IMPACT BEHAVIOR AND OPTIMUM DESIGN OF CFRP/AL HYBRID BEAM IN SIDE COLLISION OF AUTOMOBILES

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INTRODUCTION
Carbon fiber reinforced plastic (CFRP) laminates are used in various industrial fields because they have excellent properties in the specific strength and specific stiffness. The CFRP has a potential of weight reduction in the automotive structure which can contribute to the improvement of mileage as well as the reduction of carbon dioxide. On the other hand, the safety issue in case of collision should be also clarified when employing the CFRP as automotive structures. In this paper, hybrid beam which consisted of an Al Alloy and CFRP were examined by both experiments and FEM as a candidate to replace the conventional steel guarder beam used inside the automotive door. The experimental relations of impact loading to the displacement for the hybrid beam showed good agreement with those from FEM results. These results show that the numerical FEM method developed here is useful for estimating the impact behaviour of Al guarder beams reinforced with CFRP layers.

EXPERIMENT
The hybrid effect of the CFRP/Al beam has been checked from the past researches [1]. In this study, turn to the development a new hybrid beam exceeding the absorbed energy of the impact beams made from steel. The aluminum alloy beam's shape was the unsymmetrical section in the vertical direction and the effects of different types of CFRP (T700, T800 and M40) and adhesives (High-strength High-elongation and Urethane), differences of CFRP width (40, 28, 20 mm) and three kinds of thickness of CFRP (1, 2, 3 mm) on the impact absorbing energy were examined as shown in Fig.1

The 1,000 mm length of hybrid impact beam was supported by two supporters having a head radius of 25mm and the span between the two supporters was 800 mm. In order to evaluate the capacity of crash energy absorption, the beam received an impact load generated by a free drop mass of 100 kg at an impact speed of 55 km/h. The shape of the impactor was a half cylinder having a 100 mm radius and a 200 mm width and the hybrid beam was fixed by belts to prevent from scattering (Fig.2). The impact load and the displacement of the impactor were measured by load cells attached to both supporters and by a high-speed camera, respectively.

The test result of beam whose design parameters were T800, High-elongation, the thickness of 3mm and width of 40mm was shown here. The absorbed impact energy until 150mm displacement was 1822J and became the almost same value as that of the steel beam.

Fig.1 Hybrid Impact Beam  
Fig.2 Outline of impact test
IMPACT RESPONSE ANALYSIS

In the numerical analysis, a dynamic explicit F.E.M. solver (PAM-CRASH, 2006) was employed. The FEM model was created based on the sizes of the specimens, impactor and the support parts in the test. The elastic-plastic shell element for the Al part and the laminated shell element for the CFRP layer were used, respectively. The impactor and the supporters were modeled as the “rigid body”. The contact element of “Contact Type 33” was used between the impactor and the upper surface of hybrid beam and between the supporters and the lower surface of hybrid beam. Its friction and penalty coefficients were 0.15 and 0.1, respectively. For the interface of Al beam and the CFRP layer, “Link Material 303” was used for modeling adhesion of the interface. The experimental and numerical relations for the impact load to the impact displacement are shown in Fig.3 and they fairly agreed each other.

OPTIMUAL DESIGN WITH FEM

In order to obtain the larger impact energy absorption, the design parameters were changed to other values in the FEM method whose effectiveness was confirmed through the comparison of both results[2]. The cross section of Al beam was changed to other four shapes under the condition of keeping same area as the former one. The displacement-load curves of four hybrid beams having the different shape of cross section of Al beam were compared with that of original hybrid beam in Fig.4. The impact energy of absorption for the hybrid beam with the "Ⅲ" section which form of "3" of Roman numerals was 2245J. It was larger than 1822J of the former hybrid beam. The absorbed impact energy of the hybrid beam with the "Ⅲ" section was 23% larger than that of the former one.

CONCLUSION

The hybrid beam showed the same performance of impact absorbing energy as that of the steel one. From the comparison of FEM results with the experimental ones for the impact behaviour of hybrid beam, the proposed numerical method was found to be very useful for analyzing the hybrid door guarder beams. The FEM simulation method showed that the change of cross section of Al beam increased the impact energy absorption. As a result; changing the design parameters of the hybrid beam may result in further increase of impact energy absorption.

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REFERENCES