# A METHOD OF EVALUATING VEHICLE SEAT VIBRATION WITH CONSIDERATION OF SUBJECTIVE JUDGMENT

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## Introduction

Vibration magnitude and frequency of the z-axis vehicle seat are time-variant, which are influenced by not only vehicle vibration characteristics themselves but also road surfaces, speeds and the human body. There is little in the current reporting about evaluating and analyzing automobile seat vibration that focuses on the time-variant.

Yaguchi et al.[1] has proposed a method to evaluate automobile seat vibration that is based on judgments using a subjective mental state. Their method focuses on the time-variant magnitude of the peak frequency on a power spectrum density. However, their method has no consideration of all the frequency contents of the discomfort, nor comparison between different peak frequency vibrations. Suzuki[2] has emphasized that the vehicle vibration should be judged by a series of vibration stimuli to evaluate, because the vehicle vibration is time-variant, which isn't a matter of the relationship between a single vibration stimulus and a subjective response. He clarified that the human sensation to the vehicle vibration discomfort changes every moment showing the relationship between the frequency-weighted r.m.s. acceleration calculated every 5 seconds and the category judgment to vehicle vibration discomfort every 5 seconds. However, his study doesn't show what parameter connects to the subjective final judgment to vehicle vibration.

Therefore, we applied the method similar to ISO10056[3] considering the time-variant to the vehicle seat z-axis vibration evaluation. The new method for the vehicle seat vibration considering the time-variant was examined on the hypothesis that the final subjective evaluation must be conducted from the judgment summarizing a series of vibration stimuli.

## Methods

The vibration bench system, which reproduces the movement of a vehicle floor, was used for the experiment with the single-axis (vertical direction) four-post road simulator system, which is usually used for a car, as shown in Fig.1. The experiment was done on the right side of the vibration bench using the floor vibration which was 5.5 minutes, 0.822 m/sec$^2$ (Wk) over the range 0.5-20Hz with 4 male subjects (age ave21.5, SD0.5, weight ave75kg, SD7.91kg, height ave166.8cm, SD5.2cm) and 4 suspension seats. As Fig.2 shows, subjects evaluated the degree of discomfort every 5 seconds to each seat vibration measuring the seat z-axis vibration acceleration.

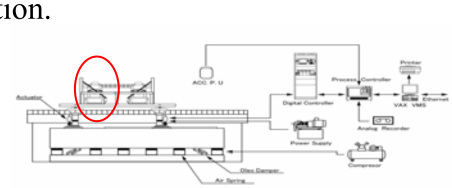

Fig1. Road simulator system

Fig 2. Right side of vibration bench system

## Results

Fig.3 shows the discomfort evaluated every 5 seconds by 4 subjects matched up to frequency-weighted r.m.s. acceleration calculated every 5 seconds. Other seats also had the same tendency. As Table1 shows, evaluations by ISO2631-1[4] didn't fit final judgments by each subject. Table2 shows statistical parameters from cumulative distribution histogram of frequency-weighted r.m.s. acceleration calculated every 5 seconds applied the method of ISO10056. Seat A and Seat B had larger frequency weighted r.m.s. acceleration of the 90% band range than Seat C and Seat D. Seat A, which had the least discomfort, as judged by most of the subjects, had smaller values over all than Seat B had.

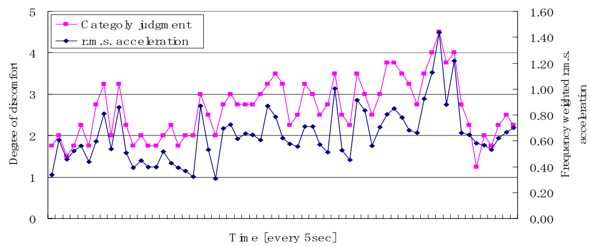


Fig.3 Seat A results of Frequency weighted r.m.s. accelerations and category judgments every 5 seconds.

Table 1. Evaluations by ISO2631-1 and subjective final judgments

| | Seat A | Seat B | Seat C | Seat D | Least Discomfort seat |
|---|---|---|---|---|---|
| Subject1 | 0.694 | 0.675 | 0.665 | **0.65** | Seat A |
| Subject2 | 0.673 | 0.728 | **0.647** | 0.66 | – |
| Subject3 | 0.674 | 0.743 | 0.688 | **0.638** | Seat A |
| Subject4 | **0.645** | 0.76 | 0.626 | 0.647 | Seat A |
| Average | 0.671 | 0.727 | 0.656 | **0.649** | |
| SD | 0.017 | 0.032 | 0.023 | 0.008 | |

Table 2. Statistical parameters of Wk r.m.s. acceleration cumulative distribution histgram

| | Seat A | Seat B | Seat C | Seat D |
|---|---|---|---|---|
| Average | 0.647 | 0.697 | 0.647 | 0.631 |
| SD | 0.216 | 0.244 | 0.166 | 0.191 |
| Max | ***1.456*** | *1.552* | 1.274 | 1.351 |
| 99%tile | ***1.425*** | *1.525* | 1.225 | 1.325 |
| 95%tile | ***1.045*** | *1.17* | 0.975 | 1 |
| 5%tile | ***0.362*** | *0.375* | 0.416 | 0.375 |
| 1%tile | ***0.287*** | *0.3* | 0.375 | 0.312 |
| Min | ***0.27*** | *0.28* | 0.36 | 0.294 |
| 80%band | ***0.5*** | *0.604* | 0.416 | 0.45 |

## Discussion

It was shown that the human sensation of discomfort to vehicle seat vibration changes every moment influenced by the time-variant seat vibration. It clarified the new evaluation and analysis method for seat vibration that was based on the hypothesis that the final judgment was conducted from summarizing a series of time-variant vibration stimuli. An additional study is required to investigate the applicability to different types of vehicle vibration using a larger number of subjects.

## References

1. Yaguchi E, Yanagishima T, Akatsu Y, Hanai T and Kato K (1994) Whole-Body Vibration and Ride Comfort, Inter-noise94, 905-910
2. Hiroaki Suzuki (1997) A study on the vibrational factors determining the riding comfort of railway vehicle, The Japanese Journal of Ergonomics Vol33, NO.6, 349-355
3. International Organization for Standardization (2001) Mechanical vibration – Measurement and analysis of whole-body vibration to which passengers and crew are exposed in railway vehicles. ISO10056
4. International Organization for Standardization (1997) Mechanical vibration and shock-Evaluation of human exposure to whole-body vibration Part1: General requirements. ISO2631-1.