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HUMAN RESPONSE TO SHOCKS

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Abstract

The evaluation of vibration containing shocks (i.e., humps on the roads) can be done by making use of the methods suggested in ISO2631-1: 1997 and ISO2631-5: 2004. In this study the two standards are compared first using sine impulses as seat accelerations then using field data. While generating the sine impulses crest factor, CF (=2.002) was kept constant; the amplitudes (amplitude range: 1-8 m/s^2) were varied. The range of the spinal acceleration dose, D_k, values indicated in ISO2631-5 were found to be in the range of ~ 0.7 – 11. The shape of the lumbar z response curve corresponding to seat accelerations, $a_{z\ seat}$, having amplitude, A, 6 m/s^2 changed significantly, compared to the shape of the response curve corresponding to $a_{z\ seat}$ having A=1 m/s^2. When the duration of the pulse is doubled a slight decrease in the D_k value was observed. The D_k values corresponding to single, double and triple pulses were respectively 0.7, 0.79 and 0.84. Even though the spacing of the double pulses did not change the D_k values, its adverse effect on the psychology of the drivers can not be ignored. The field acceleration time data used in the assessment of the standards was obtained from the measurements performed in a car driven on a track having six humps. The cross over velocity was 30 km/hr for the humps. When only one hump is considered the VDV values found according to ISO2631-1 were 0.78 on the seat and 0.83 at the lumbar level. The spinal dose value, D_k of ISO2631-5 for one (three) hump was 3.07 (3.43 in case of three humps). The spinal D_k value based on the measured lumbar accelerations however was found to be 3.56 (5.07 in case of 3 humps). It seems that ISO2631-5 overestimates the damping capacity of a person exposed to vibration.

INTRODUCTION

Human response to vibration involves not only the steady response but also the response to shocks. Shocks can be defined as transient excitations resulting in large magnitude of impulsive forces on the systems. They can be occasional or frequent (i.e., closely spaced multiple shocks). While evaluating the effect of the shocks on the spine of the exposed persons the spacing, the peak values and the number of the shocks have to be considered as the contributing parameters of the vibration severity.

The two standards, i.e., ISO 2631–1: 1997 [1] and ISO 2631–5: 2004 [2] can both be applied to vibration exposures initiated by transient vibrations. In order not to underestimate the effects of occasional shocks ISO 2631–1: 1997 suggests the usage of the fourth power vibration dose value, VDV. Whereas ISO 2631–5: 2004 recommends a sixth power vibration dose value, D_z. D_z is calculated considering only those peaks which are more than one thirds or more of the highest peak.

In this study VDV and D_z approaches are assessed using test signals and field data for vibrations having multiple, short duration, shocks.

TEST RESULTS

The excitation signals used in this study were either test signals, i.e., multiple sine pulses or random excitations collected in the field. The sampling rate for the test signals was 160 samples/s .The sampling rate of the field data was adjusted to 160 samples/s by resampling it.

Case 1 Excitation: Single sine pulse

The measurement time (= 4 s) and the duration of the pulse (t_p = 2 s) were kept constant throughout the analysis. The acceleration amplitudes, however, were varied. The range of the amplitudes was chosen to be between 1 and 8 (crest factor, CF, however, remained constant; CF = 2.0018). As can be seen in Figures 1 and 2, depending on the amplitude of the excitation not only the dose values but also the characteristics of the response curves changed. VDV values calculated according ISO 2631 – 1: 1997 varied linearly with respect to amplitude. The D_z values of ISO 2631 – 5: 2004, whereas, varied according to a power relationship between D_z and amplitude of the pulse.

Case 2 Excitation: Multiple sine pulses

In this case only the number, NP, of the pulses included in the measurement time was varied. The total measurement time (t = 16 s), duration (t_p = 2 s) of each pulse and its amplitude (A = 1 m/s^2) were kept constant (Figures 3 (a), (b) and (c)). In ISO 2631 – 5 D_z values are calculated considering only the appropriate peak values. The effect of the spacing of the pulses is therefore ignored. While trying to find the relationship between D_z and NP the spacing between the pulses was therefore taken as zero. It is however worth noting that the frequently spaced humps (simulated here as sine pulses) will not only affect the psychology of the drivers but also the car components. D_z values associated with sine pulses found to be varying according to the following relationship

$$D_z = 0.7001\,(NP)^{0.1663} \qquad ;\ (R^2 = 1) \qquad (1)$$

Figure 4 displays variation of D_z with respect to NP. Minimum (maximum) NP was chosen to be one (six). Since vibration severity along z direction is related to the compression of the spine, NP value can also be thought to indicate the number of the peaks.

Case 3 Excitation: Field data

Field data was collected in a car traveling on an asphalt road having six humps .The safety belt of the driver was "on" and the waist support of the seat was "open". The velocity of the car was 30 km/hr. Unlike the spine response observed in case of single and double sine pulses, a left wise time shift of 0.238 s was observed in the time spectra corresponding to the waist of the driver (Figure 5). Figure 5 contains only one hump. For this case VDV values found according to ISO 2631 –1 were 0.7790 ≈ 0.78 on the seat and 0.8285 ≈ at the lumbar level of the driver. Compared to VDV seat z the increase in VDV waist z value was 6.35% but a_z peak of seat was 9.36 % higher compared to a_z peak of the waist. For a road track having one hump D_z value (ISO 2631 – 5) was found to be 3.0724 ≈ 3.07. The sixth power vibration dose value calculated using the field data collected at the waist level of the driver was 3.5638 ≈ 3.56. In case of a road track having three humps and one pothole D_z value and the sixth power vibration dose value were respectively 3.4213 ≈ 3.42 and 5.0734 ≈ 5.07.

CONCLUSION

It seems that ISO 2631 – 5: 2004 overestimates the damping capacity of a person exposed to vibration in z direction.

REFERENCES

[1] "Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration Part 1: General Requirements", ISO 2631 – 1 (1997).

[2] "Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration Part 5: Method for Evaluation of Vibration Containing multiple shocks", ISO2631 – 5 (2004)

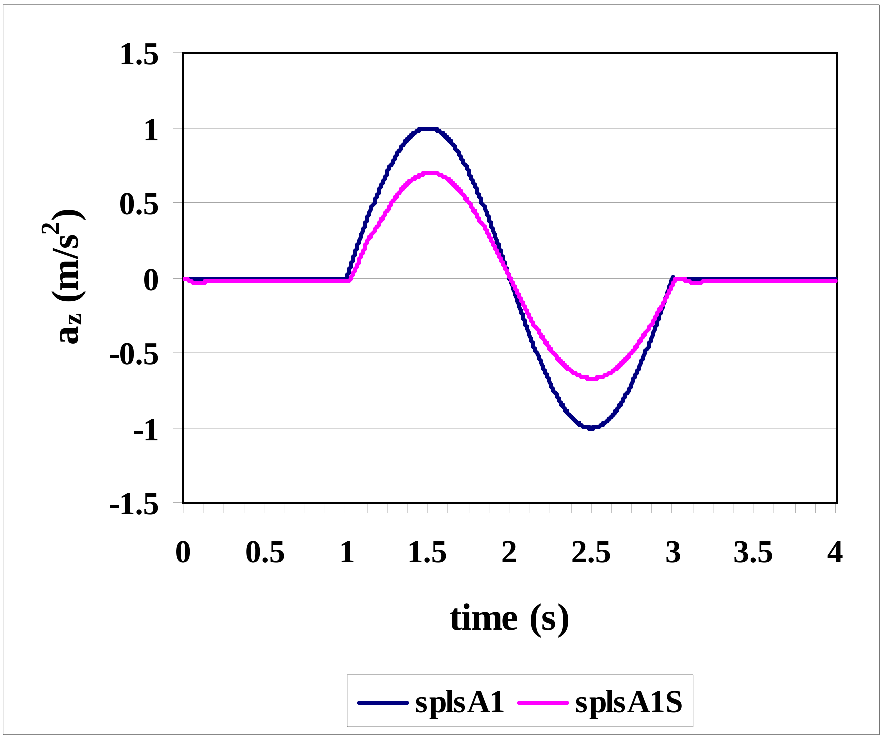

Figure 1 – Excitation – Response curves associated with sine pulse (amplitude = 1 m/s^2)

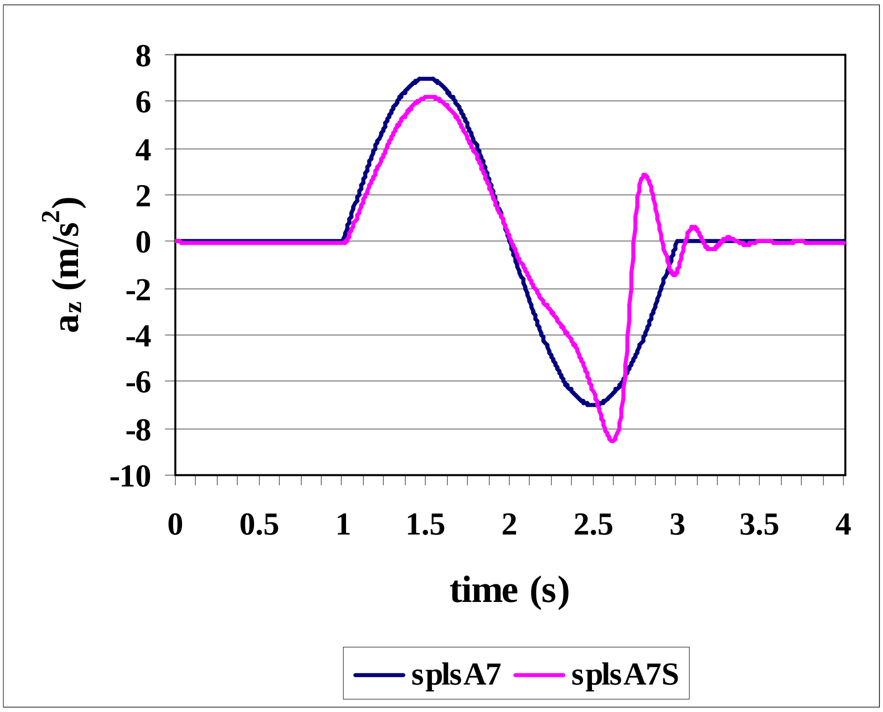

Figure 2 – Excitation – Response curves associated with sine pulse (amplitude = 7 m/s^2)

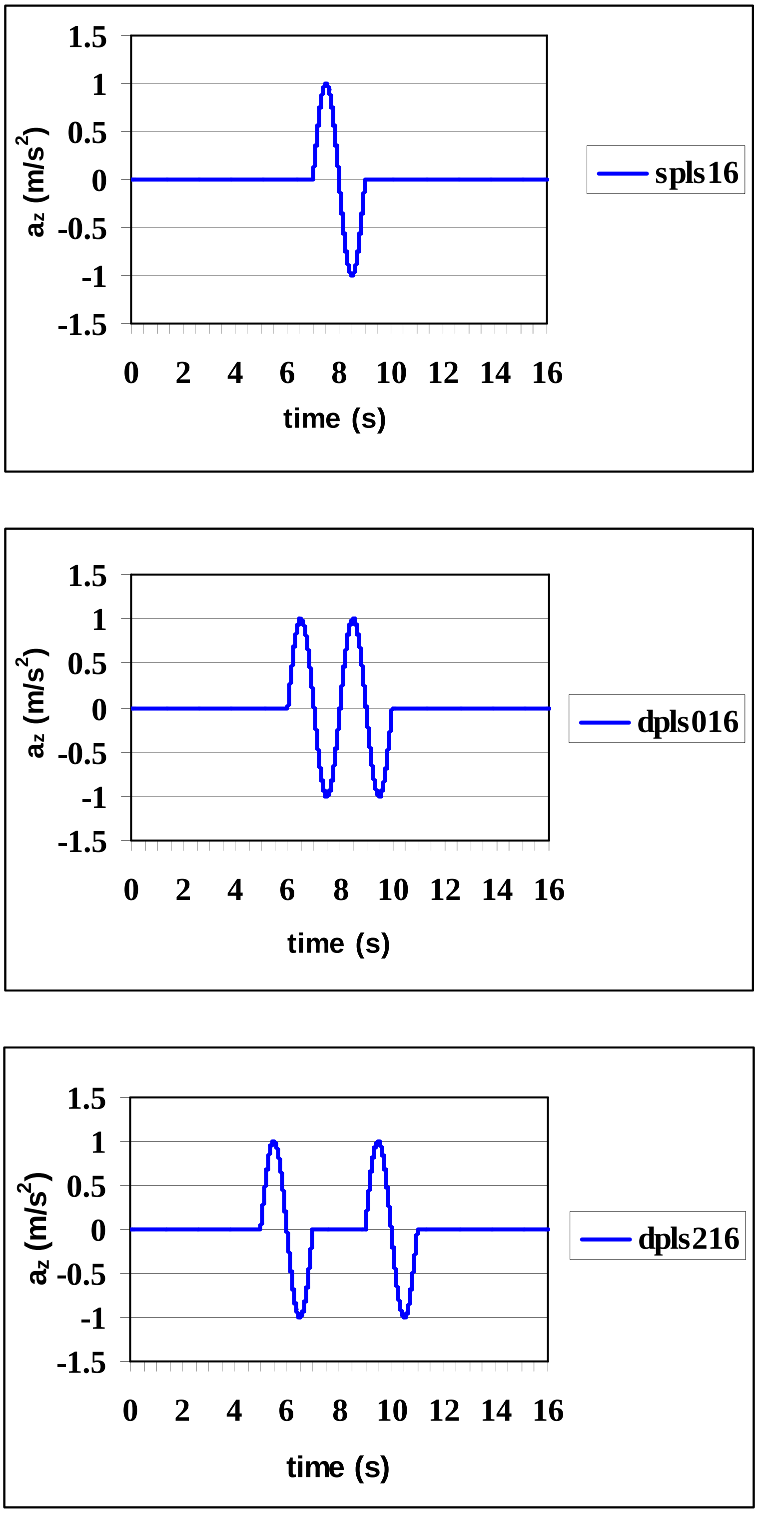

Figure 3 – Excitation: single and double pulse curves (amplitudes = 1 m/s²)

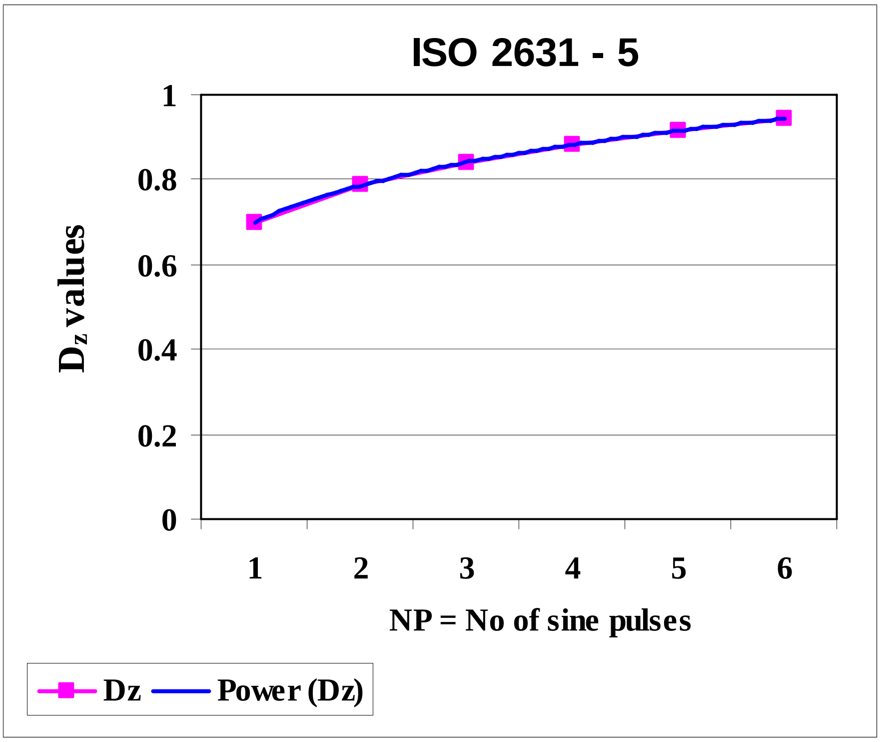

Figure 4 – Variation of D_z with respect to NP

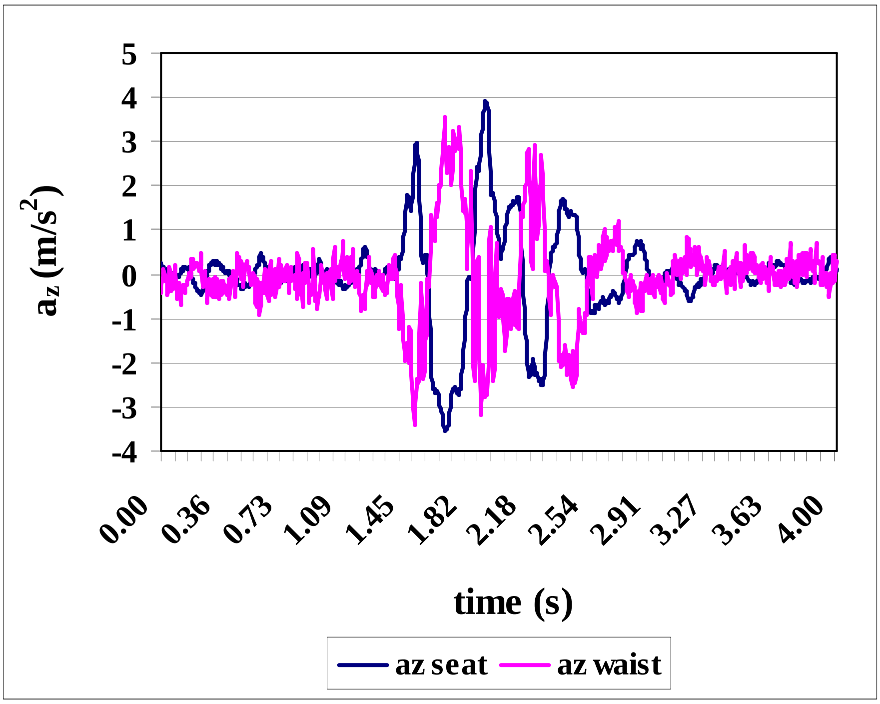

Figure 5 – Field, $a_z – t$, curves (v_{car} = 30 km/hr)