

# A Study on the Numerical Analysis of Curtain Wall with 3-Axis Displacement Absorption

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## ABSTRACT

Recently, the frequency and scale of domestic earthquakes are gradually increasing. In particular, in September 2016, a strong earthquake of 5.8 magnitude occurred in Gyeongju. As a result, the building exterior material was damaged and the glass facade fallout causing secondary damage to the vehicle. Considering the seriousness of these problems, it is necessary to develop a seismic curtain wall with seismic performance for non-structural elements.

In this study, through the structural vulnerabilities analysis of the existing curtain wall, a curtain wall module with a 3-axis mobile fastener capable of absorbing the external displacement caused by the earthquake was devised. Structural performance was evaluated based on the numerical analysis results comparing the developed curtain wall with the existing curtain wall system. The results, it was confirmed that the structural stability obtained to compare to the existing curtain wall.

## 1. Introduction

In recent years, as the frequency and scale of earthquakes in Korea increase, secondary damage is caused, such as vehicle damage due to fallout glass facade of buildings, and concerns about the safety of exterior materials of buildings are growing.

In response to this, the government revised the KBC 2016 code to establish seismic design standards for non-structural elements of buildings, but currently there is no curtain wall product with seismic resistance, so it is essential to develop a seismic curtain wall to protect the people's property and lives.

In this study, we developed a seismic curtain wall that can control the relative storey displacement occurred in major structural members by seismic loads when an earthquake occurs. For this, we developed a fastener element technology capable of responding to the 3-axis displacement in the event of an earthquake through the review of the vulnerable part of the existing curtain wall, and evaluated the seismic performance.

## 2. Experiment

### 2.1 Static seismic performance experimental plans & methods

- The seismic performance evaluation method conducts static seismic performance evaluation according to AAMA 501.4 standards.
- According to the AAMA 501.4 standard, a displacement of  $\pm 150\text{mm}$  is applied to the existing stick type curtain wall system (3,600mm x 7,600mm).
- Based on the floor height of 3,600mm, the amount of displacement is applied by dividing it into 4 steps (Repeat 3 times per grade).

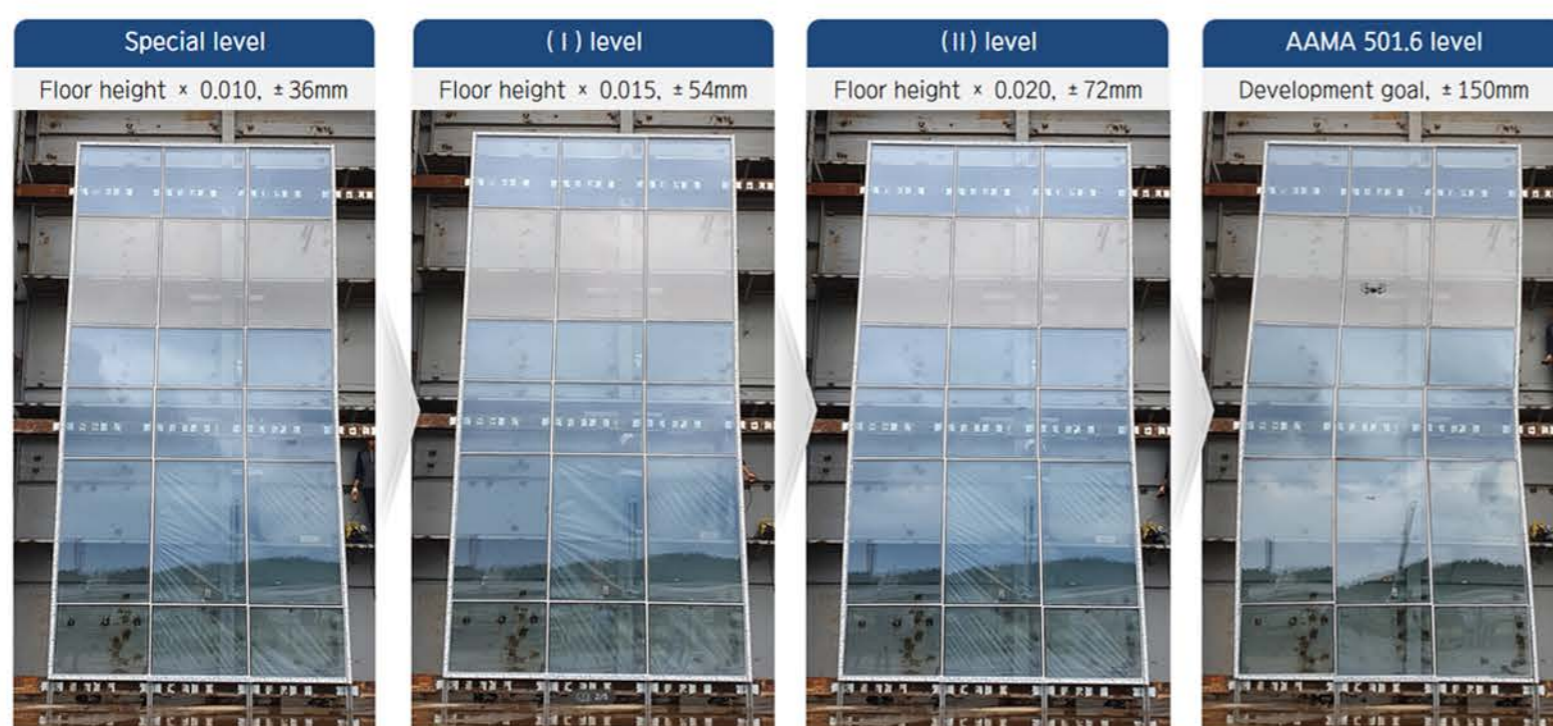


Fig 1. Levels of displacement by seismic classification

### 2.2 Experimental results



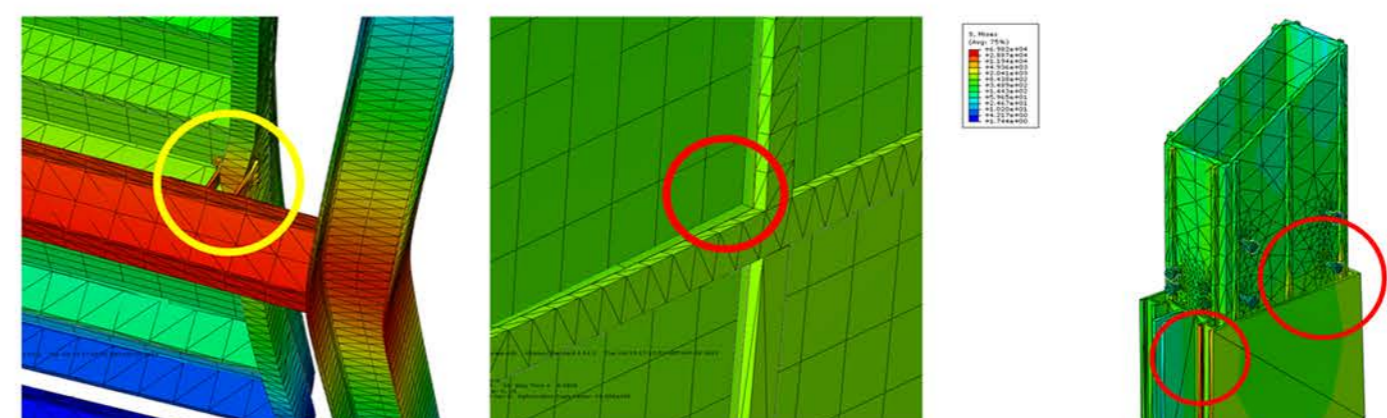
Fig 2. The main vulnerabilities of curtain wall

## 3. Numerical Analysis

### 3.1 Numerical analysis methods

- It was modeled on the same 1:1 scale as the experimental specimen.
- It is assumed that the behavior of all materials is limited to the elastic range.
- Nonlinear static pushover analysis was performed by displacement control.

### 3.2 Numerical analysis results of existing curtain wall

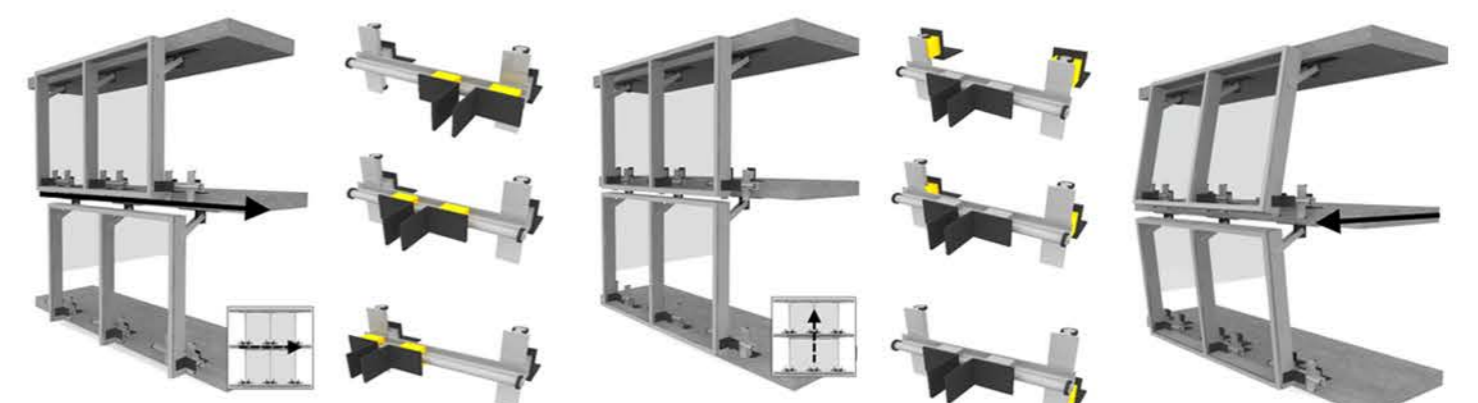


(a) Fastener distortion (b) Aluminium frame fallout (c) Expansion joint distortion

Fig 3. Vulnerabilities of existing curtain walls According to numerical analysis

### 3.3 Design of 3-axis displacement absorbing fastener

The following design proposal was developed through the review of the vulnerabilities of the existing curtain wall.



(a) X-axis behavior (b) Z-axis behavior (c) Y-axis behavior

Fig 4. Principle of displacement absorbing using mobile fastener

### 3.4 Design of 3-axis displacement absorbing fastener

Table 1. Structural performance comparison result

Direction	Curtain wall type	Peak stress (MPa)	Peak stress point
X-Axis	Existing curtain wall	405	Edge of diagonal direction aluminum and connection part of fasteners
	Absorption curtain wall	3.38	Bolt connection parts of fasteners closest to where displacement occur point
Y-Axis	Existing curtain wall	460.5	Upper and lower fastener and vertical member edges
	Absorption curtain wall	455.5	Fastener connected to upper slab
Z-Axis	Existing curtain wall	2,486	Central part of vertical aluminum frame
	Absorption curtain wall	1.2	Fastener connected to upper and lower slab

Fig 5. Von Mises stress distribution of existing curtain wall and mobile curtain wall

## 4. Conclusion

The conclusion of this study is as follows:

1. In the case of the experimental seismic performance evaluation of the existing curtain wall, weaknesses such as large deformation and concentration of stress at the joints of fasteners and expansion joints were confirmed. It was confirmed that experimental result was similar to the result of the review of the vulnerabilities by finite element analysis.
2. As a result of finite element analysis, by applying the 3-axis displacement absorption curtain wall fastener, the structural problems of the existing curtain wall were completely compensated and the effectiveness of improving the seismic performance of the curtain wall was verified.

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