

**Informational Document
regarding Effects of the Introduction
of the RCAR Bumper Test**



RCAR Damageability Working Group

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Abstract

Although RCAR's Structure Test already significantly contributed to continuous improvements of passenger vehicles' damageability and repairability over the last decades in terms of reduced claims costs and total costs of ownership, empirical evidence of inappropriate bumper beam design has been derived from analyzing real life accidents. In order to address this, RCAR developed and established the RCAR Bumper Test to promote bumper designs that interact appropriately.

This document is based on actual research conducted by several RCAR institutes worldwide and addresses potentials and improvements of bumper beams and crash management systems/structures that have been achieved with the new standard.

It was found that, depending on specific market conditions, data shows monetary disadvantages of up to 30 % for poor bumper design. More than that, inappropriate bumper beam designs have become less common in markets where the Bumper Test has become effective. And finally it could be shown that the predictive accuracy of a vehicle's risk evaluation has been significantly improved in rating systems where RCAR's Structure Test and Bumper Test have been combined.

1. Introduction

RCAR provides an international forum for members to exchange information on research findings and strategies for implementation. RCAR issues policy statements, design guides, position papers and other information for use by those involved in designing, constructing, repairing and insuring motor vehicles. This research is then used as a starting point to enter into a meaningful dialogue with vehicle manufacturers and others about putting that research to practical use.

2. Background

The RCAR Damageability Working Group addresses low speed crashes where, typically, no bodily injury should occur in contrast to published consumer tests, e.g. New Car Assessment Programmes (NCAP), which mainly address a higher level of impact speeds.

For this purpose the RCAR Damageability working group has established standards for evaluating the damageability of vehicles in low-speed crashes in order to standardize the method of analysis of repair costs to promote performance improvements in low-speed crashes worldwide. The group also wants to provide the vehicle manufacturers with a tried-and-tested measure to facilitate the design of easily repairable vehicles

While the group defines test procedures, it does typically not define rating methods for the test's results. These methods may be chosen according to local market-specific circumstances e.g. legal, technical, insurance coverage-related etc.

In the late 1980s a low speed test for the evaluation of structural damages and repairs was launched and since then has been used in several markets around the world: the RCAR Structure Test.

The RCAR Structure Test is a proven method to evaluate the capability of a vehicle to absorb impact energy in a severe city crash and support a cheap and easy repair. Today the Structure Test is the basic level where most vehicles are able to prevent their structure, e.g. side rails and subframes, from damage in such cases. It is this performance that ensures that city crash related damages can be repaired without welding and thus do not affect expensive and elaborate parts of the structure, such as high-strength-steel or cast body elements. By these means automakers have achieved and can verify the potential for an affordable cost-of-ownership of their product.

The Structure Test however, does not focus on compatibility. In the late 1990s RCAR institutes recognized that good structural behaviour did not always comply with real life findings because even sophisticated crash management systems require a counterpart for good results. In fact, insurance claims often showed spectacular damage (Fig. 1 & Fig. 2)



Fig. 1: Typical damage after underride



Fig. 2: Expensive cosmetic parts destroyed but crash management system mainly unaffected

The former RCAR Crash Working Group (today Damageability WG) started a deeper dive into the issue which unveiled that bumper designs that show good performance in tests might fail in real life. More than that, some vehicles appeared with test-optimized energy absorbers that quite obviously would not interact with a non-flat-opponent, especially not with another car. Other vehicles showed bumpers that were apparently geometrically incompatible or even missing completely. The Working Group's research ended with a proposal for the RCAR Bumper Test that was defined in order to complement the RCAR Structure Test. The Bumper Test's geometric requirements are derived from extensive testing, showing that a certain minimum overlap is required for bumper interaction and also from the evaluation of brake dives for several cars. The requirement is intended to guarantee a stable interaction in brake and non-brake conditions.

The RCAR Bumper Test was approved by the RCAR Annual Conference in 2006. Since then it has become effective in several markets and became a mandatory part of the Spanish insurance group rating in 2009, German insurance group rating in 2010, followed by the UK insurance group rating system in 2011. The most recent development is the introduction of the RCAR Bumper Test in the Korean insurance group rating system as of 2016.

Based on the gained experience, the present document aims to point out the benefits of the RCAR Bumper Test for manufacturers, insurers and customers.

3. Evaluation of the Effects of the RCAR Bumper Test

In crash tests and additional research on claims and insurance data the group reviewed the effects of the RCAR Bumper Test according to their local requirements and market specific needs. In the following the institutes present their findings.

3.1. Australia

Especially in Asian markets several vehicles without rear bumper beams could be identified. In Australia a comparative study was conducted to point out the disadvantages of such unprotected vehicle structures in common rear crashes.

Technical research

Crash research by IAG showed disadvantages resulting from misaligned bumpers as well as from missing rear bumpers.



Fig. 3: Vehicle without rear crossmember

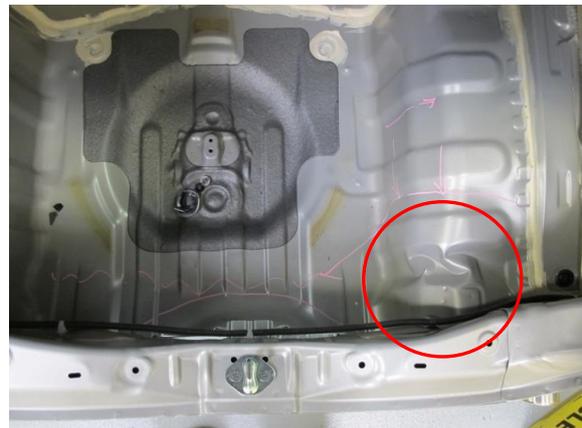


Fig. 4: Rear floor damaged after Bumper Test

Comparative testing of a vehicle without rear bumper beam/crossmember and a modified vehicle (spare parts from US version) showed these repair costs after RCAR Bumper Test:

without crossmember	7,655 AUS\$
with crossmember	1,606 AUS\$

Real life data

It is not feasible to perform bumper crash test with every car on the market due to cost. However, experience in 10 km/h bumper crash testing means that it is possible to estimate bumper performance from the measurement against the RCAR bumper overlap requirement. All cars are measured for bumper design and also missing rear bumper beam. This can result in an insurance premium penalty of up to 25%.

3.2. Germany

The German insurance group rating system evaluates newly launched vehicles using the RCAR Structure Test, which provides the data base for a rating proposal. In order to assess the vehicle's compatibility, the RCAR Bumper Test is subsequently applied. If a Bumper Test result is a fail, the initial rating proposal will be deteriorated by one class. Hence fails in both front and rear end Bumper Test lead to a disadvantage of two classes to the initial proposal. If both tests are passed successfully, the initial proposal remains unchanged. This procedure became effective in 2010. A detailed description of the German rating procedure is available on RCAR's website¹.

Technical research

Allianz Center for Technology AZT started testing with the bumper barrier in 2004. It was shown with crash tests, that repair costs of vehicles showing poor interaction with the barrier/opponent can count for up to four times that of well interacting vehicles. Car to car crashes showed a significant increase in damaged non-structural parts in underrides compared to good bumper interaction.



Fig. 5: No bumper interaction in car-to-car crash, underride



Fig. 6: Crash management system not affected, unnecessary damage



Fig. 7: RCAR Bumper Test with poor bumper alignment



Fig. 8: Appropriate bumper alignment, cut-out in bumper fascia for visualization

¹ „Information on the implementation of RCAR crash standards in the German insurance vehicle rating“



Fig. 9: Deformation with poor bumper alignment, here: underride, net repair costs 2,760 EUR



Fig. 10: Limited intrusion with appropriate bumper performance, net repair costs 1,130 EUR

Real life data

The German insurance claims data is aggregated by the insurers association GDV for the entire private vehicle market once per year. Aggregated claims costs are reassessed (for cars with >200 Annual Units AU) for each vehicle type annually with respect to the market average and a vehicles' insurance group rating is revised accordingly. Therefore all vehicles newly launched as of 2010 can be compared with respect to bumper criteria and real life performance by evaluating the change in group rating over time. The required data was kindly provided by GDV.

Analysis of changes in MOD² rating groups showed in 2014, that vehicles tested "fail" in front and rear Bumper Tests, have an average disadvantage of 2.8 groups compared to those vehicles tested "pass" in both ends. Relative to the market average this corresponds to around 30 % higher premiums in MOD for most volume models in the German market. The disadvantage increases with higher ratings (higher = more expensive), because the spread within the groups is exponential towards the higher end.

For the analysis all newly launched vehicles had been identified and their AUs and changes in group rating (ΔTKL^3) have been registered. These changes have then been weighted by the AUs and finally an average was found relative to the RCAR Bumper Test performance in the initial rating. The findings are condensed in table 1.

² MOD Motor Own Damage, here: full comprehensive

³ TKL = Typklasse = rating group

Bumper Test "pass"?	n [AU]	Δ TKL, real life claims costs	corrective factor for initial rating	effective Δ TKL
Front and rear	450,104.0	1.04	0	1.04
Front	144,856.5	-0.41	+1	0.59
rear	19,058.8	0.93	+1	1.93
None/fail	200,341.6	1.82	+2	3.82
all	814,361.1	0.97		

Table 1: Average changes of German insurance group rating for vehicles launched after 2009

In table 1 the column "corrective factor" represents the factor applied for initial rating. For a "fail" in one end, one TKL is added, hence vehicles with no "pass" have a corrective factor of +2. This added to the reassessed Δ TKL of 1.82 results in a total disadvantage of Δ TKL = 3.82 while real life change for vehicles rated good is Δ TKL = 1.04. Hence a remaining disadvantage of Δ TKL = 2.8 is real life experience in the German market.

Or in other words – the predictive accuracy of the initial insurance group rating has been significantly improved with the introduction of the Bumper Test.

The database does not allow for a direct comparison of insurance premiums. However, it is evident that customers purchasing vehicles with good bumper performance could experience rather stable insurance premiums, while owners of vehicles with poor bumper performance had to suffer significantly increased premiums for their car.

3.3. Japan

Japanese automakers have been tackling the damageability performance improvement toward the rating system in Europe and the assessment system in the United States. On the other hand, there is no similar rating or assessment system in Japan. However, Japanese consumers have recognised the insurance burden because the rate of the automobile insurance premium changed in 2013 among the Japanese big insurance companies, and from then it became necessary for the consumers to bear a bigger burden. From this point of view, Japanese automakers are making an effort in performance improvement of damageability based on the low speed tests.

The results of the low speed tests conducted by JKC have been shared with the manufacturers, and JKC proposed many improvement items to them.

JKC has performed RCAR Structure Test since 2002, and added RCAR Bumper Test from 2007. JKC continuously reported these test results to automakers. Then, regarding the comparison of the comprehensive performance, JKC used the Structure Test only until October 2013 and then added Bumper Test after December 2013. Based on this, JKC defined the weighting coefficient value based on the

relationship between the test results and insurance claim data in Japan. Unfortunately, several vehicles in Japan are sold without a rear bumper beam, so JKC then started research on this topic as well.

Technical research

A. Relation between front bumper engagement and repair costs

The results of front Bumper Tests showed that the repair costs of vehicles with low vertical bumper engagement was high. The reason is that vehicles with low vertical bumper engagement tend to "underride" the barrier and therefore expensive parts such as the condenser and radiator are damaged.

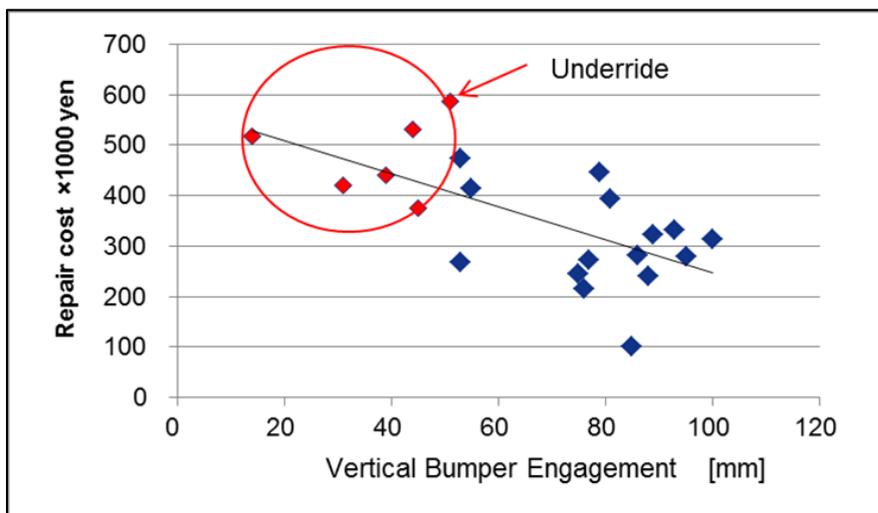


Fig. 11: Front repair costs relative to bumper engagement

B. Repair costs, effect of rear bumper beam

The results of Bumper Tests showed that the average repair costs of the vehicle without a rear bumper beam and crash box is 2.4 times higher than for vehicle with a bumper beam.

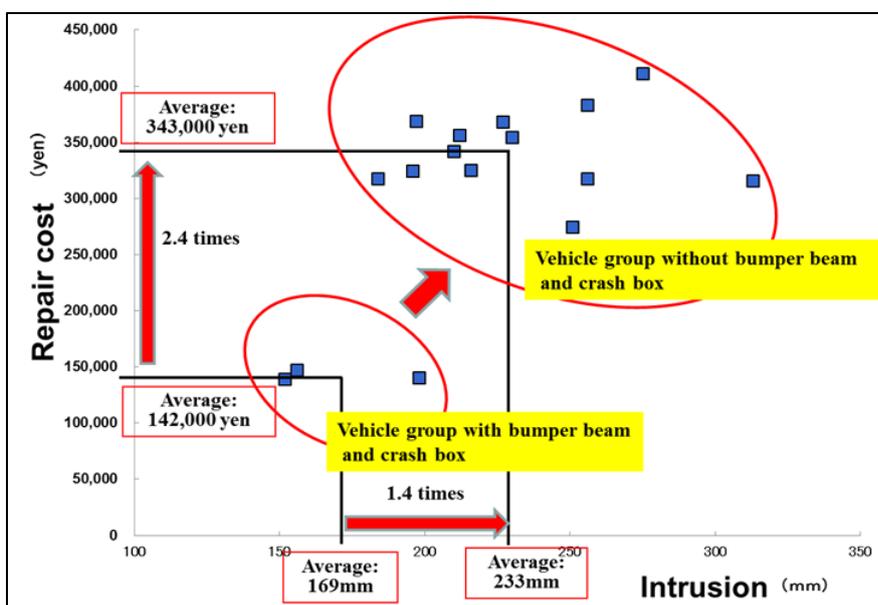


Fig. 12: Rear repair costs relative to the presence of a bumper beam structure

Real life data

The Bumper Test was combined with the Structure Test as from the assessment in November 2013. The correlation between the market claim data and the low speed test results became strong.

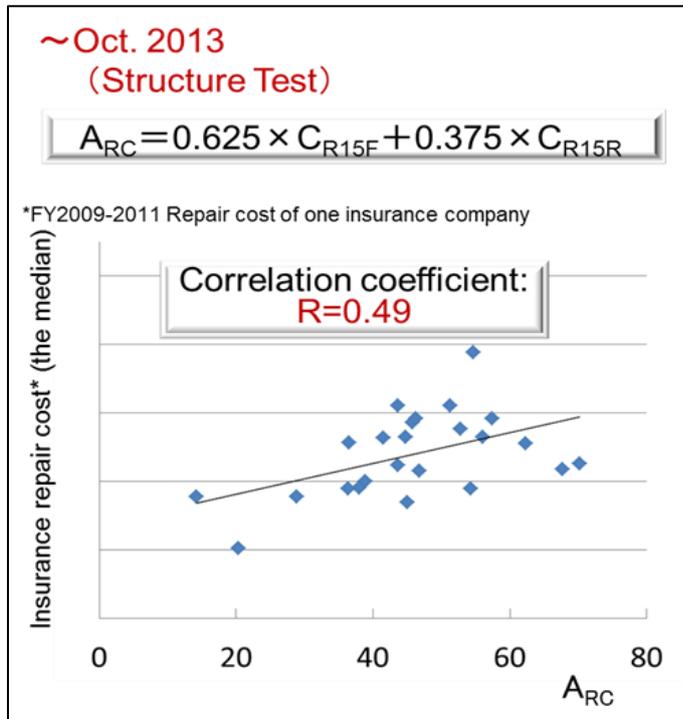


Fig. 13: Correlation of RCAR Structure Test with real life claims experience

Index:

C_{R15F} = Structure Test front
 C_{R15R} = Structure Test rear

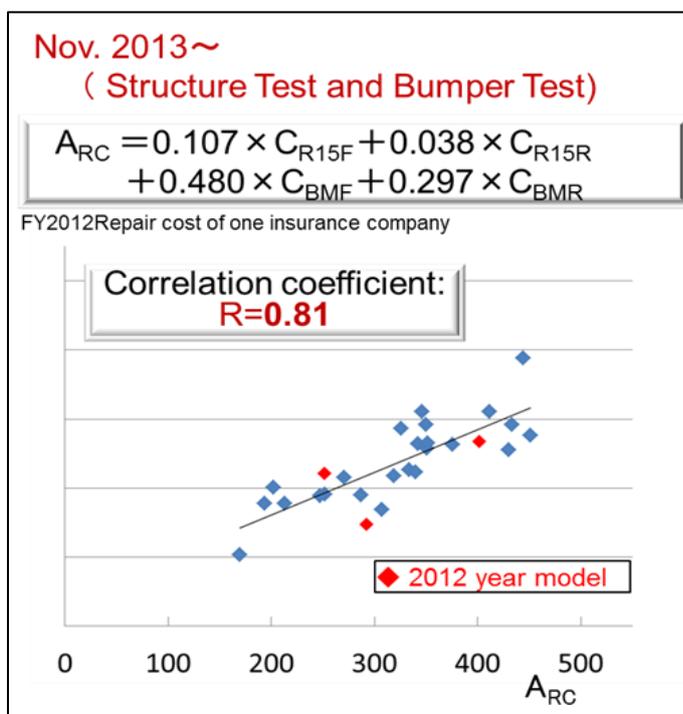


Fig. 14: Correlation of combination of RCAR Structure Test & Bumper Test with real life claims experience

Index:

C_{R15F} = Structure Test front
 C_{R15R} = Structure Test rear
 C_{BMF} = Bumper Test front
 C_{BMR} = Bumper Test rear

The significantly increased correlation coefficient indicates that the predictive accuracy of the new formula - including the RCAR Bumper Test - is far better than with the RCAR Structure Test alone.

3.4. Korea

The Korean insurance group rating system evaluates new vehicles before their launch by RCAR Structure Test only since 2007. To apply the RCAR Bumper Test to the rating system, KART has researched on the specific application method through crash tests and insurance data analysis. The Bumper Test became effective in 2016 in the insurance group rating system along with the Structure Test.

Technical research

KART has conducted tests with the bumper barrier since 2007. As a part of developing a procedure for adding RCAR Bumper Test results to the group rating system, the bumper crash tests with eight domestic vehicles were conducted in 2013 and 2014. Vehicles interacting well with the bumper barrier showed small damage, resulting in lower repair costs. It showed the trend that bumper engagements with the barrier affect the repair costs of vehicles. Fig. 15 shows that good relevant engagement results in lower repair cost.

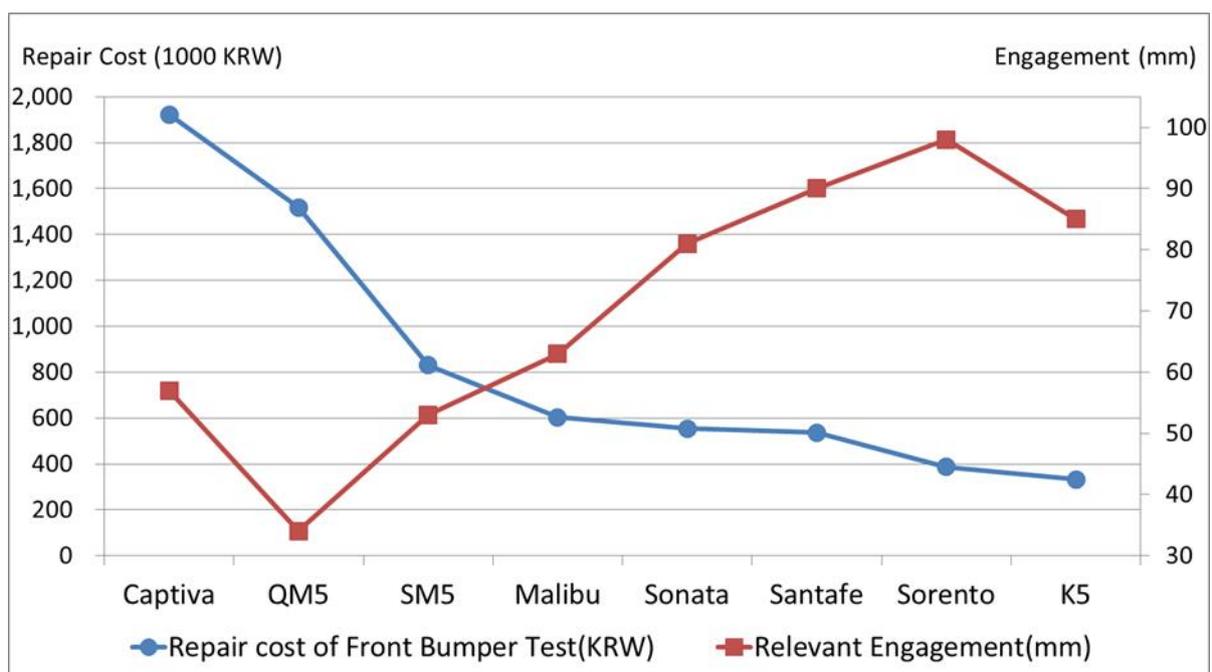


Fig. 15: Relevant engagement with the barrier and repair costs for tested vehicles

Real life data

Compared with the repair costs of the Bumper Test and their current group rating classes, data showed the trend that the vehicles with higher repair costs led to the worse rating classes, see Fig. 16. The Korean insurance group rating system has 26 groups, where class 26 is the best and class 1 is the worst.

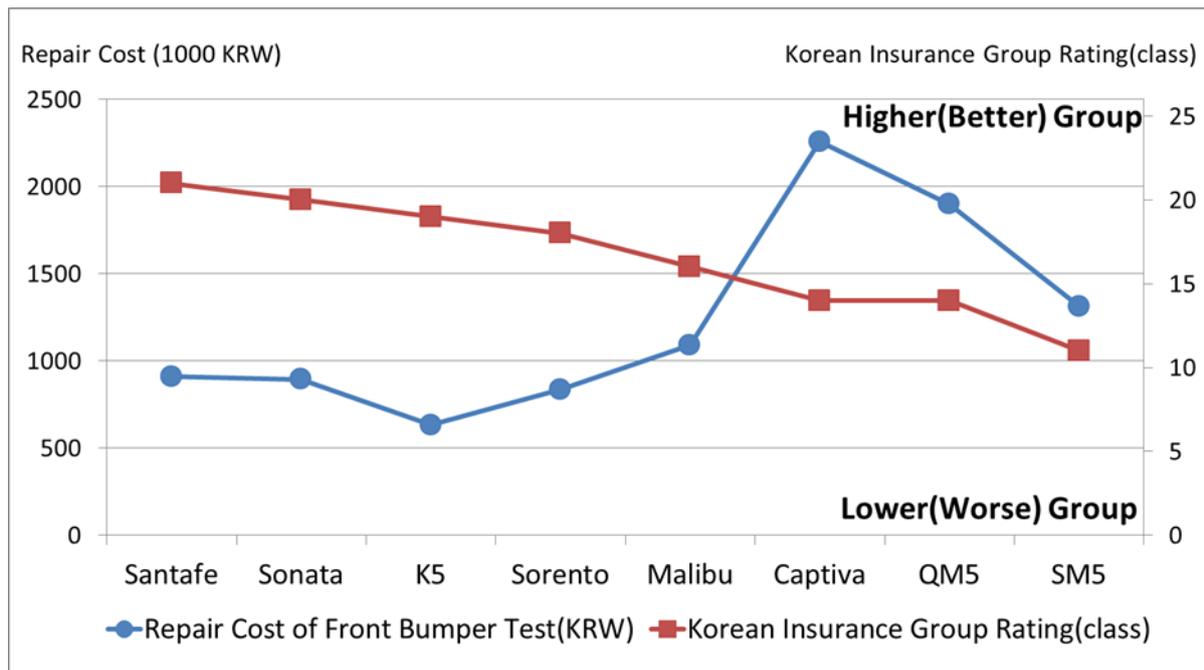


Fig. 16: Relevant engagement with the barrier and repair costs for tested vehicles

The correlation between repair costs and claim data (loss ratio) was analysed. The correlation coefficient of repair costs between the Bumper Tests and the Structure Tests was 0.26, indicating a weak correlation. It showed that the relation of repair costs between the two tests is independent.

The claim data had a strong correlation with the repair cost of both Bumper Test and Structure Test, correlation coefficients are 0.65 and 0.75 respectively. Adding the repair cost of the Bumper Test to the Structure Test, the correlation coefficient reached 0.89, indicating a substantial strong correlation. This analysis showed that adding the Bumper Test results to the Structure Test would reflect the real world accidents well.

3.5. UK

The Bumper Test was first introduced into the UK group rating system in January 2011. Depending on the performance of the bumper system in the RCAR dynamic test and the geometric alignment, the rating could be reduced by up to 2 groups out of 50 for a bumper that met all the requirements, and be penalised by up to 2 groups for a bumper that failed.

Technical research

In 2004 Thatcham started a programme of vehicle testing to help towards defining the RCAR test standard. It was very apparent that different makes and models of cars bumper systems were not compatible, even those cars manufactured within the same group had bumper systems that were found to be misaligned.



Fig. 17: Bumper height mismatch
– same segment



Fig. 18: Bumper height mismatch
– same brand

To encourage vehicle manufacturers to fit good bumper systems that aligned, in 2007 Thatcham started to publish the results from the research testing. The bumpers were rated as good, acceptable, marginal and poor, with a monetary figure being used as the measure based on the cost of repair following the impact test. By 2009 results for 32 cars had been published, with 12 still showing poor results for front and rear bumpers.

Real life data

From a sample of cars launched since 2015, of 26 new cars tested 14 have passed both the geometrical and dynamic test for the front and rear bumper, with 12 failing to meet both tests. If we then look at the real world repair cost within this sample for own damage, those that met the test have a mean repair cost of £2.233 whereas those that failed have a mean cost of £2.624 (these costs are for actuals paid and not estimates) equating to a 17.5% differential.

ANNUAL TREND in the UK

The median total repair costs year by year from 2006 to 2015 are charted in Figure 16, including a breakdown by type (labour, parts, and paint materials). This is indexed to remove inflation.

This indicates an overall trend that is fairly stable for total repair costs. Labour costs appear to have dropped very slightly in the last decade, as have parts costs (although parts costs are showing a slight increase in the last two years). It is interesting to note that the decrease in labour and parts started in 2009/2010 soon after the test being finalised and included into rating systems by RCAR members. These changes cannot be solely attributed to the Bumper Test, but as vehicle manufacturers were aware of the research as early as 2005 it is not inconceivable that RCAR has contributed toward these reductions.

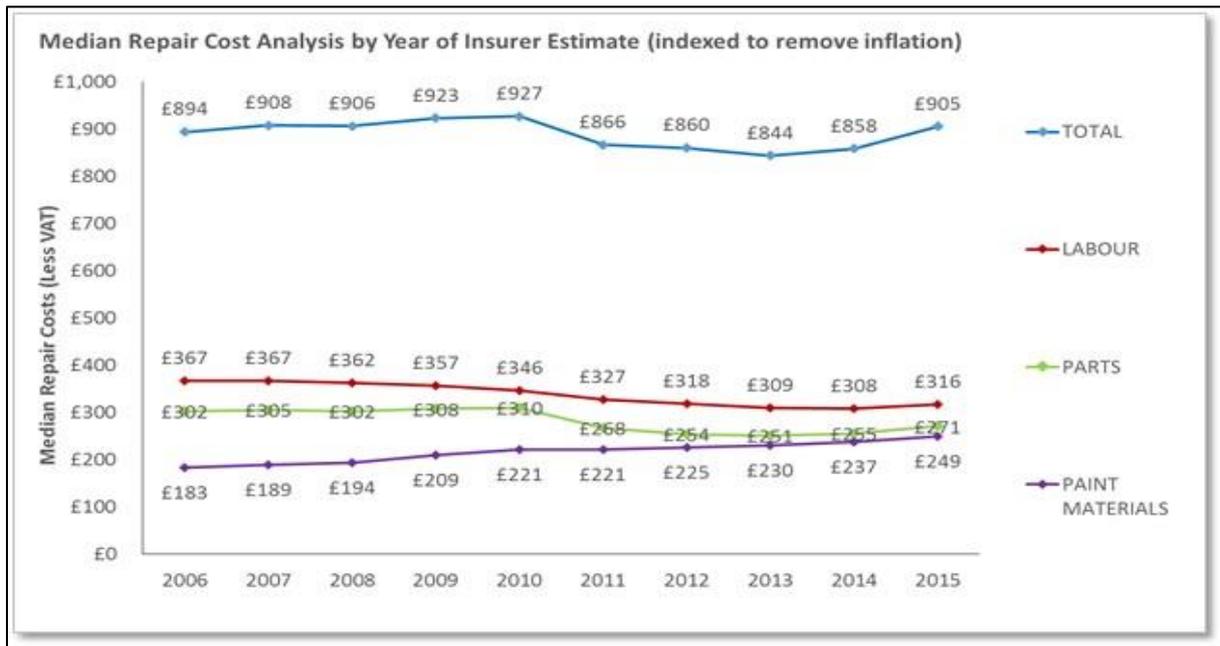


Fig. 19: Trend in repair cost by type; 2006 to 2015

AGE TRENDS IN REPAIR TIMES & COSTS:

Fig. 20 and Fig. 21 examine vehicle repair times and costs for vehicles of different ages.

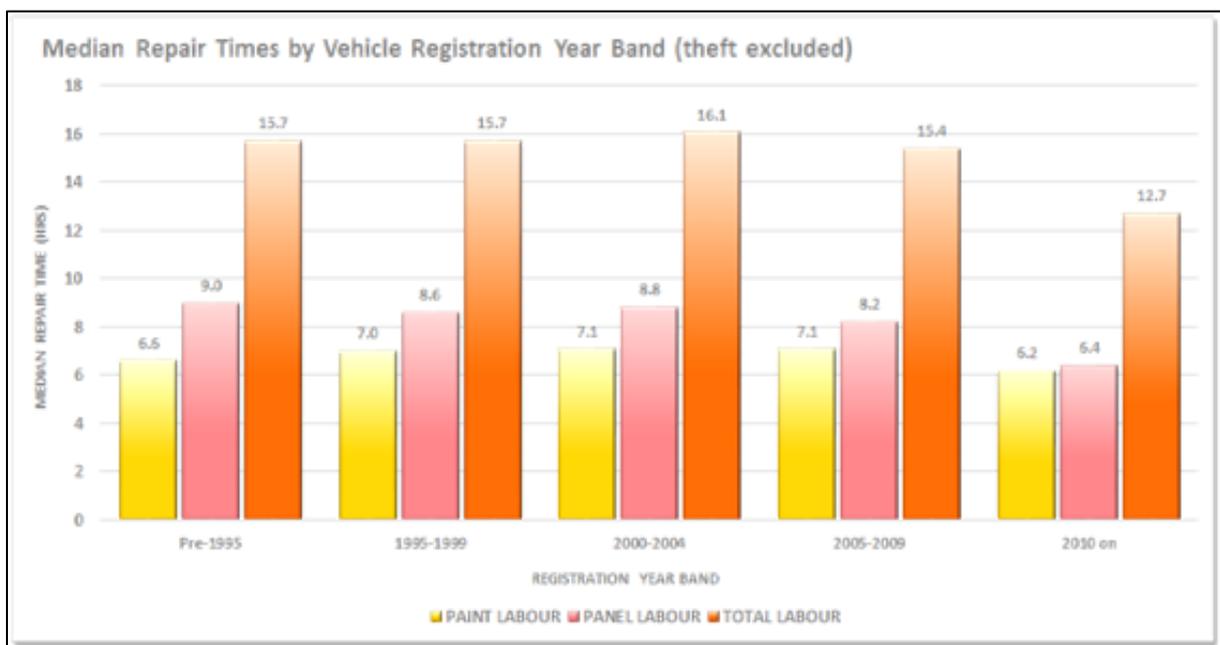


Fig. 20: Median repair times by vehicle age.

There is a trend towards reduced repair times: the average Overall Repair Time decreases by 19% from 15.7 hours for pre-95 vehicles to 12.7 hours for 2010 on vehicles. MET/Panel repair times decrease from 9 hours for pre-95 vehicles to 6.4 hours for 2010 on vehicles, a

reduction of 29%. Changes in Paint times are comparatively lower: a 6% reduction from 6.6 hours for pre-95 vehicles down to 6.2 hours for 2010 on vehicles.

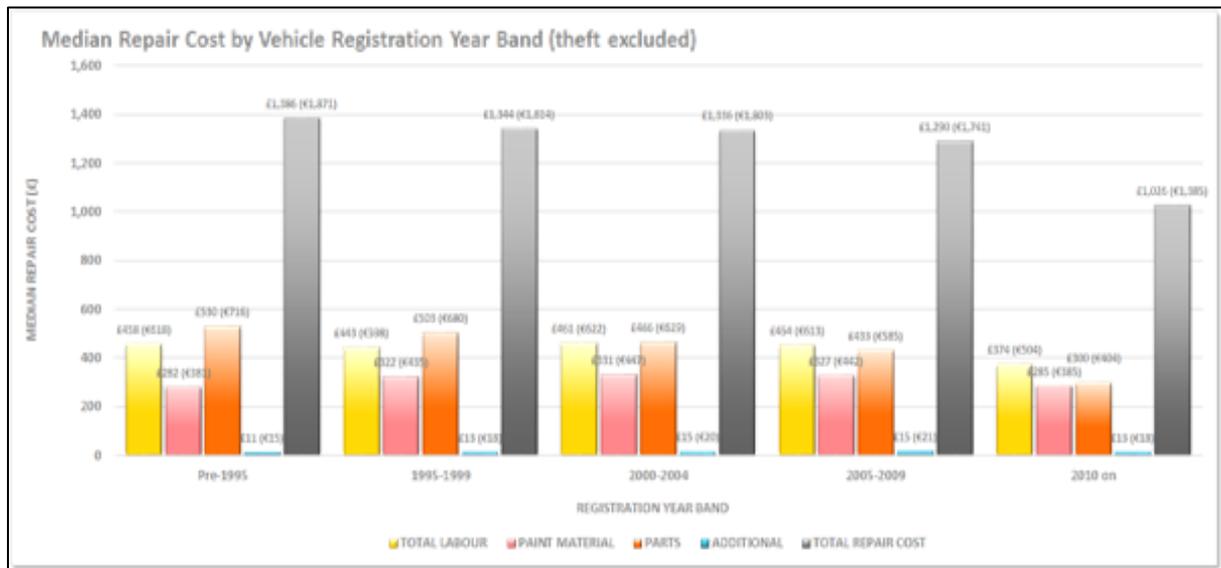


Fig. 21: Median repair cost by vehicle age

In general similar trends are observed for Median Repair Costs across vehicle age bands. The overall repair cost decreases 26% from £1,386 (€1,871) for pre-95 vehicles to £1,026 (€1,385) for 2010 on. Parts costs drop steadily, from £530 (€716) for pre-95 vehicles to £300 (€404) for 2010 on vehicles, a reduction of 43.5%. There is also a general reduction in labour cost, down from £458 (€618) for pre-95 vehicles to £374 (€504) for 2010 on vehicles, a decrease of 18.4%.

3.6. SPAIN

From January 2009 till now the Spanish insurance group rating system is based on the results of both the RCAR low speed structural crash test and the RCAR Bumper Tests. The Spanish rating procedure is as follow: the group rating obtained after the structural evaluation can improve up to 4 groups depending on the results of the front and the rear Bumper Tests.

Bumpers can be rated: GOOD, MARGINAL or POOR depending on the static evaluation and the dynamic tests.

When the result is GOOD in both front an rear bumper the structural rating of the car improves 4 groups.

Technical research

CESVIMAP started testing bumpers in 2004 as a member of the RCAR Damageability working group. This working group worked for more than four years to develop the RCAR Bumper Test protocol and the characteristics of the bumper barrier.



Fig. 22: Developing tests 2004-2007

From 2008 CESVIMAP carries out Bumper Tests with all the new cars tested in its facilities. In January 2009 CESVIMAP introduced officially the Bumper Test results in the group rating system in Spain. Rating comprises static and dynamic evaluation of bumper structures.



Fig. 23: Static evaluation front cross member

Fig. 24: Static evaluation rear cross member

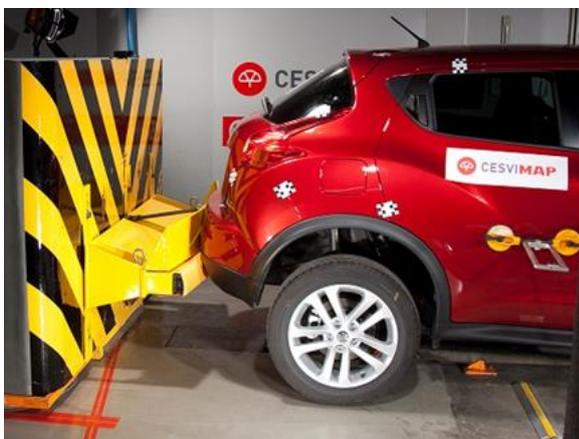


Fig. 25: Dynamic Bumper Test

Fig. 26: Dynamic Bumper Test

Real life data

From 2008 more than 100 new cars have been tested in CESVIMAP facilities. Currently more than 1100 cars have their group rating influenced by the Bumper Test results.

The improvement of the structural insurance group rating due to the bumper performance has had the following results:**Fehler! Keine gültige Verknüpfung.**Table 2:
Bumper Test results from September 2008

In the Spanish market the Bumper Test results have an influence up to 6% in the full comprehensive premium of the car

4. Summary and Conclusion

All technical research finds less damage for crashes with well interacting crash management systems. This is directly related to the cost-of-ownership, either because insurance premiums may be lower or because vehicle owners have to pay less in cases without insurance coverage. On the contrary, poor bumper performance very likely results in higher costs for both owner and insurer. The worst case can be missing bumpers, as Australian and Japanese research point out.

While lab tests with individual cars demonstrate the potential of good bumper design, real life experience finally judges the effectiveness of the Bumper Test. All claims experience so far indicates that there is a relation between bumper performance and cost-of-ownership.

Although bumper beams are not involved in all kinds of collisions, the impact is high because if the crash management system is affected in a crash, the accident will be typically a more severe one. And as soon as the radiators are affected, older cars will be near to a total loss. Hence the difference in bumper performance plays an important role in the subsequently damaged parts. The improvement with appropriate bumper design consequently is different in the markets, but data shows an overall potential of up to 30 % higher losses for poor bumper design.

Australia	25 %	insurance premium penalty
Germany	~ 30 %	statistical disadvantage
UK	17.5 %	statistical disadvantage
Spain	max 6 %	insurance premium penalty

For those countries where correlations between rating systems and RCAR tests could be evaluated, the combination of Structure Test and Bumper Test was found to be appropriate for the evaluation of a specific vehicle's risk. And it seems to be especially the combination of both tests that provides good results in risk prediction.

The RCAR Bumper Test promotes vehicles with interacting crash management systems. Inappropriate structures such as simple crash cans or thin tubes instead of crossmembers, as well as any rounded crossmembers, have virtually vanished where the RCAR Bumper Test is established. Instead, newer cars with crash management systems designed to comply with the RCAR Bumper Test, generally show more robust bumpers and automakers obviously refer to the requirements as a design guide and improve their products' cost-of-ownership by considering these findings.

Hence, for customers, insurers and OEMs the Bumper Test is an improvement. The Bumper Test

- enables the OEM to improve a vehicle's performance in crashes and self protection in a target-oriented way
- allows for a better risk prediction for the insurers and adequate premium calculation
- can lead to optimized premiums for insured vehicles and saves costs significantly where customers have no insurance coverage