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A Review on Design and Analysis of Multifunctional Seats used in Military Vehicle

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Abstract - This paper is based on the study of Design and Analysis of Multifunctional Seats Used in Military Vehicle. Border Security Technologies are being adopted by every country to ensure the safety and sovereignty of their nation. It is crucial to study and understand the latest advancements in security technologies to effectively protect against evolving threats. Just as countries are advancing in defence the threats, they face are also evolving necessitating the upgrading of defence system. Multifunctional Special Vehicles play a crucial role in ensuring the safety of their crew during operational tasks. These vehicles are equipped with specially designed seats that offer a high level of protection in the event of collisions or explosive detonations. The proposed modular structure of these seats brings numerous advantages, including cost reduction using repeatable elements and the ability to easily customize seats with different functions. Moreover, this modular structure enables a faster restoration process in case of any damage. It is essential for the modules to be versatile and adaptable to various seat configurations, considering factors such as their location within the vehicle (e.g., driver's seat, troops' seats, system operators' seats), installation method (e.g., wall, floor, ceiling), and assembly direction (e.g., side mount, rear mount, bottom mount).

***Key Words*:** Analysis of Multifunctional Seat, explosion-proof seat, absorb explosion energy, Study of Vibration, Human body Impact and Safety in Transport.

1.INTRODUCTION

Human safety in transportation is a crucial aspect that is becoming more prominent in our everyday lives. This is primarily due to the advancements in road infrastructure, urban expansion, and the efficiency of logistics supply chains. In essence, the safety of individuals relies on the harmonious interaction between humans (drivers and passengers), vehicles, road conditions, and the proper maintenance of each of these components.[1] A 6-degree-of-freedom (DOF) exciter was utilized to simulate the vibration experienced by a military vehicle on a field terrain test road in this study. - The muscle fatigue analysis involved measuring electromyography (EMG) signals from subjects before and after they were exposed to the simulated vibration. - The deltoid and trapezius muscles of the subjects were targeted for surface EMG (sEMG) measurements during the muscle fatigue analysis. - The study aimed to analyze the impact of vibration on muscle fatigue by examining the EMG signals of the deltoid and trapezius muscles. - By using the 6-degree-of-freedom exciter and measuring sEMG signals, the study aimed to gain insights into the effects of vibration on muscle fatigue in a military vehicle context.[2] Mounted war fighters often experience spinal injuries and pain as common complaints.[3] A ride that consists of intense and consistent accelerations will be evaluated in a completely different manner compared to a ride that combines moderate accelerations with sporadic shock loads.[4] A typical reflection occurs when the blast wave impacts a surface at a right angle.[5] The fundamental shock wave equations, known as the Rankine-Hugonoit equations, are derived from the equations for conservation of mass, momentum, and energy in the medium by choosing a fixed reference in space (the shock front), where the material motions are derived with respect to that region Consider the one-dimensional model[5] Prevent sound, vibration, and thermal energy at the source with molded polyurethane foam solutions. Our POLYFORM® custom molded foam, developed at our PMP Division, is fabricated to absorb impact energy, sound waves, and provide damping.[6] Our materials have found extensive application in military vehicles due to their adherence to the latest standards for enhanced flame resistance, heightened durability, reduced smoke generation, and decreased toxicity emissions.[6]

2. Human Body Impact

Major Impact of Human body on Musculoskeletal Injuries in that most of the focus on Neck, Shoulder, and Spinal Cord. While on seating the war chair or crew chair it's been tough for handle continuous war in between body impact is more like Neck Shoulder and Spinal Cord nerve block.

When driving, the experience can vary greatly depending on the condition of the road. For instance, driving on a rough road with many small bumps is quite different from driving on a relatively smooth road with occasional large potholes [2] Surprisingly, both types of roads can result in similar ISO 2631 statistics in terms of vibration. However, the level of comfort, fatigue, and even the risk of injury can be dramatically different. Recognizing this limitation, the ISO 2631 committee introduced the concept of crest factor. Crest factor is the ratio of the maximum amplitude of vibration to the standard deviation of the vibration. In vibration environments where the crest factor exceeds 6, the ISO 2631 dosage measures are not recommended for use. This highlights the importance of considering the crest factor when assessing the impact of vibrations [2].

Charts

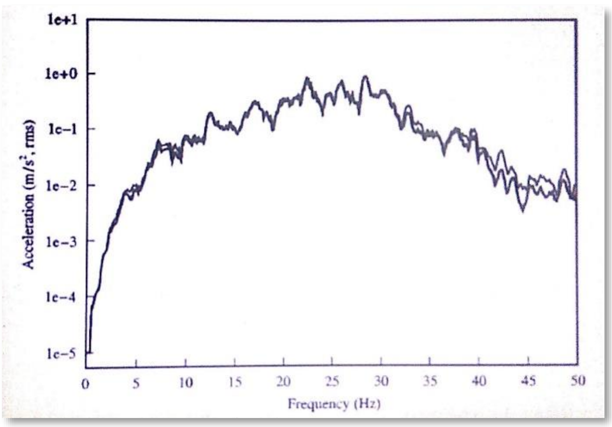


Fig - 01[2,7] : Power Spectral Density Plots for white noise vibration with and without shocks, white noise vibration, white noise & 8 Hz Shocks.

The background white-noise vibration was compared to the shocks, which had a peak-to-peak amplitude of 19.6 m/s2. This amplitude resulted in a crest factor of 8. Figure 1 displays the power spectral density plots for both categories of vibration. However, the shocks depicted in the plot are hardly distinguishable when utilizing the power spectral density technique. It is advisable to employ alternative statistical measures to evaluate the level of mechanical shock present in a vibration signal. To this day, the research conducted on the comparison of various vibration signals containing mechanical shocks on humans has been somewhat restricted. In one study, a substantial mechanical hammer was employed to strike the seat beneath a test subject who was elastically suspended [7].[2] The data obtained from the impact test were utilized to ascertain the linear mechanical response characteristics of the seated individual.

3.Vibration

Military vehicles are known to expose occupants to high levels of noise and vibration [3][4] Military vehicles are required to traverse various terrains, such as rugged cross-country areas and at high velocities. The intensity of vibrations typically rises as the vehicle's speed increases (Griffin, 1990) [3][4][5]. In contrast, vehicles traveling on paved roads have been found to produce lower sound pressure levels compared to off-road terrains (Luha et al., 2019). This research focuses on assessing the levels of noise and whole-body vibration in a Viking amphibious armoured vehicle. The objectives of this study were to ascertain: (i) the extent of variability in measurements taken repeatedly, (ii) the impact of vehicle speed, and (iii) the influence of various terrain types.

Driver Commander

Fig - 2[7] : Driver and Commander Seat

Personnel were instructed to remain seated during the measurements in order to accurately assess the vibrations on the seats.[7] The weights of the personnel occupying the seats were also necessary to consider, as they could potentially impact the vibrations experienced; Table 1 shows weights of people in the front cabs of the vehicles [8].

Table - 1[7] : Weights of the seat occupants in the front cabs of the vehicles

Weights of the seat occupants in the front cabs of the vehicles		
	Eg. Viking (RE 97 AB)	Eg. Viking(R54A)
Driver	67Kg	81Kg
Commander	74Kg	74Kg
Crew Right	58Kg	58Kg

Charts

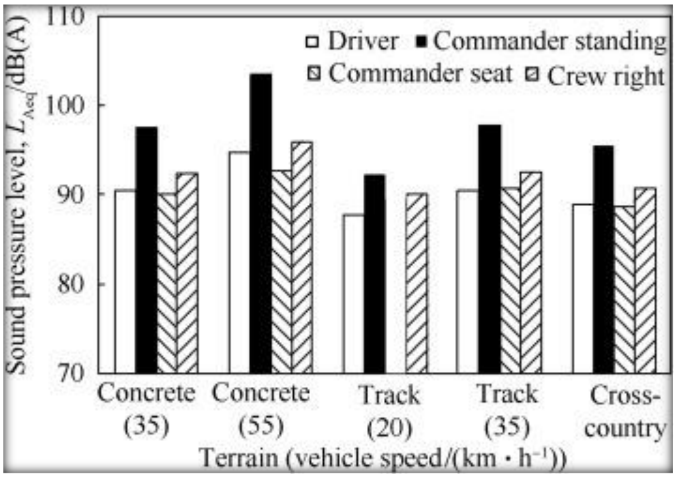


Fig - 3[7] : Frequency weighted vibration magnitudes (m/s2 r.m.s.) measured in the front (driver's seat, commander's floor, commander's seat, and crew right seat) and rear.

This demonstrates the level of variation that can be anticipated and acknowledged when assessing vibration levels in a Military vehicle. In order for the impact of a parameter to be considered significant, it would need to exceed the range of variation observed in repeated measurements. Hence, according to the data, the vibration magnitudes depicted in Figure 03. exhibit greater similarity across seats rather than differences. Additionally, the disparities in vibration magnitudes between speeds are also less pronounced compared to the ones shown in Figure 03[7]

4. Angles

Comfort angles have been devised within the subject standards to establish the ideal angles for achieving a comfortable sitting position while minimizing fatigue. These angles define the flexion and inclination of specific body segments, promoting muscle freedom and relaxation while demanding minimal physical exertion - as depicted in Figure 1.[1]

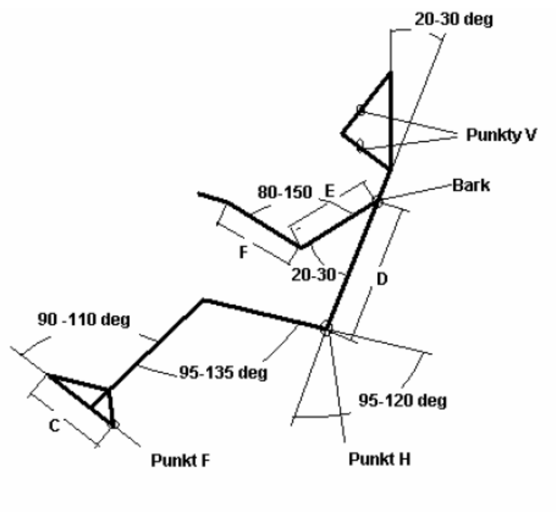
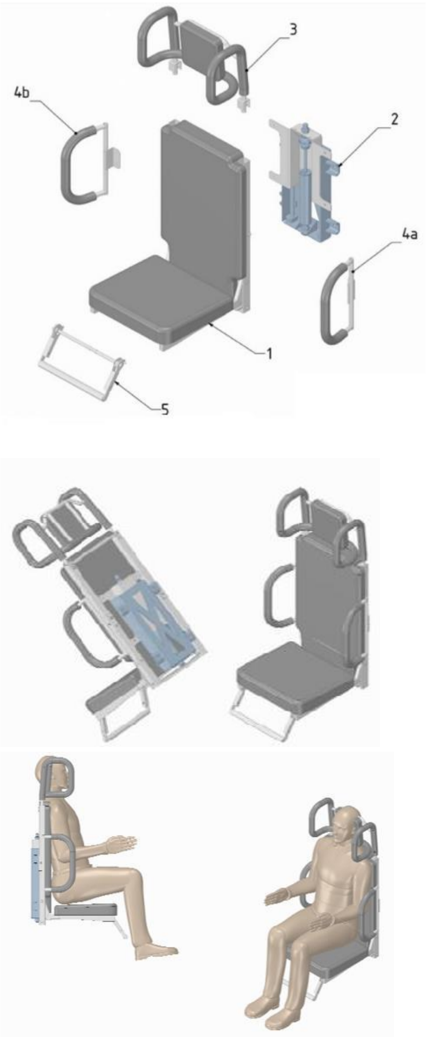


Fig - 4[1] : The angles required in a sitting position for optimal comfort.

To accomplish this, one can utilize profiling and adjusting the seat plate (ensuring a tilt angle ranging from 3 to 15 degrees) as well as shaping the side parts and backrests (with a support radius greater than 101.5 cm). Additionally, supports for the feet, elbows, and head can be incorporated based on their respective functions.[1]

The seat's properties in the event of a mine blast under the vehicle were modelled taking into account various factors. It was ensured that the seat's resistance to mechanical vibrations and impacts aligns with the requirements stated in Defence Standard NO-06-A103 "Weapons and military equipment", UNECE Regulation No. 14 for seat belt anchorages, and UNECE Regulation No. 17 for checking the strength of the backrest and headrest. Special attention was given to the seat's energy consumption, specifically its ability to dissipate the energy from an impact. This was done in accordance with the requirements outlined in the NATO STANAG 4569 standardization agreement "Levels of protection of persons in logistic and light armored vehicles" and the accompanying AEP-55 Volume 2 procedure. To facilitate numerical calculations, a seat model was prepared, as shown in Figure 05.[1]



1- Seat
2- Absorber Module
3- Headrest Module
4- (4a-4b) Side Support
5- Footrest

Fig - 05[1] : Model of the modular seat

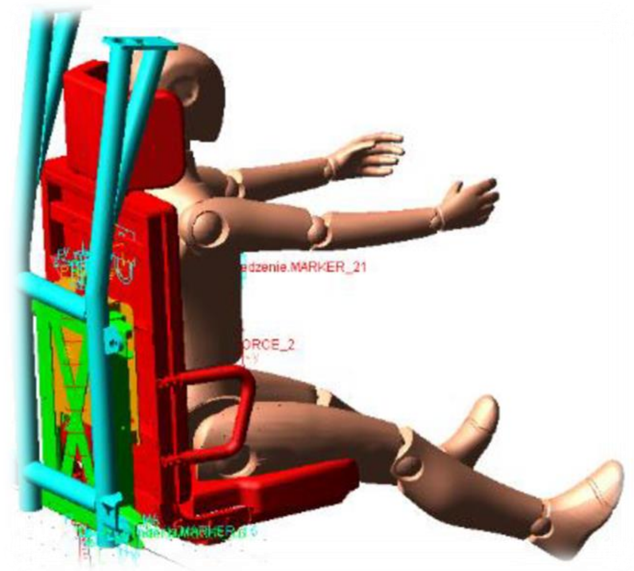


Fig - 06[1] : Parametric simulation model of the seat.

In the forthcoming years, there will be a continued focus on enhancing the safety of the crew in the construction of military combat vehicles. This will involve the implementation of various measures such as the modernization of existing systems or the addition of new ones.

5. CONCLUSIONS

Currently, none of the manufacturers providing mine-blast proofing seats offer a solution that enables the seat to be optimally adjusted to meet the specific needs of the end user. This forces the user to make a compromise between the level of protection and the ergonomics of the seat. However, given the current market demand and the armed forces' modernization plan, there is a pressing need to develop multifunctional seats that can effectively shield crew members in special military vehicles from the impact of high-intensity, short-term dynamic loads. It is crucial to create a product that is currently unavailable in the domestic market.

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