, which might have its own dynamic responses to the transmitted vibration.

Vikas Kumar, et al. [2] studied the vibration dose Value (VDV) has been recorded for the driver as well as the pillion of two wheeler vehicle for the different road profile having speed breakers, at different speed. The methodology adopted from the International Organization for Standardization (ISO) guidelines for whole body vibration (WBV) exposure having frequency ranges from 0 to 100 Hz. VDV of six healthy male subjects was recorded through the Human Vibration meter via seat-pad tri-axial accelerometers for two minutes drive and psychophysical response were measured with the help of Borg CR10 scale. The Time to reach 15 VDV and comfort decreases with the increase in vehicle speed and speed breaker's height, for both driver and pillion. Pillion feels more discomfort with the increase in vehicle speed and speed breaker's height when compared with driver. Ornwipa Thamsuwan, et al. [3] examined whether differences exist in WBV exposures between two buses commonly used in long urban commuter routes: a high-floor coach and a low-floor city bus. Each bus was driven over a standardized test route which included four road types. On average, the seats only attenuated 10% of the floor transmitted vibration and amplified the vibration exposures on the speed humps. Due to the low vibration attenuation performance of the bus driver's seat, evaluating different types of seats and seat suspensions may be merited

## 3. METHODS FOR MEASUREMENT OF VIBRATION AND ANALYSIS

The principal measurement and analysis procedure for evaluating health and comfort from vibration exposure is described in the standard ISO 2631-1 (1997). It is based on several studies conducted on subjects in a laboratory. Also other methods exist, which can be used to evaluate effects, mainly relating to health (i.e. physical effects). Some methods can be used for discomfort evaluation as well, but beyond frequency weighted r.m.s. method in ISO 2631-1 there are no validations of their applicability to discomfort (Els 2005). Four main methods exist for objectively evaluating ride comfort (Els 2005): 1) ISO 2631-1 (1997), 2)
BS 6841 (1987), 3) VDI 2057 and 4) Average Absorbed Power (AAP), but also additional methods exist, which have been used for specific purposes regarding comfort and health (e.g. Jerk or Spinal response method in ISO 2631-5). Even though the methods used in this thesis are limited to ISO 2631-1 and BS 6841 standards, it is necessary to understand other methods and reasons for their existence. This gives insight to different aspects of the vibration effects. Most methods are based on manipulating acceleration signal measured near or between the human body and a vibration platform. The purpose of signal manipulation is to emphasise frequencies and axes that are most harmful to a human body. Typically a single value is calculated, which can be compared to other environments and criteria determining the severity. There are some methods which are based on force input or calculating transient shocks from vibration.
Two main methods exist for evaluating the effects from vibration:
1) Frequency weighted r.m.s. and
2) Frequency weighted vibration dose value (VDV).
These are the most widely used methods for producing results from vibration measurements. Both methods use same filters (i.e. weighting curves) to process the acceleration data and multiplying factors for emphasising each axis. The difference is that the r.m.s. method has second power averaging while VDV uses fourth power without averagingduration. Thus VDV emphasises more shocks than the r.m.s. method. Additionally BS 6841 introduced a r.m.q. method, which is similar to the r.m.s. method, but using fourth power averaging.

**Root Mean Square (r.m.s.)**

The r.m.s method calculates the acceleration value by the square root of mean value obtained from the integration of the squared value of the signal. For the signal containing shocks, the r.m.s rapidly increases during each of these events, but also decays as the averaging time increases. The weighted r.m.s acceleration is expressed in *ms*$^{-2}$ for translational vibration as follows

$$a_w(T) = \left( \frac{1}{T} \int_{o}^{T} a_w{}^2(t)dt \right)^{\frac{1}{2}}$$

Where $a_w$(T)weighted acceleration time history and T is duration of measurement.

**Vibration Dose Value (VDV)**

Vibration Dose value shows a fourth power relationship between vibration magnitude and dose value of vibration which affects the health as well as comfort of human beings. VDV always accumulates for the vibration exposure and does not decay during periods of low value of vibration magnitude. As recommended by the ISO 2631 standard, daily vibration dose value (VDV) usually causes severe discomfort and health related problems. VDV has calculated as follows:

$$VDV = \left[ \int_{t=0}^{t=T} a_w{}^4(t)dt \right]^{1/4}$$

Where $a_w$(T)weighted acceleration time history and T is duration of the measurement.

**Different techniques to measure the vibration they are as follow**:

- Optical method
- Ultrasonic method
- Interferometer method
- Accelerator with FFT method

**A) Optical Method.**

The availability of high speed digital cameras has enabled three-dimensional (3D) vibration measurement by stereography and digital image correlation (DIC). The 3D DIC technique provides non-contact full-field measurements on complex surfaces whereas conventional modal testing methods employ point-wise frequency response functions. It is proposed to identify the modal properties by utilizing the domain-wise responses captured by a DIC system. This idea will be illustrated by a case study in the form a car bonnet of 3D irregular shape typical of many engineering structures. The full-field measured data are highly redundant, but the application of image processing using functional transformation enables the extraction of a small number of shape features without any significant loss of information from the raw DIC data.

**B) Ultrasonic Method**

The ultrasonic torsion converter transforms the sinusoidal power signal into mechanical twist oscillations and injects torsion waves into one end of the load train. Such converters are commercially available and consist of ferroelectric ceramic layers in the centre and solid aluminum alloy cylinders at both ends. The ferroelectric ceramic layers generate shear oscillations of sufficient magnitude, if the stimulation frequency is equal to the resonance frequency of the converter, i.e. if half wavelength of the generated torsion waves coincides with the length of the converter. All components of the load train must be designed appropriately to allow the formation of a standing wave at the resonance frequency of the ultrasonic torsion converter, which is 20 kHz in the present case. The design of the ultrasonic torsion load train is based on principles described by Mori and Uno and the actual realization using titanium alloy Ti6Al4V to manufacture the components.

**C) Interferometery Method**

Digital speckle pattern interferometry (DSPI) technique is a full field, non-contact, non-evasive and almost real time method to measure the vibrations of structures subjected to various kinds of loading. DSPI is faster in operation and less sensitive to environmental perturbations than holography. In DSPI, the speckle pattern is formed by illuminating the surface of the object by laser light. The object wave is imaged on the photosensitive part of the CCD camera where it is allowed to interfere with an in-line reference beam. The interferograms of two different states of the object are grabbed and subtracted. The speckle correlation fringes are thus displayed on computer monitor using digital techniques.

**D) Accelerometer with FFT**

The purpose of this system is: 1. To gather real-time field vibration data for the future use in the seat suspension system simulation research. 2. To have the means to analyse the seating dynamics concurrently in three mutually perpendicular axes. In this way, the various interactions could be analysed in each vehicle. The research effort could then focus on the vibration mitigation in the axis of the highest influence (acceleration value).

**E) Harmonic Analysis**

From this analysis, the displacements of various nodes and stresses for different elements over the entire frequency range

0 – 80Hz with amplitude of 0.05m were obtained. The displacements at various nodes were plotted against frequency. Maximum displacement was obtained at the right end of the rear chassis. The variation in the displacement values at the suspension bottoms at the rear and front suspensions.

## 4. CASE STUDY

Fig: 1(a) shows that, for driver and pillion, the VDV value at speeds 20 kmph and 30 kmph are 3.7 ms, 4.4 ms and 4.6 ms, 5 ms respectively for the speed breaker DARK EYE DA 1005. Fig.1 (b) shows, that for driver and pillion, the VDV value at speeds 20 kmph and 30 kmph are 4.5 ms , 5 ms and 5.2 ms , 6.2 ms respectively for the speed breaker of DARK EYE DA 1006. VDV value for the driver has been found to be less compared to the pillion for both the speed breakers i.e. driver is exposed to less vibration severity as compared to the pillion on the same vehicle. Fig. 1(c) shows that VDV values for driver at 20 kmph 30 kmph for speed breaker DARK EYE DA 1005 and DARK EYE DA 1006 are 3.7ms , 4.5ms and 4.4 ms and 5ms respectively.

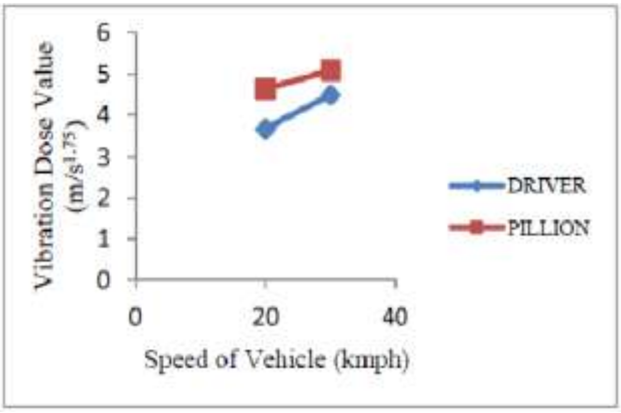


Fig 1(a)- *Mean value of VDV of six subjects on Speed Breaker Dark Eye DA 1005.*

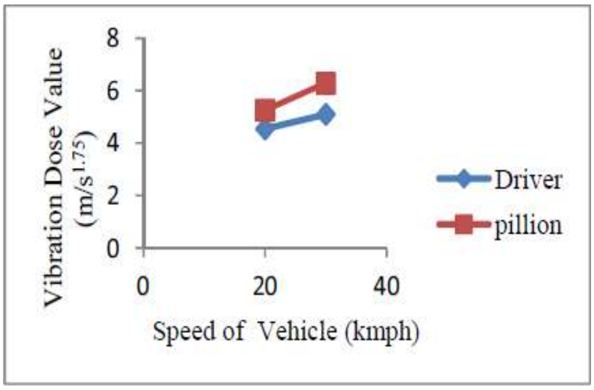


*Fig:1(b)Mean value of VDV for six subjects acting as driver and pillion ata speed of 20 kmph and 30 kmph on Speed Breaker Dark Eye DA 1006.*

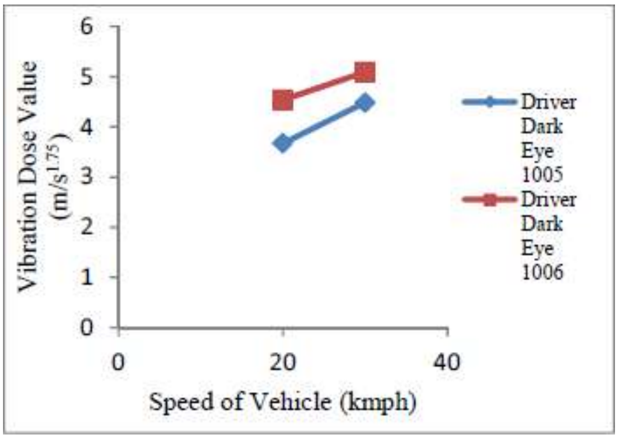


*Fig1(c) Comparison of Mean VDV values for driver on Speed Breaker Dark Eye 1005 and Speed Breaker Dark Eye DA 1006*

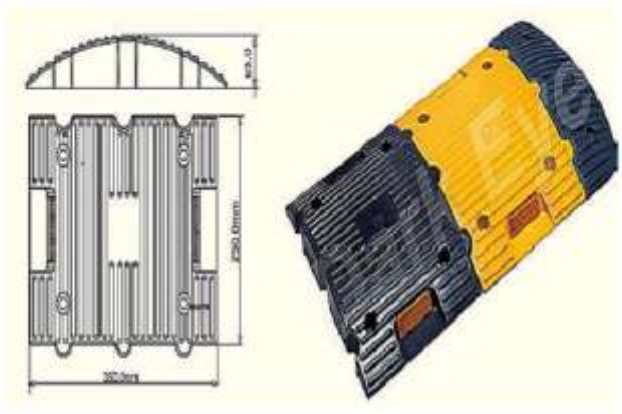

Fig 3(a) Speed Breaker DARK EYE DA 1005

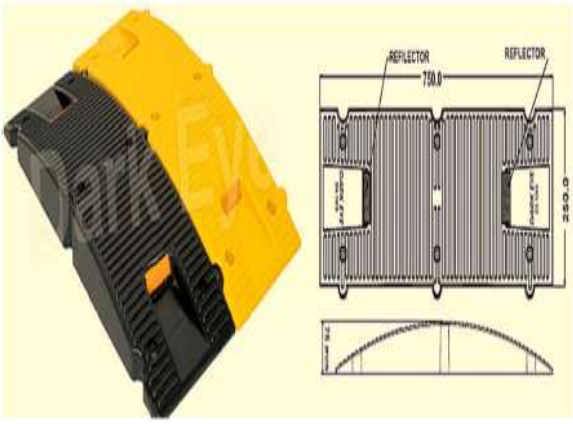


Fig 3(b): Speed Breaker DARK EYE DA 1006

WBV exposures comparing buses by road type.

| Parameter | Axis | Smooth freeway Low floor, N = 15 | Smooth freeway Coach, N = 12 | p-Value | Rough freeway Low floor, N = 15 | Rough freeway Coach, N = 12 | p-Value | City street Low floor, N = 15 | City street Coach, N = 12 | p-Value | Speed bumps Low floor, N = 15 | Speed bumps Coach, N = 12 | p-Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A(8) [m/s²] | 1.4x | 0.16 ± 0.01 | 0.16 ± 0.01 | 0.98 | 0.19 ± 0.00 | 0.21 ± 0.02 | 0.16 | 0.20 ± 0.00 | 0.19 ± 0.01 | 0.61 | 0.24 ± 0.01 | **0.75 ± 0.09** | <0.0001* |
| | 1.4y | 0.18 ± 0.01 | 0.15 ± 0.01 | 0.01* | 0.21 ± 0.00 | 0.17 ± 0.01 | 0.01* | 0.19 ± 0.00 | 0.15 ± 0.00 | 0.0002* | 0.26 ± 0.01 | **0.74 ± 0.09** | <0.0001* |
| | z | 0.42 ± 0.02 | 0.37 ± 0.01 | 0.03* | **0.55 ± 0.02** | **0.50 ± 0.01** | 0.31 | 0.38 ± 0.01 | 0.35 ± 0.01 | 0.02* | 0.38 ± 0.02 | 0.44 ± 0.05 | 0.19 |
| Crest factor | x | 14.1 ± 1.3 | 8.1 ± 0.4 | 0.0004* | 13.3 ± 1.3 | 6.6 ± 0.2 | 0.0001* | 14.2 ± 1.8 | 12.4 ± 0.8 | 0.40 | 9.9 ± 0.7 | 6.9 ± 0.4 | 0.003* |
| | y | 10.9 ± 0.8 | 6.6 ± 0.4 | 0.0001* | 9.3 ± 0.6 | 6.0 ± 0.2 | <0.0001* | 14.4 ± 2.1 | 9.7 ± 0.3 | 0.06* | 7.2 ± 0.4 | 6.8 ± 0.3 | 0.23 |
| | z | 9.0 ± 0.3 | 8.7 ± 0.5 | 0.009* | 8.2 ± 0.3 | 9.3 ± 0.3 | 0.02* | 12.8 ± 0.4 | 14.3 ± 0.8 | 0.005* | 11.3 ± 0.8 | 10.4 ± 0.8 | 0.45 |
| VDV(8) [m/s$^{1.75}$] | 1.4x | 4.7 ± 0.4 | 3.8 ± 0.2 | 0.02* | 5.4 ± 0.4 | 4.3 ± 0.4 | 0.06 | 5.5 ± 0.6 | 4.6 ± 0.2 | 0.19 | 6.0 ± 0.3 | **16.9 ± 2.1** | <0.0001* |
| | 1.4y | 4.1 ± 0.2 | 2.8 ± 0.1 | 0.0001* | 4.5 ± 0.3 | 3.2 ± 0.1 | 0.0002* | 5.0 ± 0.7 | 3.2 ± 0.08 | 0.03* | 5.5 ± 0.3 | **16.4 ± 2.2** | <0.0001* |
| | z | 8.5 ± 0.3 | 8.0 ± 0.2 | 0.41 | **10.5 ± 0.4** | **11.1 ± 0.3** | 0.25 | 8.9 ± 0.3 | **9.2 ± 0.3** | 0.56 | **9.9 ± 0.6** | **10.5 ± 0.9** | 0.61 |
| $S_{ed}$(8) [MPa] | x | 0.09 ± 0.01 | 0.07 ± 0.01 | 0.04* | 0.11 ± 0.00 | 0.08 ± 0.01 | 0.05* | 0.12 ± 0.02 | 0.09 ± 0.00 | 0.24 | 0.12 ± 0.01 | 0.26 ± 0.03 | <0.0001* |
| | y | 0.17 ± 0.01 | 0.10 ± 0.00 | 0.0002* | 0.18 ± 0.02 | 0.10 ± 0.00 | 0.0001* | 0.22 ± 0.05 | 0.12 ± 0.00 | 0.10 | 0.20 ± 0.01 | **0.57 ± 0.06** | <0.0001* |
| | z | 0.24 ± 0.01 | 0.23 ± 0.01 | 0.44 | 0.32 ± 0.01 | 0.27 ± 0.01 | 0.0001* | 0.32 ± 0.02 | 0.30 ± 0.01 | 0.94 | 0.47 ± 0.05 | 0.49 ± 0.08 | 0.41 |

Table 1- WBV exposures comparing buses by road type.

The WBV exposures measured on the high-floor coach and lowfloor buses were compared separately by road type (Table 1). The predominant direction of most WBV exposures was the z-axis except when the coach bus traveled on the road segment containing the speed humps, where there was more than one predominant axis for the A(8) and VDV(8) exposures. Since some of the data had exposures in multiple axes, the vector sum WBV exposures were also compared (Figs. 2e4). Furthermore, when crest factors were greater than 9, ISO 2631-1 states that A(8) exposures should be interpreted with caution (since they may underestimate exposures due to impulsive content) and VDV(8) exposures may be more representative of the potential health risks.

Mean (S.D.) of RMS, estimated 8-h vibration dose value ($VDV_{(8)}$) and estimated 8-h static compression dose ($S_{ed}$) on different roadways and at speed limits.

| Exposure parameters | Roadway | A (rural 5 km) | | B (provincial 5 km) | | C (urban 10.6 km) | | A+B+C (20.6 km) | |
|---|---|---|---|---|---|---|---|---|---|
| | Speed limit (km/h) | 55 | 40 | 55 | 40 | 55 | 40 | 55 | 40 |
| RMS (m/s²) | Scooter (n=6) | 0.97 (0.15) | 0.96 (0.18) | 0.68 (0.17) | 0.68 (0.17) | 0.79 (0.10) | 0.79 (0.10) | 0.88 (0.17) | 0.90 (0.15) |
| | Motorbike (n=6) | 1.18 (0.20) | 1.05 (0.22) | 0.84 (0.14) | 0.82 (0.22) | 0.90 (0.13) | 0.88 (0.13) | 0.94 (0.14) | 0.90 (0.15) |
| | Sedan (n=5) | 0.40 (0.03) | n.a. | 0.35 (0.08) | n.a. | 0.27 (0.02) | n.a. | 0.30 (0.02) | n.a. |
| $VDV_{(8)}$ (m/s$^{1.75}$) | Scooter (n=6) | 24.35 (6.80) | 23.30 (4.25) | 21.89 (5.28) | 19.26 (5.24) | 22.67 (4.55) | 21.71 (4.51) | 22.38 (4.96) | 21.54 (4.17) |
| | Motorbike (n=6) | 28.18 (5.98) | 24.42 (3.63) | 23.69 (4.39) | 21.73 (4.52) | 24.09 (4.54) | 22.51 (2.94) | 25.22 (4.80) | 23.42 (3.18) |
| | Sedan (n=5) | 8.85 (0.27) | n.a. | 8.28 (0.55) | n.a. | 8.85 (0.55) | n.a. | [illegible] | n.a. |
| $S_{ed}$ (MPa) | Scooter (n=6) | 1.22 (0.70) | 0.98 (0.18) | 1.12 (0.44) | 0.86 (0.14) | 1.26 (0.45) | 1.11 (0.21) | 1.22 (0.46) | 1.06 (0.09) |
| | Motorbike (n=6) | 1.16 (0.16) | 0.97 (0.26) | 1.25 (0.36) | 1.00 (0.19) | 1.29 (0.26) | 1.00 (0.26) | 1.27 (0.22) | 1.00 (0.17) |
| | Sedan (n=5) | 0.28 (0.02) | n.a. | 0.23 (0.08) | n.a. | 0.23 (0.03) | n.a. | 0.24 (0.02) | n.a. |

Table 2- RMS /VDV, comparison on different roadways & at different speed limit

Significant roadway effect (p< 0.001) was found in RMS and VDV(8), and significant speed limit effect (p < 0.05)was found in and Sed, respectively. (Table 4) The greatest mean RMS (1.08 m/s2), VDV(8) (26.55 m/s1.75) and Sed (1.24 MPa) was obtained on the rural roadway with the speed limit at 55 km/h. The average motorcycle speed in this case was 31.6 km/h (Table 2). A slower average riding speed or lower speed limit lowered the vibration to which the riders were exposed. Lowering the speed limit from 55 km/h to 40 km/h caused the mean Sed, VDV(8) and RMS to fall on average by 21%, 7%, and 3%, respectively (Table 4). However, riding speed was not the only factor influencing the WBV exposure of the motorcycle riders. The WBV exposure on the urban roadway was greater than that on the provincial roadway, even at the slowest riding speed.

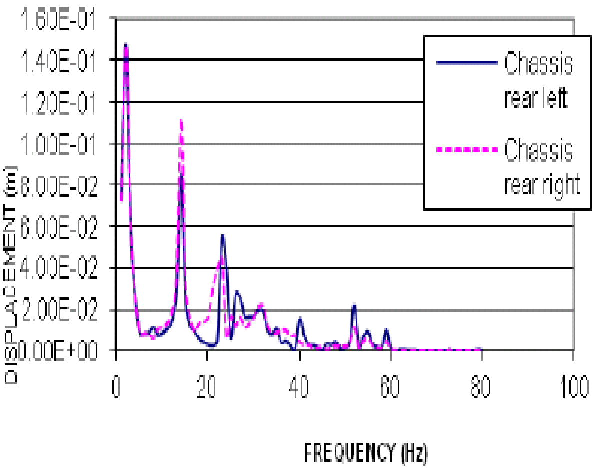


Fig 2 (a)- Variation in displacement at left and right end of the rear chessis

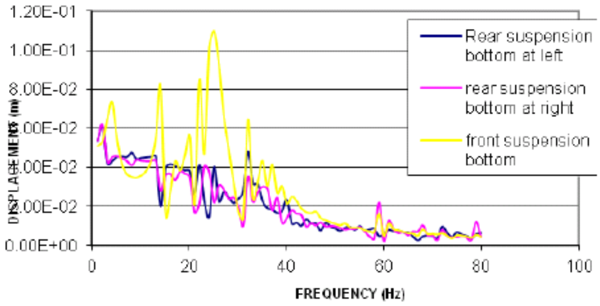


Fig 2(b)- Variation of displacement at suspension bottom

The variation in displacement at the left and right end of the rear chassis was represented in Fig 1 .the displacements of various nodes and stresses for different elements over the entire frequency range 0 – 80Hz with amplitude of 0.05m were obtained. At the right end of the rear chassis Maximum displacement was obtained. The variation in the displacement values at the suspension bottoms at the rear and front suspensions were represented in Fig 2. The maximum displacement was observed at the front suspension bottom at the third peak (25Hz).

## 5. SUMMARY-

The nature of vibration that is present in a vehicle depends upon the dynamic characteristics of the automobile and road surface characters. Its effect on the human body depends mainly on the frequency, magnitude, direction, area of contact and duration of exposure. Exposure to HAV and WBV will result in transmission of vibratory energy to the entire body and leads to localized effects. It affects comfort, normal functioning of the body and health. Exposure to certain frequencies of vibration may have profound effectson specific systems of the body depending upon the natural frequencies of it and acceleration of the vibration at that frequency.
The vibrational effects are more hazardous on motorcyclist. As for as possible, measures is to be taken to avoid prolonged exposure to vibration. Also, it is very important to keep the Rms value of HAV acceleration well below 1m/s2, WBV acceleration within 0.315 m/s2 and total acceleration within 0.8m/s² as safety standard levels of the vibration. If possible it is necessary also to avoid vibrational frequency below 90 hz.

## REFERENCES

**[1].** Ornwipa Thamsuwan Ryan P. Blood, Randal P. Ching, Linda Boyle, Peter W. Johnson "Whole body vibration exposures in bus drivers: A comparison between a high-floor coach and a low-floor city bus" International Journal of Industrial Ergonomics, 2013, 9-17

**[2].**Gourav.P.Sinha, P.S.Bajaj"Vibration analysis of hero honda vehicle" IJMPE, Volume-2,Issue 2 Feb-2014
**[3].** Vikas Kumara, V.H. Saranb and Veeresalingam Guruguntla " Study of Vibration Dose Value and Discomfort due to Whole Body Vibration Exposure for a Two Wheeler Drive" Proc. of the 1st International and 16th National Conference on Machines and Mechanisms (iNaCoMM2013),
IIT Roorkee, India, Dec 18-20 2013
**[4].** M K Naidu, S Srinivasa Rao and T Tejesh "Ride Analysis of Three Wheeled Vehicle Using MATLAB/Simulink" AMAE Int. J. on Manufacturing and Material Science, Vol. 02, No. 01, May 2012

**[5].** Jaimon Dennis Quadros, Suhas, Vaishak N.L, Shilpa. B "Study of vibration and its effects on health of a two wheeler rider" IJRET,Volume-2,Issue 08 | Aug-2013