Detail of Modeling in the Blind Analysis of NCREE Shaking Test 2018

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Outline

1. Our Motivation

2. Outline of Contest & Shaking table test

3. Detailed Finite Element Model

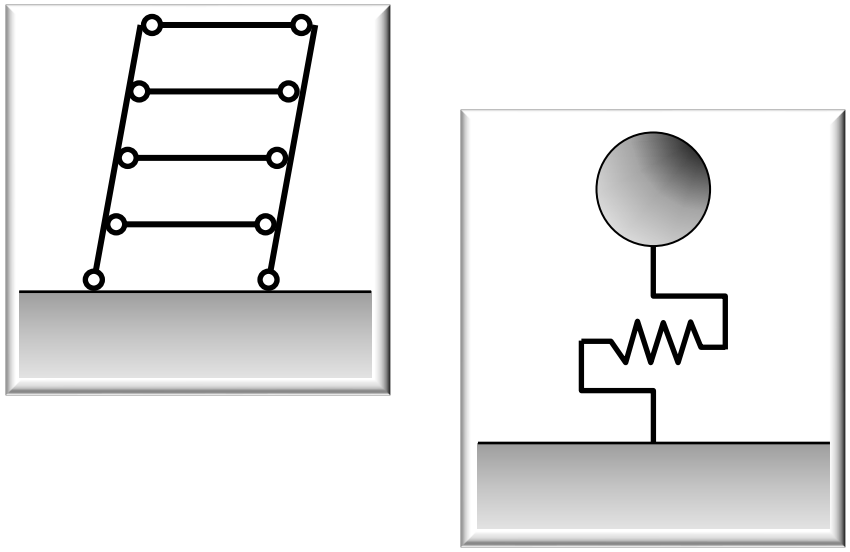
4. Analytical Result

5. Influence of rocking motion

6. Coclusions

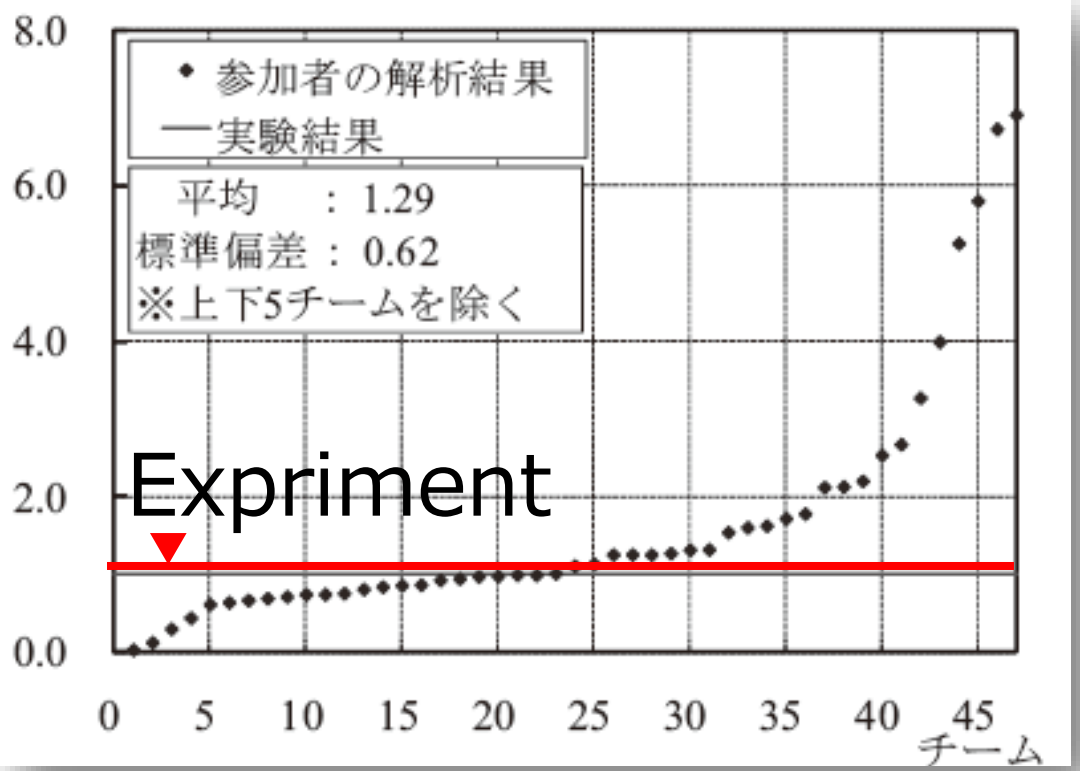
Our Motivation

Simple models are not enough to simulate strong non-linear behavior???



Our Motivation

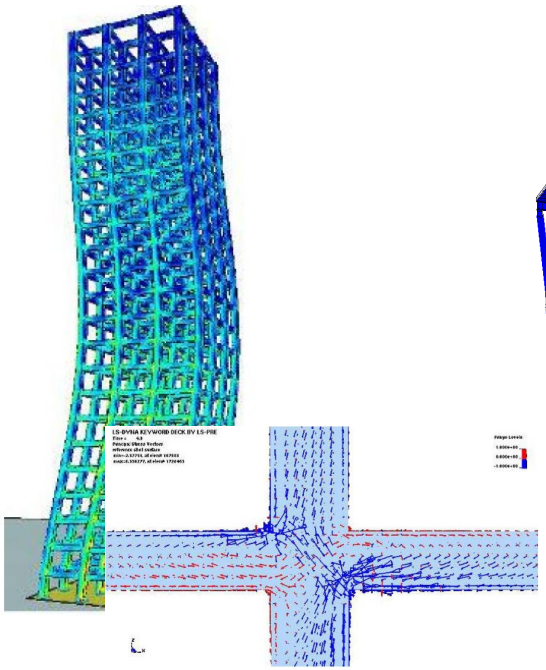
Results by simple models can vary widely

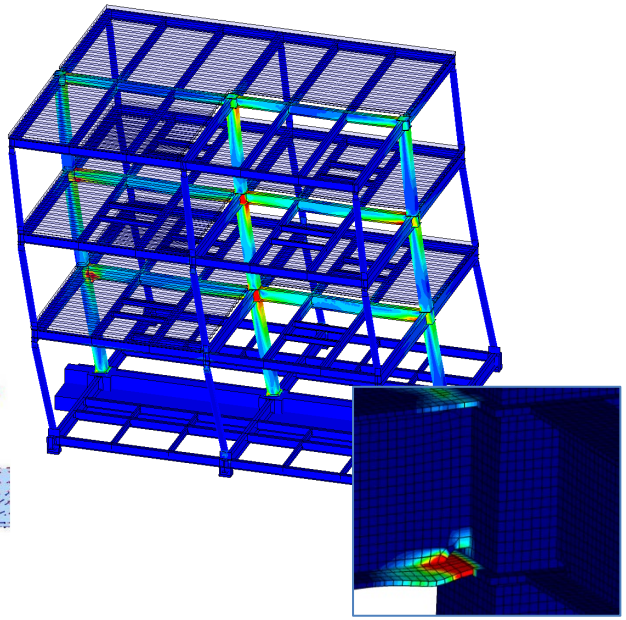


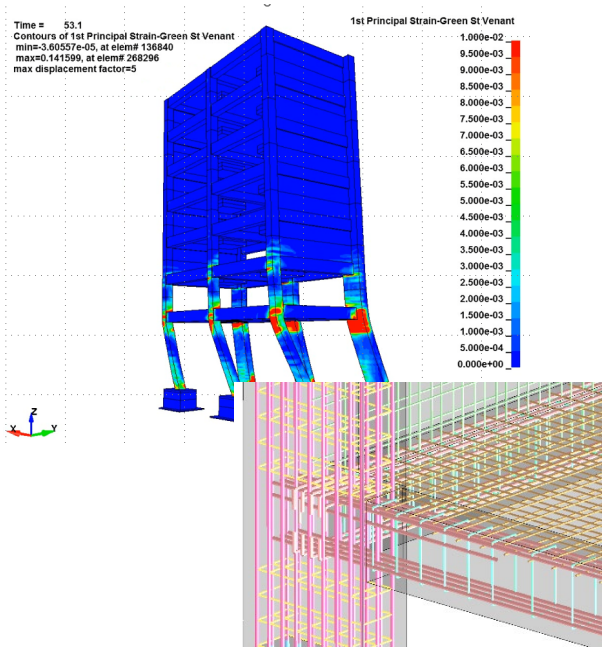
Result of Past Blind Analysis

Our Motivation

Detailed FE models have high accuracy and robustness







Our Motivation

The contest was the best opportunity for us !!

https://www.ncree.org/conference/UserData/0/C20180501A/Download/BlindAnalysisContest_ContestResults.pdf

Outline of experiment and blind analysis contest

Outline of contest

The contest was held as an event in International Conference in Commemoration of 20th Anniversary of the 1999 Chi-Chi Earthquake in 2019

https://www.ncree.org/conference/index.aspx?n=C20180501A0

Outline of experiment

7-story RC building, half-scale, 3-D excitation

Analytical Model

Detailed FE Model

Concrete : Solid Elements

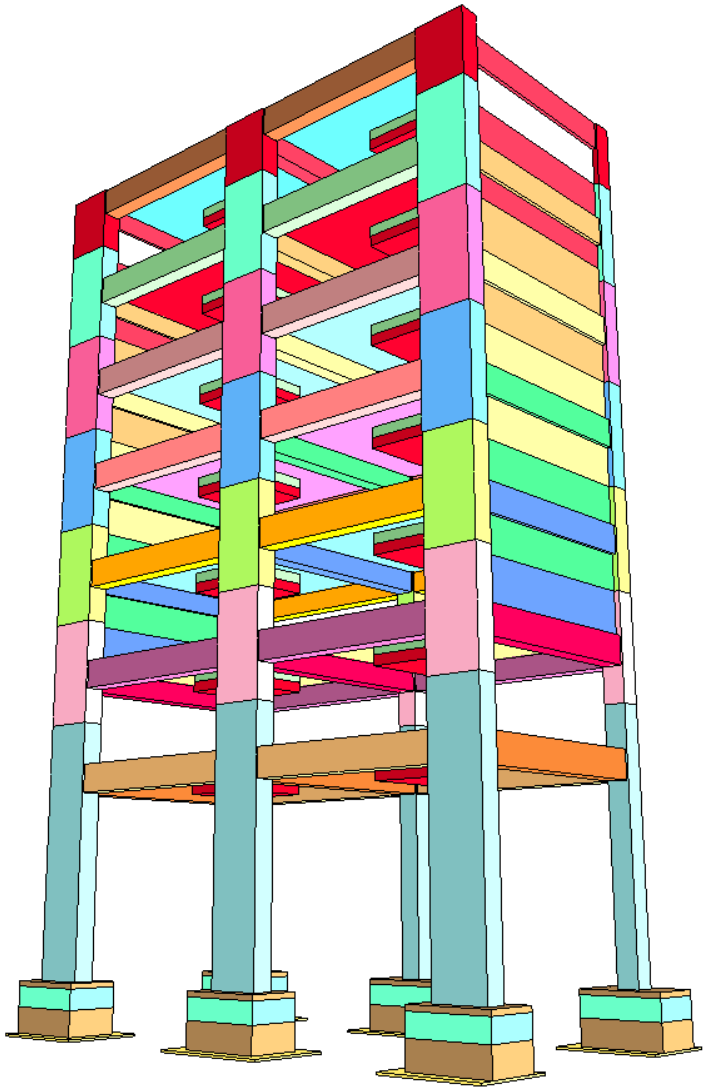
8-node
1-integration points
about 40 mm
about 300,000 elements

Rebar : Beam Elements

2-node
generated separately
from solid mesh
coupled with solid mesh
about 80,000 elements

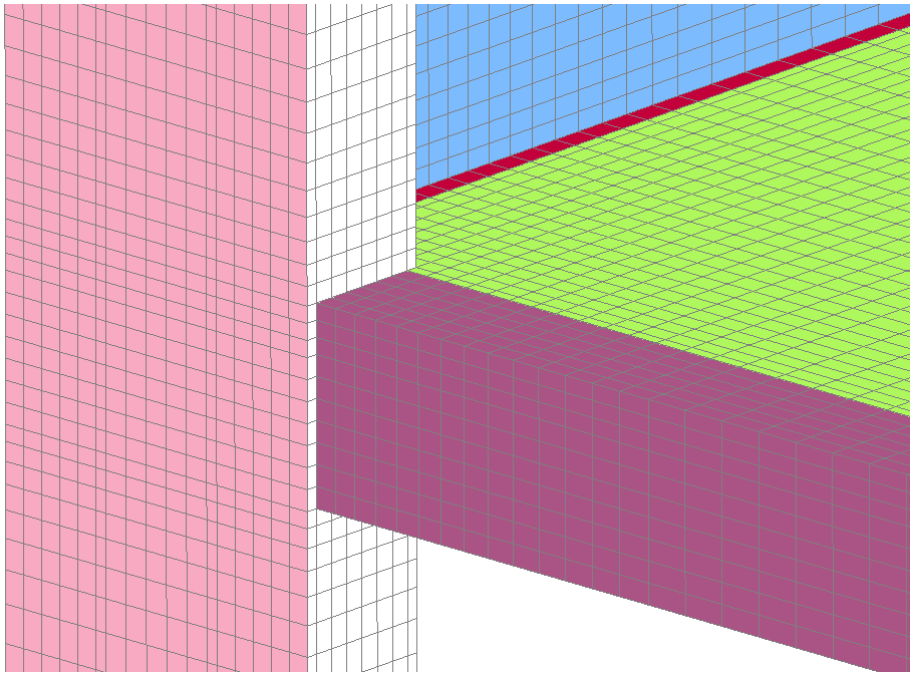
Total **373,758** elements
449,101 nodes

LS-DYNA was used

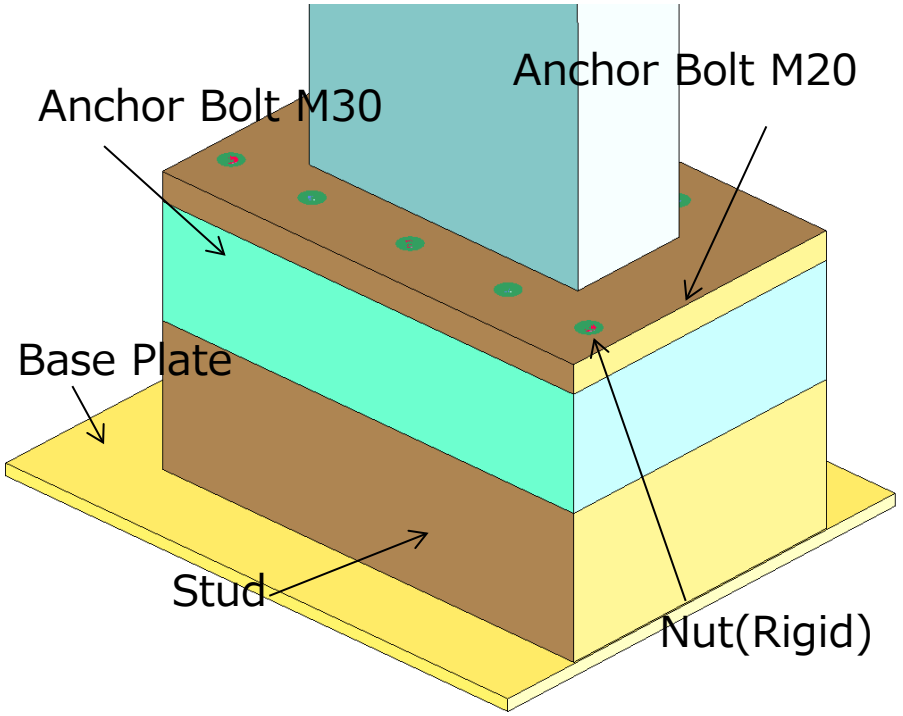


Detailed FE Model

Joint Area



Bottom of Column

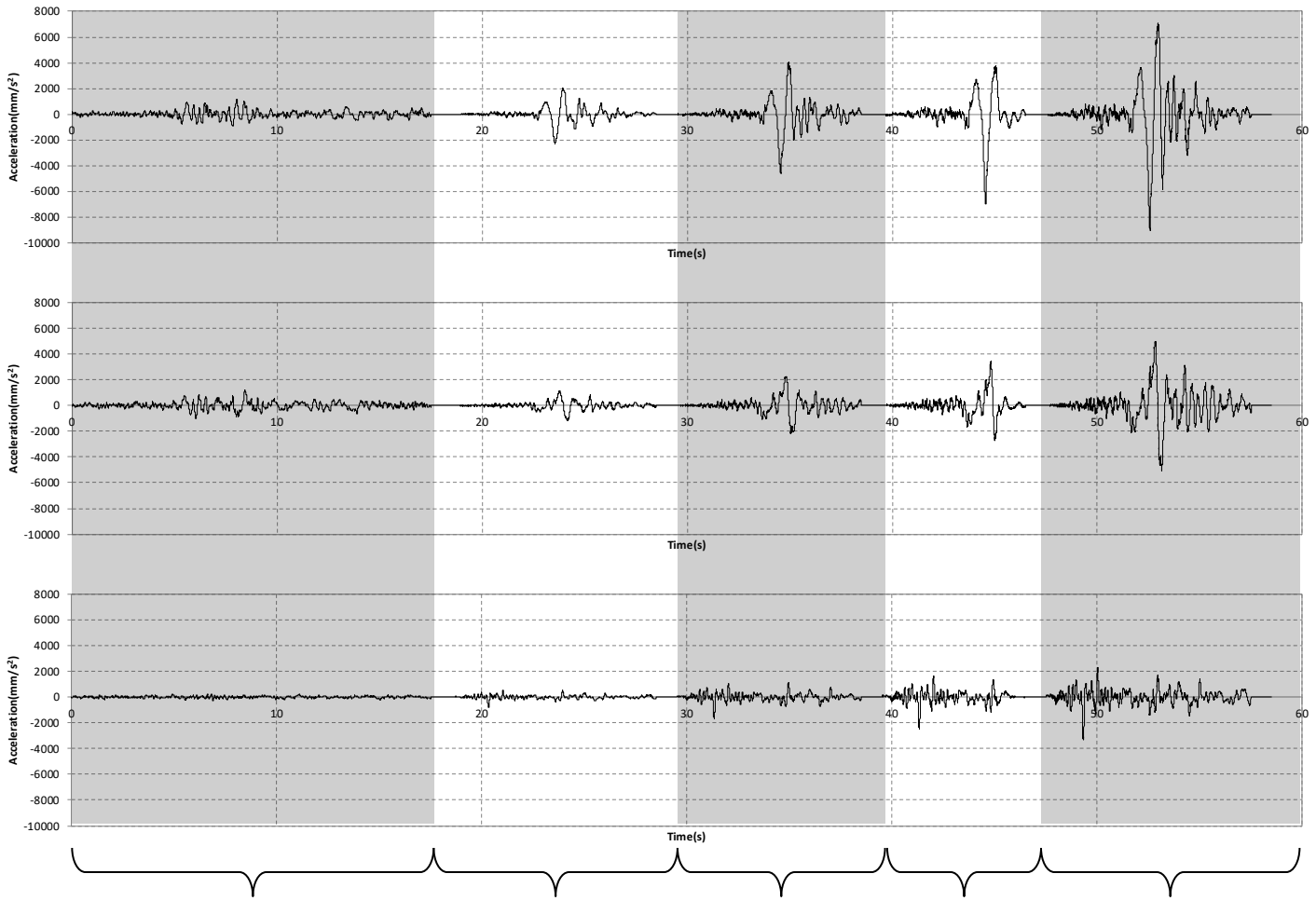


Excitation

X

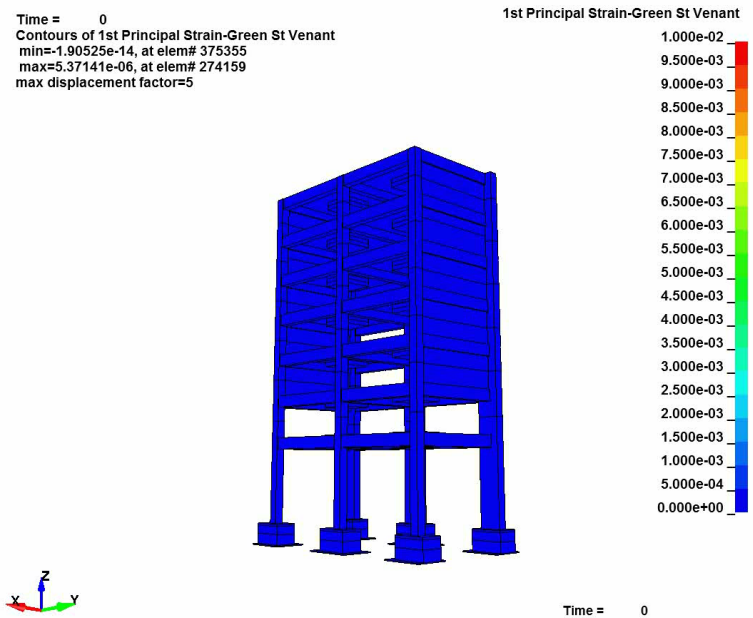
Y

Z

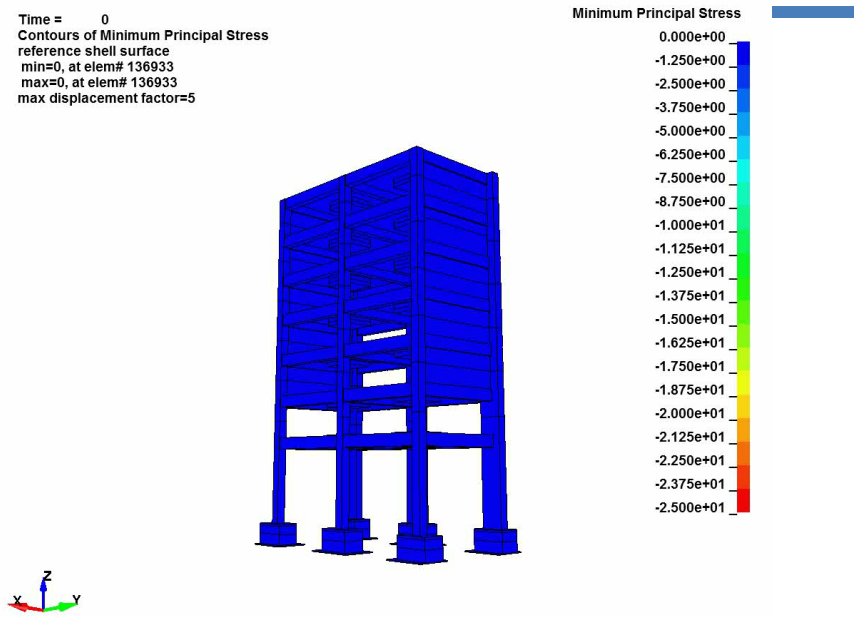


Analytical Result

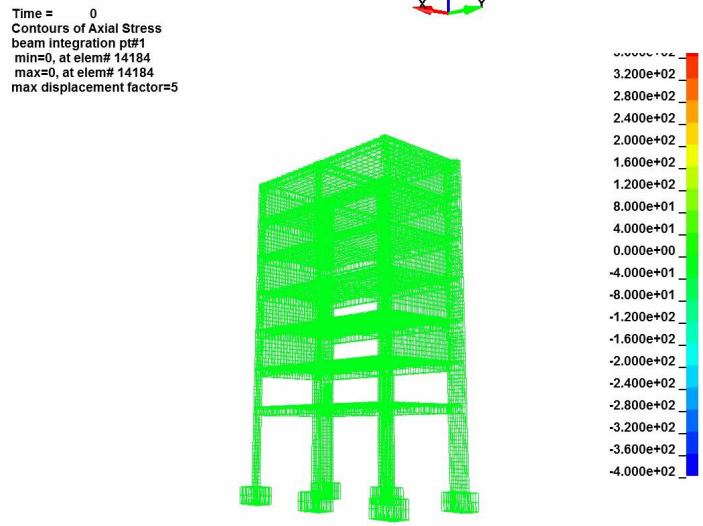
Analytical Result



Max Principal Strain



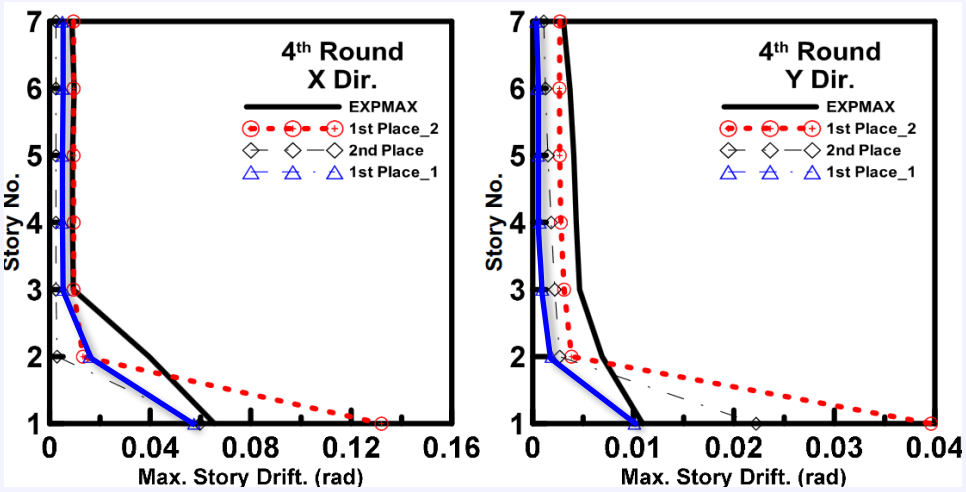
Min Principal Stress



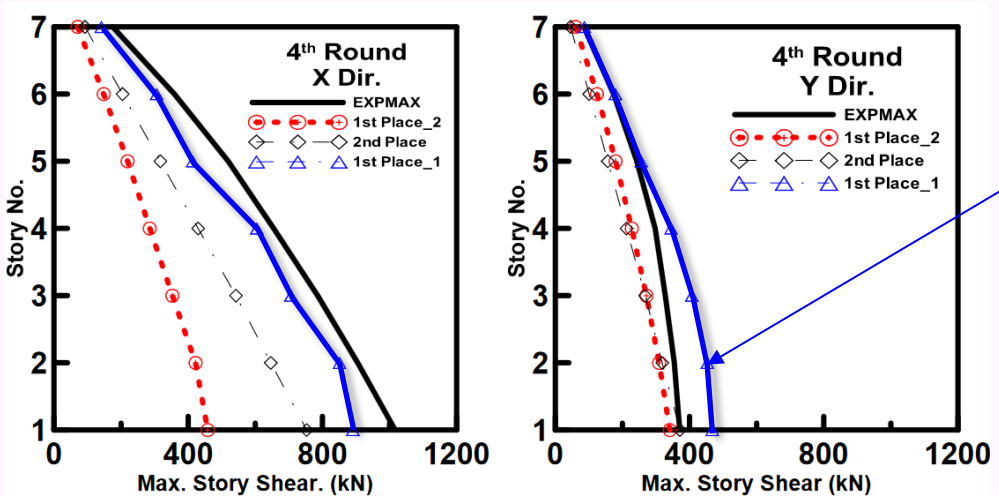
Reinforcement Stress

Analytical Result

Story Drift



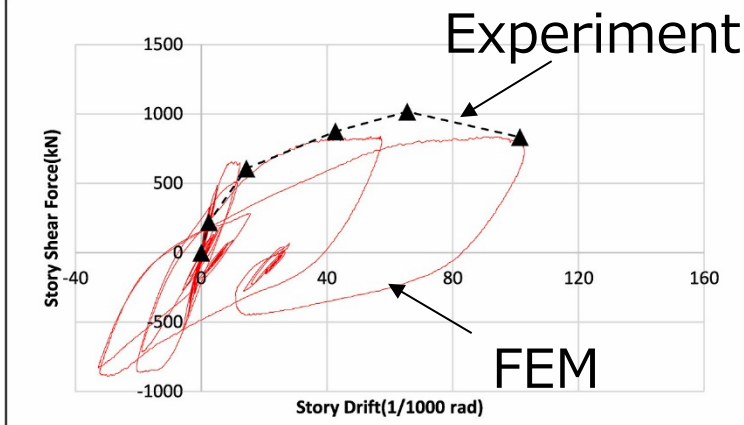
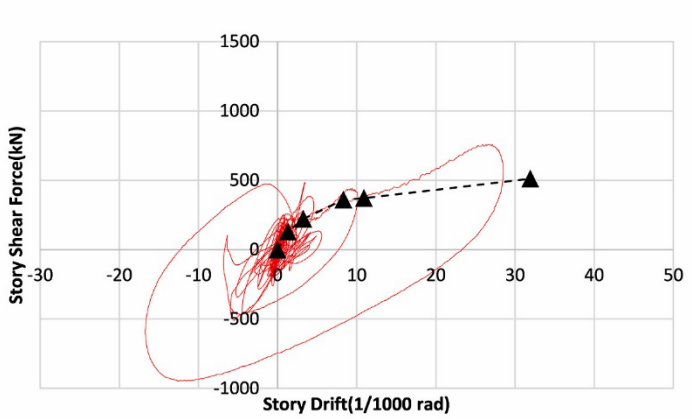
Shear Force



Our Team

Analytical Result

1st Story

	X	Y
FEM		

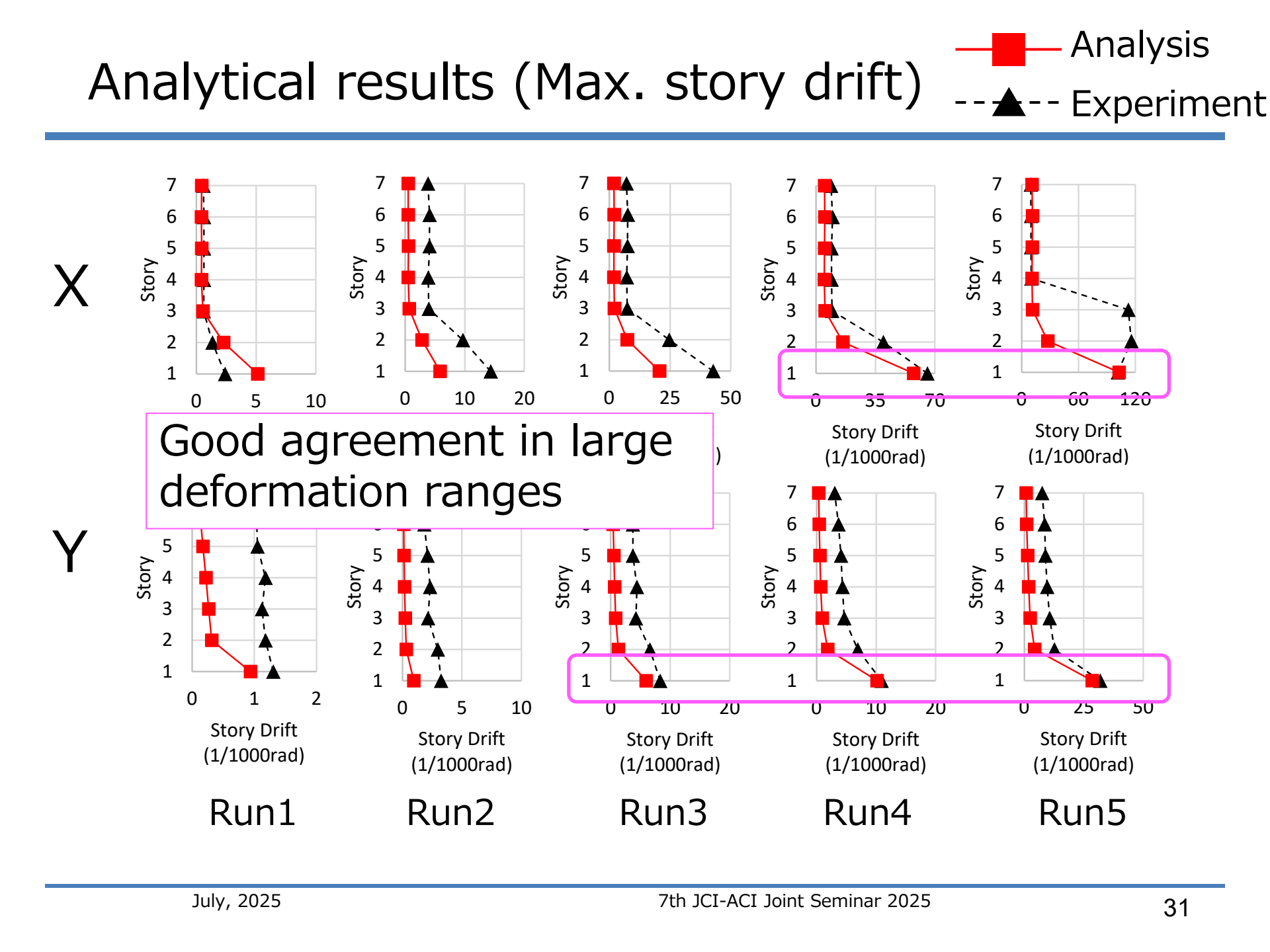
Note

Experimental result:

Pseudo Q–d curves, based on peak story drift and shear in each run, since displacement and acceleration measuring systems were not synchronized.

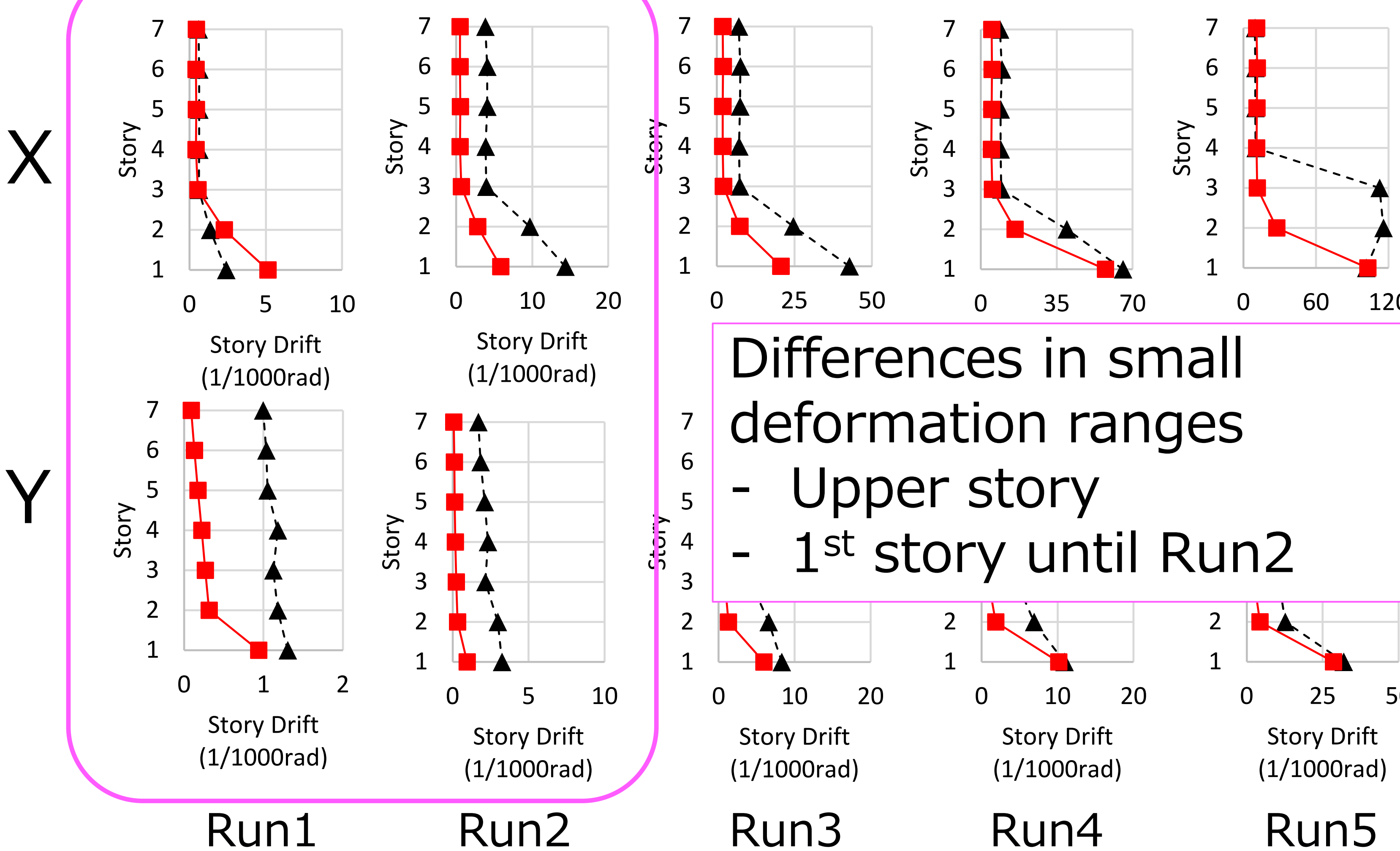
Influence of rocking motion

Analytical results (Max. story drift)



Analytical results (Max. story drift)

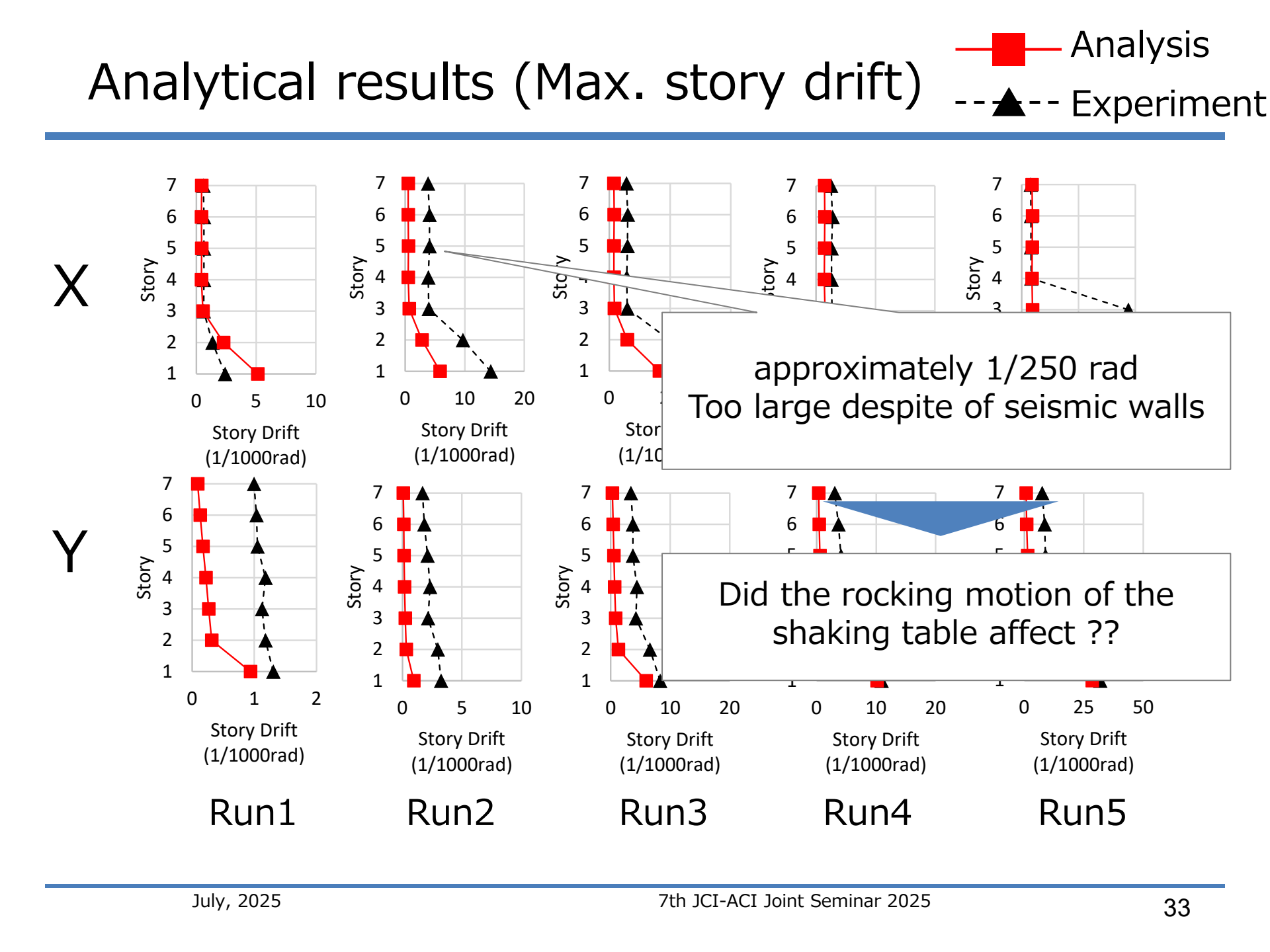
Analysis
Experiment



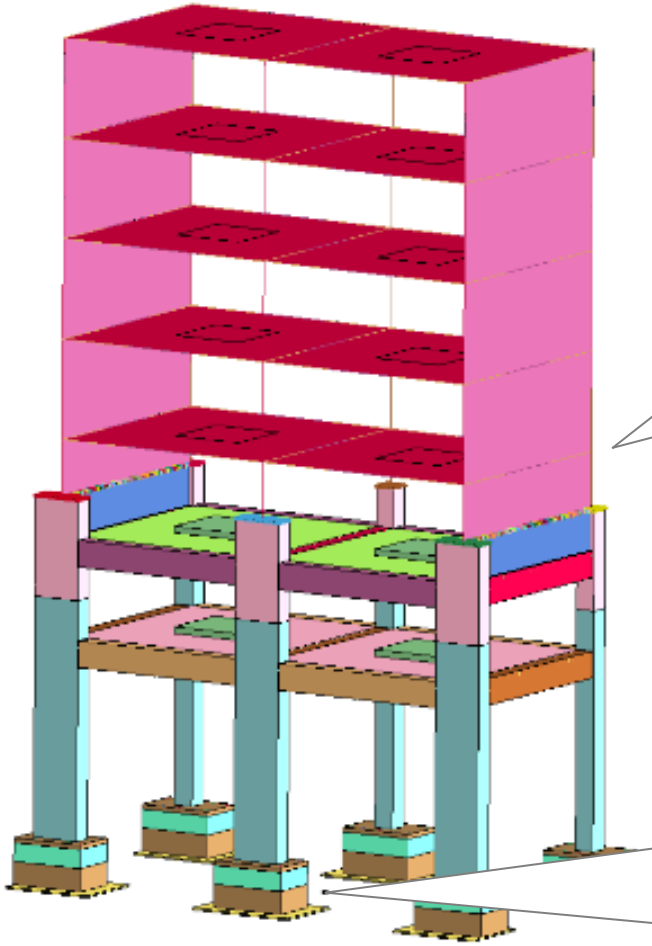
Differences in small deformation ranges

- Upper story
- 1^{st} story until Run2

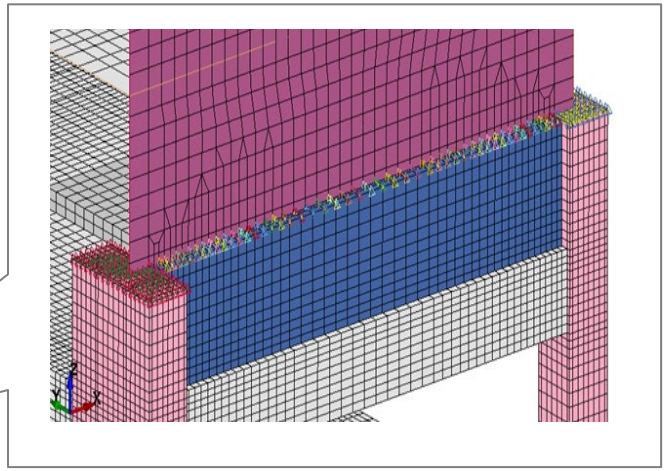
Analytical results (Max. story drift)



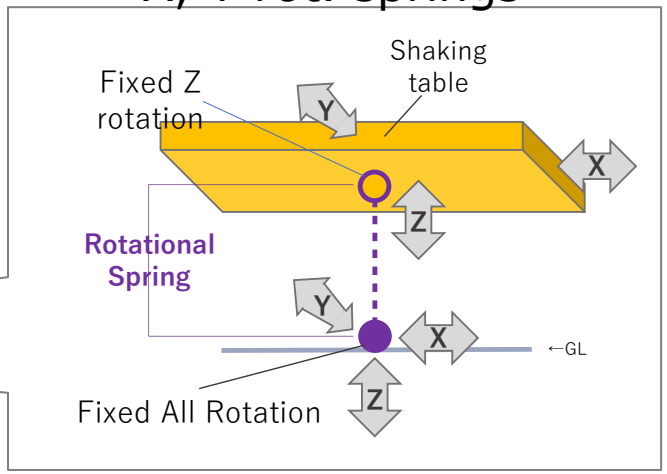
Analysis model used in the identification



Upper stories were simplified



X, Y rot. springs



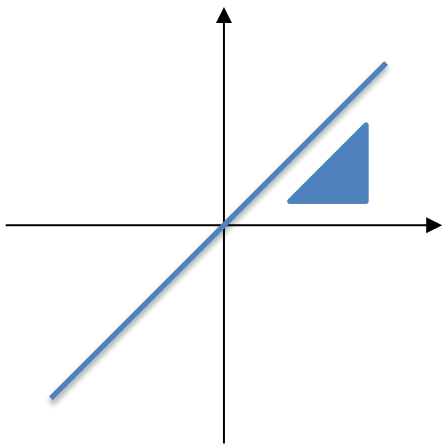
Analysis model used in the identification

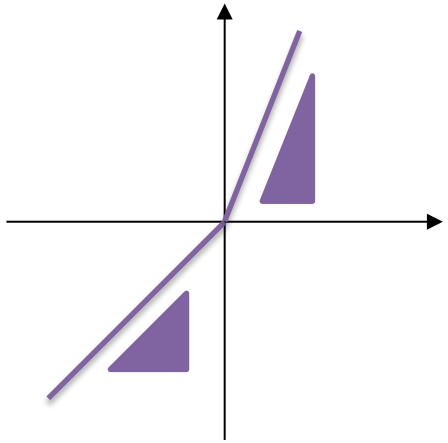
Using symmetrical spring

	Rotational stiffness[kN-m/rad]		Damping ratio
	X	Y	
Initial value	1.06×10^6	1.06×10^6	0.03
Maximum value	3.98×10^6	3.98×10^6	0.10
Minimum value	5.30×10^6	5.30×10^6	0.01

Using asymmetrical spring

	Rotational stiffness[kN-m/rad]	
	X	Y
Initial value	4.00×10^6	1.60×10^6
Maximum value	1.00×10^7	3.00×10^6
Minimum value	1.10×10^6	8.00×10^5





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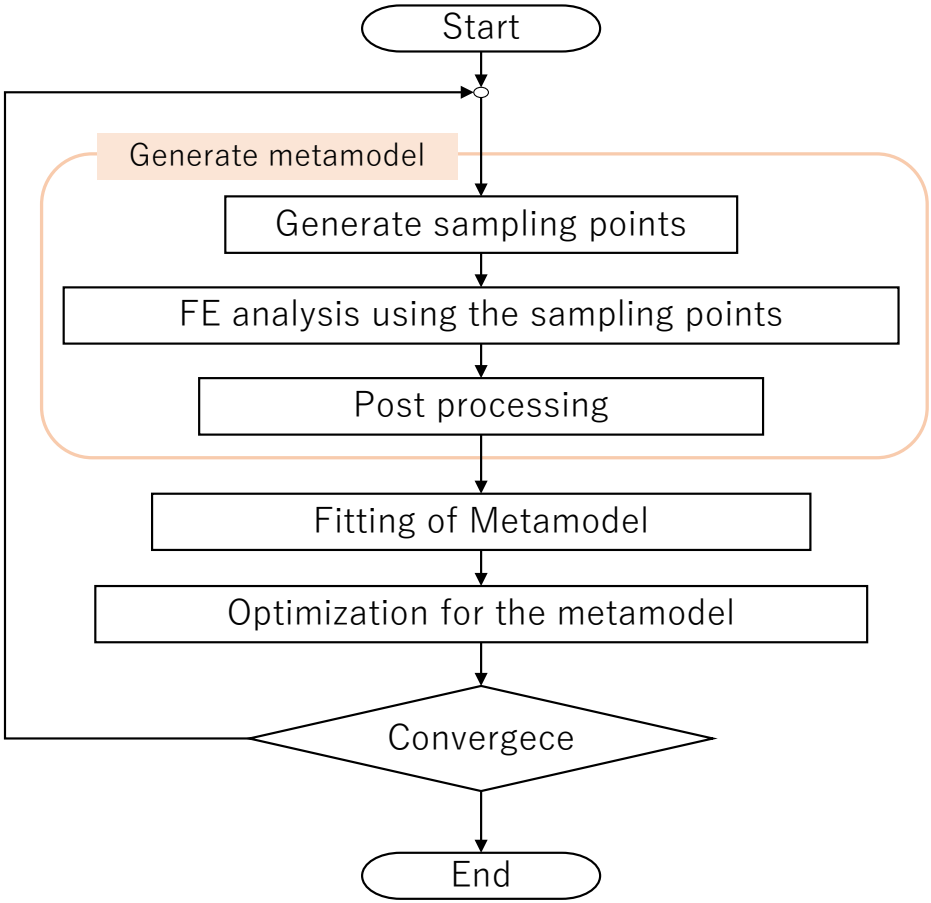
Damping ratio

Optimization

Objective function:
Errors between experimental and analytical results of 1st story

Design variables:
Elastic stiffnesses of rotational springs & damping ratio

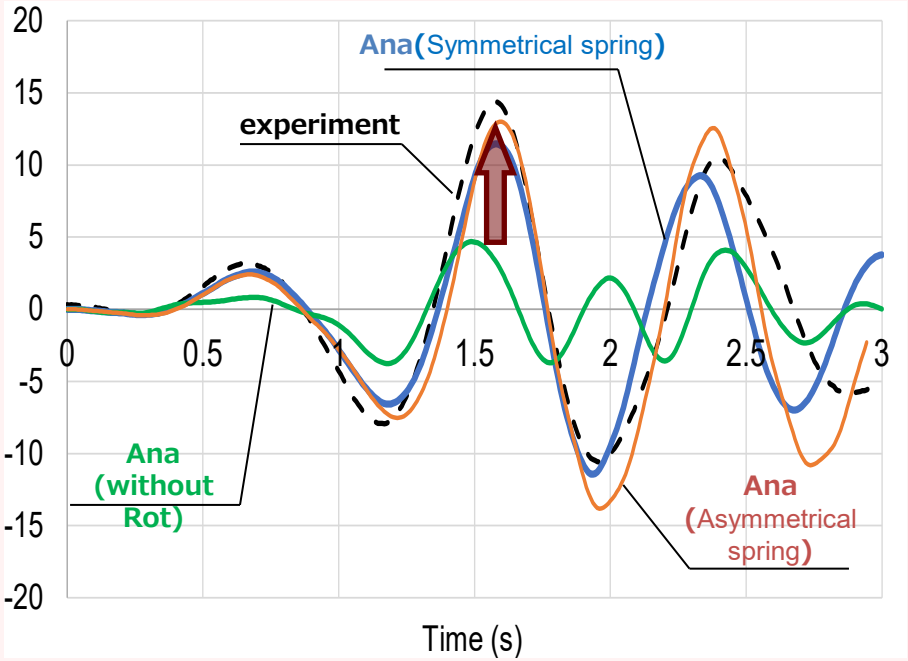
Optimization method:
- Sampling :D-optimal
- Metamodel :Linear Polynomial
- Opt Algorithm :ASA + Leap frog



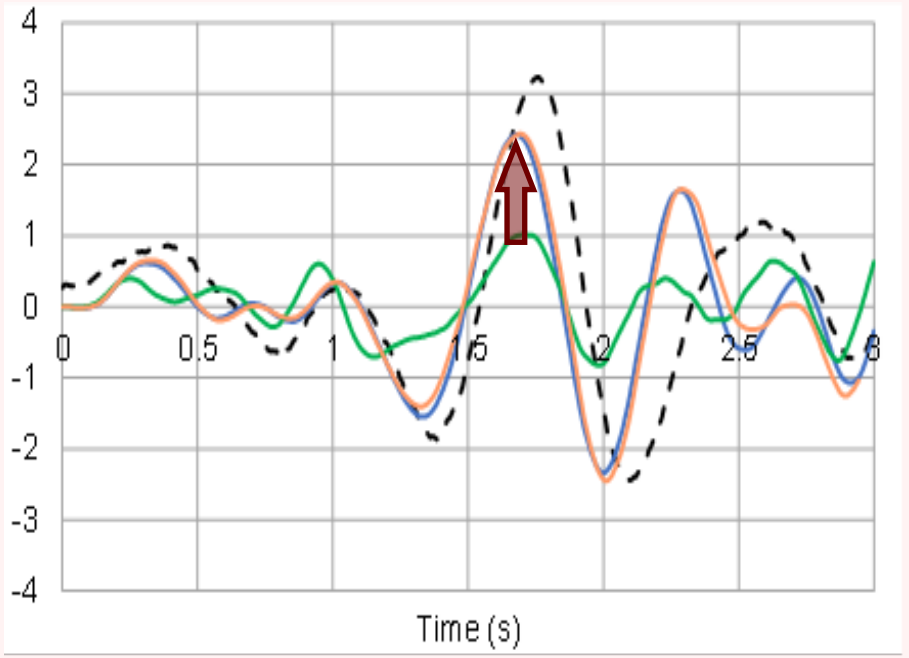
Results after identification of rocking motion

Story drifts of 1st story

X-story drift ratio[1/1000rad]



Y-story drift ratio[1/1000rad]



Summaries

- In 2019, a blind analysis contest was held on the shaking table test of a half-scale RC building.
- We participated in the contest with analysis results obtained from a detailed FE model. The concrete and the reinforcement parts were modeled by solid and beam elements, respectively.
- We won the 1st place in the contest. Our results showed higher accuracy in reproducing the structural behavior, especially in the large deformation range, compared to other teams.
- By considering rocking motion, the analysis model was effective in small deformation ranges