

# *Introduction of Kimura Laboratory*



# Research topics



Development of Mid-Story Pin Connection System  
Preventing Column Yield and Assessment of Ultimate  
Seismic Capacity of Steel Moment Resisting Frames

Construction of Ultimate State Design Method of Steel  
Piles and Elucidation of Dynamic Buckling Behavior of  
Steel Piles in Liquefied Soil

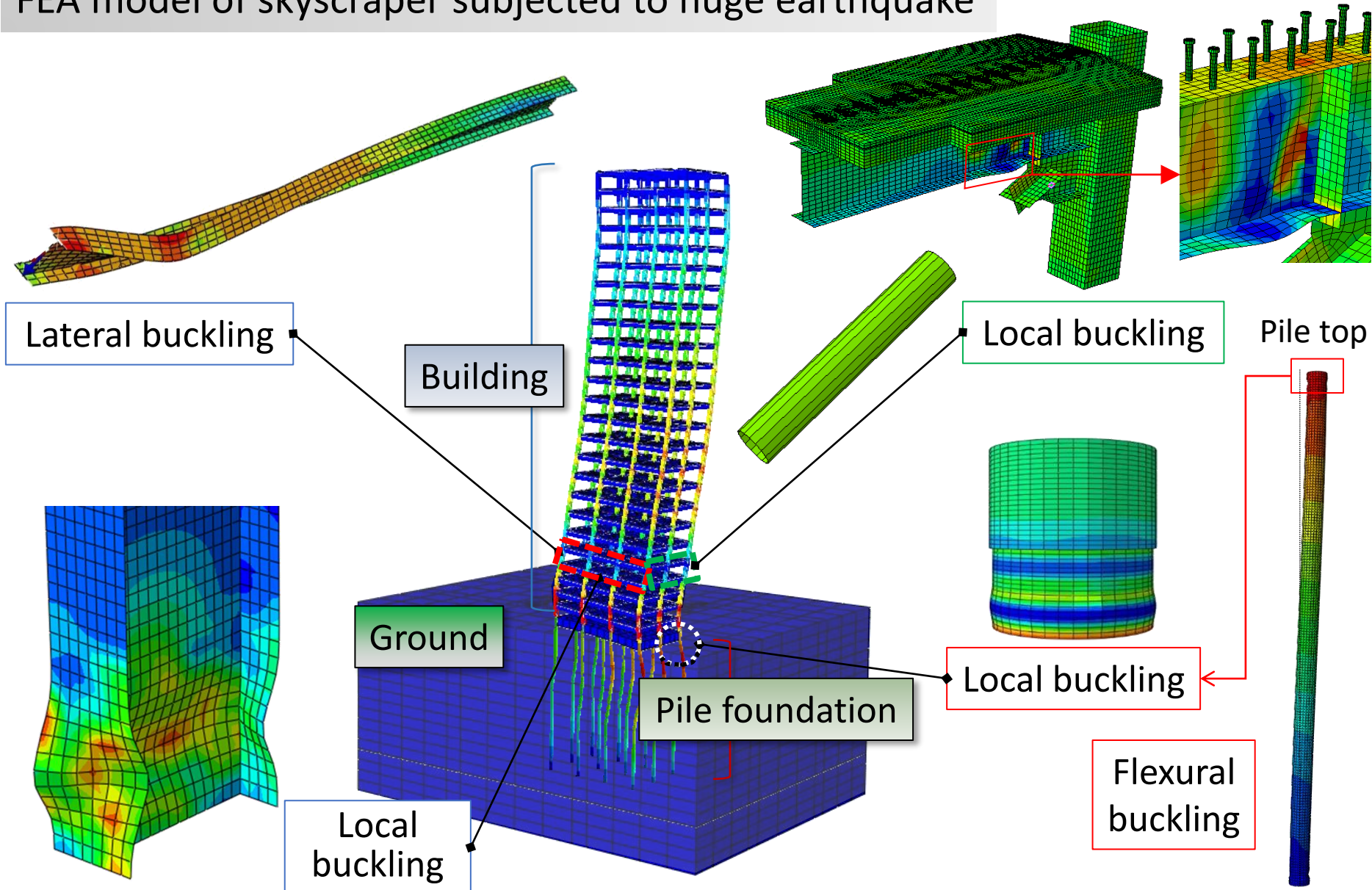
Invention of Evaluation Method of Lateral  
Buckling Strength of Large-Span Beams

Creation of Seismic Design Method of Buckling  
Restrained Braced Frame with Concrete Slab

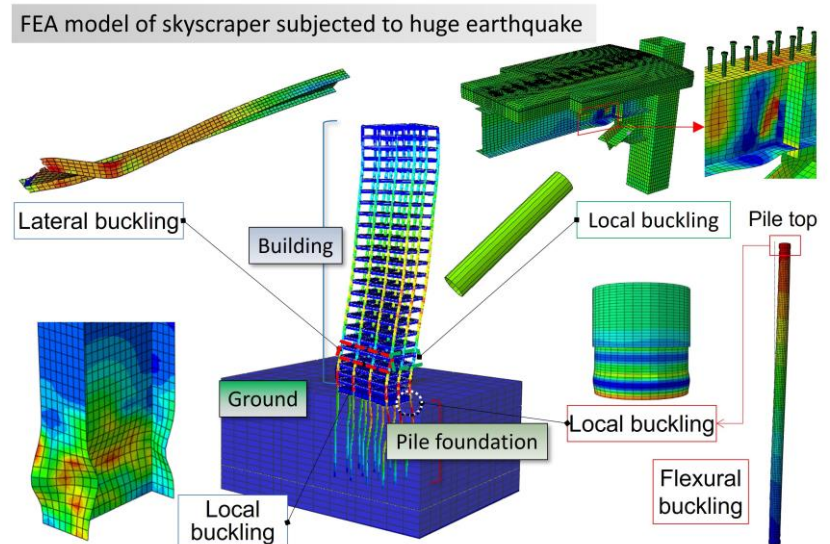


# Research topics

FEA model of skyscraper subjected to huge earthquake

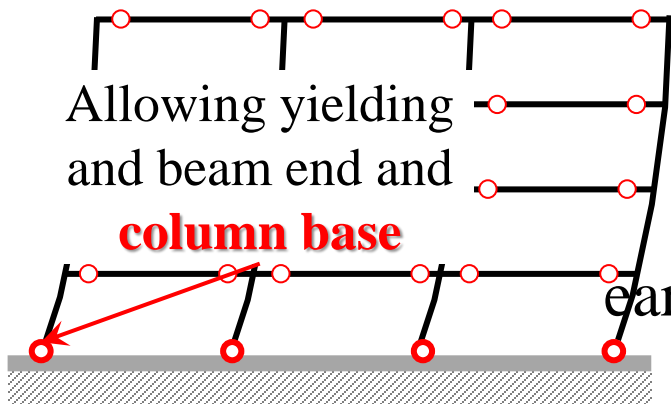


# Development of Mid-Story Pin Connection System Preventing Column Yield and Assessment of Ultimate Seismic Capacity of Steel Moment Resisting Frames

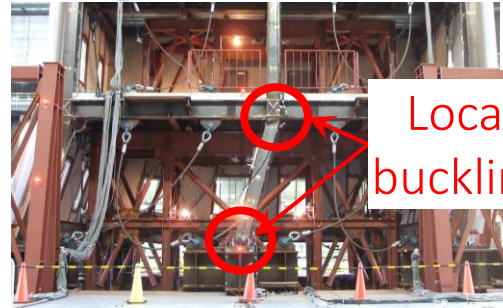


# Development of new column base system

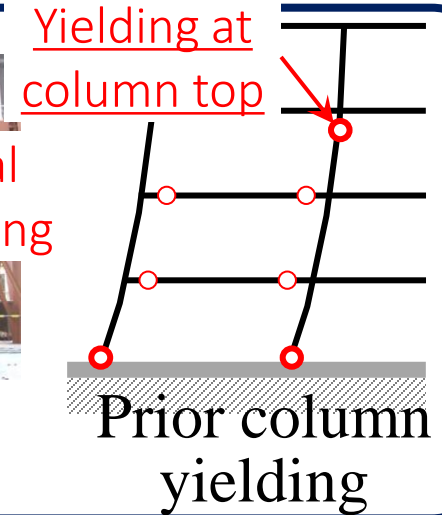
## Conventional moment resisting frame



Huge earthquake



Story collapse at 1<sup>st</sup> story

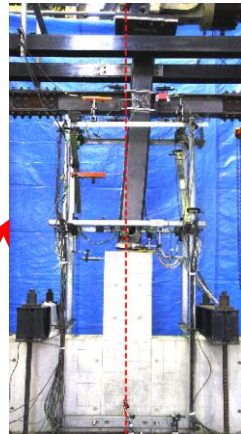
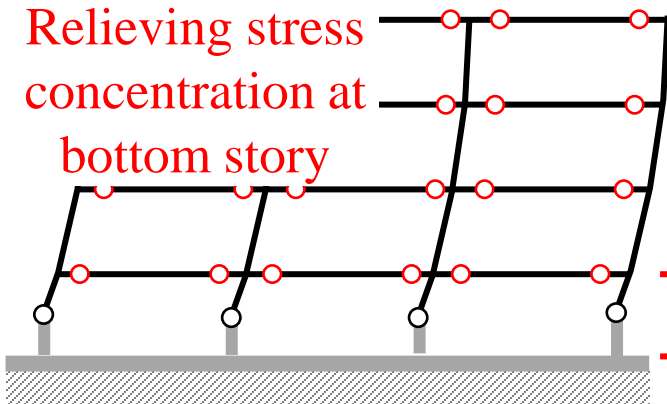


Relieving stress at hot-spot of structure

## New steel moment resisting frame

1) Mid-story pin-support system

Relieving stress concentration at bottom story



2) Installation of leaning column

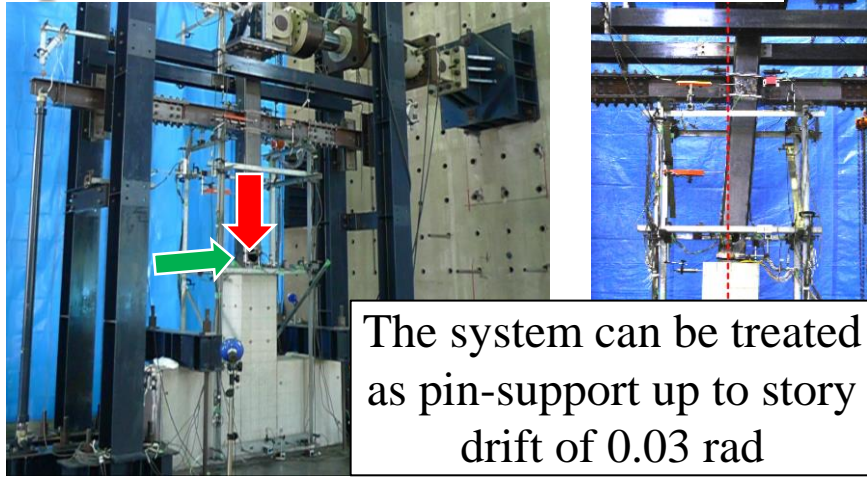
Alleviation of damage concentration





# Development of new column base system

## Understanding mechanical performance of connection



The system can be treated as pin-support up to story drift of 0.03 rad

Loading test on bottom story subassemblies

## Manualization

1.3 選した構造形式

2. これまでの設計・施工事例

事例1: 新築建築

事例2: 工場内原形試験

層中間ピン柱脚構法

層中間ピン柱脚構法研究会

建物の用途(実績)  
工場、倉庫、事務所、タワシユック、保庫等 等

建物の構造形式  
・4層程度の中低層鉄骨構造物  
・階状比1.5以下

最下層鉄骨柱の軸力比  
長期荷重時 短期荷重時  
中柱: 0.20程度 長期の1.3倍  
側柱: 0.15程度 長期の1.6倍

RC柱断面寸法  
最下層RC柱の幅  
→最下層鉄骨柱のせい+内側150mm<sup>(\*)</sup>

RC柱への作用せん断力  
/RC柱のせん断耐力

中柱: 長期荷重時 0.6程度  
短期: 0.4程度

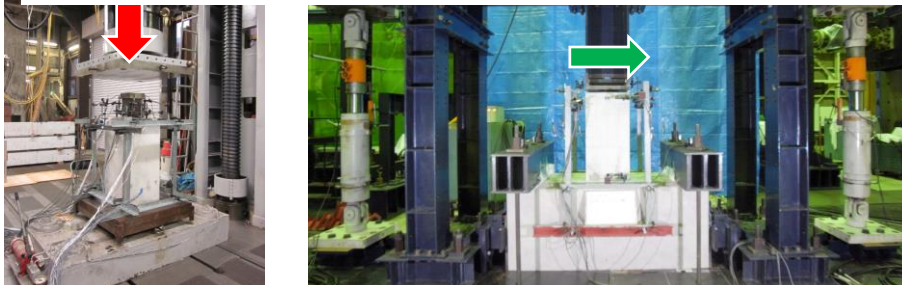
(\*) 規定の適用範囲外より、構法による場合は、図2.10を参照

設計上の工夫:  
耐震ブレースを千鳥状に配置することで、柱脚間に発生する軸力を低減している。また、1階ブレース脚部を半割としたことで壁及び梁に力を受けやすくなる。ブレース脚部は同一方向に発生する軸力を受ける。これにより発生軸力はブレースからの応力差を吸収する必要がある鉄骨柱を低減することができる。

設計上の工夫:  
1階の1階柱については、1Fに1200mmの長さで鋼管を設けた管状柱脚構造を採用している。1階に必要を計りしおり、必要の鋼管長さで鋼管を設けたことにより、1階の1階柱に発生する軸力を低減し、1階の1階柱に発生する軸力を低減することができる。

設計上の工夫:  
1階の1階柱については、1Fに1200mmの長さで鋼管を設けた管状柱脚構造を採用している。1階に必要を計りしおり、必要の鋼管長さで鋼管を設けたことにより、1階の1階柱に発生する軸力を低減し、1階の1階柱に発生する軸力を低減することができる。

## Proposition of capacity evaluation formula of connection

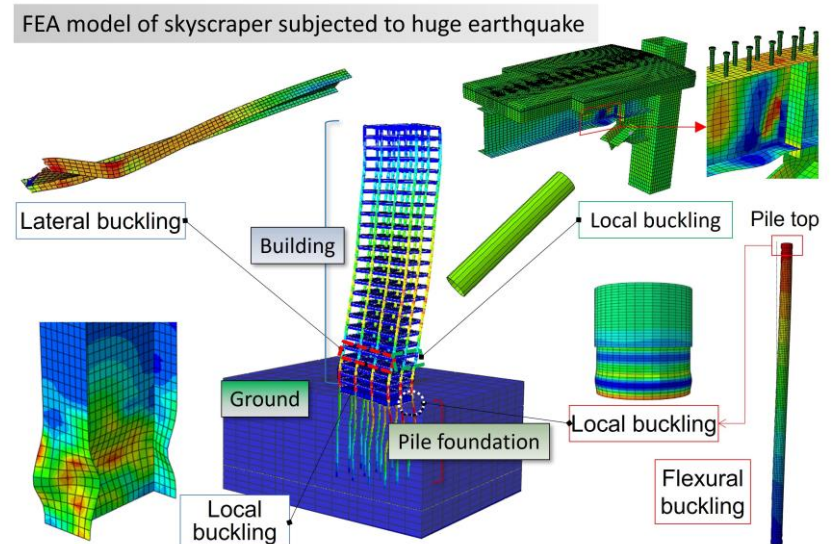


Compression test

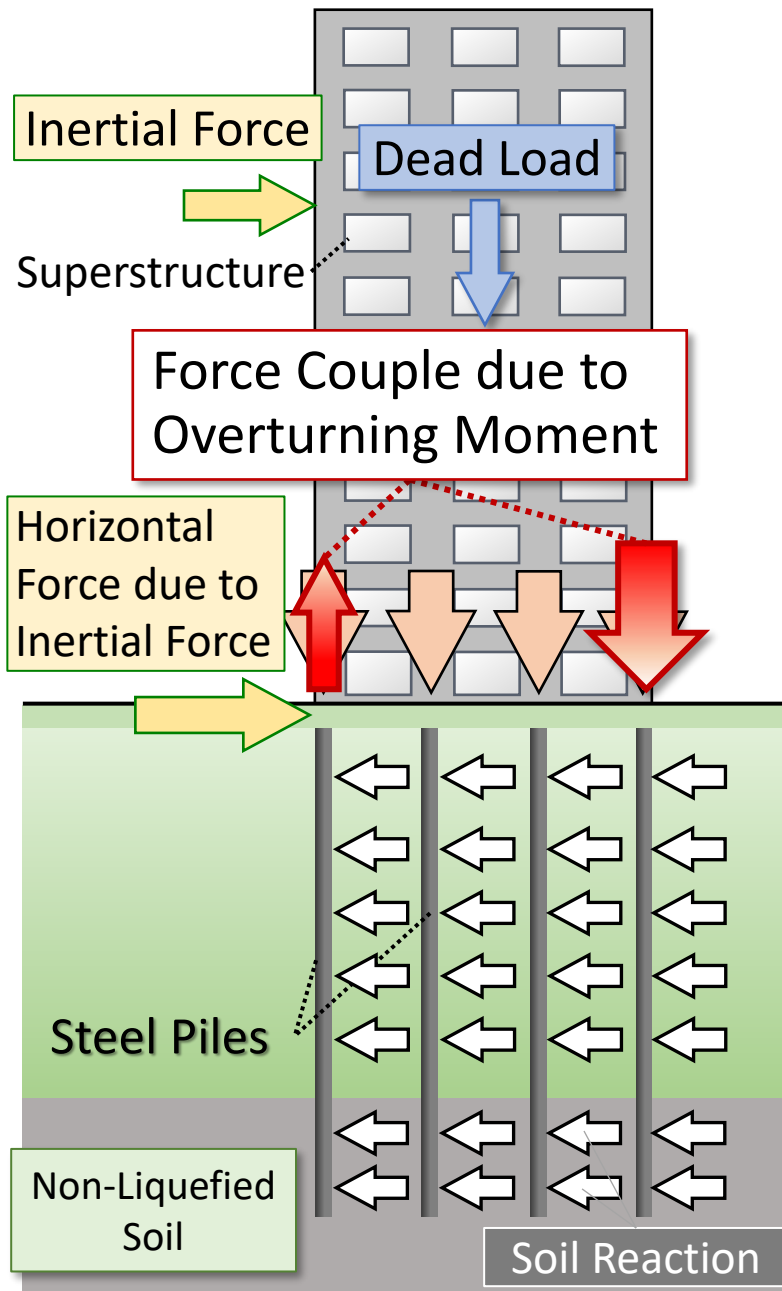
Shear test



# Construction of Ultimate State Design Method of Steel Piles and Elucidation of Dynamic Buckling Behavior of Steel Piles in Liquefied Soil



# Collapse mechanism of pile



Current Japanese design codes

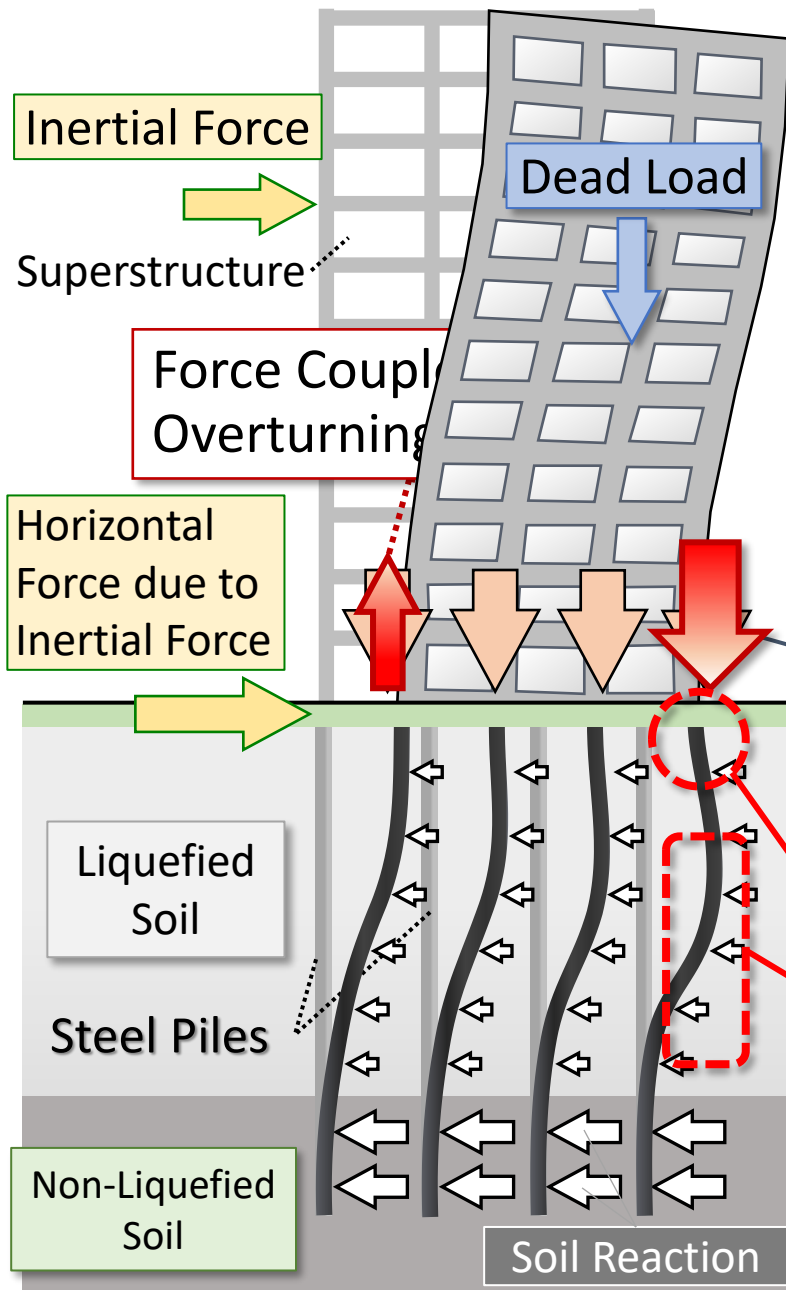
It is assumed that **steel pile's flexural buckling does not occur** because of soil restriction against piles lateral deformation.

The design codes have **no prescription about the limitation of slenderness** for steel piles.

Reference: Architectural Institute of Japan, Recommendation for Design of Building Foundations, 2001. (in Japanese)



# Collapse mechanism of pile

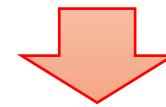


However, when liquefaction occurs during an earthquake,

horizontal stiffness of the ground is reduced drastically.

+

Slender steel piles beneath **high-rise buildings** experience **large axial compression force**.



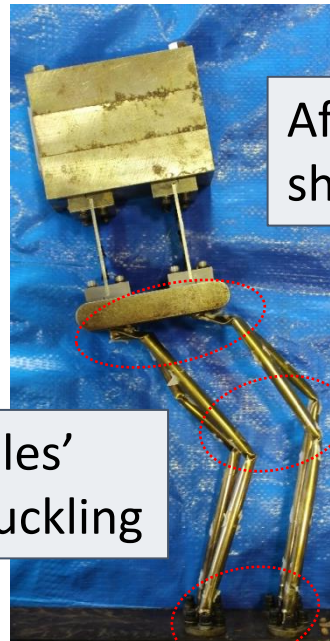
Steel pile's flexural buckling may occur.

# Collapse mechanism of pile

## ◆ Collapse Mechanism of Steel Piles below High-Rise Building in Liquefied Soil

Centrifugal tests of high-rise superstructure, steel piles, and liquefied soil system

under the centrifugal acceleration of 40G



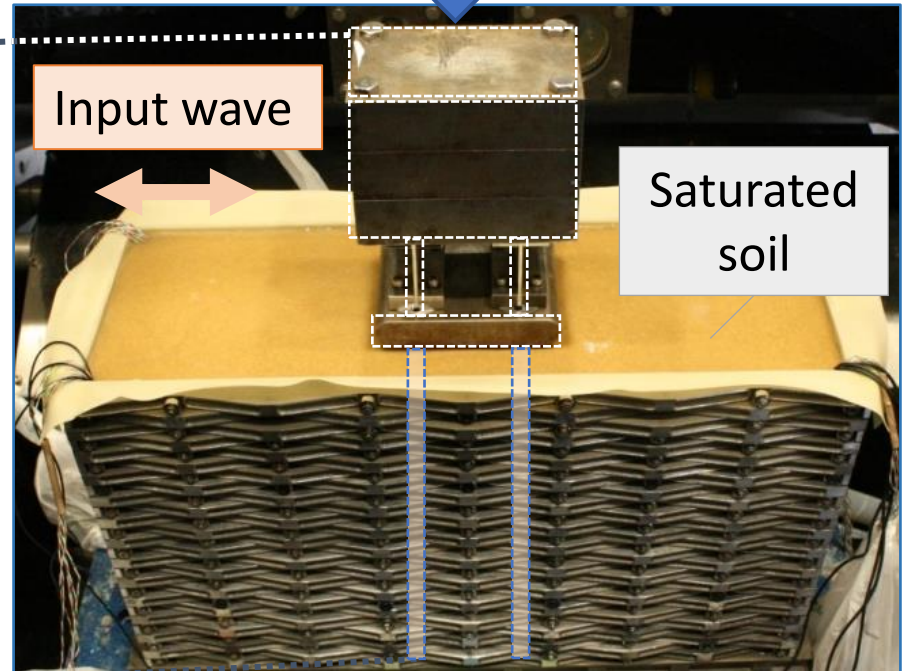
After shaking

Piles' buckling

Ultimate state



Initial state

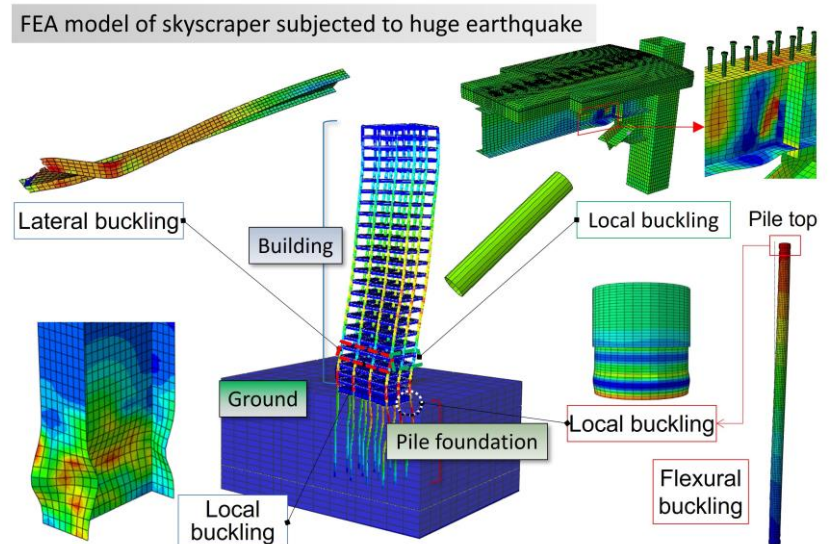


Input wave

Saturated soil

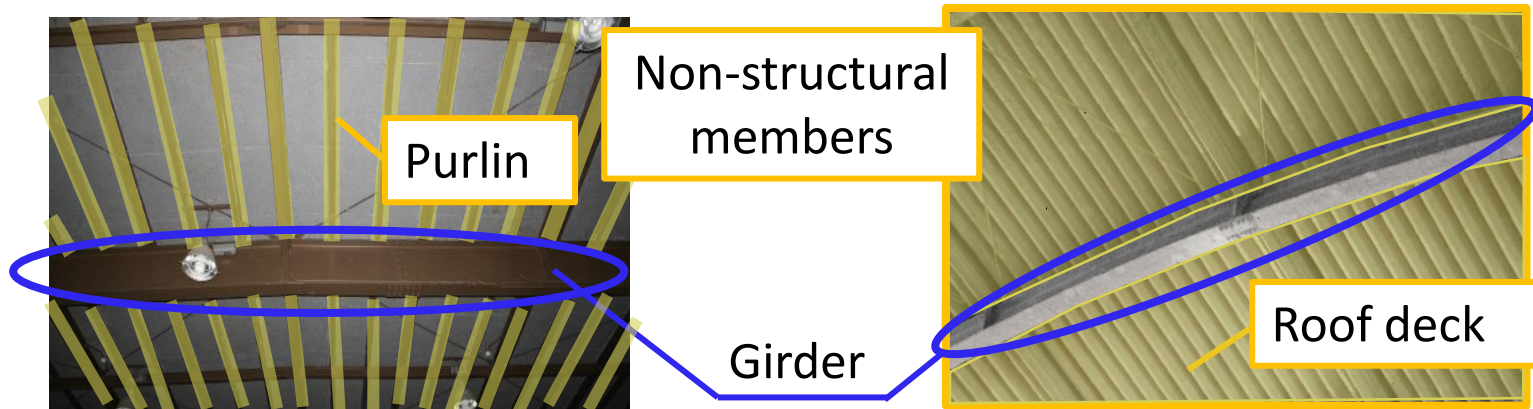
Specimen for centrifugal test

# Invention of Evaluation Method of Lateral Buckling Strength of Large-Span Beams





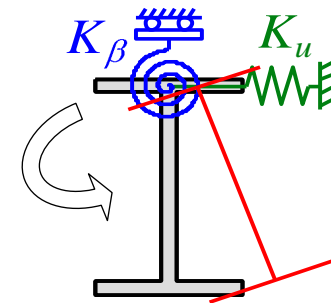
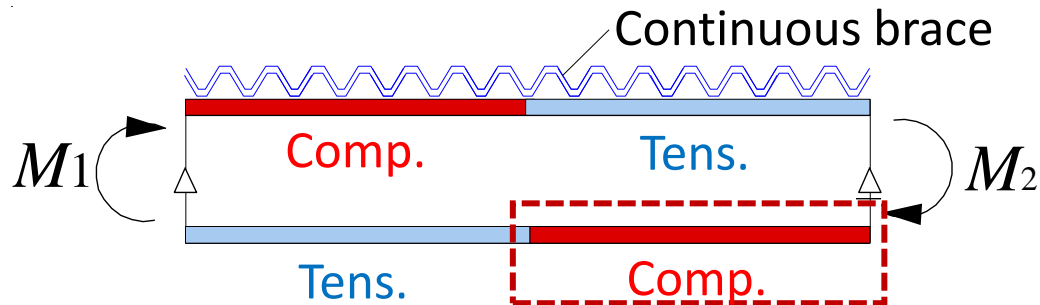
# Lateral buckling of I-beam



Non-structural members settle on a top flange (continuous brace)

- Constraint against lateral buckling deformation

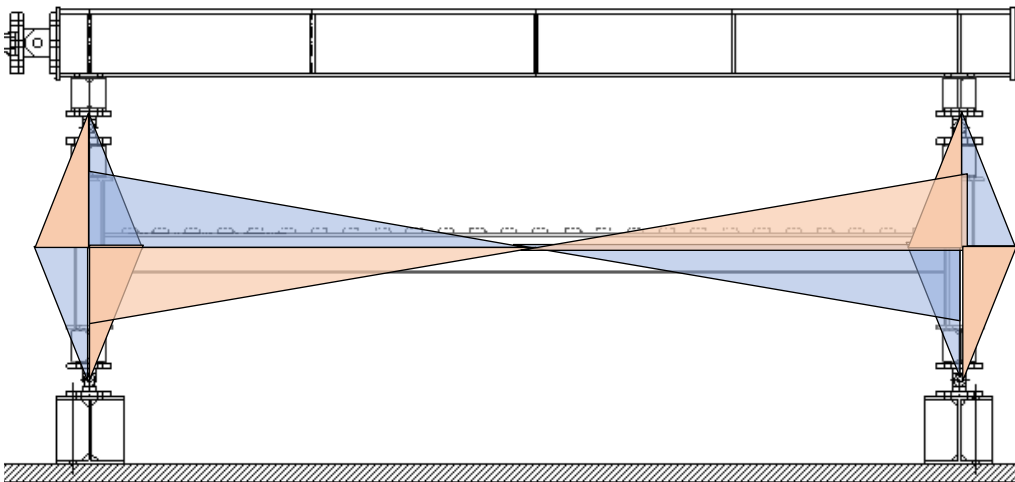
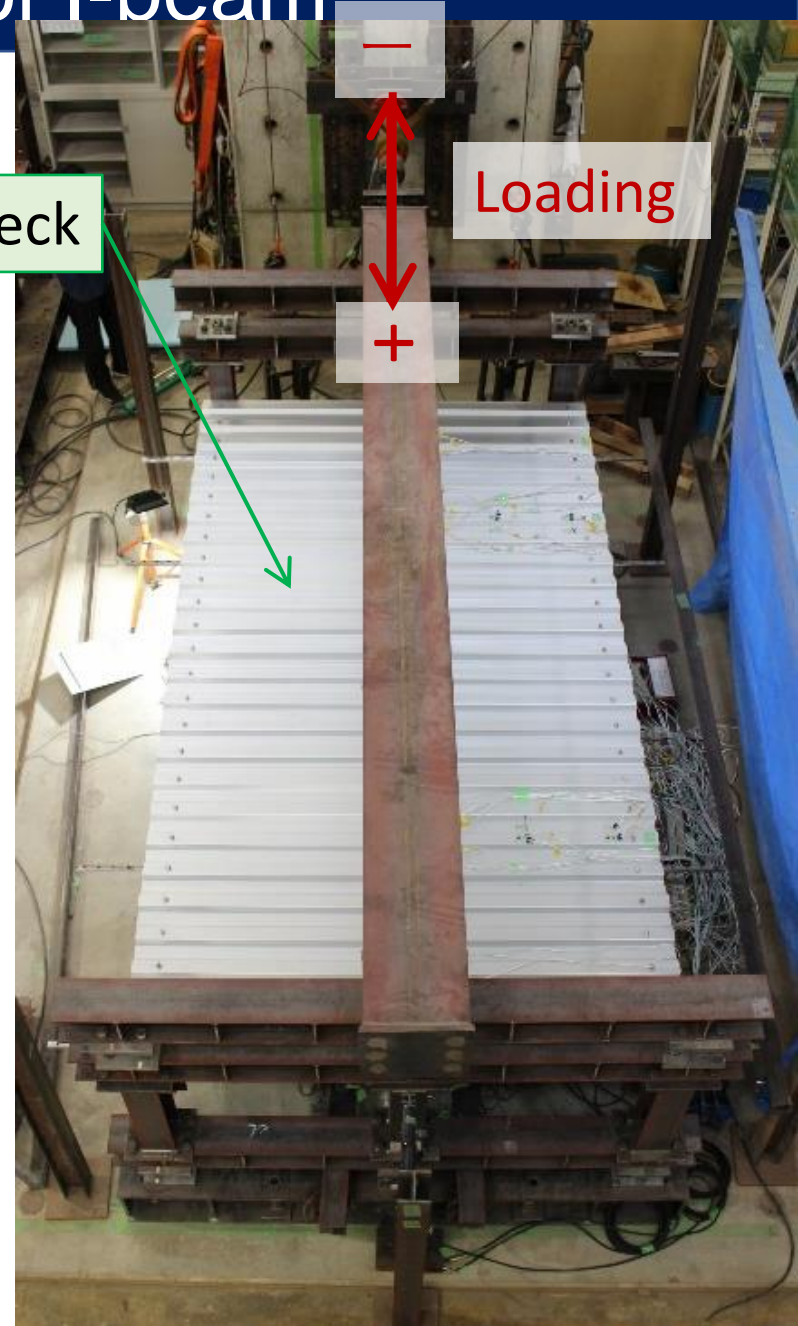
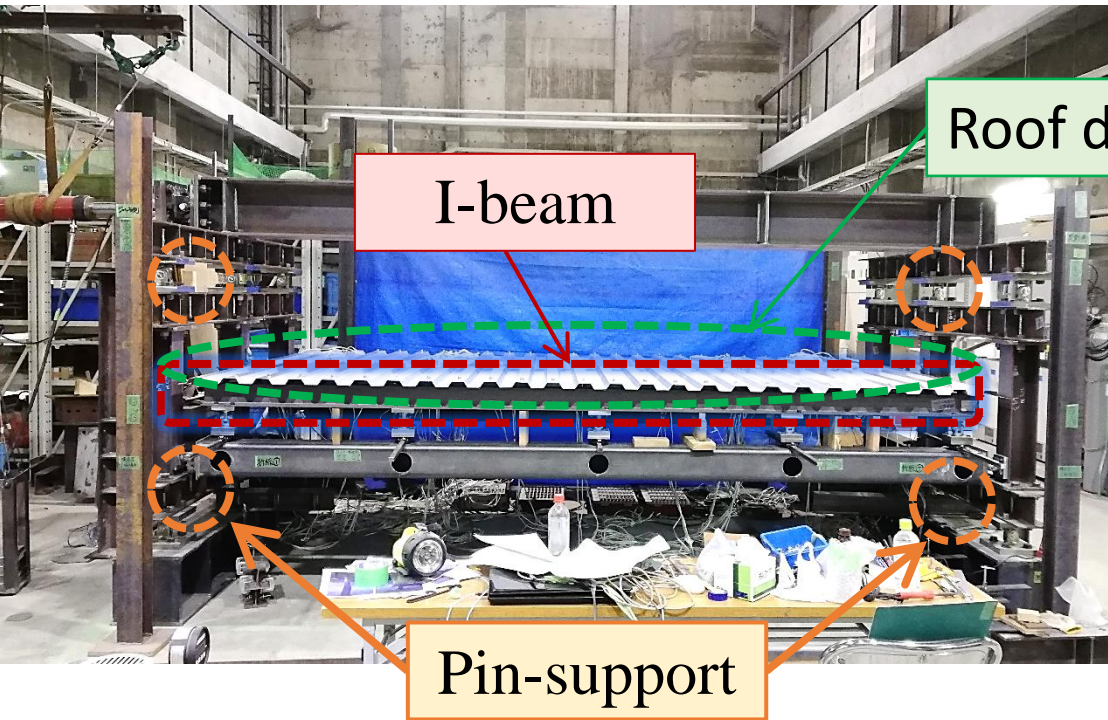
⇒ This effect is ignored in the current design guideline



Lateral buckling on bottom flange

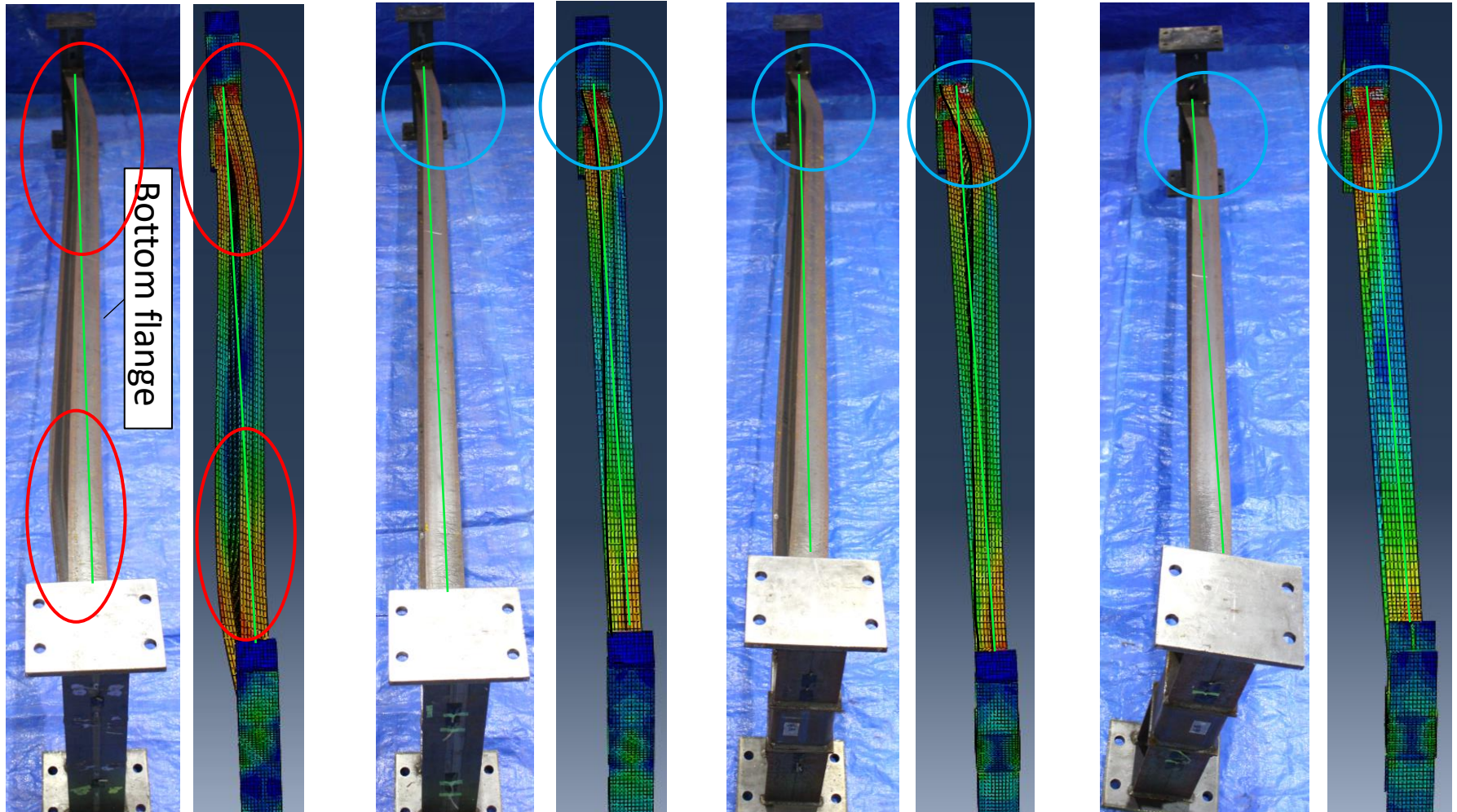
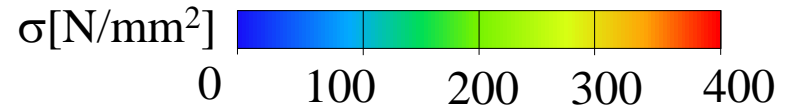
→ Bracing on top flange = Horizontal and rotational bracings are necessary

# Lateral buckling of I-beam





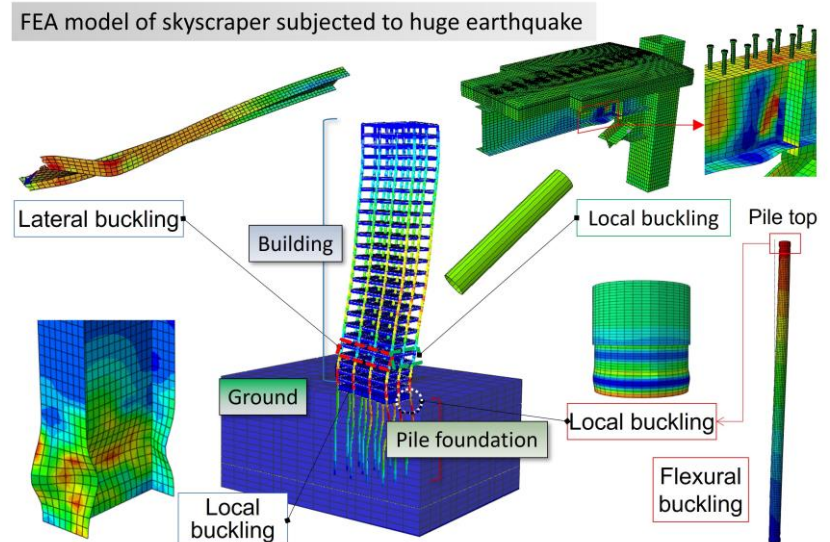
# Lateral buckling of I-beam



Buckling behavior is revealed based on experimentation and FEA



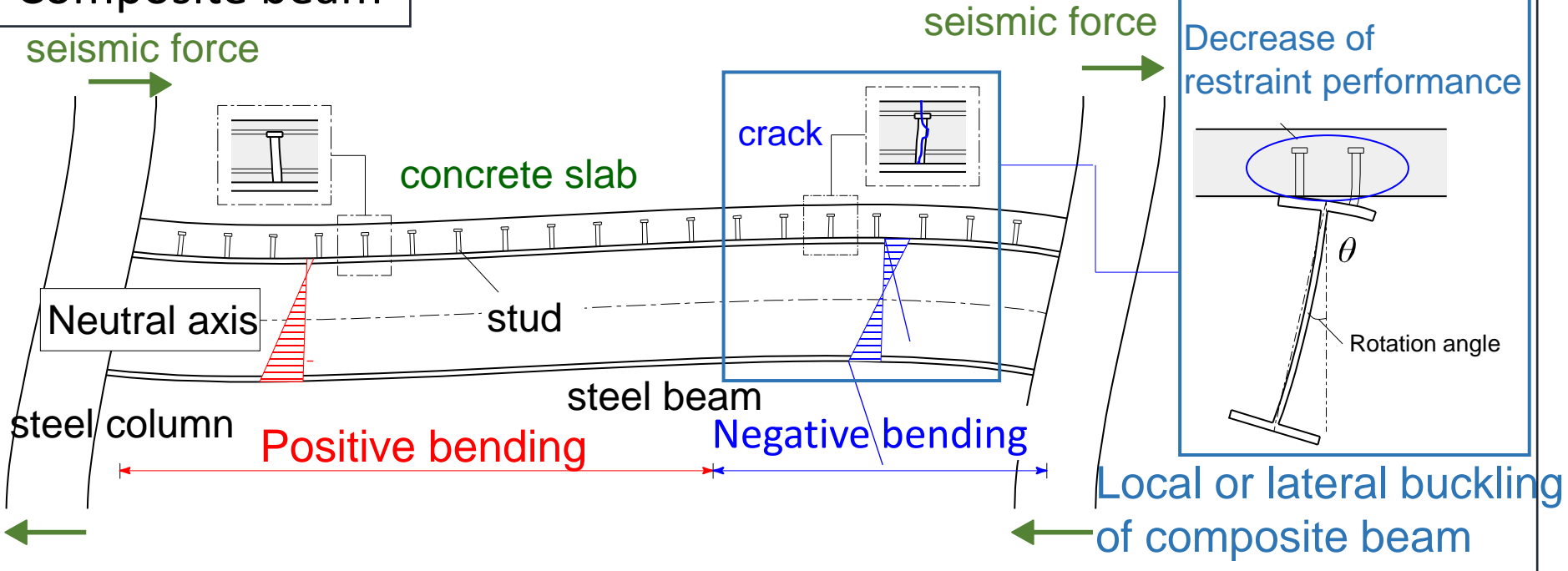
# Creation of Seismic Design Method of Buckling Restrained Braced Frame with Concrete Slab



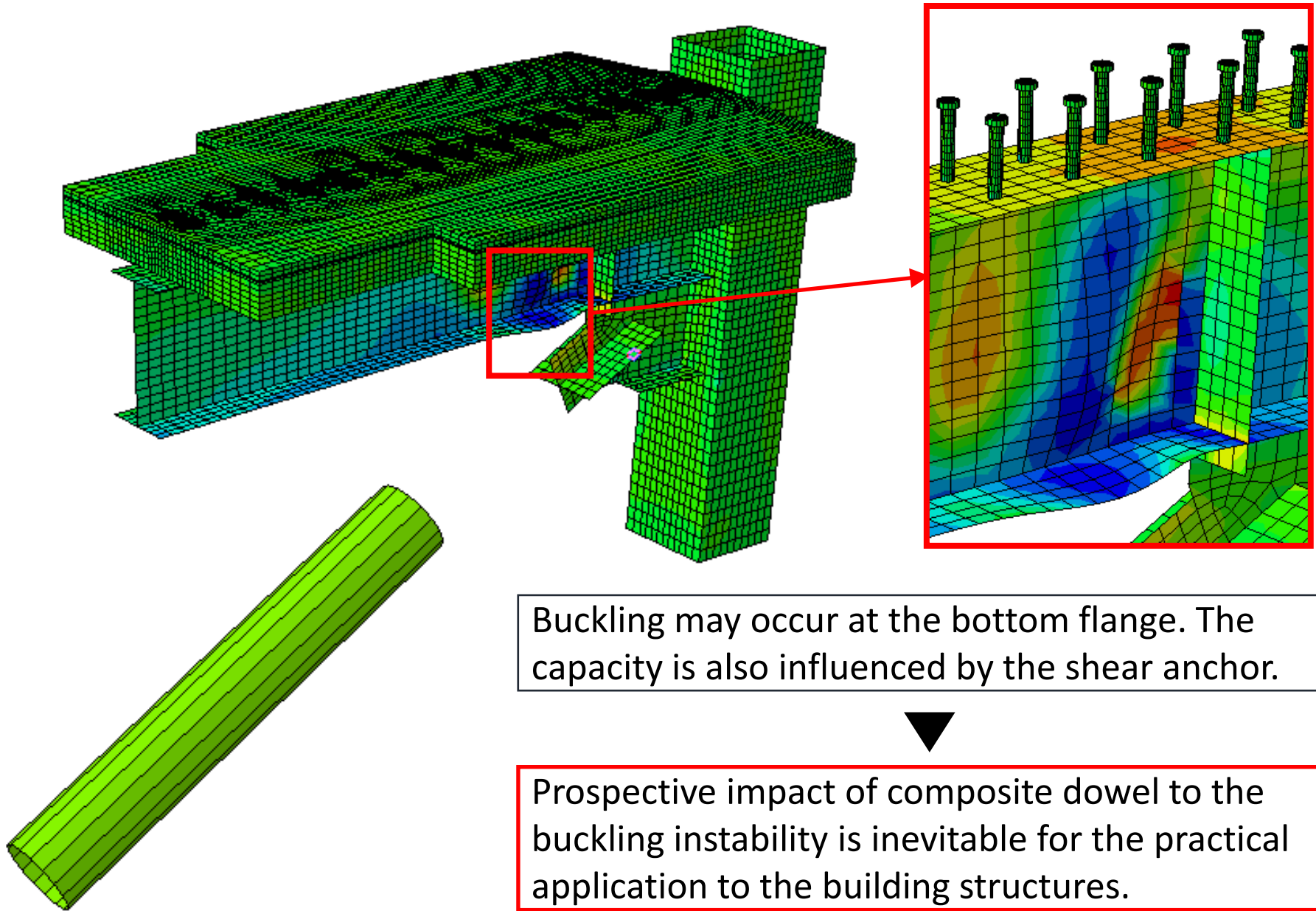
# Stress transfer mechanism of composite beam

The neutral axis location varies due to the composite effect during positive bending and negative bending.

## Composite beam



# Stress transfer mechanism of composite beam



Buckling may occur at the bottom flange. The capacity is also influenced by the shear anchor.



Prospective impact of composite dowel to the buckling instability is inevitable for the practical application to the building structures.