Development of a Support Bump for Increasing the Energy Absorption of a Jounce Bump

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Abstract. In this study, we developed a support bump to increase the energy absorption of the jounce bump. This support bump is made of TPE material, and the jounce bump is made of TPU material. The support and jounce bump each verified the simulation model using the load deflection test. The developed support and jounce bump were satisfied with the durability test. The support bump was assembled with the jounce bump and confirmed that the energy absorption amount was increased compared with the single jounce bump. Finally, we verified the validity of the simulation by comparing the load deflection data under the same conditions as the test using the verified the support and jounce bump simulation model.

1. Introduction
The jounce bump is a shock absorber located at the top of the shock absorber. In the past, the jounce bump was mostly made of rubber, which simply acted as a stopper to protect the shock absorber, so it was a safety assisting device to protect the strut complete from being stopped at the height required for compression. However, nowadays, it is expected not only to function as a safety device but also to improve ride comfort and driving performance. The jounce bump disperses the impact energy generated when passing through an irregular road or passing through a bump, thereby reducing impact and reducing noise. Therefore, the development of jounce bump with increased energy absorption has been carried out to improve ride comfort and steering stability of the vehicle. Schudt J A et al developed a dual rate jounce bump with increased energy absorption and were first applied to vehicles in 2009. [1] And Wang Y et al developed a jounce bump which made of polyurethane with skin and transition layer and confirmed that the energy absorption was increased. [2] And a negative poisson’s ratio structure was introduced and applied on the jounce bumper. [3] In this study, we developed a component called a support bump to increase the energy absorption of the jounce bump. This support bump was made by benchmarking the rebound bump. [4] The support bump is made of a thermoplastic elastomeric (TPE) material and is assembled with jounce bump which is made of thermoplastic polyurethane (TPU) to increase the energy absorption. The load-deflection test was carried out for the verification of the support and the jounce bump simulation model. Next, by comparing the energy absorption amount of the support-jounce bump assembly and the single jounce bump, the effect of increasing the energy absorption amount of the support bump was confirmed. The analysis was carried out under the same conditions as the test conditions, using the previously proven support and the jounce bump simulation model. Test and simulation results were compared and validated for testing and analysis. Finally, it was confirmed that the support and
jounce bump satisfies the durability test, respectively, and the permanent compression strain was confirmed by measuring the height before and after the test.

![Rebound bump](image)

**Figure 1.** Rebound bump

### 2. Support-jounce bump model

#### 2.1. Material property test

TPU material for the support bump and TPU material for the jounce bump were selected. The TPE material has high durability against repeated fatigue and large deformation cycles and is selected as the material of the support bump. The TPU material has higher strength, durability and energy absorption than rubber, and is selected as the material of the jounce bump. For the simulation model, specimens were fabricated and material properties were tested to confirm the physical properties of the TPE and TPU materials.

![Specimens fabrication](image)

**Figure 2.** Specimens fabrication

![Physical material test](image)

**Figure 3.** Physical material test

#### 2.2. Support bump model

The support bump model is shown in figure 4. The support bump has been developed with a limitation in increasing the energy absorption amount by a single jounce bump. The support bump was made to benchmark the rebound bumps to have the same performance as the rebound bumps. Figure 5 shows the load-deflection test result of the developed support bump and simulation model. From the test results, it was confirmed that the results agree well with no large error. Abaqus software was used in this study.

![Support bump](image)

**Figure 4.** Support bump

![Load-deflection results](image)

**Figure 5.** Load-deflection results of support bump test & simulation
2.3. Jounce bump model
Jounce bump is made of TPU material. The production model is shown in figure 6. Load-deflection test was conducted to verify the simulation model of the jounce bump. From the results, the jounce bump simulation model is verified.

![Figure 6. Jounce bump](image)

![Figure 7. Load-deflection results of jounce bump test & simulation](image)

3. Support, jounce bump durability test

3.1. Support bump durability test
The support bump is made of TPE material. TPE material has compressive strain due to its characteristics. Therefore, before and after the durability test, the post compression length was measured to confirm the permanent compressive strain. The durability test result was satisfied and the permanent compression strain, which was originally aimed, was satisfied within 10%. The test conditions are shown in table 1. And the length before and after the test is shown in figure 8.

\[
\Delta H(\%) = \left(\frac{|(H-H_0)| \times 100}{H_0}\right) = \left(\frac{|(60.02-65.88)| \times 100}{65.88}\right) = 8.89
\]

![Table 1. Support bump durability test conditions](image)

![Figure 8. Support bump after durability test](image)
3.2. Jounce bump durability test
The jounce bump was fabricated TPU material and has higher strength and durability than the rubber. The permanent compressive strain was confirmed before and after the durability test, and the results were satisfied within 10%. The durability test conditions of the jounce bump are shown in table 2. As a result of the durability test, it was confirmed that the test conditions were satisfied.

\[
\Delta H(\%) = \frac{|(H-H_0) \times 100|}{H_0} = \frac{|(6897-72) \times 100|}{72} = 4.21
\]  

Table 2. Jounce bump durability test conditions

| Contents          | Condition          |
|-------------------|--------------------|
| Temperature [℃]   | 20±5               |
| Stroke [mm]       | 0 ~ 39.3           |
| Frequency [Hz]    | 1.5                |
| Cycle             | 300,000            |

※ The load response at the time of excitation should be more than 4.9kN.

4. Support-jounce bump assembly
To verify the increase in energy absorption of the support-jounce bump assembly, it was compared with the load-deflection test of the single jounce bump. The energy absorption amount corresponds to the area in the load-deflection. As a result of the test, it can be confirmed that the energy absorption amount of the support-jounce bump assembly is increased by about 8%.
Next, the previously verified support and jounce bump model were analyzed in the same test conditions. The amount of deformation was confirmed by controlling the load of the upper plate while the support-jounce bump was fixed to the lower plate. The validity of the test and simulation results of the support-jounce bump assembly was verified by comparing the test and simulation results.

![Energy absorption comparison between support-jounce bump assembly test & simulation](image)

**Figure 13.** Energy absorption comparison between support-jounce bump assembly test & simulation

5. **Conclusion**

The support bump was developed to increase the energy absorption of the jounce bump. There is a limitation in increasing the amount of energy absorption by a single jounce bump, and it is disadvantageous in that tuning is difficult depending on the purpose of use. In this study, it was confirmed that the support bump was assembled with the jounce bump and increased by about 8% compared with the single jounce bump energy absorption. When the developed support bump is assembled to the jounce bump, the energy absorption amount of the support bump can be adjusted according to the purpose of the user while increasing the energy absorption amount. Also, in this study, we verified the support and the jounce bump simulation model using the load-deflection test. The validated simulation model was verified by comparing the actual test with the load-deflection test with the support-jounce bump assembly.

The simulation models that have been verified in this study can perform shape optimization to increase energy absorption. Further, it is possible to develop support bumps of various performances according to the purpose of the user.

**Acknowledgments**

This research is supported by the global expertise development project (10076515) supported by the Ministry of Commerce, Industry and Energy and the Korea Industrial Technology Evaluation and Management Institute (KEIT).

**References**

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