

# Whole-Body Vibration and Its Impact on Heavy Earth Moving Machinery Operators in Opencast Coal Mines



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**Doctor of Philosophy**

by

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## Chapter 8

# Conclusions

### 8.1 Introduction

This chapter of the thesis presents the conclusions part of the research work. At the end, a few suggestions for future work have also been put forward.

### 8.2 Conclusions

The study of WBV is interdisciplinary in nature. The impact of WBV on human health depends on numerous parameters. Here, some of the contributing parameters have been considered to assess three groups of HEMM operators to understand the occupational risk they were facing. Based on the research work carried out, the following conclusions can be drawn:

- The comparison of vibration magnitudes of three groups of HEMM operators revealed that the mean exposure of A(8) in dumper, drill, and shovel is 0.85, 0.32 and 0.43  $\text{m/s}^2$  respectively [as depicted in the box-plot (Figure 5.1)]. Therefore, it is observed that the dumper operators are exposed to maximum level of daily vibration exposure and drill operators, the minimum.
- The mean exposure of VDV(8) in dumper, drill and shovel is 25.03, 12.06 and 12.58  $\text{m/s}^{1.75}$  respectively, [as depicted in the box-plot (Figure 5.2)]. Maximum VDV(8) is for the dumper operators, and the minimum for drill operators.

- Maximum crest factor is for dumper operators, and the minimum for drill operators [as shown in the box-plot (Figure 5.3)]. The values of mean crest factors are 10.72, 9.44, and 9.16 for dumper, drill and shovel operators respectively. The maximum crest factor is for dumper operators because of their driving on uneven haul roads.
- Mean A(8) exposure, VDV(8) value, and crest factor for dumper operators are higher than those for drill and shovel operators mostly because of undulated and uneven haul road surface.
- It is observed that 38% operators of the case group is exposed to high health risk, i.e., above the upper limit of HGCZ based on A(8) value, daily frequency-weighted r.m.s. acceleration, and 61% of operators are exposed to moderate health risk. However, based on VDV(8), daily exposure in terms of vibration dose value, 94% operators are exposed to high health risk, and the rest 6% operators are exposed to moderate health risk.
- Discomfort survey reveals that both dumper and shovel operators are having maximum discomfort in the lower back region and minimum in hand region. On the other hand, the drill operators are having maximum discomfort in the lower back as well as in leg, and minimum in hand region.
- The correlation analysis reveals (i) A(8) value of dumper, drill and shovel operators is directly correlated (0.81- 0.97) to VDV(8) value and (ii) Body DI

of only dumper and shovel operators is directly correlated (0.83-0.87) to hand DI.

- In case-control study, 11 variables were considered. Out of these, only two variables, lower back pain and mine, were found to be significant. Examining the odds ratio of the case group showed that the risk of lower back pain is 2.52 times more as compared to the control group. The case group of Mine-2 is 2.0 times more prone to vibration hazards as compared to Mine-3 (the reference mine).
- The concept of discomfort analysis has been introduced for the first time in the Indian mining industry through this research work. No literature has been found for other countries either.
- Carrying out WBV measurement and discomfort survey in tandem, would help in mapping out the various human body parts that would be liable to induce early pain due to machine vibration. This would guide the mine management to take appropriate steps before aggravating the situation.
- It is envisioned that the present study would provide useful data-base for assessing the appropriateness of ISO 2631-1:1997 under Indian mining condition, and thereby, formulating pertinent occupational health policies to protect the millions of Indian mine workers, especially the dumper operators, who are badly exposed to workplace WBV.

### **8.3 Suggestion for Future Works**

In this thesis, 150 HEMM operators were assessed for the risk of vibration hazards. In the control group, 110 other categories of workers, not exposed to vibration were assessed through a questionnaire survey. More number of workers can be considered for the WBV measurement. This research work analyzes the health impacts based on the symptoms through a questionnaire survey; however, medical diagnosis of workers can provide more realistic assessment of the health impacts of WBV. Indian standards may be formulated to protect the mine operators from the health hazards of WBV.