On Field Tractor Seat Vibration Analysis for Improving the ride Comfort of Driver

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Abstract— Low back pain is an important clinical, social, economic and public health problem affecting the population indiscriminately. It is a disorder with many possible etiologies, occurring in many groups of the population, and with many definitions. Many industry based investigations have found that low back pain (LBP) is associated with exposure to whole body vibration (WBV). Tractor drivers, in particular, seem to have more LBP as they reported regular backache more often than non-tractor driving farmers. In the present study, the experiments where vibration measurements were conducted at the farms terrains in the village on tractor the data acquisition will be carried out by attaching the accelerometer to lower side of seat as per conforming ISO standards and measurement of Vibration amplitudes using OR34-2,4 Channel FFT Analyzer. Then the analysis has done in terms of root mean square (rms) accelerations in one-third-octave band & International Standard Organization (ISO) weighted overall rms. Both predicted and measured values exceeded the health norms of ISO standards. Then we have made changes in the tractor operator's seat system with an anti-vibration suspension system by using springs, which reduces the vibration energy and frequencies into a range suitable for the operator. 32 tests have been conducted, on 3 different accessories, 3 different tracks, 2 different speeds and repeating each test for 2 times. Finally, the experimental result indicates, the modified tractor operator's seat meets the requirements of 'health guidance zone' of ISO 2631-1 in all farms terrains. Measurements of vibrations were conducted on tractors of different sizes, analysis has been done in terms of root mean square (rms) accelerations & International Standard Organization (ISO) weighted overall rms.

Keywords— Health norms, ISO Standards, LBP, FFT analyzer, rms accelerations, vibration energy, WBV

INTRODUCTION

The literature shows that farmers have not received significant attention in developing countries. It is true for tractor drivers who operate the tractor in so many operating conditions of roads & field of agricultural land without any provision of vibration damping design for tractor seats. Tractors in developed countries have become very sophisticated and almost all have enclosed environment controlled suspended cabins and well-designed instrumentation and controls such tractors are difficult to become common in countries like India. Conventional agricultural tractors have no enough suspension systems. So, the vibration levels are high compared to other vehicles. The problem of tractor ride becomes more critical as the dominant natural frequencies of the tractor lie within the critical frequency range of human body (e.g. human trunk and lumbar vertebra have a natural frequency of 4-8 and 4-5 Hz, resp.) Vibrations experienced by the driver at the tractor seat lie especially in this vulnerable range.

The usage of suspension systems in tractors can improves the ride comfort. Existing studies on tractor drivers either deal with vibration measurements and comparison of these with International Standard Organizations health standards (ISO 2631-1985, 1997) or concentrate on the effect of vibrations on health. Measured vibrations and simulated vibrations with the model were compared with ISO standards. These results were used to determine if the mathematical model of the tractor could be used to predict the severity of tractor vibrations in the absence of experimental data.

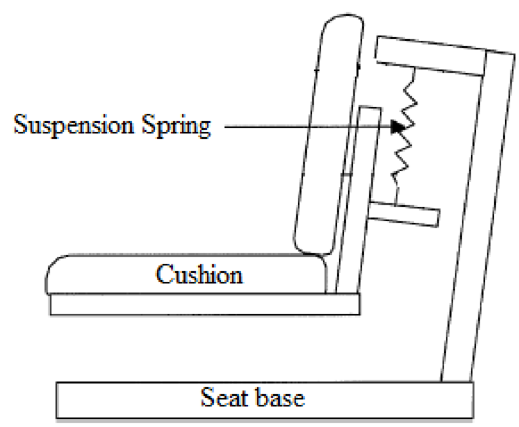


Fig.1. Schematic of Agriculture Tractor Seat

LITERATURE SURVEY

The previous study shows that in men the problem of low back pain (LBP) is more as compare to the women & also in that research we found that the percentage of men having LBP are farmers compare to blue & white collar employees. The following papers give some brief introduction about the topic.

A. A.J. Scarlett et al, (2009) was conducted a study to quantify whole-body vibration (WBV) emission and estimated exposure levels found upon a range of modern, agricultural tractors, when operated in controlled conditions performing selected agricultural operations and while performing identical tasks during 'on-farm' use. The potential consequences of operator WBV exposure limitations, as prescribed by the European Physical Agents (Vibration) Directive: 2002 (PA(V)D), upon tractor usage patterns were considered. Tractor WBV emission levels were found to be very dependent upon the nature of field operation performed, but largely independent of vehicle suspension system capability (due to the dominance of horizontal vibration). However, this trend was reversed during on-road transport. Few examples (9%) of tractor field operations approached or exceeded the PA(V)D Exposure Limit Value (ELV) during 8 h operation, but this figure increased (to 27%) during longer working days. However virtually all (95%) 'on-farm' vehicles exceeded the Exposure Action Value (EAV) during an 8-h day. The PA(V)D is not likely to restrict the operation of tractors during an 8-h day, but will become a limitation if the working day lengthens significantly.

B. Ch. Sreedhar, et al, (2008) have been developed and optimized with an anti-vibration suspension system (Tempered Springs) for agricultural tractor. These seats were examined and determined their static and dynamic physical characteristics. These seats are designed on the basis of ISO standards and an artificial track was used to simulate a farm field based on BIS to examine vibration the transmissibility of the seats when installed in tractor. The results indicated that the transmissibility from under the seat to on the seat in the vertical direction was approximately 0.22, and little reduction of vibration was observed in the fore-aft direction. The results of these experiments indicate that significant differences exist between the characteristics of tempered springs and non- tempered springs of seat. This suggests that the oblique seats with tempered springs are applicable to the agricultural field. Considerable effort has been made to establish the optimum design parameters for tractor seats. Further reductions in the level of ride vibrations experienced by tractor seats appear to be necessary and some possible methods of achieving significant improvements have been outlined. Standardized (ISO) methods of agricultural vehicle WBV measurement require further development to permit quantified effectiveness of tractor WBV-design during in-field operation.

C. E.H. Shiguemori et al., (2005) Inverse problems in vibration is a process of determining parameters based on numerical analysis from a comparison between measured vibration data and its predicted values provided by a mathematical model. In this work the displacement data have been chosen in order to identify the stiffness matrix which will cause a changing in the time-history of the system displacement. This is an inverse problem, since the stiffness matrix evaluation is obtained through the determination of the modified stiffness coefficients. In this work, the artificial neural network technique is applied to the inverse vibration problem where the goal is to estimate the unknown time-dependent stiffness coefficients simultaneously in a two degree-of-freedom structure, using a Multilayer Perceptron Neural Network model. Numerical experiments have been carried out with synthetic experimental data considering a noise level of 1%. Good recoveries have been achieved with this methodology.

D. M.J. Griffin et al (2005) has been investigated the transmission of roll, pitch and yaw vibration from the floor of a small car to the seat backrest. There are complex multi-axis motions on the floors of cars, with combined translational and rotational components. The vibration is transmitted through car seats and contributes to the vibration discomfort of drivers and passengers. Most previous studies of the transmission of vibration through car seats have assumed a single-input model in which vertical vibration at the seat base contributes to vertical vibration at the surface supporting the seat occupant. A small number of studies have investigated the transmission of horizontal vibration from the seat base to the seat surface but there have been a few investigations of the transmission of fore-and-aft, lateral or vertical vibration to the backrest. Using multi-input models of seat transmission, two recent studies have investigated the extent to which the fore-and-aft, lateral and vertical vibration at a car floor contributed to fore-and-aft, lateral and vertical vibration at a seat backrest. It was found in these studies that the vibration on a car floor differed between the four corners of the seat base, implying that there were rotational (i.e. roll, pitch and yaw) inputs to the seat. The transmission of rotational vibration from the non-rigid seat base to fore-and-aft, lateral and vertical vibration at the seat backrest was investigated using single- and multi-input models. It was found that, pitch and roll vibration together with translational vibration at the seat base, made significant contributions to seat backrest vibration.

E. T.P. Gunston et al., (2004) Many off-road machines are equipped with a suspension seat intended to minimize the vibration exposure of the operator to vertical vibration. The optimization of the isolation characteristics of a suspension seat involves consideration of the dynamic responses of the various components of the seat. Ideally, the seat components would be optimized using a numerical model of the seat. However, seat suspensions are complex with non-linear characteristics that are difficult to model; the development of seat suspensions is therefore currently more empirical than analytical. This paper presents and compares two alternative methods of modeling the non-linear dynamic behavior of two suspension seats whose dynamic characteristics were measured in the laboratory. A 'lumped parameter model', which represented the dynamic responses of individual seat components, was compared with a global 'Bouc–Wen model' having a non-linear degree-of-freedom. Predictions of the vibration dose value for a load placed on the seats were compared with laboratory measurements. The normalized r.m.s. errors between the predictions and the measurements were also determined. The median absolute difference between the measured and predicted seat surface vibration dose values over all test conditions for both models was less than 6% of the measured value (with an inter-quartile range less than 20%). Both models were limited by deficiencies in the simulation of top end-stop impacts after the load lifted from the seat surface. The lumped parameter model appears best suited to the development of the overall design of a suspension seat.

F. Adarsh Kumar et al., (2001) were measured the vibrations conducted on different sizes of tractors under varying terrain conditions. Analysis has been done in terms of root mean square (rms) accelerations in one-third-octave band and International Standard Organization (ISO) weighted overall rms. The values were compared with ISO 2631-1, 1985 and 1997 standards. The comparisons reveal that measured vibrations exceed the '8 h exposure limit' in one-third-octave frequency band procedure of ISO 2631-1 (1985) on both farm and non-farm terrains. In the overall ISO-weighted rms acceleration procedure of ISO 2631-1 (1997) in all farm and non-farm terrains working time of 3 h exceeded the upper limit of & health guidance caution zone'. A tractor-operator model was adapted for prediction of the rms accelerations on the ISO 5008 track. This model gave results for vibration exposure similar to measured values. Effect of whole-body vibrations on degenerative changes in the spine of 50 tractor-driving farmers was evaluated by comparing them with a control group of 50 non-tractor-driving farmers matched for age, sex, ethnic group, land holding and work routine. All participants were interviewed in detail for occurrence of low back pain, examined clinically and a magnetic resonance image (MRI) of the lumbar spine region was obtained. Evaluation of data revealed that the tractor-driving farmers complain of backache more often than non-tractor-driving farmers but there was no significant objective difference in clinical or magnetic resonance imaging between the two groups.

OBJECTIVE

The designs of tractors used in high-income countries (HICs) as discussed above are not likely to become common in countries such as India in the near future because of economic reasons. Tractors do not have suspension systems so; the vibration levels are high compared to other road vehicles.

The primary aim of this project is to bring the rms acceleration value to minimum health and safety requirement's "exposure action values" and "exposure limit values" for improving the ride comfort of conventional tractor. In order to achieve this goal, following specific objectives are determined:

- Data Acquisition
- Analyse the data in order to improve the ride comfort of tractor drivers.
- Modifying the existing design of the suspension system
- Validate the result

METHODOLOGY

Primary conventional tractors have only the tires as the elastic component between road and tractor driver seat, where tires are unable to provide proper suspension characteristics. Seat and cabin suspensions are able to improve the ride comfort, where as chassis suspension can increase road stability besides the ride comfort of tractors. So to work on ride comfort we have to work on seat suspension of conventional tractors because there is very little scope of chassis suspension. Also in field work maximum vibration are pitching & vertical types. So here we are going to focus on vibrations of seat (pitching & vertical translation) considering the rigid structure of chassis or housing & finding solution to minimize the vibrations.

EXPERIMENTAL SETUP

Vibration at the seat base (i.e. Tractor floor) will be measured during field work tests on Swaraj (735 35HP). Swaraj tractor has a mass of 1895 kg and a wheelbase of 1950 mm. Tests will be made in three different field conditions during plough in an around the Loni area of Rahata Taluka, Ahmednagar: a grains field (wheat or jawar), a Sugarcane wavy field (4x2 feet sugarcane crests valleys), and a smooth field (non aggregated i.e. on road). Driving/plough speed will be 05 Kmph with the tractor in 3rd low gear.

In next step we will attach the accelerometer to lower side of seat as per conforming ISO standards and measure the Vibration amplitudes using OR34-2,4 Channel FFT Analyser. Test reading will be recorded as per ISO standards.

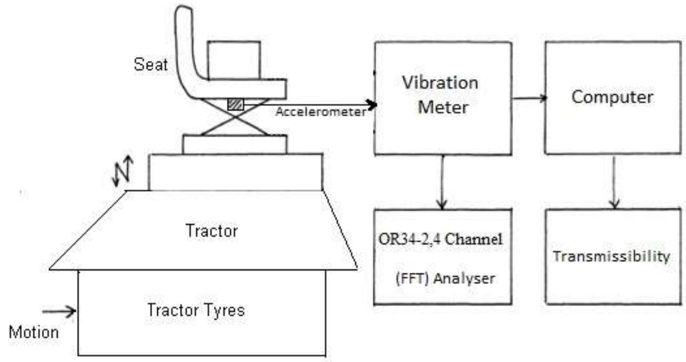
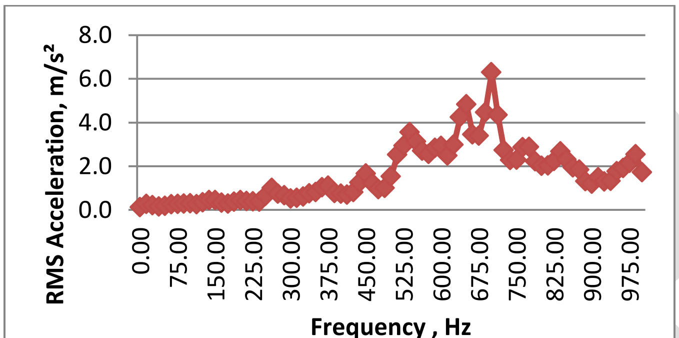


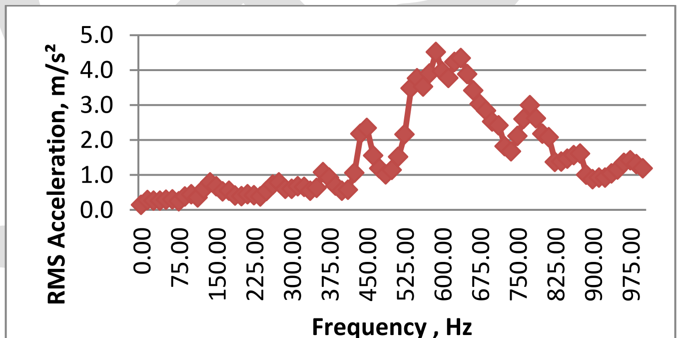
Fig.2. Schematic of Experimental setup of Agriculture Tractor Seat

RESULTS & DISCUSSION

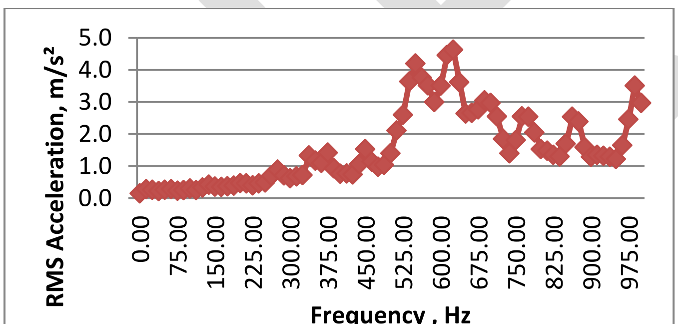
A) Results of rms acceleration before modifying tractor seat



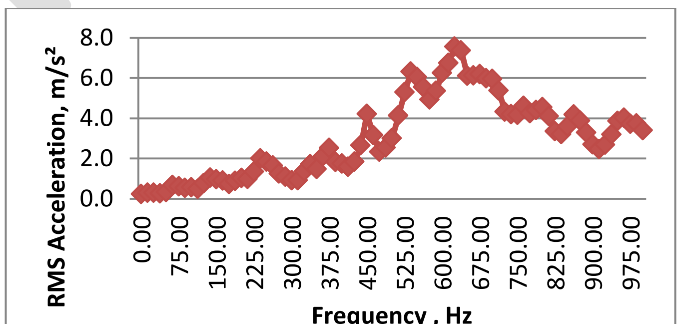
(a) Cultivator on Grain Field



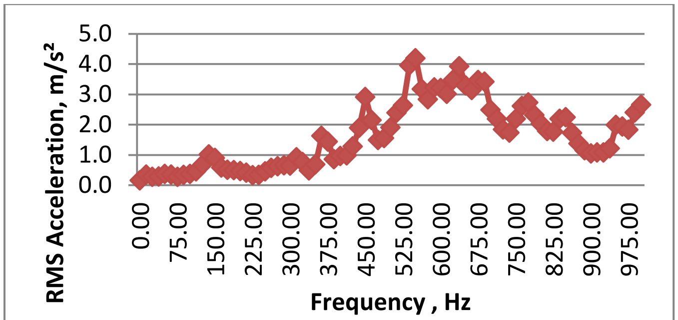
(b) Cultivator on Plain Road



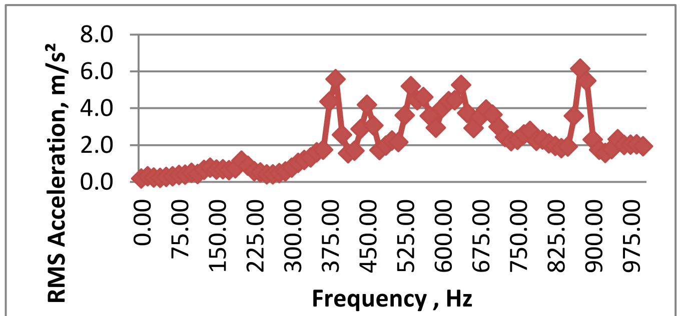
(c) Cultivator on Sugar Cane Field



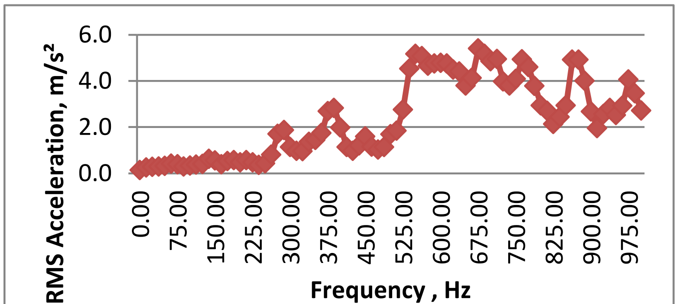
(d) Plough on Grain Field



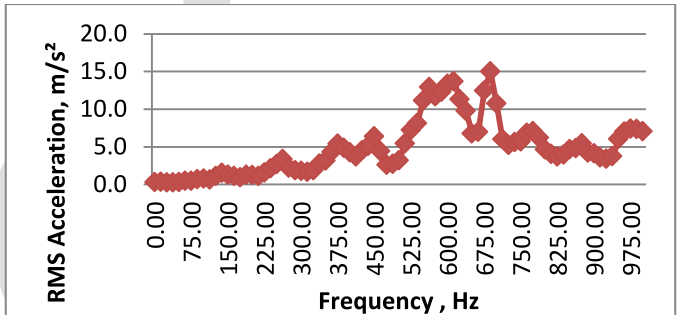
(e) Plough on Plain Road



(f) Plough on Sugar Cane Field

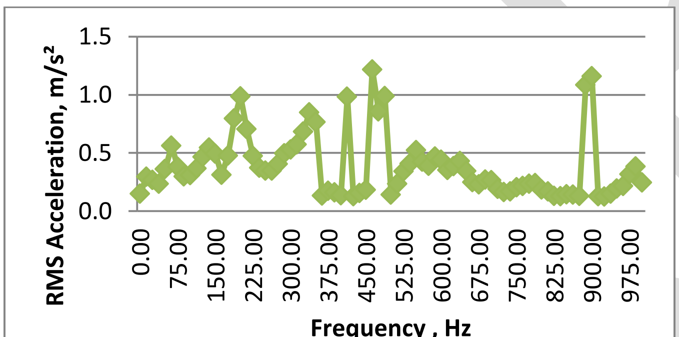


(g) Horrow on Grain Field

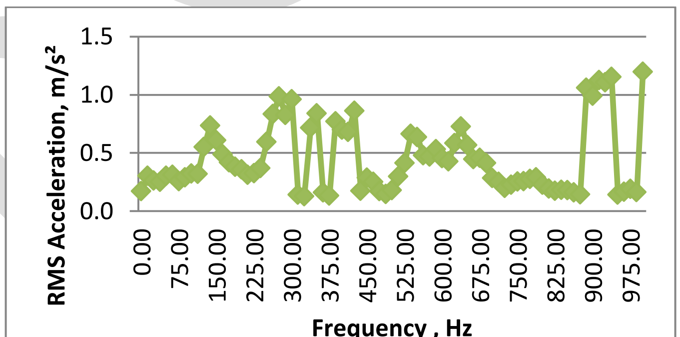


(h) Horrow on Sugar Cane Field

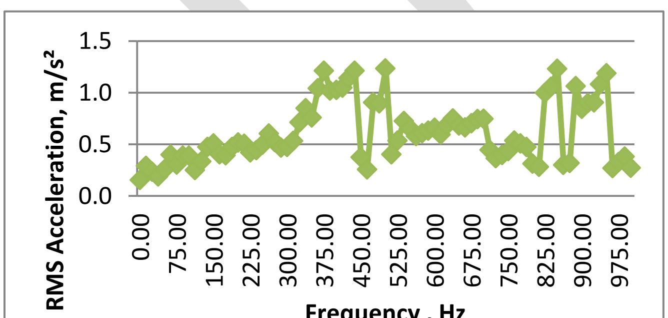
B) Results of rms acceleration **after modifying** tractor seat



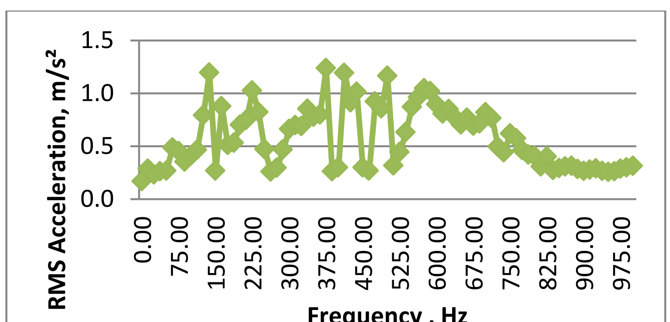
(a1) Cultivator on Grain Field



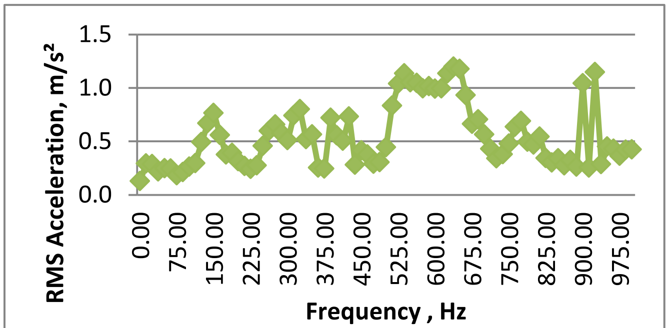
(b1) Cultivator on Plain Road



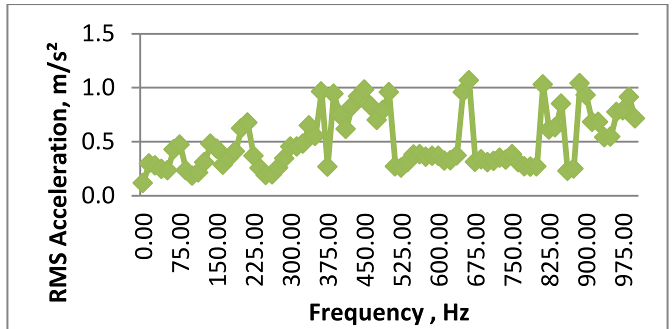
(c1) Cultivator on Sugar Cane Field



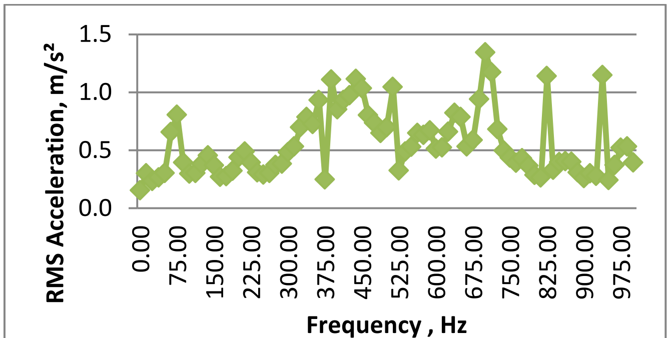
(d1) Plough on Grain Field



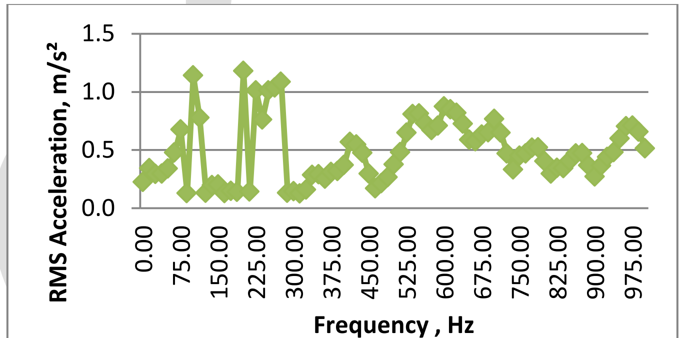
(e1) Plough on Plain Road



(f1) Plough on Sugar Cane Field



(g1) Horrow on Grain Field



(h1) Horrow on Sugar Cane Field

The notations a, b, c, d.... are given for the graph **before modifying** tractor seat and the notations a1, b1, c1, d1... are given for the graph **after modifying** tractor seat.

From all above graphs you can see that in all terrain conditions RMS acceleration of existing seat is much higher than required value of RMS acceleration prescribed in 'health guidance zone' of ISO 2631-1[7], while the acceleration has been controlled in Modified tractor seat and their values are desirable as per ISO 2631-1.

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CONCLUSION

An efficient tractor seat suspension model of anti-vibration system has been developed and investigated. The practical results show that the modified seat has overcome the previous drawbacks of the suspension system & it also confirms the requirements of 'health guidance zone' of ISO 2631-1 in all farms terrains conditions.

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