

CAE Analysis for Development of Magnesium Cross Car Beam

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ABSTRACT

A magnesium cross car beam has been developed in order to achieve automotive weight savings and thus greater fuel efficiency, while maintaining safety performance.

In the development of a magnesium cross car beam, CAE analysis was used to increase the accuracy of predicting cracks, elongation, and deformation.

This paper will discuss the use of CAE analysis in this development project.

The developed magnesium cross car beam will be employed in the 2008 year model FCX.

1. Introduction

As the auto industry continues to address fuel efficiency through automotive weight savings, cross car beams are increasingly being manufactured from magnesium and aluminum⁽¹⁾⁻⁽⁴⁾, in particular in Europe and the U.S.

Compared to steel and aluminum, magnesium is a brittle material. Thus it is important to address the issues of cracking, elongation, and deformation of magnesium in a collision in instances where a magnesium cross car beam is employed.

To address this issue, CAE analysis was employed to predict cracking during the development of a magnesium cross car beam. This paper discusses the use of CAE analysis in this development project.

The use of CAE analysis resulted in the achievement of a level of performance equivalent to that of a steel cross car beam with a weight saving of approximately 5 kg (40%).

2. Development Using CAE Analysis

The performance of numerous calculations for a CAE

collision analysis at the preliminary examination stage would require an enormous amount of time. For this reason, the CAE collision analysis in the initial examination was replaced by a simple static load CAE analysis that required less calculation time.

The coincident hot spot monitoring approach⁽⁵⁾ developed by Meridian Technologies Inc. was employed to predict cracking in the magnesium cross car beam. In this method, areas of both high strain and high maximum principal stress are defined as “hot spots.” These hot spots indicate that tensile stress is acting on the areas in which they appear, and suggest that there is a potential for fracture. This enables cracks to be predicted.

2.1. Basic Shape of Cross Car Beam and CAE Analysis

Figure 1 shows the structure of a conventional steel cross car beam and the magnesium cross car beam developed in this project.

A conventional steel cross car beam is a welded structure consisting of a pipe that forms the main beam and stamped parts including the steering column and center frame.

In the case of a magnesium cross car beam, parts that can be cast, including the main beam, steering column and

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Table 1 Chemical composition of AM60B (weight %)

Al	Zn	Mn	Si	Cu	Ni	Fe	Others
5.5-6.5	≤0.22	0.24-0.6	≤0.10	≤0.010	≤0.002	≤0.005	≤0.02

Table 2 Mechanical properties of AM60B

Tensile strength [MPa]	Yield stress [MPa]	Elongation [%]
223	124	10

center frame, are integrally formed by die casting. Based on a standard wall thickness of 2.5 mm and a C-section as the basic sectional shape of the main beam, repeated CAE studies were conducted to define the areas that needed extra ribs, increased wall thickness and modification of the corner radii, enabling optimization of the main beam geometry.

Based on the above considerations, a CAD layout was formulated, and mesh models for CAE analysis were created.

2.2. Die Casting Material

AM60B⁽⁶⁾⁻⁽⁸⁾ was employed to cast the magnesium cross car beam. Table 1 shows the chemical composition of AM60B, while Table 2 provides representative values for the mechanical properties of the material.

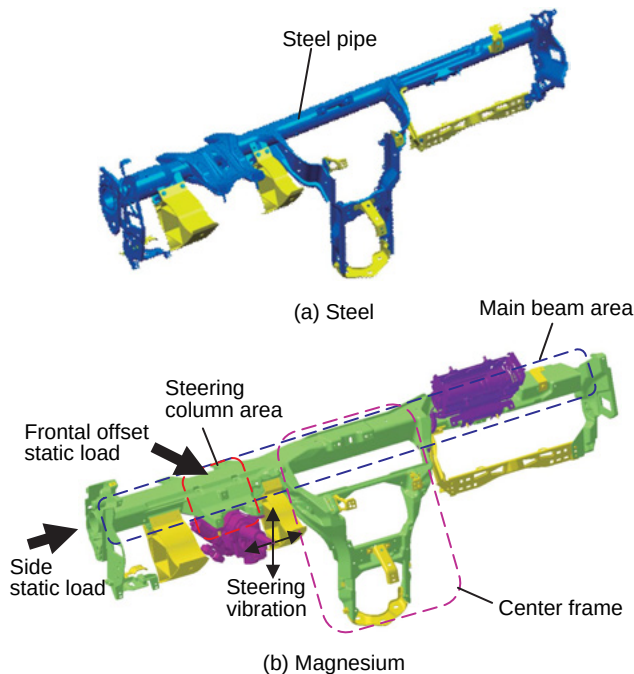


Fig. 1 Cross car beam configuration

3. Results of CAE Analyses

Figure 2 shows the results of CAE analysis of steering vibration as a vertical strain energy distribution diagram. A high level of strain energy indicates a high level of sensitivity in terms of steering vibration. These results indicate that the stiffness of the main beam on the driver side and the center frame are important factors in steering vibration performance.

Figures 3 and 4 show the results of a frontal offset static load CAE analysis and a side static load CAE analysis, respectively. The results indicate that during the application of a frontal offset static load, stress

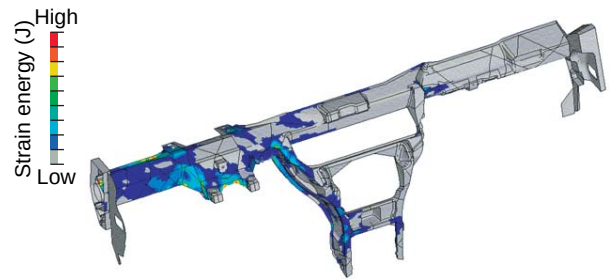


Fig. 2 Steering vibration CAE result (strain energy distribution)



Fig. 3 Frontal offset static load CAE result (Stress distribution)

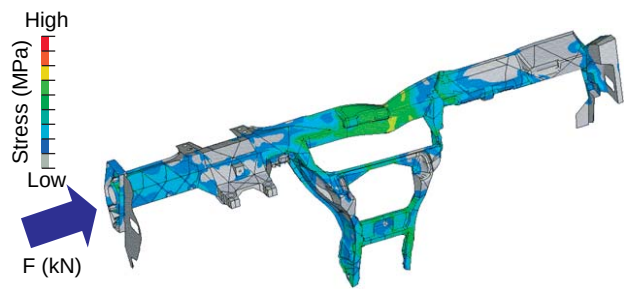


Fig. 4 Side static load CAE result (Stress distribution)

concentrates in the main beam on the driver side, while during the application of a side static load stress concentrates on the main beam from the driver side through to the passenger side.

4. Correlation of CAE Analyses and Test Results

Tests were conducted using cast prototypes. This section will discuss the correlation between representative test results and the results of CAE analyses.

4.1. Steering Vibration Test Results

Figure 5 shows the results of component tests of steering vibration (vertical natural frequency). Natural frequencies are higher in the case of the magnesium cross car beam than the steel cross car beam. The results of complete vehicle tests indicate that the magnesium cross car beam displays an equivalent level of performance to that of the steel cross car beam.

4.2. Correlation between Results of Static Load Tests and CAE Analyses

Figure 6 shows the relationship between load and stroke in side static load tests. Figure 7 compares

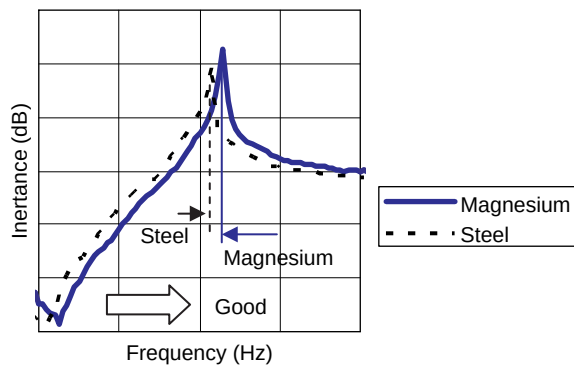


Fig. 5 Steering vibration test result (Vertical steering natural frequency)

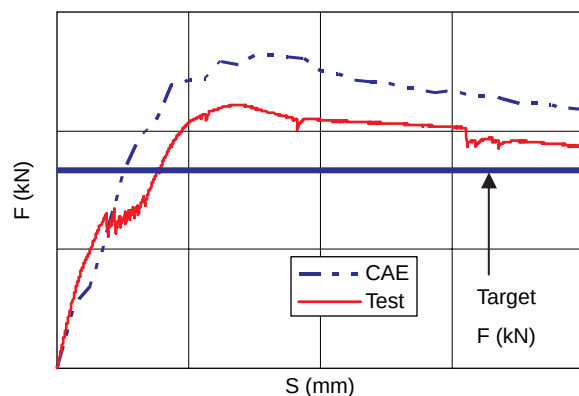


Fig. 6 CAE and test results for side static load: FF (kN)-S (mm)

deformation, and cracking under maximum load, in CAE analyses and tests. The target load was reached, but a comparison with test results shows that differences in the CAE analysis results exist. These CAE analysis differences should be taken into consideration in

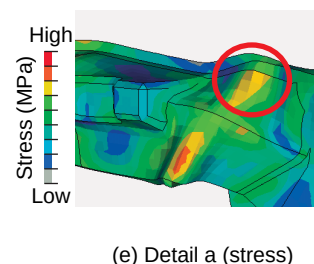
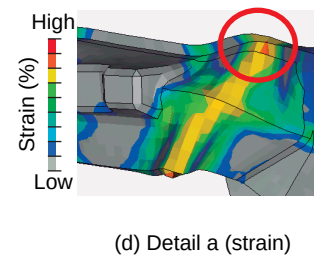
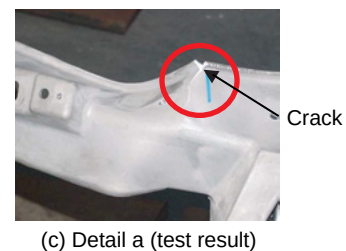
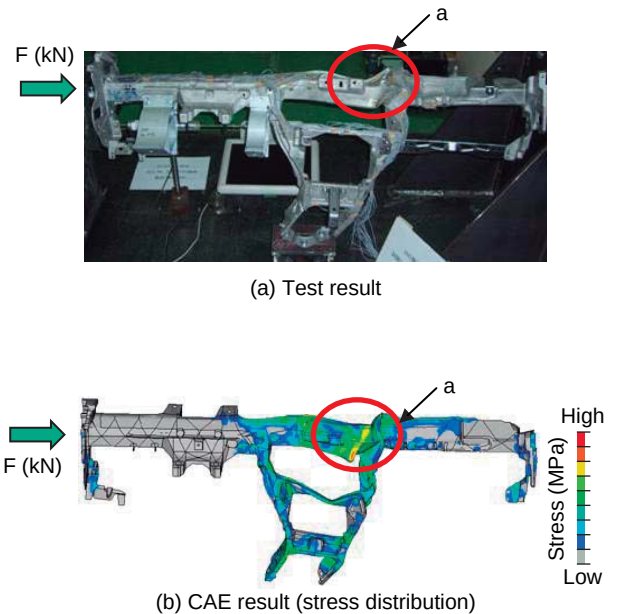


Fig. 7 CAE and test result for side static load

component design in the future. Test results were equivalent to those of the CAE results for deformation. At maximum loads, cracks appeared in the areas in which cracking had been predicted by CAE analysis, confirming the effectiveness of the coincident hot spot monitoring approach⁽⁵⁾.

Figure 8 compares deformation, and cracking under maximum load, in offset static load CAE analyses and

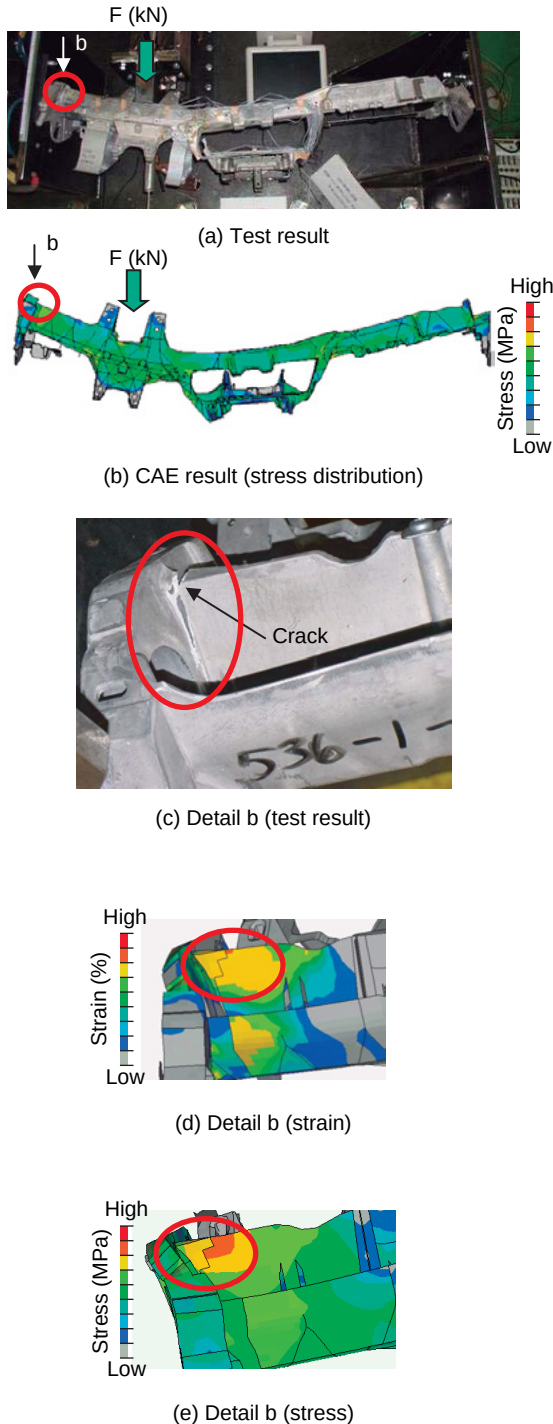


Fig. 8 CAE and test result for frontal offset static load

tests. Equivalent results were also obtained for frontal offset static loads.

4.3. Collision Test Results

Complete vehicle collision tests were conducted on the basis of the static load tests discussed above.

Figures 9 and 10 respectively show photographs of the results of a frontal offset collision test and a side collision test. No cracks occurred in the main beam in either case. Passenger injury values conformed to collision safety standards, and the level of deformation was equivalent to that of a steel cross car beam.



Fig. 9 Frontal offset crash test result



Fig. 10 Side crash test result

5. Conclusion

CAE analysis has been employed in the development of a magnesium cross car beam, with the following outcomes:

- (1) Test results confirmed the viability of predicting cracks using CAE analysis, verifying the effectiveness of CAE analysis in development. Differences between the results of CAE analyses and tests should be taken into consideration in advance when using the method.
- (2) No cracks were generated during complete vehicle collision tests using a static load test method, demonstrating the validity of using static load tests.

The project resulted in the development of a magnesium cross car beam that displays an equivalent level of performance to that of a steel cross car beam and can be fitted in an equivalent instrument panel space, while achieving a weight saving of approximately 40%.

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