COMPATIBILITY FOR FRONTAL IMPACT COLLISIONS BETWEEN HEAVY AND LIGHT CARS

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ABSTRACT

Recently, frontal impact compatibility is discussed internationally and various procedures to assess compatibility and various measures to improve compatibility have been proposed. Considering the above, car to car tests between a heavy car and a light car were conducted to clarify the effect of homogenizing the front structure on compatibility. Then correlation between the results of the barrier impact tests proposed as the procedures to assess compatibility and the car to car test results and the requirements for the assessment procedure were discussed.

INTRODUCTION

The frontal impact performance is assessed by the impact tests of a car against a fixed barrier. These impact tests contributed to the reduction of the casualties in traffic accidents. Recently, frontal impact compatibility is recognized as an area where additional safety enhancements might be made. Through many studies in the world, it has become clear that the fundamental issues of frontal impact compatibility are (1)structural interaction, (2)frontal stiffness and (3)passenger compartment strength. The procedures to assess each issue have been proposed. Considering these things, car to car tests between a heavy car and a light car were conducted to clarify the effect of the front structure homogeneity on frontal impact compatibility. Then the barrier tests which are proposed as the test to assess frontal impact compatibility were conducted. From the comparison of the barrier test results and the car to car test results, the items which should be considered in case of deciding the assessment procedure of frontal impact compatibility were discussed.

CAR TO CAR TESTS

Structural interaction is one of the most important requirements for frontal impact compatibility. Therefore, a homogeneous front structure that can absorb the impact energy in a uniform manner in a wide variety of impact configurations is desired. It is assumed that not only the front structure homogeneity of heavy car but also that of light car is required to improve structural interaction in car to car tests. In order to confirm if this assumption is appropriate, car to car tests between a heavy car and a light car were conducted as shown in Table 1. The aim of mounting multiple load paths is to achieve the front structure homogeneity.

Table 1.
Car to car tests matrix

		Heavy car
		With multiple load paths
Light car	Without multiple load paths	X (Test No.:C2C01)
	With multiple load paths	X (Test No.:C2C02)

Test Conditions

Test details are shown in Table 2 and pre test position of both cars are shown in Figure 1 and 2.

Table 2.

Test details

		C2C01	C2C02
Test speed		56km/h	←
Overlap		50% of the smaller car's width	←
Mass	Heavy car	1539kg	←
	Light car	1125kg	←

Figure 1. Pre test side view.

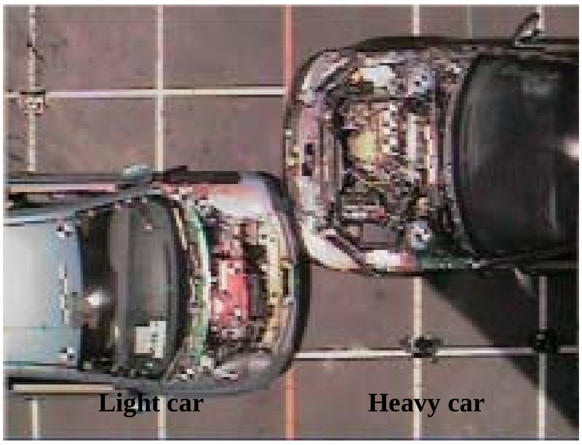

Figure 2. Pre test plan view.

Result of Car to Car Test between Heavy Car and Light Car without Multiple Load Paths

Figure 3 and 4 show the post test view of each car and Figure 5 shows the comparison of the firewall intrusion between two cars. The passenger compartment deformation of light car without multiple load paths is larger in comparison with that of heavy car. The result of this car to car test is not considered compatible.

Figure 3. Post test side view of light car in the C2C01 test.

Figure 4. Post test side view of heavy car in the C2C01 test.

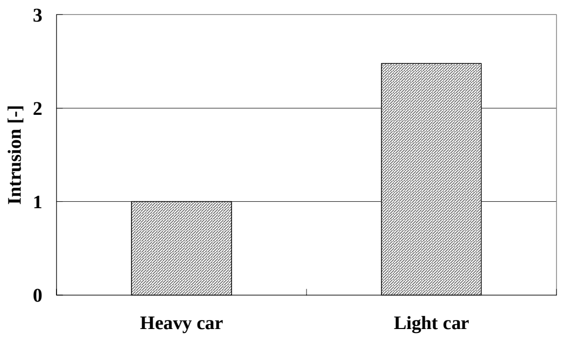

Figure 5. Comparison of firewall intrusion in the C2C01 test. (Each value is normalized by the intrusion of heavy car in the C2C01 test.)

Result of Car to Car Test between Heavy Car and Light Car with Multiple Load Paths

Figure 6 and 7 show the post test view of each car and Figure 8 shows the comparison of the firewall intrusion between two cars. The passenger compartment deformation of light car with multiple load paths in this test reduced significantly in comparison with that of light car without multiple load paths in the C2C01 test. On the other hand, the passenger compartment deformation of heavy car in this test slightly increased in comparison with that of heavy car in the C2C01 test. This car to car test is considered more compatible than the C2C01 test. Therefore, by comparing the results of these car to car tests, it indicates that the incorporation of multiple load paths in the light car improved frontal impact compatibility.

Figure 6. Post test side view of light car in the C2C02 test.

Figure 7. Post test side view of heavy car in the C2C02 test.

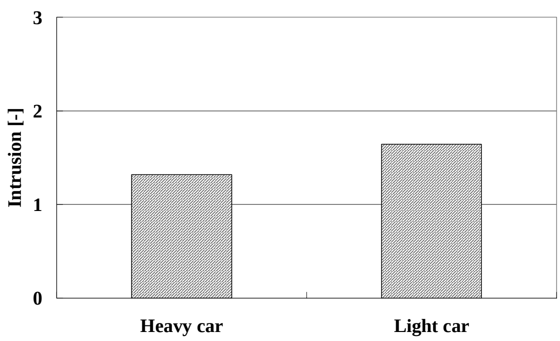

Figure 8. Comparison of firewall intrusion in the C2C02 test. (Each value is normalized by the

intrusion of heavy car in the C2C01 test.)

Comparison of Two Car to Car Tests

In frontal car to car impact between a heavy car and a light car the passenger compartment deformation of the light car is apt to be large in comparison with that of the heavy car because the passenger compartment strength of light car is weaker than that of heavy car, generally speaking. The C2C01 test illustrates this situation. However, in the C2C02 test the passenger compartment deformation of light car reduced significantly although the passenger compartment structure of light car was not varied. The reason is assumed as follows.

In the C2C01 test, where the light car did not have multiple load paths, the front structures of both cars did not interact with each other sufficiently. On the other hand, in the C2C02 test, both cars had multiple load paths, which resulted in the considerable improvement of compatibility performance.

It is often mentioned that the measures to achieve compatibility are (1)to homogenize the front structure of heavy car and (2)to increase the passenger compartment strength of light car. However, These test results show that it is effective for compatibility improvement to homogenize the front structure of light car as well as heavy car. In other words, it is not sufficient for achieving good compatibility that the front structure of only either one of two cars is homogeneous. These test results illustrate the importance that the front structures of both cars are homogeneous.

BARRIER TESTS

Various tests to assess the fundamental issues of compatibility are proposed as shown in Table 3 (refer to [1] and [2]). To verify the previous discussion on car to car tests results, the 80km/h ODB tests of the same cars as were used in car to car tests were conducted (see Table 4). In 80km/h ODB tests, passenger compartment strength is measured. And it is indicated as “End of crash force (refer to [3])”.

Table 3.

Proposal of the tests to assess frontal impact compatibility

	Tests proposed by TRL	Tests proposed by Renault
Structural Interaction	56km/h Full width deformable barrier test	60km/h PDB test
Frontal stiffness	64km/h ODB test	
Passenger compartment strength	80km/h ODB test	60km/h ODB test

Table 4.

Barrier tests matrix

	Heavy car (With multiple load paths)	Light car (Without multiple load paths)	Light car (With multiple load paths)
80km/h ODB test	X	X	X

Results of 80km/h ODB Tests

Figure 9, 10 and 11 show the force vs. displacement curve of each car. In these figures, broken line shows “Mechanical force (refer to [1])” and chain line shows “Structural force (refer to [1])”. Figure 12 shows the comparison of the “End of crash force” values. There is little difference in the “End of crash force” between the light car with multiple load paths and the light car without multiple load paths. On the other hand, there is a great difference in the “End of crash force” between heavy car and light cars.

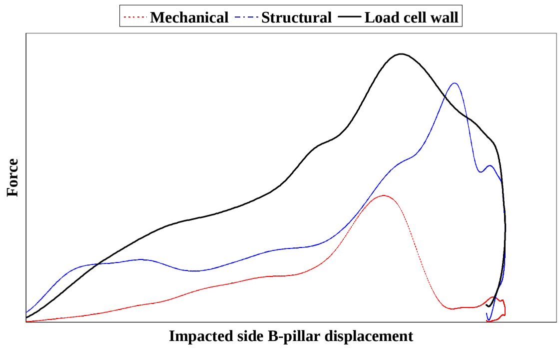

Figure 9. Force vs. displacement curve of heavy car in the 80km/h ODB test.

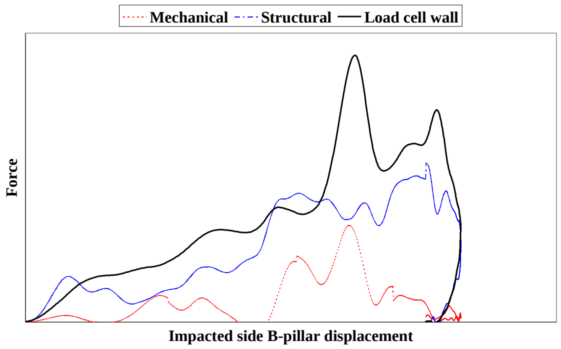

Figure 10. Force vs. displacement curve of light car without multiple load paths in the 80km/h ODB test.

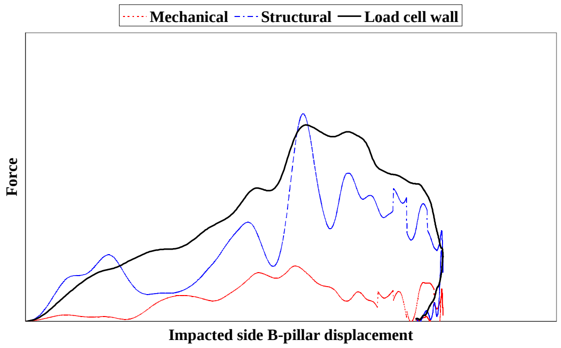

Figure 11. Force vs. displacement curve of light car with multiple load paths in the 80km/h ODB test.

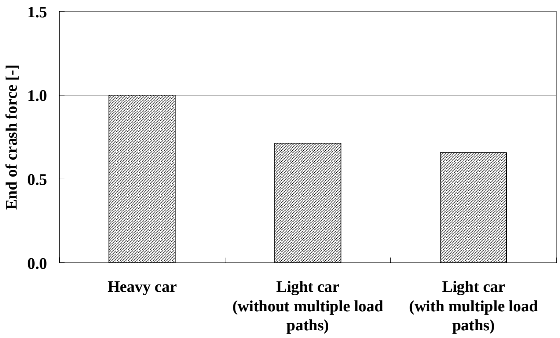

Figure 12. Comparison of "End of crash force". (Each value is normalized by the "End of crash force" of heavy car.)

Discussion

In case that there is a great difference in the "End of crash force" between heavy car and light car, consequently it is expected that the passenger compartment deformation of light car will be larger than that of heavy car when these cars collide each other (see Figure 13). However, the heavy car vs. light car with multiple load paths test resulted in compatible result although the heavy car vs. light car without multiple load paths test resulted in incompatible result.

The reason why the heavy car vs. light car with multiple load paths test resulted in compatible result is not that the passenger compartment strength increased, but that the energy absorbing capability of front structure was increased due to the improved structural interaction (see Figure 14).

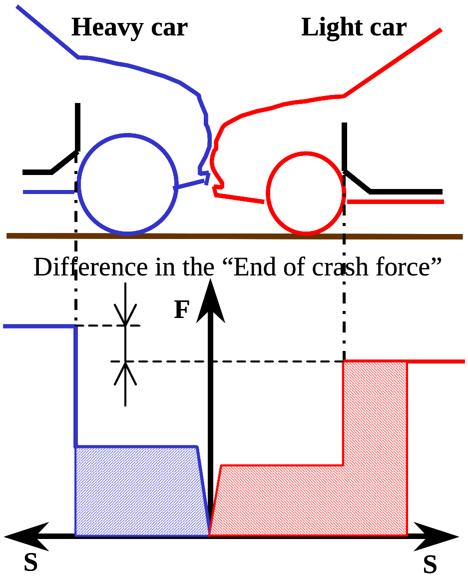

Figure 13. Force vs. deformation curve of each car (There is a great difference in the "End of crash force" between two cars.).

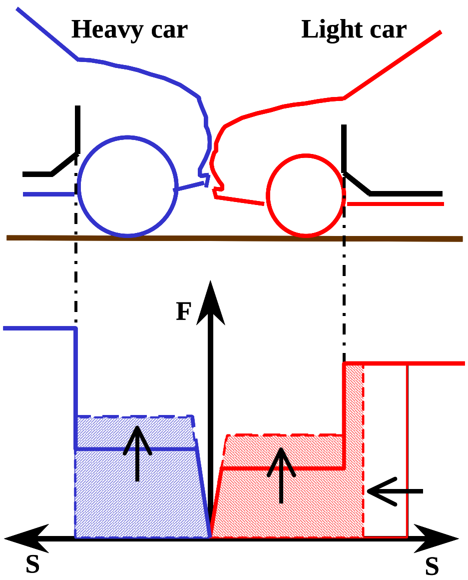

Figure 14. Force vs. deformation curve of each car (The energy absorbing capability is improved.).

CONCLUSIONS

Through the car to car test results and the barrier test results, the following have been shown. These findings should be considered in future development of test procedures for vehicle compatibility assessment.

(1) In order to achieve compatible result in a car to car impact between a heavy car and a light car, it is important to homogenize not only the front structure of the heavy car but also that of the light car.

(2) In case that compatibility of a light car is evaluated in the barrier tests, the front structure homogeneity as well as the passenger compartment strength should be analyzed.

REFERENCES

[1] Edwards, M., Hobbs, A., Davies, H. and Thompson, A. "Development of Test Procedures and Performance Criteria to Improve Compatibility in Car Frontal Collisions." Vehicle Safety 2002.

[2] Diboine, A. and Delannoy, P. "Improvements in car to car compatibility: Physics, design constraints and assessment test methodology and criteria." Vehicle Safety 2002.

[3] Steyer, C., Delhommeau, M. and Delannoy, P. "Proposal to Improve Compatibility in Head On Collisions." Sixteenth International Technical Conference on the Enhanced Safety of Vehicles.