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# VIBRATION ISOLATION CHARACTERISTICS OF TRACTOR SEATS OF INDIAN MAKE AND THE DESIGN IMPROVEMENT

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## ABSTRACT
Experimental studies of the vibration isolation characteristics of various tractor seats of Indian make have been conducted and compared by mounting the seats on a mechanical exciter capable of generating vertical oscillations over a frequency range up to 8 Hz. As a measure of vibration isolation, only the vertical transmissibilities of various seats have been studied with a light-weight subject (55 kg, 540 N) and sand dummy of equivalent weight in the seats. Most of the seats have been found to be fitted with springs and dampers of high rating and thus they provide poor isolation. The transmissibilities with the sand dummy in the seat are somewhat comparable with that of the subject; but it can not be used as a substitute for the subject. An isolation system with resilient springs and damper having adjustable rating has been designed and developed. Its performance has been found to be considerably better than that of the existing systems. Some studies have also been conducted under the actual field conditions. Keeping in view some discrepancy introduced due to non-linear response of the seat at different levels of vibration, the field results have been found to compare well with those obtained in the laboratory.

## 1 - INTRODUCTION
Motion in off-road vehicles like agricultural tractors consists of vibration and shock. Besides discomfort and fatigue, tractor operators can suffer physical impairment after many years of exposure to excessive vibration levels. Tractor operators are subjected to vibrations in all the three directions [1], but they can endure more severe vibration in the longitudinal and transverse directions than in the vertical direction [2]. Griffen [3] reported that the extent to which vertical vibration was transmitted through vehicle seats, was a major determinant of the discomfort of seated vehicle occupants. The agricultural tractors always traverse rough terrain and the vibrations are transmitted to the tractor seat. Thus the effective method to reduce discomfort and fatigue to the operator is by way of isolating the seat from the vibration transmitted to its mount. Most assessments of the seat dynamics have been in terms of the vertical transmissibility, which is the ratio of amplitude of acceleration levels measured at the interface of the seat cushion and the ischial tuberosities, and at the seat mount [4].
Also in the work presented here, vibration isolation characteristics of the various tractor seats of Indian manufacture were studied in a similar way. The vertical transmissibilities have been studied over a frequency range of 2 to 7.5 Hz with a light weight subject and sand dummy of equivalent weight in the seat. Most of the seats have been found to provide poor isolation. Suspension system has been designed and developed for a locally made seat and its isolation characteristics compared with that of the existing seats. Most of the studies have been conducted under the laboratory conditions by mounting the seat on a mechanical exciter. Some studies were also conducted under the actual field conditions.

## 2 - TRACTOR SEATS AND THEIR PERFORMANCE EVALUATION
Most of the tractor seats have suspension systems consisting of two tension springs and a hydraulic damper. These are housed in the vertical component of the seat mainframe attached to the vibration table. Its horizontal component rests on a hinged support, such that the seat and the back rest fixed to the movable frame are free to move up and down against the springs and the damper. The upper

ends of the springs and the damper are attached to the vertical component of the seat mainframe that is fixed to the vibration table and moves with it. The details of the experimental set up including the mechanical exciter and instrumentation are the same as presented earlier [5]. A constant amplitude of vertical oscillations of 10 mm peak to peak was maintained throughout this study and a frequency range of 2 to 7.5 Hz at an interval of 0.5 Hz was covered. A narrow frequency interval was, however, used near the resonance frequency. In the present investigations a light weight subject weighing 55 kgf (540 N) and a sand dummy of equivalent weight were used. Suspension system of one of the local seats was replaced by a new one tuned to have the resonance frequency below 2 Hz and optimum damping. This was obtained with the help of springs of low stiffness and an orifice type hydraulic damper with adjustable damping coefficient. The dynamic performance of the improved suspension system was studied and compared with that of the existing one and also with the best one out of all the seats studied. Some limited studies were also conducted under the actual field conditions. A ploughed field was selected to carry out the field studies. The tractor was driven in the first higher gear against the ridges. The local seat with the existing suspension system fitted on the Eicher tractor was used to conduct field investigations. Both the laboratory and field studies were conducted with the same subject of medium weight in the seat.
In all the studies, the input was measured by attaching the accelerometer to the base of the seat mainframe that moves with the vibration table or the seat mount of the tractor. The output was measured by placing the accelerometer at the interface of the seat cushion and the ischial tuberosities of the subject with the help of special rubber pad, as per ISO 5007 standard [6].

## 3 - RESULTS AND DISCUSSIONS

Fig. 1 compares the response in terms of the transmissibilities of eight different seats with light weight subject (540 N) in the seat. All these seats are fitted with dampers, except a local seat and the one with a leaf spring. Almost all the seats have resonance peaks that lie between 2 to 4 Hz. Due to the limitations of the instrumentation used, observations below 2 Hz could not be recorded and only an expected trend of the curves down to 1 Hz has been shown. The peak transmissibilities (at the resonance frequencies), Tr (fn) for the various tractor seats are: 2.1 (3.5 Hz) for seat with leaf spring; 1.88 (4.0 Hz) for H.M.T. tractor seat; 1.88 (3 Hz) for local seat with spring and damper; 1.8 (3.5 Hz) for Manhindra and Manhindra tractor seat; 1.7 and 1.6 (2.5 Hz) for the local seat without damper and the Escorts tractor seat, respectively; 1.44 (3.5 Hz) for the Swaraj tractor seat; and 1.4 (2 Hz) for the Massey Ferguson seat. The seat with a leaf spring has the highest transmissibility and that of the Massey Ferguson tractor seat is the lowest.
The transmissibilities of the HMT. seats and the local seat with damper are quite high in the higher frequency range and that of the HMT tractor seat is the highest. The peak transmissibility of the seat with the leaf spring is the highest. Although the peak transmissibilities of the Swaraj and Massey Ferguson seats are both quite low (1.44 & 1.4), the transmissibility of the former is considerably higher than of the latter in the higher frequency range. This is because it is highly damped and its springs are also comparatively hard as indicated by its higher resonance frequency. The local seat with springs and damper is normally used by the tractor operators to replace the worn out/ damaged original seats that come with the new tractors. Comparison of transmissibilities of these seats studied with the subject of medium weight 77 Kgf [5] indicates that with light weight subjects in the seats the peak transmissibilities occur at lower frequencies, as expected in the case of a spring-mass-damper system.
Transmissibility of the local seat fitted with the new suspension system as compared to the existing system has reduced for 1.88 to 1.07. The values at the higher frequencies (5 to 7.5 Hz) have also been reduced by an average value of 0.35; besides having lower transmissibility in the rest of the frequency range. The isolation characteristics of the designed suspension system are also quite superior to that of the Massey Ferguson seat, which has the best suspension system among the eight seats studied. The results obtained with the sand dummy in the seat slightly differ from those of the subject, because of higher amount of damping introduced by sand.
The results under the field conditions with the same subject of medium weight were found to compare well. Peak transmissibilities in both the cases corresponded to 3 Hz and the values of the field result being 1.42 was lower only by 0.06 as compared to that of the laboratory results. In the higher frequency range, the response of the seat under laboratory conditions is, on the average, lower by 0.2. The slight variation in the results is due to the nonlinear character of the response at different excitation levels; which are different under the two conditions.

## 4 - CONCLUSIONS

The peak transmissibility of the seat with leaf spring and without a damper being 2.1 is too high. The isolation characteristics of most of the rest of the 7 tractor seats are also poor, except that of the

Massey Furguson tractor. Isolation provided by the local seat with the suspension system replaced by the properly designed system has improved considerably over the whole frequency range. Also it provides better isolation than the best among the existing seats. Keeping in view some discrepancy introduced due to the nonlinear behaviour of the seat at different vibration levels, the field results compare well with those obtained in the laboratory.

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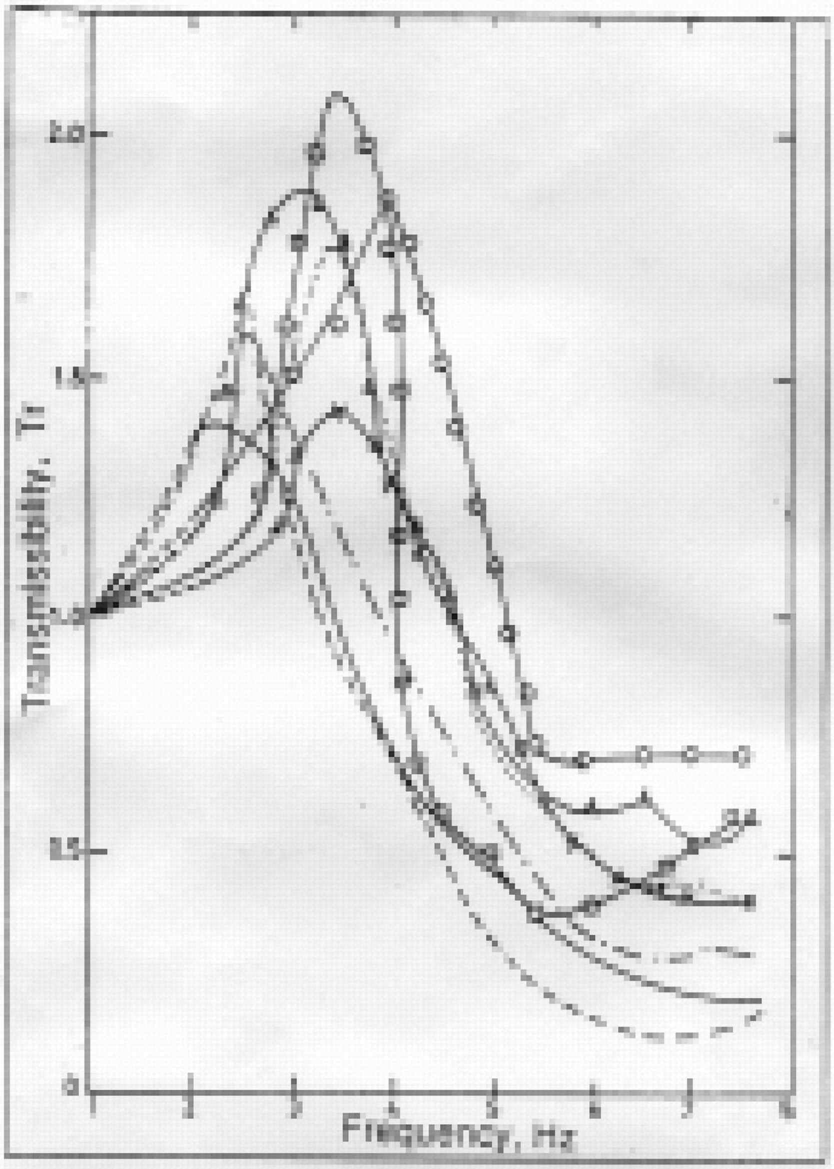


Fig 1. Comparison of the response of various tractor seats. —·—·—·—, Escorts; - - - - - - - - -, Mahindra and Mahindra; x——x, Swaraj; o——o, HMT; ———, Massy-Ferguson; △——△, Local seat with damper; — — — — — —, Local seat without damper; □——□, Seat with a leaf spring only.

**Figure 1.**