# Application of ADAMS for Vibration Analysis and Structure Evaluation By NASTRAN for Cab Floor of Heavy-Duty Truck

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**Abstract**

The load transfer paths in the cabin structures of heavy-duty trucks are investigated under static loading, and the results are applied to the reduction of vibration in cabins. In a preliminary simulation using a simple model with ADAMS/Vibration, it is shown that vibration in the floor panel is closely related to the stiffness of the front cross-member of the floor structure. Load path analyses using the finite element method with NASTRAN show that the load paths have some discontinuities and nonuniformities in the front cross-member, reducing that member's stiffness.

## 1. Introduction

The requirement of comfort in motor vehicle cabins has increased recently not only for passenger cars but also for commercial vehicles such as trucks. According to the authors' past research, it is known that floor panel vibration affects the booming noise in a truck's cabin, and that this noise can be reduced by increasing the thickness of the front cross-member panel. This finding showed us that the input force at the point, such as the cab mount, should be transferred effectively to all panels of the cab through the front cross-member.

In this research, a simple cab model with ADAMS was created to evaluate the relationship between floor panel vibration and the connectivity between the front cross-member and its neighbor panels. In the next step, the load transfer path from the cab mount to panels on the cab was analyzed using the cab FE model and load transfer path technology developed by Keio University. This analysis was done with NASTRAN.

## 2. ADAMS cab simple model

The ADAMS model for a cab consists of lumped masses (PARTs) for the cab mount, a front cross-member, a side member, a floor panel and upper body and connectivity elements (BUSHs) with constant stiffness. The values for connectivity were estimated with a NASTRAN model described below. Fig.1 shows the components of the simple cab model. Fig.2 shows the ADAMS model.

The eigenvalue analysis was done with the ADAMS model, and two normal modes below 200Hz were obtained. The model shapes are shown in Fig.3. The transfer function (inertance) between the input force at the cab mount and acceleration on the floor panel was calculated with these normal modes as shown Fig.4. The calculated transfer function is close to the physical test results shown in Fig.5. The eigenvalue analysis and response analysis were done with ADAMS/Vibration.

By referencing the past research showing that the booming noise is reduced by thickening the front cross-member panel, the transfer function was calculated when the stiffness between the front cross-member and the upper body was doubled. The effect of this increase in stiffness is shown also in Fig.5.

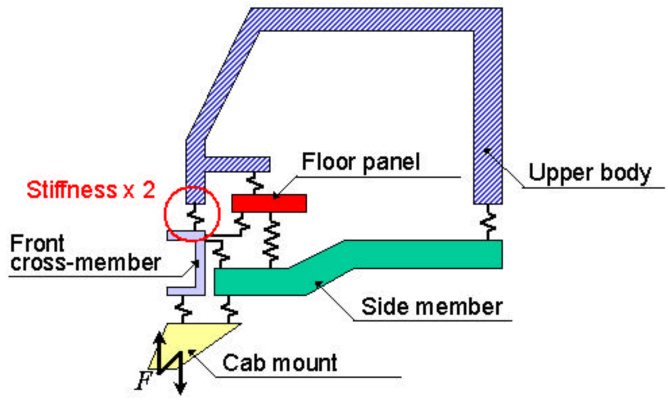



Fig.1 Simple cabin model

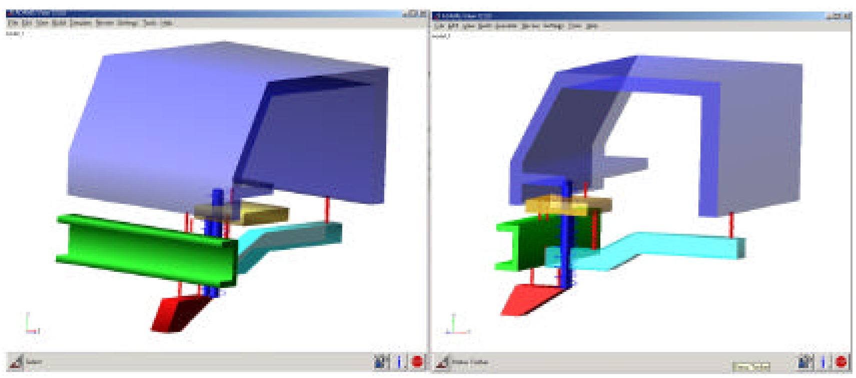


Fig.2 ADAMS model

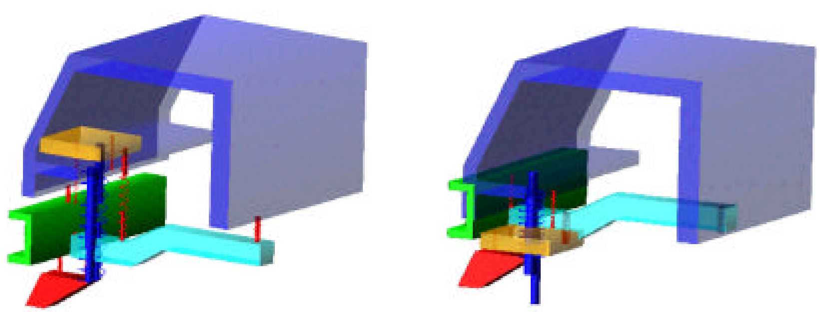


Fig.3 Normal modes (Left: 118Hz, Right: 181Hz)

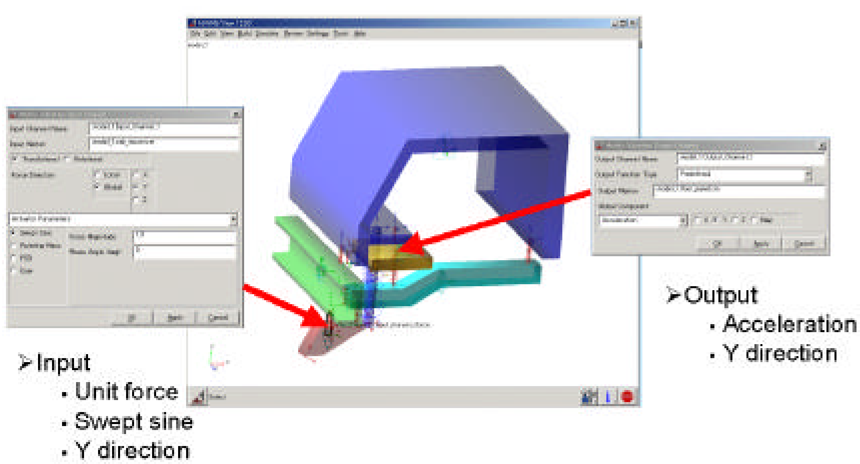
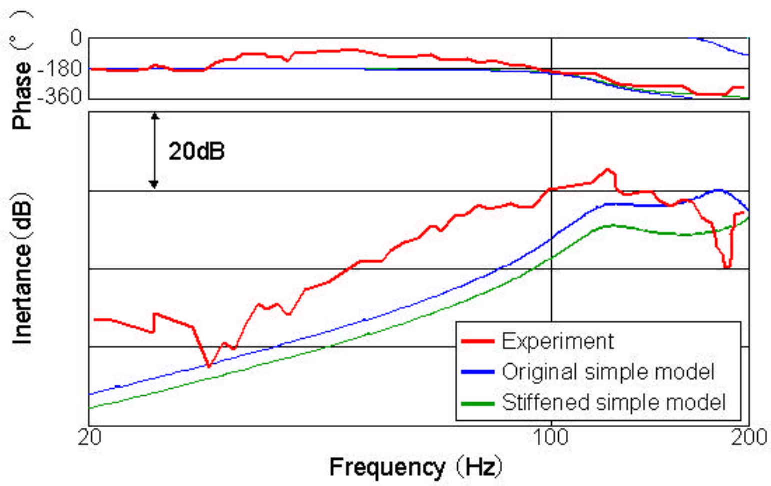



Fig.4 Setting for transfer function analysis




**3. Concept of load transfer path technology**

Figure 6 explains the relative stiffness between the loaded point and the supported point for any general structure. Points A, B and C are , respectively, the loaded point, supported point and any given point on the structure. The relationship between load and displacement is described as equation (1). ***K*** is relative stiffness, ***p*** is load and ***d*** is displacement. Point C in Fig.6 (b) is restrained. The value *U* * is defined from the strain energy *U* in Fig.6 (a) and the strain energy *U* ' in Fig.6 (b) as equation (2). This *U* * can be useful for evaluating the load transfer path.

$$\begin{Bmatrix} \boldsymbol{p}_{\mathrm{A}} \\ \boldsymbol{p}_{\mathrm{B}} \\ \boldsymbol{p}_{\mathrm{C}} \end{Bmatrix} = \begin{bmatrix} \boldsymbol{K}_{\mathrm{AA}} & \boldsymbol{K}_{\mathrm{AB}} & \boldsymbol{K}_{\mathrm{AC}} \\ \boldsymbol{K}_{\mathrm{BA}} & \boldsymbol{K}_{\mathrm{BB}} & \boldsymbol{K}_{\mathrm{BC}} \\ \boldsymbol{K}_{\mathrm{CA}} & \boldsymbol{K}_{\mathrm{CB}} & \boldsymbol{K}_{\mathrm{CC}} \end{bmatrix} \begin{Bmatrix} \boldsymbol{d}_{\mathrm{A}} \\ \boldsymbol{d}_{\mathrm{B}} \\ \boldsymbol{d}_{\mathrm{C}} \end{Bmatrix} \qquad (1)$$

$$U^* \equiv 1 - \frac{1}{U'/U} = 1 - \frac{\boldsymbol{p}_{\mathrm{A}}{}^T \boldsymbol{d}_{\mathrm{A}}}{\boldsymbol{p}'_{\mathrm{A}}{}^T \boldsymbol{d}_{\mathrm{A}}} = 1 - \frac{(\boldsymbol{K}_{\mathrm{AA}} \boldsymbol{d}_{\mathrm{A}} + \boldsymbol{K}_{\mathrm{AC}} \boldsymbol{d}_{\mathrm{C}})^T \boldsymbol{d}_{\mathrm{A}}}{(\boldsymbol{K}_{\mathrm{AA}} \boldsymbol{d}_{\mathrm{A}})^T \boldsymbol{d}_{\mathrm{A}}} \qquad (2)$$

Figure 7 shows an example of a contour plot of *U* *. The arrow in this figure represents the load transfer path from point A to point B.

The quality of a structure can be evaluated by the characteristics of *U* * along the load transfer path. Three kinds of conditions shown in Fig. 8–uniformity, continuity and path consistency--are used for structure design.

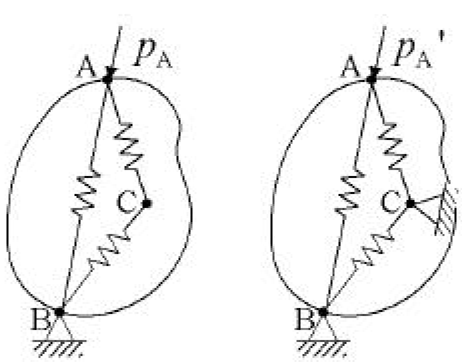



Fig.6 Relative stiffness

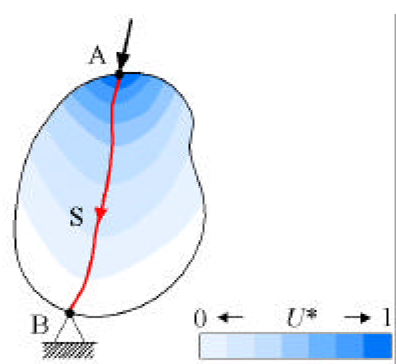



Fig.7 Load transfer path

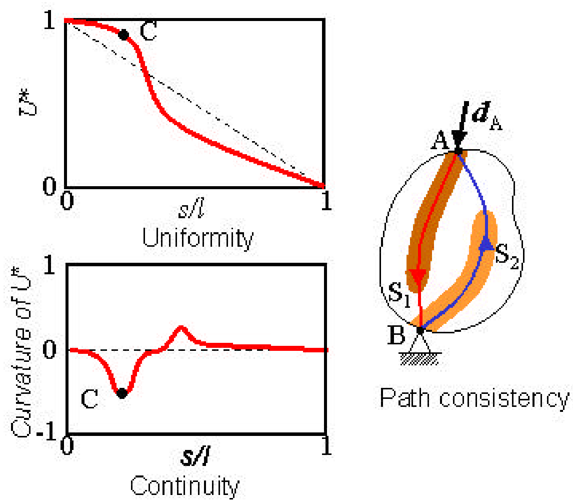



Fig.8 Three conditions for structure design

**4. Load transfer path analysis by NASTRAN**

In order to calculate *U* *, we created an FEM model of a cab floor panel for NASTRAN. The model has around 10000 nodes and 10000 elements, as shown in Fig.9. The physical test done by the authors shows that the booming noise is affected most by the load from the left cab mount. Therefore, the loaded point is at the left cab mount and the supported points are on nodes which should be connected with the cab upper body.

The value of *U* *s were calculated by NASTRAN static analysis. The results for the cab floor panel are shown in Fig.10. The results reveal three load transfer paths. Path 1 goes up along the front cros-member, path 2 goes to the left on the front cross-member and path 3 goes along the side member on the floor panel. An overview of these paths is shown in Fig.11.

According to the three conditions for structure design in Fig.8, it is understood that path 1 should be modified. The uniformity and continuity of path 1 are shown in Fig.12. These conditions are not good for transferring a load at the portion where the front cross-member and upper body meet. In order to improve these conditions, some structure modification of the front cross-member should be required

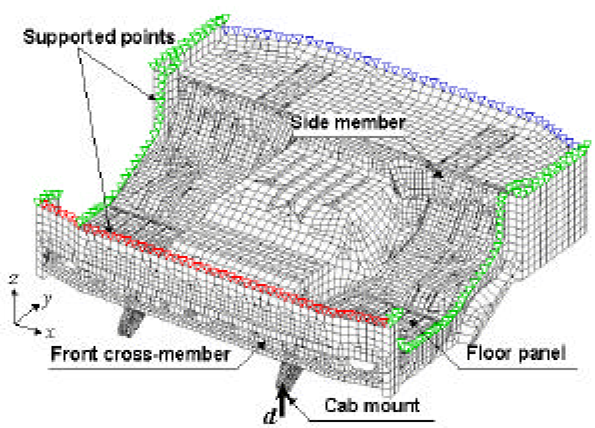



Fig.9 FE model

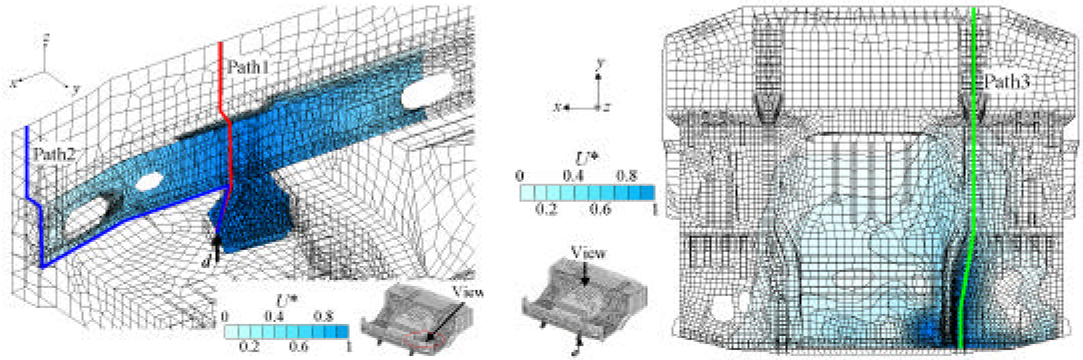



Fig.10 Distribution of *U* * and load path (left: front cross-member, right: floor panel)

This result is consistent with the results of cab simple model analysis using ADAMS. This means that the effect of front cross-member thickness on floor panel vibration is due to the increase in spring stiffness in the ADAMS simple model shown in Fig.1.

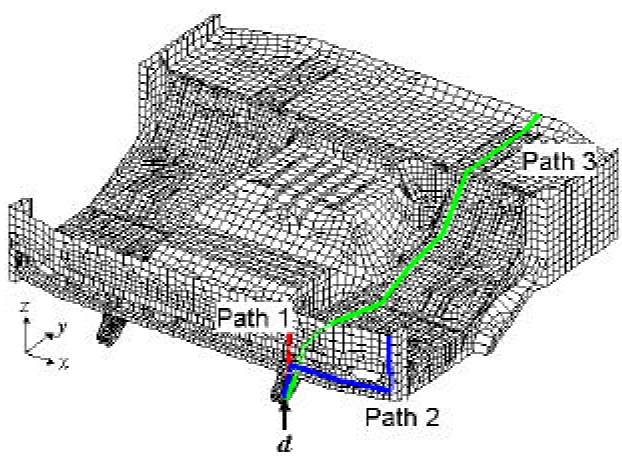



Fig.11 Load paths of truck cabin

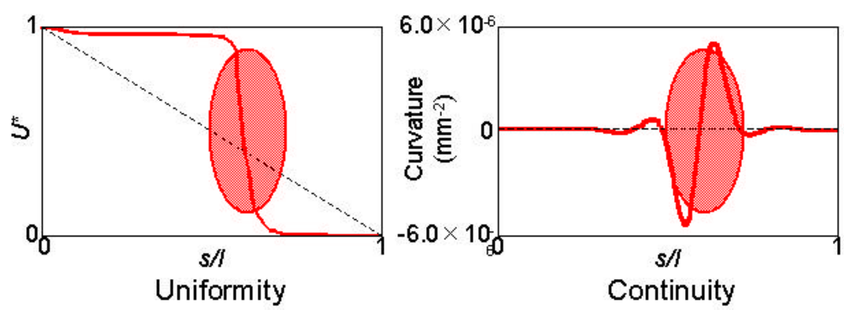



Fig.12 Uniformity and continuity of load path 1

**5. Conclusion**

We investigated the reduction of vibration in the floor panel of a truck cab using MSC.ADAMS and MSC.NASTRAN. ADAMS/Vibration was used for the evaluation of spring stiffness between cab components in assuming the rigidity of these components. In order to find a way to stiffen the spring between components, the load transfer path analysis using NASTRAN static analysis was useful.

In the case that we studied, it was confirmed that the connecting spring stiffness between the front cross-member and the upper body should be increased in order to reduce the vibration in the floor panel.

**References**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