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THE INFLUENCE OF VIBRATION FREQUENCY ON DRIVER DROWSINESS, REACTION TIME, AND DRIVING PERFORMANCE

Motor vehicle accidents cause 1.25 million deaths worldwide each year, while the associated injuries lead to 40 million years lost due to disability. Although speeding and intoxication are leading contributors to vehicle accidents, approximately 20% of accidents are due to a loss of attention caused by drowsiness. In the USA alone, 41,000 injuries and more than 800 deaths are caused annually by driver drowsiness. This toll places an enormous burden on society due to lives lost, decreased productivity, as well as additional costs borne by the national healthcare system resulting from the management of disability and rehabilitation. In the context of commercial vehicles, accidents stemming from driver drowsiness or inattentiveness are notably amplified, accounting for approximately 39% of such incidents. This issue is particularly widespread within the trucking sector, where a substantial 47.1% of truck drivers in the United States have acknowledged experiencing drowsiness at some point in their professional trajectory, with 25.4% revealing such occurrences within their first year of operation. Correspondingly, data from Ukraine indicates that a considerable number (exceeding 60) of fatal accidents involving heavy motor vehicles each month are due to drivers either dozing off or succumbing to fatigue.

Distinctions can be made between the definitions of fatigue and drowsiness. Fatigue is characterized as a gradual and cumulative process, linked with a reluctance for exertion, a pervasive sense of weariness, inhibitions, impaired cognitive function, diminished efficiency, and decreased alertness. On the other hand, the term “drowsy” refers simply to a proclivity for falling asleep. Specifically, “drowsiness” denotes the transitional phase between wakefulness and the initial sleep stage. A driver experiencing drowsiness contends with the urge to stay awake, oscillating between varying degrees of alertness and drowsiness. A distinguishing feature between fatigue and drowsiness lies in their fluctuation patterns over short intervals; the former typically lacks rapid fluctuations within seconds, unlike the latter. In line with common experiences, rest and inactivity alleviate fatigue but exacerbate drowsiness.

A driving simulator (Fig. 1) was used to carry out the experiments. A seat obtained from a motor sedan, whose back was inclined at 15^{0} to the vertical direction, was mounted at the centre of an aluminium platform (dimensions: 1300 mm × 900 mm × 16 mm). This allowed the participants to be comfortably seated for driving. The platform was designed to have natural frequencies outside of the 1–80 Hz range in order to avoid any confounding influence of structural vibration. The platform was suspended on four air mounting bags. A servo-controlled hydraulic actuator was fixed under the platform at the centre, allowing it to deliver a vertical (z-axis) input vibration to the platform and the seat. A 42-inch video screen was placed 1.5 m in front of the participant to display the driving scenario.

The purpose and the procedure of the experiment were verbally explained to potential participants, and consent to participate was obtained. The experiments were all conducted during the daytime, between 9 a.m. and 1 p.m. Each participant had to attend six sessions, which were held on different days. There was one non-vibration session (control condition) and five vibration sessions. The order of the sessions differed between participants. Participants were allowed to choose the start time for the experiments but had to keep it the same for all six sessions. Before commencement, participants were instructed to assume a comfortable driving posture and to undertake minimal non-driving physical movement during the sessions. Training was given to the participants about how to properly respond to the reaction time test while simultaneously performing the driving task.

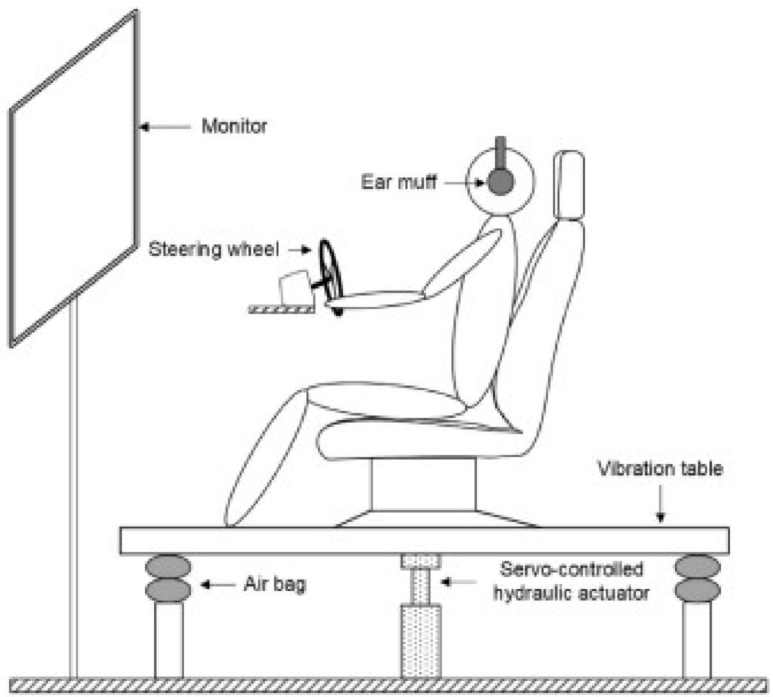

Fig. 1. The schematic diagram of the setup in the laboratory.

This study investigated the effects of vibrational frequency on driver drowsiness by the objective assessment of driving performance. The findings of the behavioural evaluation demonstrated that low-frequency vibration (1–4 Hz and 4–8 Hz) was more detrimental and faster at inducing drowsiness and slowed reaction times than higher-frequency vibration (8–16 Hz, 16–32 Hz, and 32–64 Hz). These results were supported by the subjective reports of drowsiness. The results of this study have important implications for the development of vibration-induced drowsiness contours for road safety and transport vehicle design.

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DESIGN OF WOODEN STRUCTURES TO ENSURE STABILITY AND SAFETY DURING A FIRE EVENTS

With growing public interest in sustainable building and with the addition of "mass timber" Construction Types IV-A, IV-B, and IV-C to the 2021 International Building Code (IBC), design professionals are increasingly required to design mass timber building elements to fire-resistance ratings prescribed by the IBC. While many members of the public, and even building design professionals at times, associate wood construction with inherent fire risks, it is feasible and can even be cost-effective to design wood structures for resilience and safety during fire events.

Specialty engineers and architects routinely handle fire protection design. This standard of design is effective and sensical for non-combustible structural materials as many commercially available products can be used to directly obtain a time-based fire-resistance rating. On the other hand, combustible materials, such as wood, used in building structures are not typically covered with sprayed fire-resistant materials and are often intentionally exposed for aesthetic purposes. The charring of a structural wood member, as well as the associated reduction of the member's cross-section and material properties, necessitates the involvement of a structural engineer.

To properly protect wood structural connections, one must first understand char depth, effective char depth, and char contraction. Wood members exposed to fire develop a char layer that extends into the member cross-section over an exposure time. This char layer can, in turn, act as an insulator for the member, slowing char growth over time. Due to the insulative properties of the char layer, a linear growth rate tends to underestimate char depth under short time frames and overestimate char depth under longer time frames.

Cross-laminated timber (CLT) manufactured with certain adhesives exhibits different char growth behavior due to the tendency for char to fall off as the char depth approaches the glue line. This fall-off behavior leads to a speed up and a slowdown of charring encom. New fire test protocols have been developed and are included in Standard for Performance-Rated Cross-Laminated Timber, to ensure adhesives used in CLT will not result in this behavior.

For determining the fire-resistance rating of a structural member, this conservatively increased loss of structural section is all that is required. However, it becomes necessary to consider the effects of char contraction when unbonded members abut, such as at structural connections or where wood trim is used as an insulative protective layer.

As wood members exposed to fire begin to char, the charred wood shrinks such that the volume occupied by the charred member is less than the original volume of the wood before fire exposure. In fact, the actual thickness of char is approximately 70% of the calculated char depth. This gradual member shrinkage is termed char contraction. Char contraction plays a critical role in determining the fire protection of connections. For two abutting but unbonded members, the joint between the two members grows as char contraction occurs at the abutting corners. The gap that forms at the joint reveals the initially protected faces and allows ignition to occur increasingly at the location where the unbonded members meet. At these abutting edges, recommends using a depth of ignition into the formed gap of twice the calculated approximate char depth (Fig. 1).