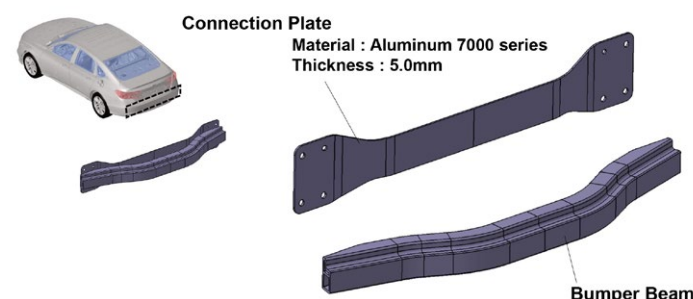


Electric vehicles

Enhancing the crash resistance of new, heavier cars

- Electric vehicles are heavier than conventional cars, which increases both the energy of potential crashes and risks to passengers.
- Atsushi Hasegawa from Honda Motor Co., Ltd. developed simple bow-shaped door and rear bumper beams to enhance passenger safety.
- The beams performed well in crash tests and computer simulations, with high energy absorption and less car body deformation.
- As we move into a landscape populated with heavier electric vehicles, Hasegawa's team aims to ensure road safety for everyone.

Methodology : New bumper beam



Safety and carbon neutrality are the top priorities for future automotive technology. Technologies that reduce the damage to passengers through the combination of advanced driver-assistance systems (ADAS) to avoid accidents and reduce collision speeds, such as seat belts and airbags, are becoming more futuristic and optimised.

Electric vehicles will be key to promoting a carbon-neutral society in the near future. These vehicles run on electricity stored in a battery and are heavier than standard cars because their battery components are heavier than conventional fuel tanks. Crashes involving heavier cars have higher collision energies that lead to much greater vehicular damage and pose higher risks for passengers.

Safety first

Over the years, manufacturers and policy-makers across the world have developed safety standards to ensure passengers are as protected as possible. The USA's FMVSS301 standard describes a vehicle hitting a deformable barrier at 80km per hour to the rear bumper. On the other hand, the new IIHS MDB standard was developed to describe a side-on car crash with a barrier that has a hardened front section. This can simulate the situation when the door penetrates the car body as it occurs in real accidents.



Hasegawa and his team at Honda Motor Co., Ltd. investigated the effect of structure on the energy-absorbing (protective) capacities of vehicle frames.

For instance, in the case of FMVSS301 which targets rear-end collisions, as the non-collision side of a vehicle cannot absorb most of the energy from a crash, safety experts must explore innovative ways to better distribute this load across the car body. The protective features around a car should ideally absorb as much of the crash energy as possible while limiting vehicle deformation.

Weight is another factor that plays into modern vehicle development. Lighter cars require less fuel, regardless of the type of fuel they use. This means researchers must address safety issues while also minimising vehicle weight, a key point when choosing the composition and structure of a protective feature.

Exploring a new bumper beam structure

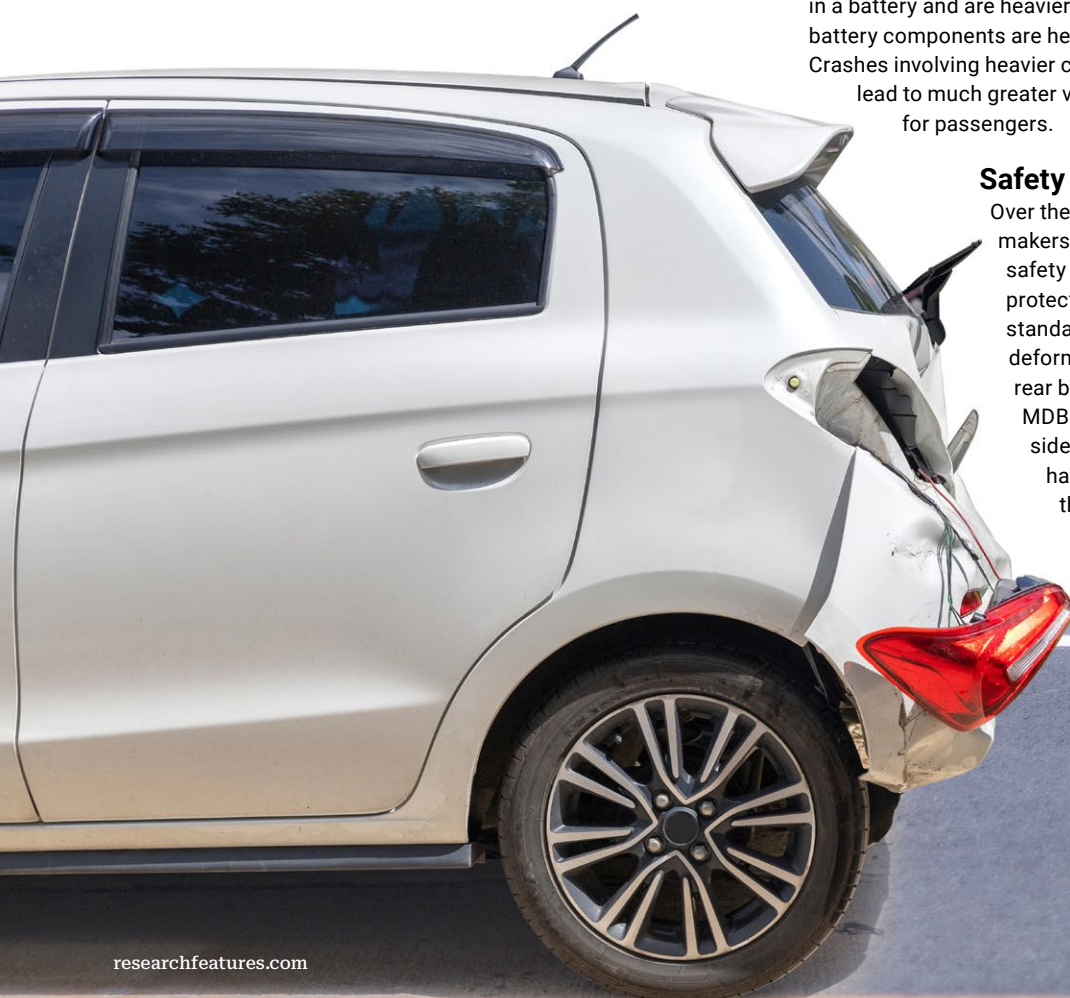
Chief engineer Atsushi Hasegawa and his team at Honda Motor Co., Ltd. investigated the effect of structure on the energy-absorbing (protective) capacities of vehicle frames. They developed and tested new rear bumper beam and rear side-frame structures using high-energy test standards for car crashes at FMVSS301 (80km per hour). A rear bumper – which contains a fascia (a covering) and a high-strength bumper beam – is the first component to transmit the load of the impact of a rear-end crash to both frames. Ideally, the rear bumper beam should transmit high loads steadily to the two frames.

Crashes involving heavier cars have higher collision energies that lead to much greater vehicular damage and pose higher risks for passengers.

Rear-end collisions

The engineers devised a way of absorbing more impact energy using the idea of a bow. When a bow's arch is pressed, it strains to maintain its shape due to the tension in the attached string. With this in mind, the team created a new component called a connection plate, which fitted in front of the bumper and worked like a string attached to an arched rear bumper beam. Pushing the bumper from behind placed a load on the connection plate and bumper beam. These two opposing loads cancelled each other out, suppressing sideways deformation and allowing for the load to be more evenly distributed across the rear frame.

Hasegawa and team dropped heavy barriers on their bow-shaped rear bumper beam to test its performance. Compared to standard bumpers, the new beam structure was more evenly distributed. The team found that compared to standard rear side-frames, the new beam allowed a greater load to be stably and equally absorbed on the collision and non-collision side of frames, both of which collapsed on impact. Each side absorbed more energy, while the colliding barrier also showed increased absorption. All this collision energy absorbed into the rear side-frames and barrier can help protect passengers from injury.



This image is for illustrative purposes only and does not represent a Honda vehicle.



Inspiration



A kids' pop-up toy that launched the car horizontally at the press of a button served as the inspiration for this project.

Side-on crashes

The team also tackled side-on car accidents. A conventional car has beams fitted across each door and a B-pillar between the doors. In a side-on car crash, a door beam behaves like a bar which is fixed at both ends and receives a concentrated load in its middle. A significant bending deformation of the door beam and B-pillar then supports most of the load. Hasegawa aimed to make this side structure more collision-resistant by reducing door beam bending.

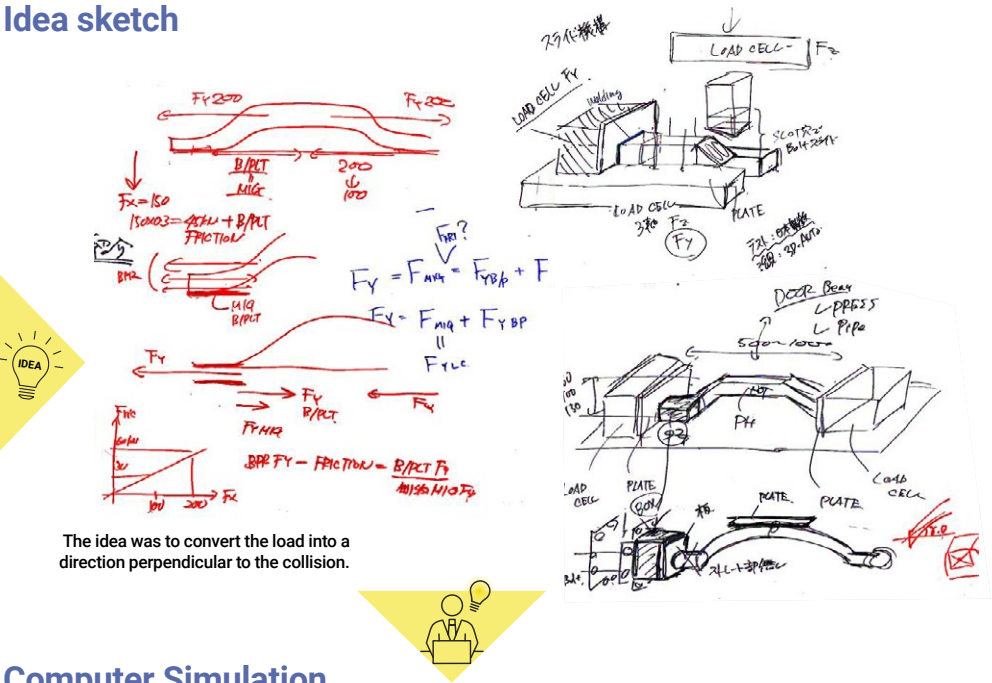
The team avoided standard straight door beams and instead opted for an arched shape. In this way, if the outwards-curving middle of the beam were pushed inwards, it would strain to extend itself. The engineers expected that by transmitting the axial loads to the pillars through the arch beam, higher lateral loads could be generated compared to conventional methods, thus reducing deformation.

Computer simulation of side impact test

Hasegawa and his team attached an arched door beam prototype to a mass-produced sedan to see how it would perform in a car crash. They evaluated safety performance based on dummy injury value (the extent of the injuries to the dummy), head protection, and structure using the IIHS MDB standard.

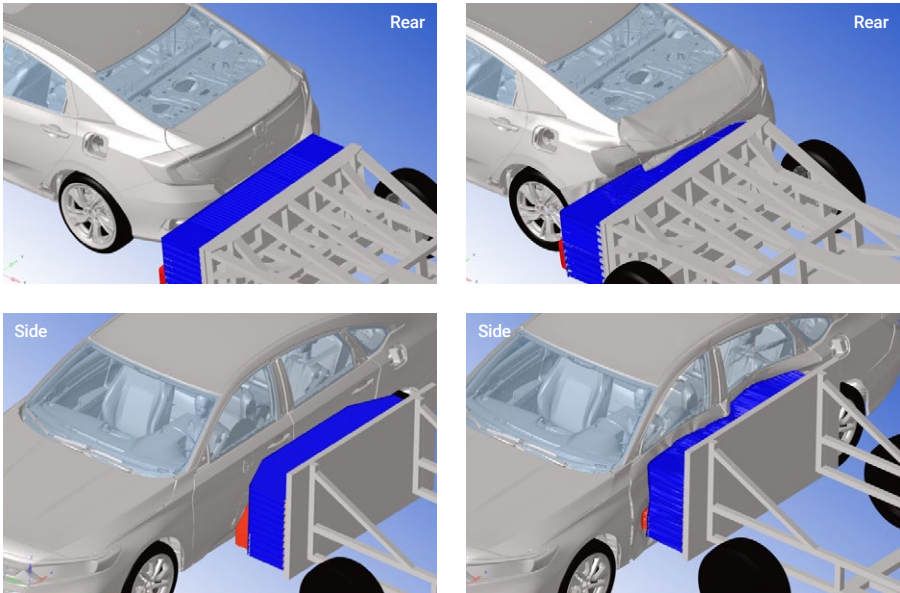
These computer simulations predicted lowered car body deformation and showed

Idea sketch



The idea was to convert the load into a direction perpendicular to the collision.

Computer Simulation



The team evaluated safety performance based on dummy injury value, head protection, and structure using the IIHS MDB and FMVSS301 standard.

Hasegawa and his team of engineers aim to delve deeper into passenger safety, combining these passive safety measures with active safety devices and elderly occupant protection.

that the dummy's spine acceleration was reduced over half. Hasegawa's new door beam clearly increased the car body's load gradient (generated load divided by amount of deformation), reduced car body deformation, and slowed the door's intrusion into the car – features that enhance passenger safety.

Simple but effective

Carmakers would not need to drastically reconfigure existing car body components to adopt the team's rear bumper and door

beams – a crucial point for mass production. The developed beam structures are also of a simple design that exploit naturally occurring loads.

Hasegawa and his team of engineers aim to delve deeper into passenger safety, combining these passive safety measures with active safety devices and elderly occupant protection. As we move into a landscape populated with heavier electric vehicles, Hasegawa's team aims to ensure road safety for everyone.

Personal response

What inspired you to focus on door and rear bumper beams as key safety features?

The door beam and rear bumper beam are the first structures to receive the load in a side or rear collision. These components transmit the load to the main framework of the vehicle, allowing each part to perform its function. Specifically, they absorb energy by deforming or generating high loads to maintain their shape. Additionally, the load transmitted from the door beam and rear bumper beam is used to define the specifications and design of each component. Therefore, we consider the door beam and rear bumper beam to be very important parts for ensuring the performance of all vehicle components.

What is a common misconception people have about car safety?

There might be a misconception that advancements in technology can completely prevent accidents and minimise injuries. Car safety has enhanced over the past few decades due to crash avoidance and collision safety. For example, many people feel safer thanks to Lane Keeping Assist System (LKAS) and Collision Mitigation Braking System (CMBS), which help avoid accidents. But, we must not be overconfident in the evolution of safety technology. It is essential for drivers to maintain their health, follow traffic rules, and be mindful of other vehicles and pedestrians. Traffic safety is a shared responsibility, built by all participants, not just car manufacturers.

Did anything in this project surprise you?

The moment that sparked my idea was the biggest surprise for me. I had been thinking daily about ways to enhance performance, but hadn't come up with anything for a while. One day, I was watching my twin sons play with a pop-up toy. When they pressed a button from above, a car was launched horizontally. The direction of action changed relative to the direction of the input. Seeing this, I had a sudden inspiration. The idea was to convert the load into a direction perpendicular to the collision.

How could your protective beams be integrated into electric vehicles?

To transition these new structures from the research stage to mass production, we need to further optimise both performance and environmental impact. It is also important to integrate our work with the structures being researched by other teams. Additionally, we should ensure that the technology is versatile enough for different types of vehicles and integrate it with new product design.

How would you integrate active safety measures like car-to-car communication into your research?

It's difficult to handle all accidents with passive safety measures alone. We need to analyse accident situations that can be avoided or mitigated with preventive safety technologies. Based on this analysis, we can establish the conditions that passive safety should address and develop new structural designs. By considering passive and active safety interactively, we can approach vehicle safety as a comprehensive system.

Details



e: atsushi_hasegawa@jp.honda
w: www.hondarandd.jp/index.php

Bio

Atsushi Hasegawa graduated from the Department of Mechanical Engineering at Waseda University (2004) and obtained a master's degree in Integrative Bioscience and Biomedical Engineering from Waseda University (2006). He then joined Honda R&D Co., Ltd., where he engaged in research on automotive safety technology and served as a collision CAE (Computer-Aided Engineering) specialist. He became assistant chief engineer in 2014 and chief engineer in 2021. Hasegawa contributed to the development of mass-production models such as the Civic and Accord. Subsequently, he took on the role of project leader in the research of vehicle structures to enhance the rear-end and side collision safety performance. Hasegawa won the ICRE 2024 Title, International Best Researcher of the Year Award for his specialisation in automobile/safety.

Collaborators

- Benteler Automotive, K.K.: Tomohiro Shimizu
- Honda R&D Co., Ltd.: Takayuki Fujii, Norikazu Matsuura, and Yasuhisa Egawa

Further reading

Hasegawa, A, Fujii, T, Matsuura, N, Shimizu, T, (2023) [Load distribution structure of rear bumper beam to enhance vehicle body energy absorption in rear-end collisions](#). *Traffic Injury Prevention*, 24(sup1), S75–S79.

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Hasegawa, A, Fujii, T, Matsuura, N, et al, (2020) [Load distribution by rear bumper beam in FMVSS 301R test protocol](#). *Honda R&D Technical Review*, 32(1).



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