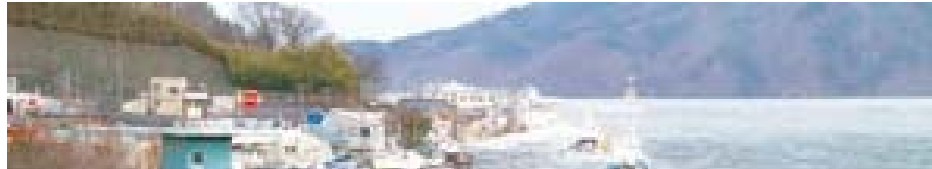


Categorization of Damage to Buildings Caused by the 3.11 Tsunami



Damage to RC Buildings and Steel Buildings is discussed in order to develop structural design methods for Tsunami Evacuation Buildings



Miyako City URL
<http://www.city.miyako.iwate.jp/cb/hpc/Article-6834.html>

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Damage to RC Buildings

Most of RC buildings survived without any structural damage



- ▪ ▪ However, severe damage were observed in a part of RC Buildings

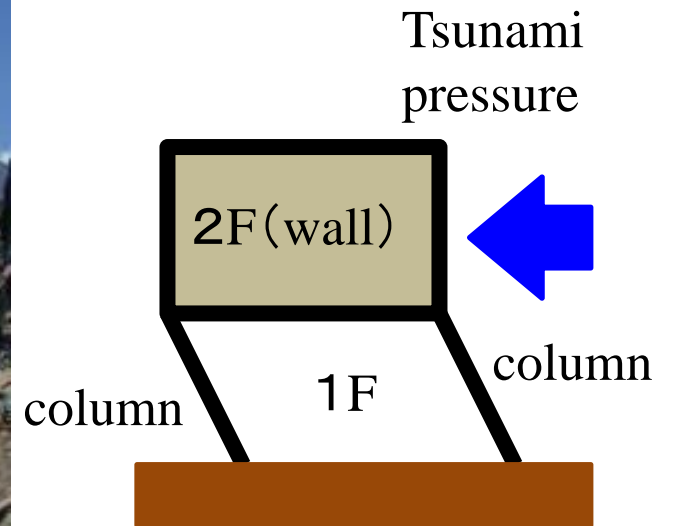
Damage to RC buildings (1) Total collapse



Natori City, Yuriage district

Damage to RC buildings

(2) Collapse of 1st story

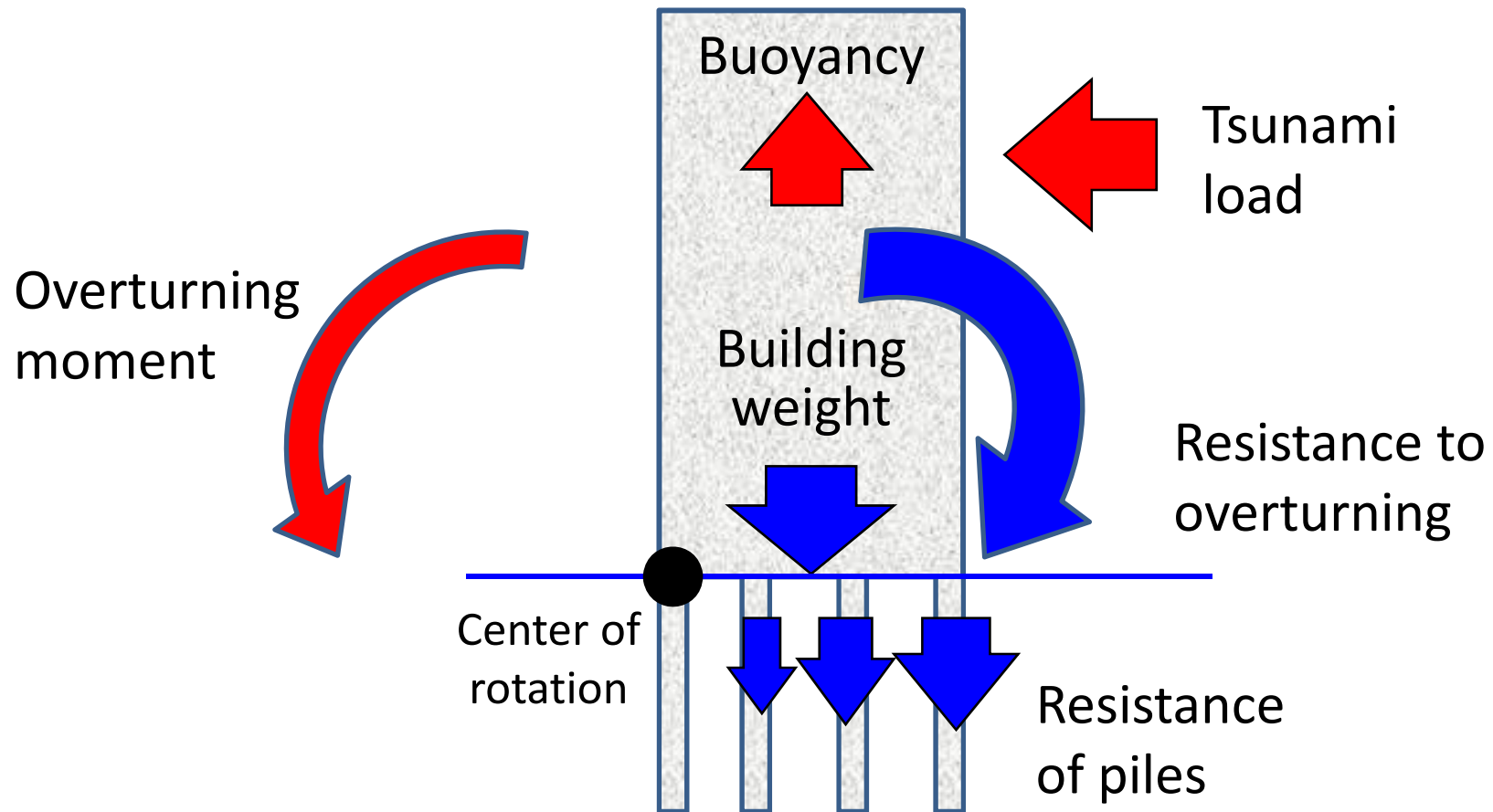


Damage to RC buildings (3) Overturning



Refrigerated warehouse got over the fence

Mechanism of overturning

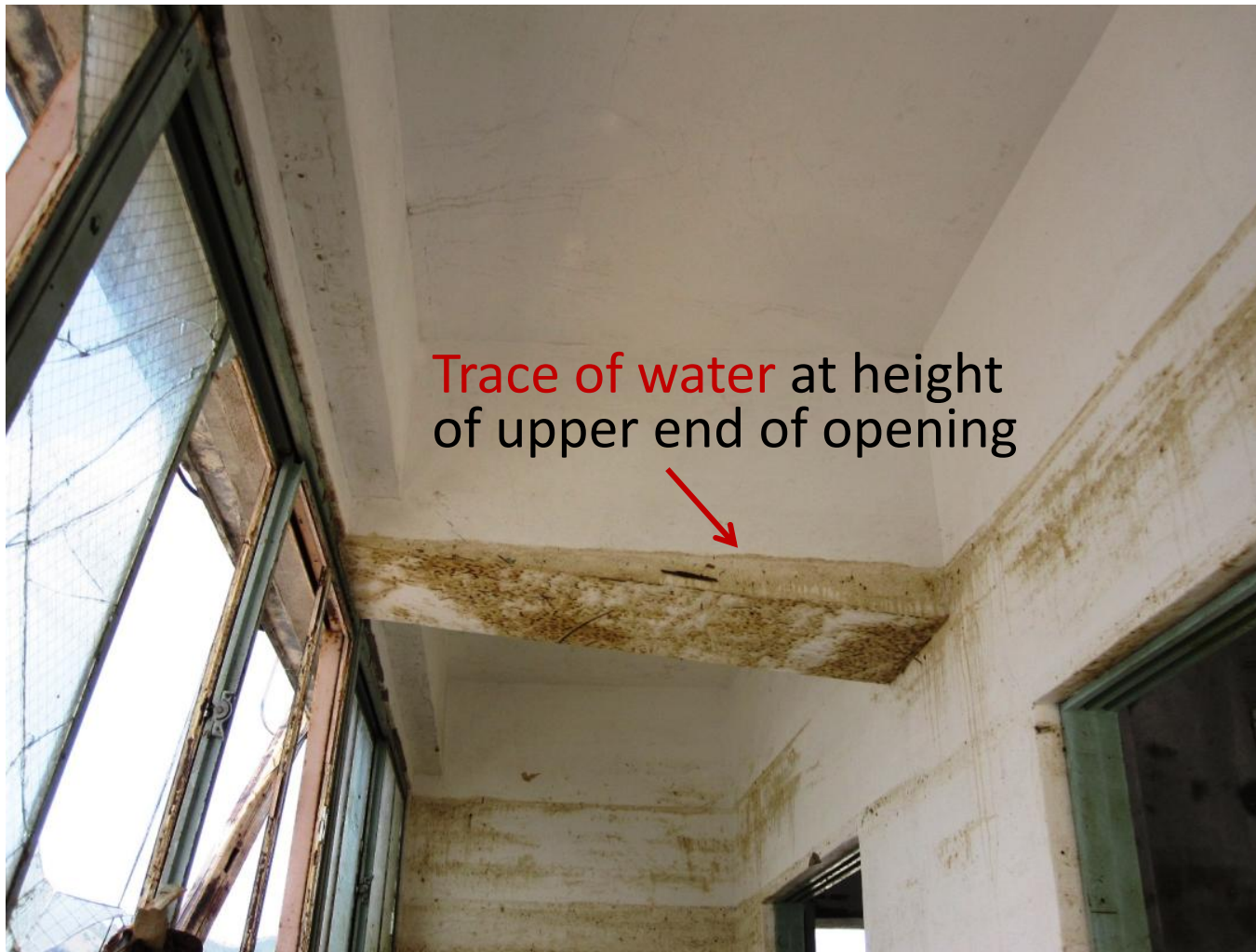


Damage to RC buildings

(3) Overturning



Trapped air below floor slab caused buoyant force



The building was submerged completely

Damage to RC buildings (4) Failure of walls



A filtration plant

Damage to RC buildings

(5) Scour



Very strong stream was generated around the corner of the building, resulted in large holes on the ground

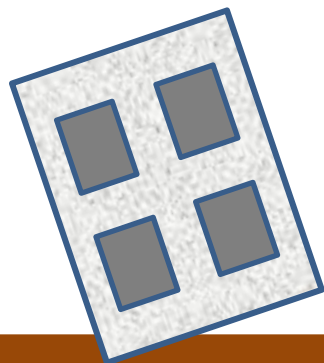
Damage to RC buildings (5) Scour & Tilting



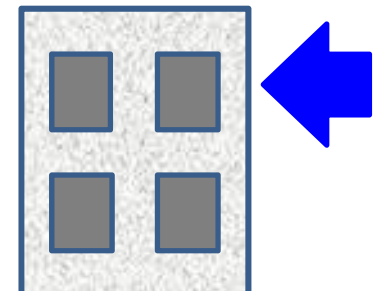
In case of mat foundation

12

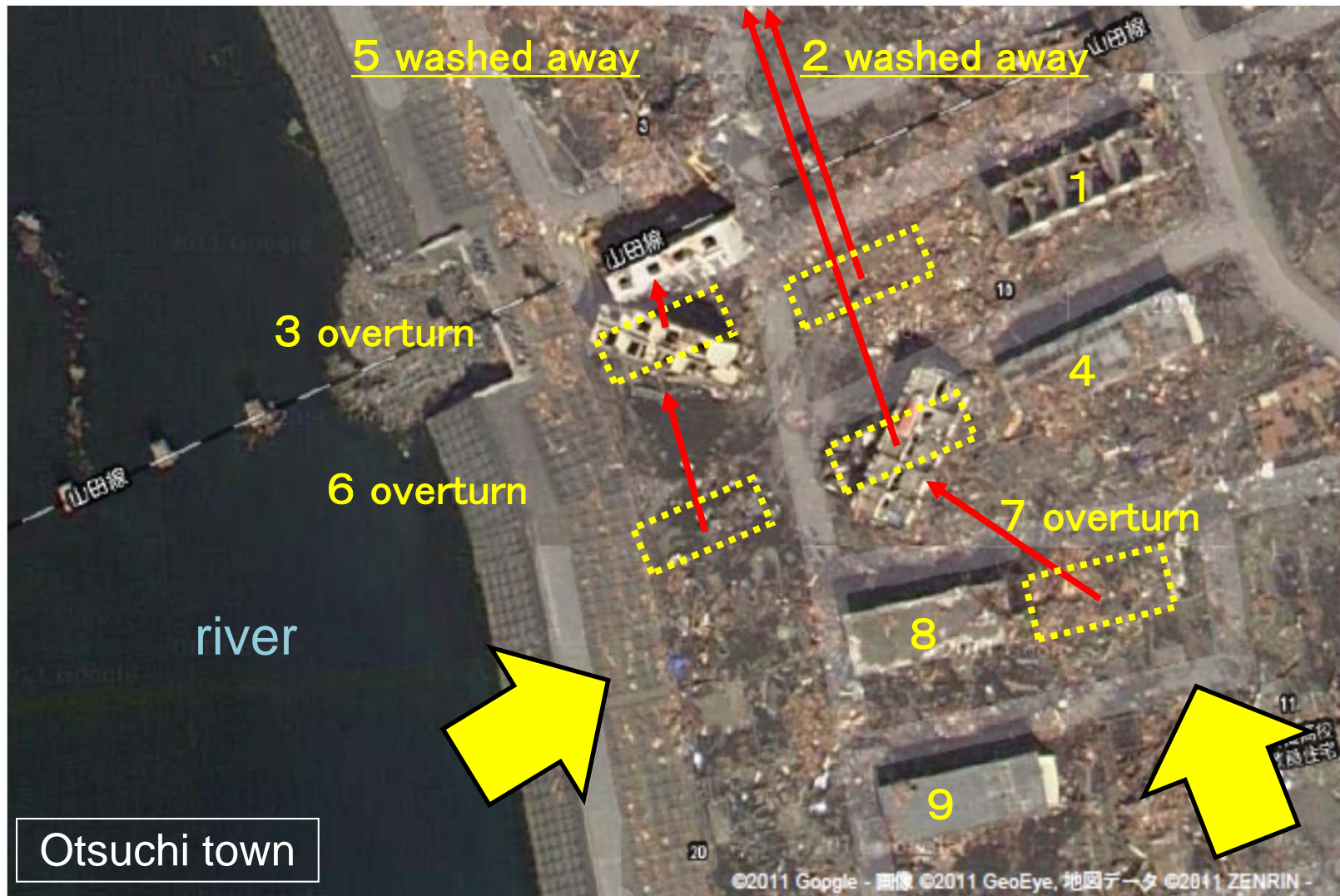
Damage to RC buildings (6) Sliding



Tsunami pressure



Overturning, Sliding & Washing away



Overturning, Sliding & Washing away



Survived



Partially damaged



Overturned



Overturned (upset)

Damage to RC buildings

(7) Debris impact



Damage to Steel Buildings

Damage to Steel buildings

(1) Failure of exposed column



Rupture of anchor bolt, base-plate or welding part between column and base-plate

Damage to Steel buildings

(2) Failure of column top connection



Damage to Steel buildings

(3) Overturning



Exterior finishing was survived
Then large tsunami load and buoyancy happened

Overturning due to rupture of anchor bolt and buckling of 1st story columns



Damage to Steel buildings (4) Washed away of finishing



Damage to Steel buildings (5) Large residual deflection



Damage to Steel buildings (6) Collapse of 1st story



Damage to Steel buildings
(7) Deformation of columns due to
tsunami pressure and/or debris impact



Summary

Damage pattern to buildings are categorized

< RC Buildings >

- Total **collapse**
- **Collapse** of 1st story
- **Sliding**
- **Washed away**
- **Overturning**
- **Debris impact**
- Tilting due to **scour**
- **Failure** of walls

< Steel Buildings >

- **Collapse** of 1st story
- Failure of column base
- Failure of column top connection
- **Washed away** of finishing
- **Overturning**
- **Debris impact**
- Large residual deflection

Based on the categorization, structural design methods of tsunami evacuation buildings were discussed

Design target

1) Not to collapse:

Tsunami load on each floor will never be higher than the lateral capacity

2) Not to overturn:

Overturning moment by tsunami load will never be higher than the resistance moment considering buoyancy

3) Not to slide:

Lateral force will never be higher than the friction of the foundation or the lateral capacity of the piles

Design items

- Design for preventing failure of exterior elements (walls & columns)
- Design for debris impact
- Design for scour

Thank you for your attention



Otsuchi town