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Vehicle Upper Body Structuring Method for Low-Frequency NV phenomena in Early Development Stage Using Component Mode Analysis

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This paper proposes a vehicle upper body structuring method for low-frequency NV phenomena that can be commonly applied across different vehicle types, with the aim of supporting efficient performance consideration in the early stages of vehicle development, where shorter development cycles are increasingly required due to advances in electrification and intelligent technologies. Low-frequency NV performance is influenced by upper body panels such as the windshield and tailgate, and therefore depends on exterior design and basic vehicle structure. For this reason, managed eigenmodes and their target eigenfrequencies related to the upper body have conventionally been determined individually for each vehicle type, based on past development experience, vehicle testing, and CAE analyses. In this paper, component mode analysis is used to identify the minimum set of managed eigenmodes associated with upper body panels that is necessary for reproducing acoustic transfer functions for each vehicle type. These eigenmodes are then aggregated to define a common set of managed eigenmodes for vehicle upper body structuring. Verification using several vehicle types confirms that acoustic transfer functions can be reproduced with sufficient accuracy using only the common managed eigenmodes. In addition, changes in the eigenfrequencies of the managed eigenmodes are shown to be useful for predicting response variations caused by structural modifications in CAE models, as well as relative changes in acoustic transfer function resulting from differences in exterior design. The proposed method provides a unified approach to vehicle upper body structuring independent of vehicle type and is expected to contribute to more efficient low-frequency NV performance design in the early stages of development.

Table1 List of common managed eigen modes

Panel	Mode	Hatchback SUV Minivan	Sedan
Front Windshield	Upper / 1st	○	○
	Upper / 2nd	○	○
	Lower/ 1st	○	○
	Lower/ 2nd	○	○
Roof	Panel/1st	○	○
	Sunroof/1st	○	○
Tailgate	Bounce	○	–
	Squash	○	–
	Longitudinal bending	○	–
Rear Windshield	Upper / 1st	–	○
	Upper / 2nd	–	○
	Lower/ 1st	–	○
	Lower/ 2nd	–	○
Trunk	Bounce	–	○
	Squash	–	○
	Longitudinal bending	–	○

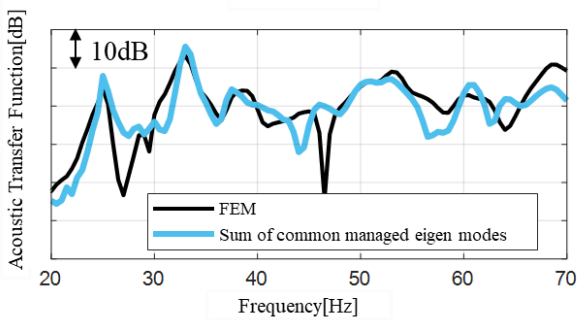

Fig.1 Comparison of acoustic transfer functions from rear suspension mounting points to driver's ear

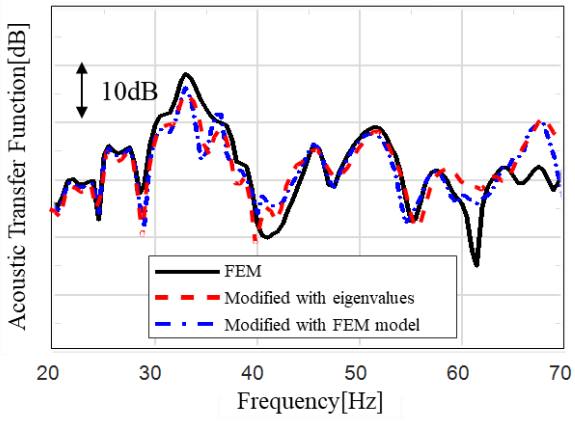

Fig.2 Comparison of acoustic transfer function at representative points