



# JSCA's RECOMMENDATION "DESIGN AND DETAIL OF NON- STRUCTURAL ELEMENTS FOR STRUCTURAL, BUILDING AND BUILDING-EQUIPMENT ENGINEERS"

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## Background of Publication

### Attention matters

Non-structural elements have received more attention in recent years in terms of ensuring building safety.

### Seismic measures of non-structural elements

In earthquake, there were human damages due to falling down or over-turning of non-structural elements.

Seismic measures of non-structural elements, such as suspended ceilings, external claddings, building equipment, partitioning walls, are not advanced enough yet.

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## Sendai Mediatheque



(From sendai mediatheque <http://www.smt.jp/en/>)



## Sendai Station





## Sendai Station



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## Ground motion wave

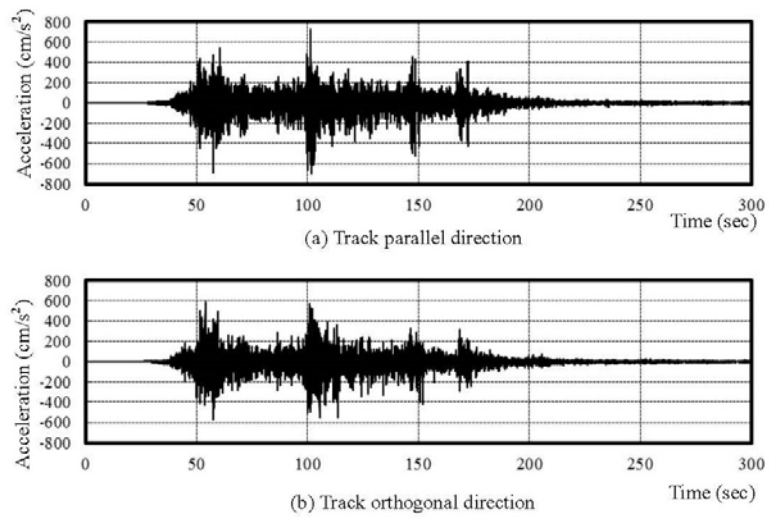


Figure 14. Ground motion wave monitored on March 11, 2011

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## The 6<sup>th</sup> World Conference on Structural Control and Monitoring



**WHAT**  
The Sixth World Conference  
on Structural Control and  
Monitoring

**WHEN**  
July 15 - 17  
2014

**WHERE**  
At Edifici Vertex, Universitat  
Politécnica de Catalunya  
Barcelona, Spain

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(1)

## Background of Publication

JSCA released the recommendation

In June 2012

“Lessons from The Great East Japan Earthquake 2011”

About necessity to discuss who does what for seismic  
measures of non-structural elements

In July 2014

“To secure the seismic safety of non-structural elements”

About a system what kind of role and responsibility

- building-engineers
- construction-engineers
- element suppliers

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(1)

## Background of Publication

### Without sufficient knowledges

Structural engineers have insufficient knowledges of non-structural elements.

→ We should have wide knowledges of non-structural element details in order to contribute to seismic.

### As one of references

References are not enough.

This book was one of references before.

It described attention points **at the construction stage** with a focus on how to connect non-structural elements to structural frame.

→ JSCA had begun to work to revise the book in November 2011.



JSCA, 2006, “How to connect non-structural elements and building equipment to structural frame”

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(1)

## Background of Publication

JSCA published the renamed book in June 2015

Include

- **reminders** that engineers shall express seismic measures on drawings and particular specifications **at the planning phase**.
- JSCA’s recommendation of “The lessons from The Great East Japan Earthquake 2011” and “To secure the seismic safety of non-structural elements”
- The key points of the revision of cabinet order and announcement and policy trend
- Various types of material performance evaluation test and technical information



JSCA, 2015, “Design and Detail of non-structural elements for Structural, Building and Building equipment engineers”

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## (2) Target of Non-Structural Elements

- Suspended ceiling boards
- External claddings such as ALC panel
- Glass curtain wall
- Ribbed glass and glass block
- Partition walls
- Furniture and household equipment
- Escalators
- Stairs
- Expansion joints
- Building equipment

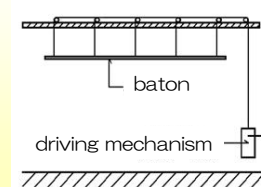


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## (2) Target of Non-Structural Elements

- Steel shutter
- Sign board
- Hanging equipment such as baton
- Chimney
- Mechanical parking system



⇒ The damage examples are examined for the cause and countermeasure.

Key points of attention at the design stage are listed also.

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## (2)

### Contents of The Book

- |           |   |
|-----------|---|
| Chapter 1 | Light Gauge Steel Frame/ Ceilings and Partition walls   |
| Chapter 2 | Precast concrete wall panel /Flat panel, Parapet, Corner-panel and so on  |
| Chapter 3 | ALC panel and Excluded cement panel   |
| Chapter 4 | Doors and Windows /Door, Glass window, Glass wall and Steel shutter   |
| Chapter 5 | Metal elements /Expansion joint, Metal panel, Metal hand rail and Ladder  |
| Chapter 6 | Finishing /Furniture, Sign board and Hanging equipment such as Baton and Curtain                                      |
| Chapter 7 | Mechanical equipment  |
| Chapter 8 | Elevator and Escalator  |
| Chapter 9 | Connection to structural members / Post-installed anchor, Embedded anchor bolt and Welding of non-structural elements |

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## (3)

### Composition of the Book

- 1) **Cause** and **counter-measures** of damage examples in JSCA's recommendation of "Lessons from The Great East Japan earthquake 2011"
- 2) Commentaries how cabinet order and announcement have revised by seismic damages
- 3) Key points of attention and items to be expressed on drawings and particular specifications **at the design stage**
- 4) Key points of attention and supervising checklists **at the supervision stage**
- 5) Introduction of performance tests for ceilings, partition wall, ALC panel and others
- 6) Introduction to legal treatment and technical work of post-installed anchor

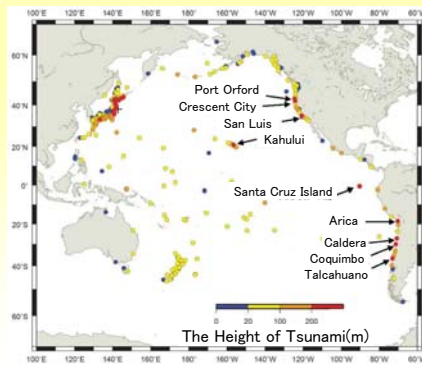
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## (4)

### Composition of Each Chapter

The following is  
composition of each chapter  
and  
major damages caused by **The Great East Japan Earthquake 2011**.



[Main shock]

- Time : At 14:46 JST  
on March 11, 2011
- Epicenter : the coast of Sanriku on  
northeastern Japan's main  
island of Honshu
- Depth : 24km
- Magnitude : M9.0
- Dead and Disappearance persons : 19,300  
(Japan Meteorological Agency)

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## (1)

### 4.1 Chapter 1 Light Gauge Steel Frame

#### (1) Ceiling

Seismic damage  
Case 1



- **Type of Damages** : Whole ceiling falling down
- **Cause** : It suffered a complex rocking motion due to concavo-convex ceiling shape. The seismic load was so large due to heavy dead load and ceiling members did not resist to these forces.
- **Countermeasure** : In case of complex ceiling shape, structural engineer should figure the dynamic motion of ceiling after the discussion with building and building-equipment engineers.

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## 4.1 Chapter 1 Light Gauge Steel Frame

### (1) Ceiling

Seismic damage  
Case 2



Example of  
opened clip

- **Type of Damages** : Damages caused by collision to the wall
- **Cause** : Seismic brace did not existing. Ceiling frames were damaged by repeated collision to the wall. Attachments such as clips and hangers were slipped and ceiling board fall down.
- **Countermeasure** : This displacement should be controlled by arrangement of connecting brace.

## 4.1 Chapter 1 Light Gauge Steel Frame



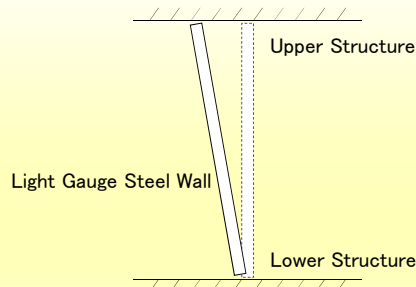
Example of broken hanger



Example of fractured welding part

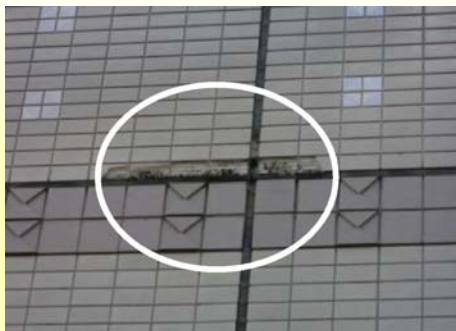
## 4.1 Chapter 1 Light Gauge Steel Frame

### (2) Partition Wall



- **Type of damages** : Dropped off to out-of-plane
- **Cause** : Nails connecting wall-frame to structural-frame did not have enough bearing force.
- **Countermeasure** : It is recommended to use nails of large bearing force, or to use them in smaller pitch.

## 4.2 Chapter 2 Precast Concrete Wall Panel



Example of tiles exfoliation



Example of panels drop off

In case of non-curtain wall style, heavy damages were several cases at time of [The Great East Japan Earthquake 2011](#), only there were light damages such as joints moving or falling out of ceramic tiles at corner.

Damages of curtain walls were few.



### 4.3 Chapter 3 ALC Panel

#### (1) ALC Panel



There were many damages which type of **two-staged wall** with intermediate collar. The main cause is that connecting part was damaged by **over drift**, **rotation** and **torsion moment in-plane** or **out-of-plane direction**.



### 4.3 Chapter 3 Extruded Cement Panel

#### (2) Extruded Cement Panel



Example of tiles to be loosed

## 4.3 Chapter 3 Extruded Cement Panel



Example of cracking around opening

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## 4.4 Chapter 4 Doors and Windows

### (1) Doors, Glass Windows and Glass Block



- **Type of damages** : Breaking or cracking of ribbed glass
- **Cause** : There was little clearance at face or edge of glass to supporting member.
- **Countermeasure** : The clearance should be wider than the story drift.

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## 4.4 Chapter 4 Doors and Windows

### (2) (EXP.J) Expansion Joint

#### Seismic damage Case 1



- **Type of damages** : Clash between structures
- **Cause** : There was little clearance between structures.
- **Countermeasure** : The clearance should be wider than the story drift.

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## 4.4 Chapter 4 Doors and Windows

### Seismic damage Case 2



- **Type of damages** : Falling of EXP.J cover
- **Cause** : The EXP.J cover fell because it did not allow the displacement caused by story drift.
- **Countermeasure** : The cover shall be planned in details considering story drift.

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## 4.5 Chapter 6 Finishing



At time of **The Great East Japan Earthquake 2011**, furniture have over-turned, moved and fallen down where they are faced at **the escape route**. These caused problems to escape, rescue work and human safety at just soon after the earthquake. In case of a big earthquake, making sure to secure **human safety** and **their escape route** is very important.



## 4.7 Chapter 7 Mechanical Equipment

At time of **The Great East Japan Earthquake 2011**, almost all damages of equipment were shown below.

- (1) Damage and falling down of **suspended equipment inside ceilings**
- (2) **Over-turning equipment** on the roof
- (3) Damage of **equipment steel base**
- (4) Slipping out or breaking of **anchor bolts**

## 4.7 Chapter 7 Mechanical Equipment



## (5)

## Conclusion

This paper introduced the book JSCA published to revise for the safety of non-structural elements, which includes JSCA's recommendation of "The lessons from The Great East Japan Earthquake 2011" and "To secure the seismic safety of non-structural elements", "The key points of the revision of cabinet order and announcement and policy trend" and "Various types of material performance evaluation test and technical information".

We hope this revised book will be useful for not only structural-engineer but also for many people in construction such as **building-engineers, equipment-engineers, construction-engineers and all that**, and lead to better safety of non-structural elements.



Thank you for your attention.