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.
Sendai Mediatheque

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

Sendai Station

June 2016  16th U.S.-Japan-N.Z. Workshop
Sendai Station

Ground motion wave

Figure 14. Ground motion wave monitored on March 11, 2011
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
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 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
(2) Target of Non-Structural Elements

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

⇒ The damage examples are examined for the cause and countermeasure. Key points of attention at the design stage are listed also.

(2) Target of Non-Structural Elements

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

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
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)

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.
(1) Ceiling

Seismic damage

Case 2

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

Example of opened clip

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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.

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4.2 Chapter 2 Precast Concrete Wall Panel

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

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.
(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.

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.
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.

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
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.