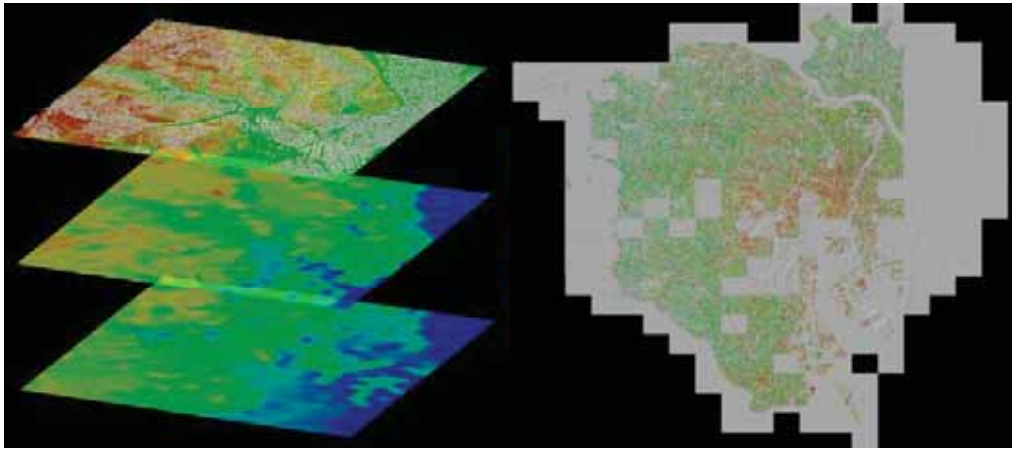
観測に基づく
都市の地震被害評価技術の開発

◆ H25年度までの成果

- 地震被害評価技術の基盤である，シミュレーションベースの地震動・地震応答解析と計算結果の先端可視化技術が完成

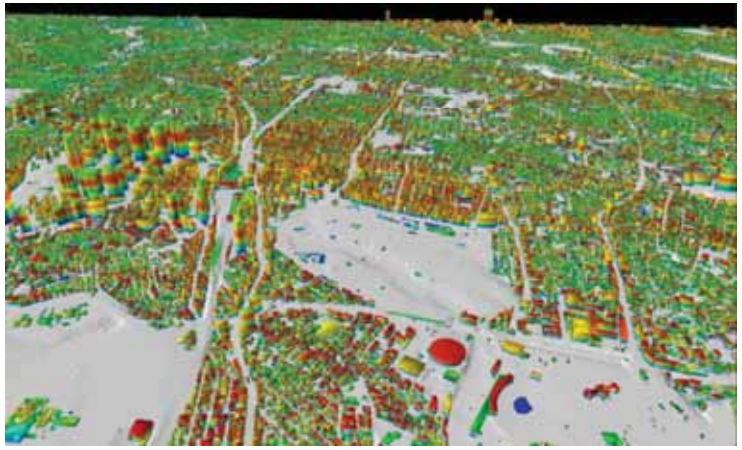
◆ 最終的な成果の見込み

- 地震被害評価技術を利用した，東京23区の高度な地震ハザード予測



東京23区の地盤モデルと構造モデル

- 3次元・非線形・超詳細表層地盤モデル
- 構造種別・築年代等を考慮した詳細構造モデル



想定された地震に対するハザード予測

- MeSO-net基づく多数の地震シナリオ
- 動画・3次元・マルチスケール表示

H25年度の予想される成果概要

◆地震動・地震応答の大規模数値解析法の開発

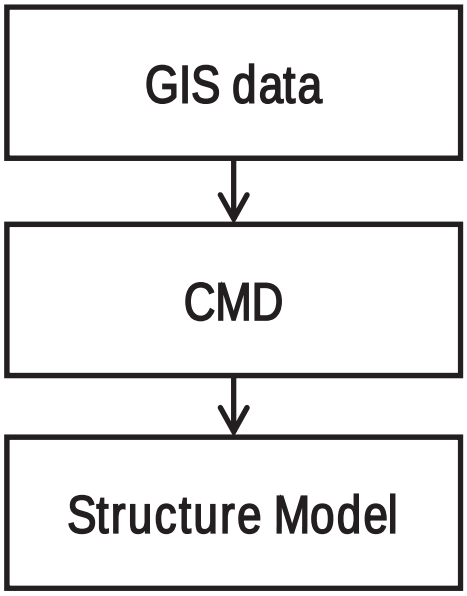
- 前年度開発したコードを利用し，大規模シミュレーションを使った地震動・地震応答解析を開発する.
- サブプロジェクト②との連携を継続する.

◆大規模数値解析結果の先端可視化技術の開発

- 前年度に開発した都市モデルを利用し，東京23区全体の都市地震被害の先端可視化技術を開発する.
- サブプロジェクト③との連携を継続する.

地震被害評価技術の基盤である，地震動・地震応答解析と先端可視化技術が完成

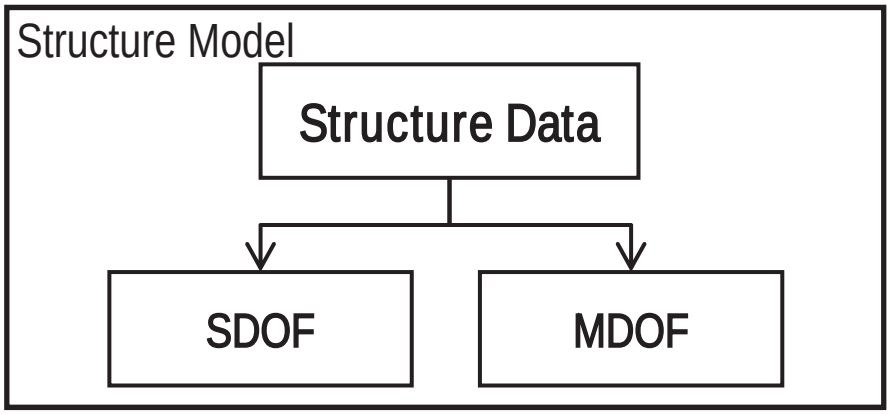
OUTLINE



polygon set

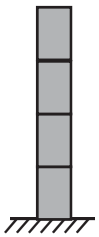
building height
floor

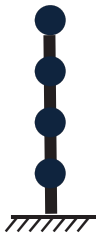
check
- negative height
- too small area
- floor given by neighboring polygon
- non-building structure



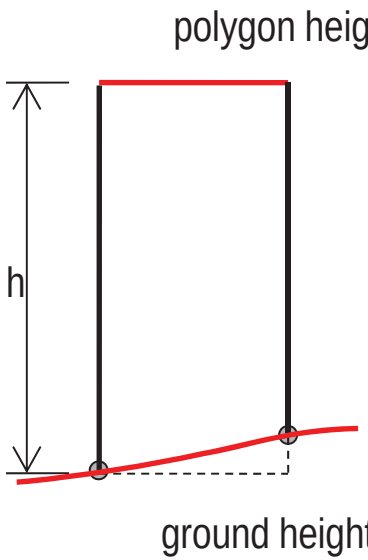
SDOF: determine
- building height
- building area
- stiffness
- strength

MDOF: determine
- story number
- story height
- story area
- story-wise stiffness
- story-wise strength





HEIGHT DETERMINATION



number of negative height building

negative height	number
~ -20	2
-20 ~ -10	5
-10 ~ -5	10
-5 ~	0

possible reasons
- does not exit
- fake building
- basement or underground space
- error

solution
- remove

number of short height building

negative height	number
0 ~ 1	4493
1 ~ 2	50,500
2 ~ 3	151,165

around 10 % of data

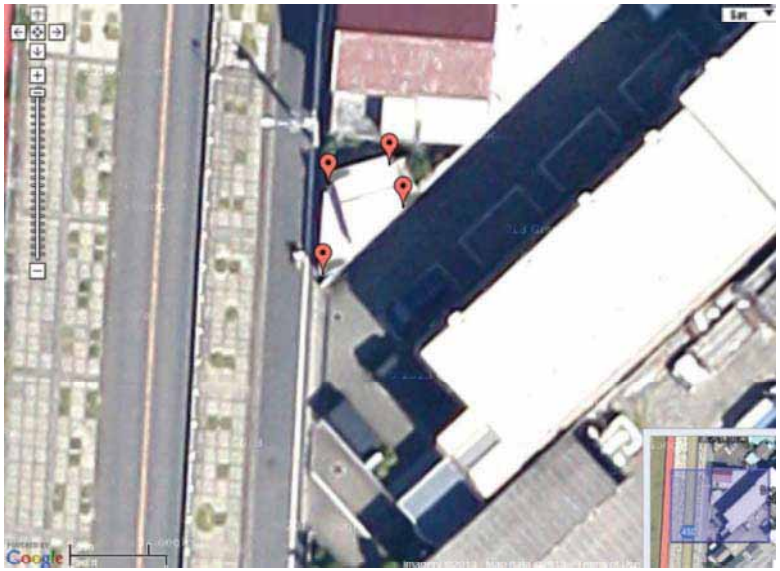
non-building object shorter than 3 m
- small area (less than 15 m^2)
- small width (less than 3 m)

solution
- remove

-36.41 m (error)

-27.23 m (does not exist)

-16.71 m (error: at the slope)



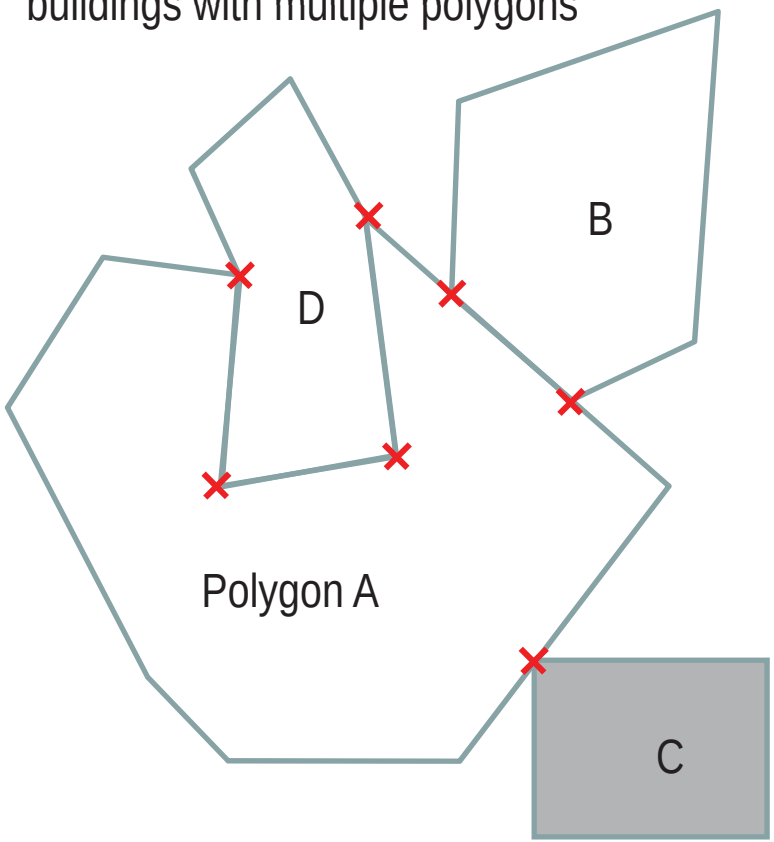
1.0 m (non-building structure, 19.6 m^2)

0.9 m (non-building structure, 18.3 m^2)

0.9 m (non-building structure, 35.0 m^2)

PROCESSING OF GIS DATA

buildings with multiple polygons



- Polygon A, B & D are for one building with multiple polygons
- Polygon C is for another building

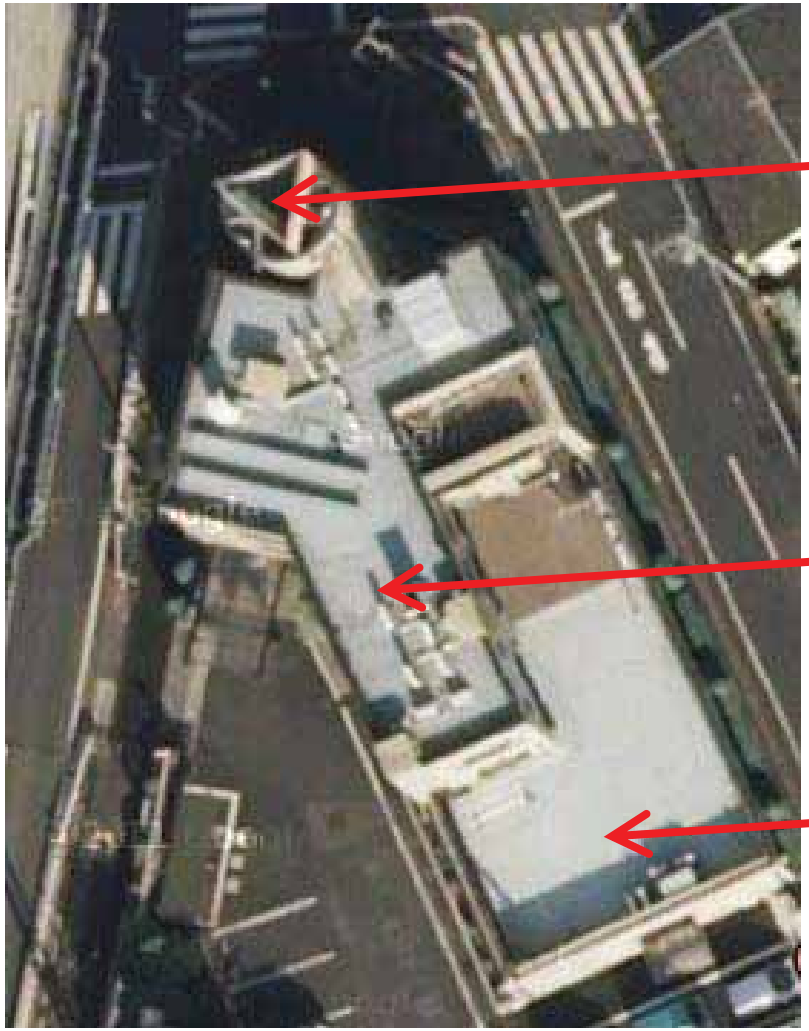
Procedure of finding connected polygons

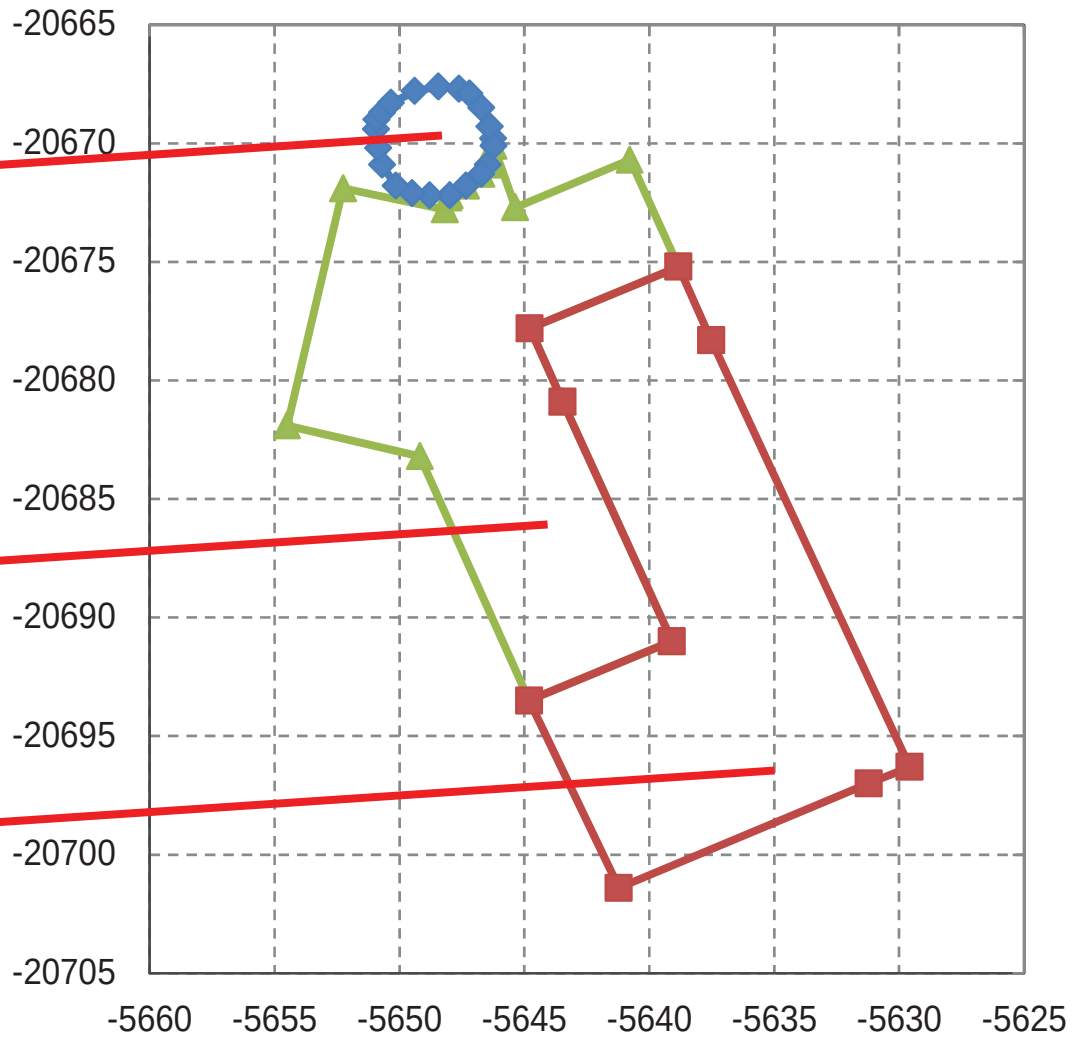
1. find two polygons which have more than 2 vertices that are attached to them
2. repeat 1 until all combined polygons for a common building are found

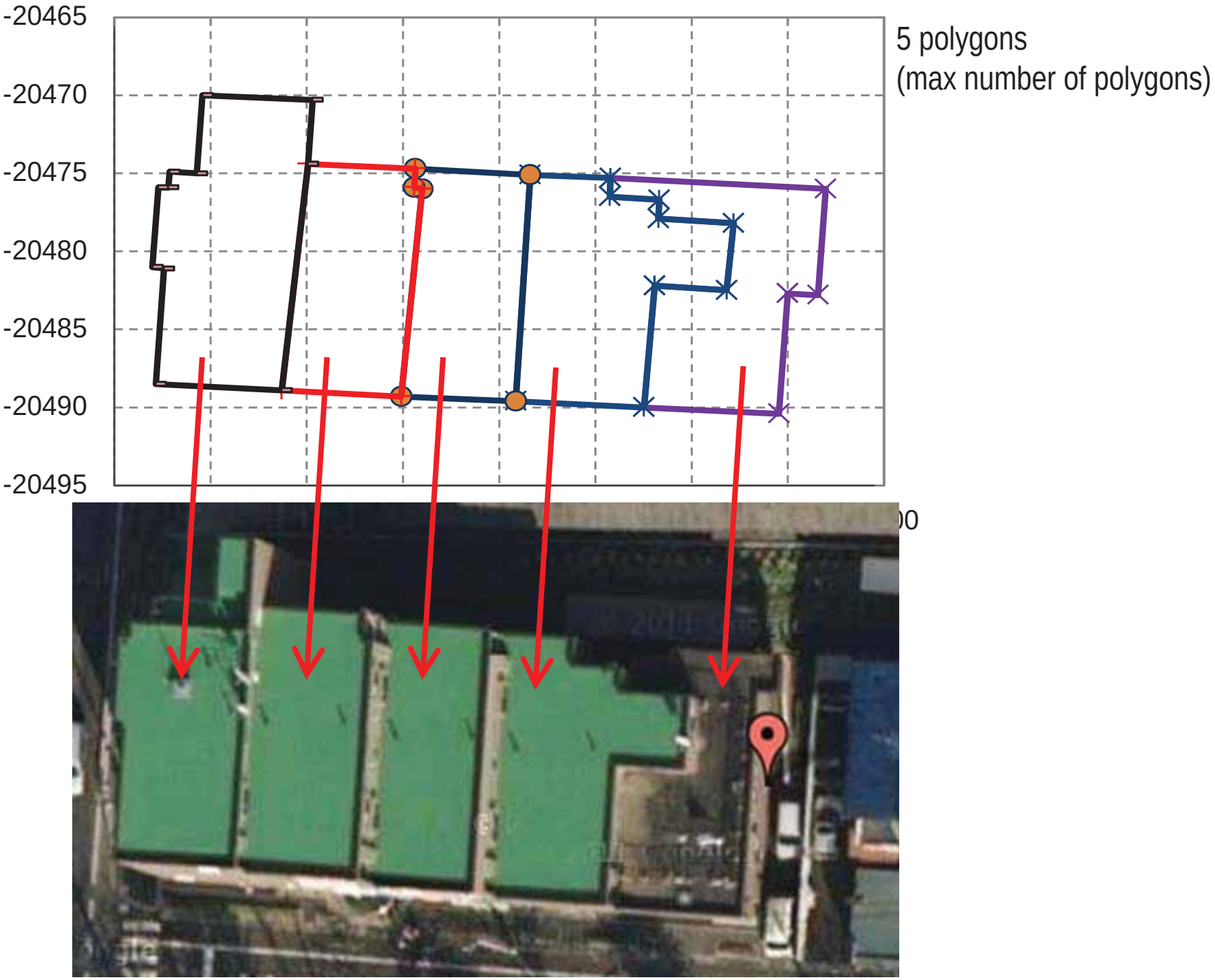
Case study for one block;
dimension of block is 2.0 by1.5 km

Number of buildings with multiple polygons is 23 out of 1978 (1.6%)

3 polygons

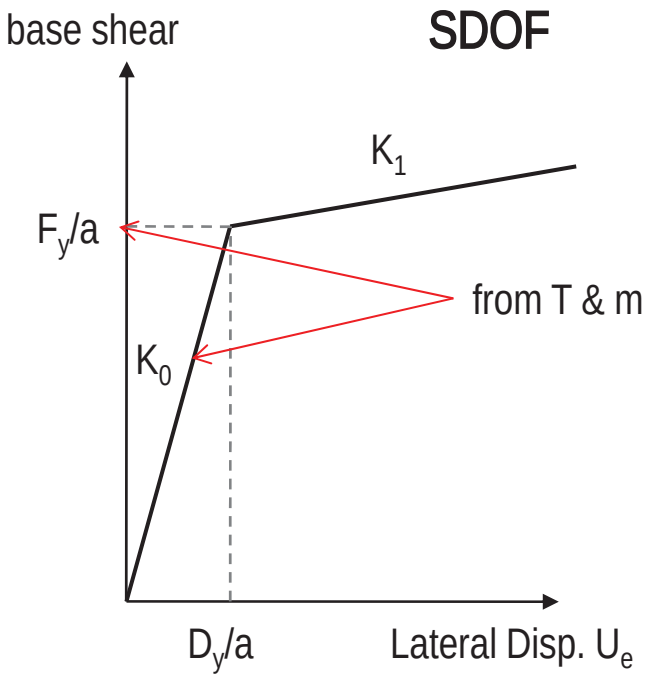


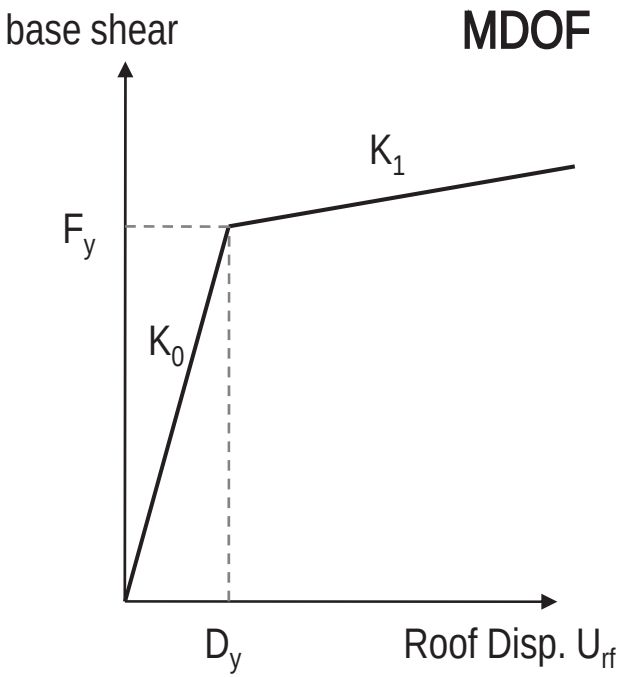

-20665
-20670
-20675
-20680
-20685
-20690
-20695
-20700
-20705
-5660
-5655
-5650
-5645
-5640
-5635
-5630
-5625

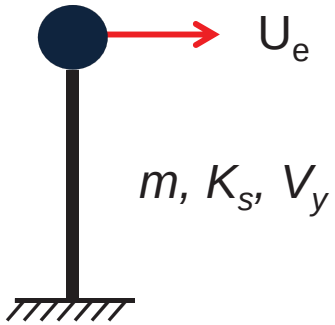

-20465
-20470
-20475
-20480
-20485
-20490
-20495
5 polygons
(max number of polygons)

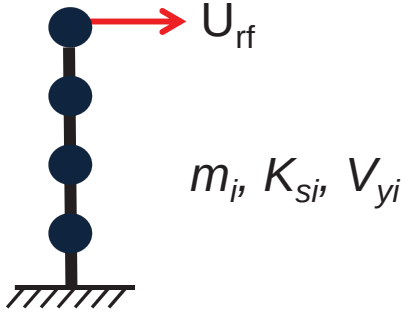
PARAMETERS OF MDOF

- Distribution of story shear strength $V_y i$
  - Uniform
  - Linear
  - Ratio of capacity and demand
- Distribution of story stiffness K_i
  - Uniform
  - Linear
- Selection of ground motions
  - High mode effect
  - Failure modes

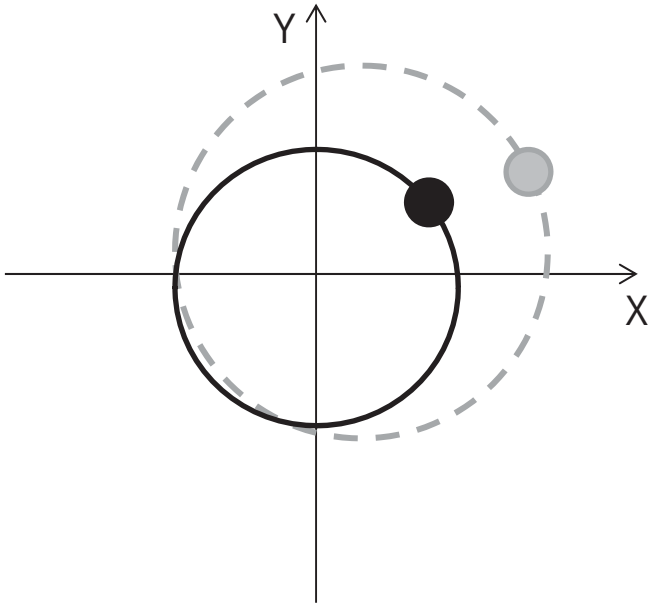

base shear
SDOF
K1
Fy/a
from T & m
K0
Dy/a
Lateral Disp. Ue


base shear
MDOF
K1
Fy
K0
Dy
Roof Disp. Urf


Ue
m, Ks, Vy

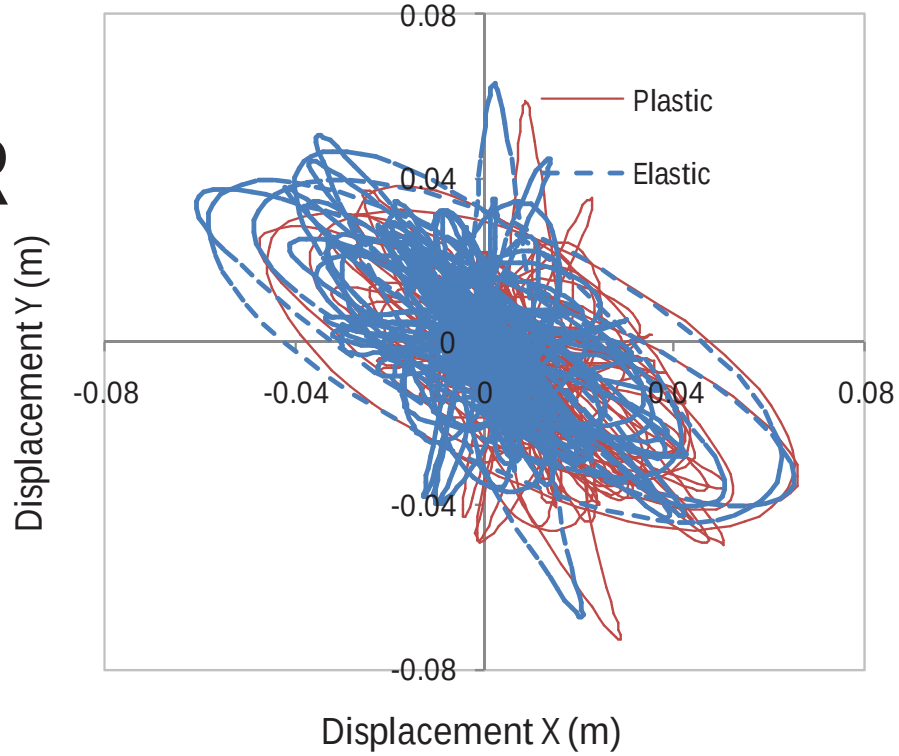

Urf
mi, Ksi, Vyi

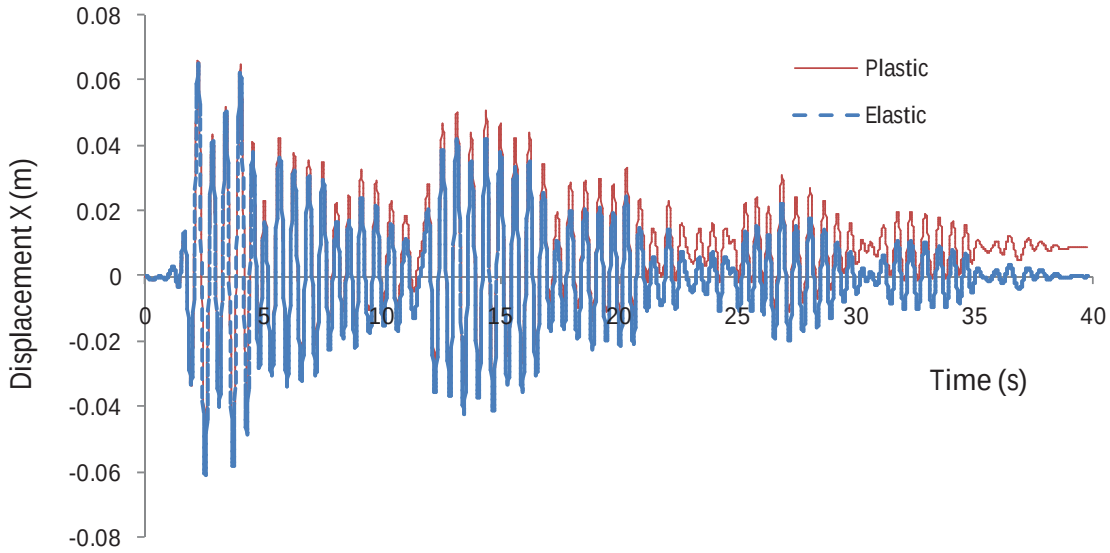
SDF:
NON-LINEAR BEHAVIOR



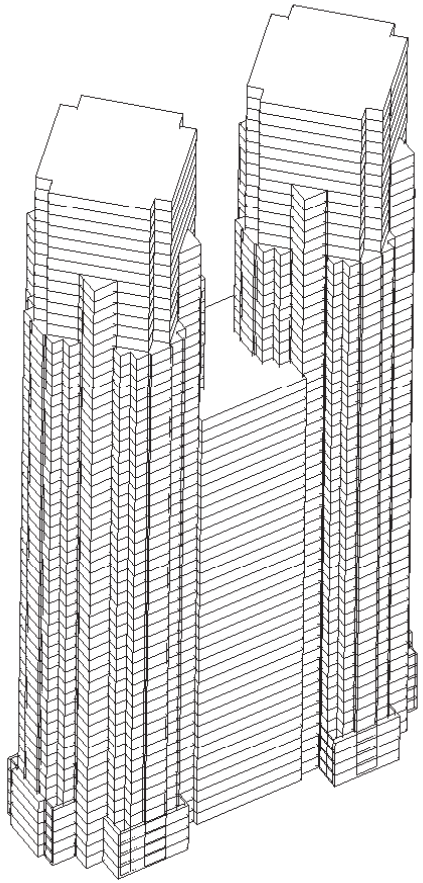
Hardening rules

- Change in yield radius
- Shift of yield cycle



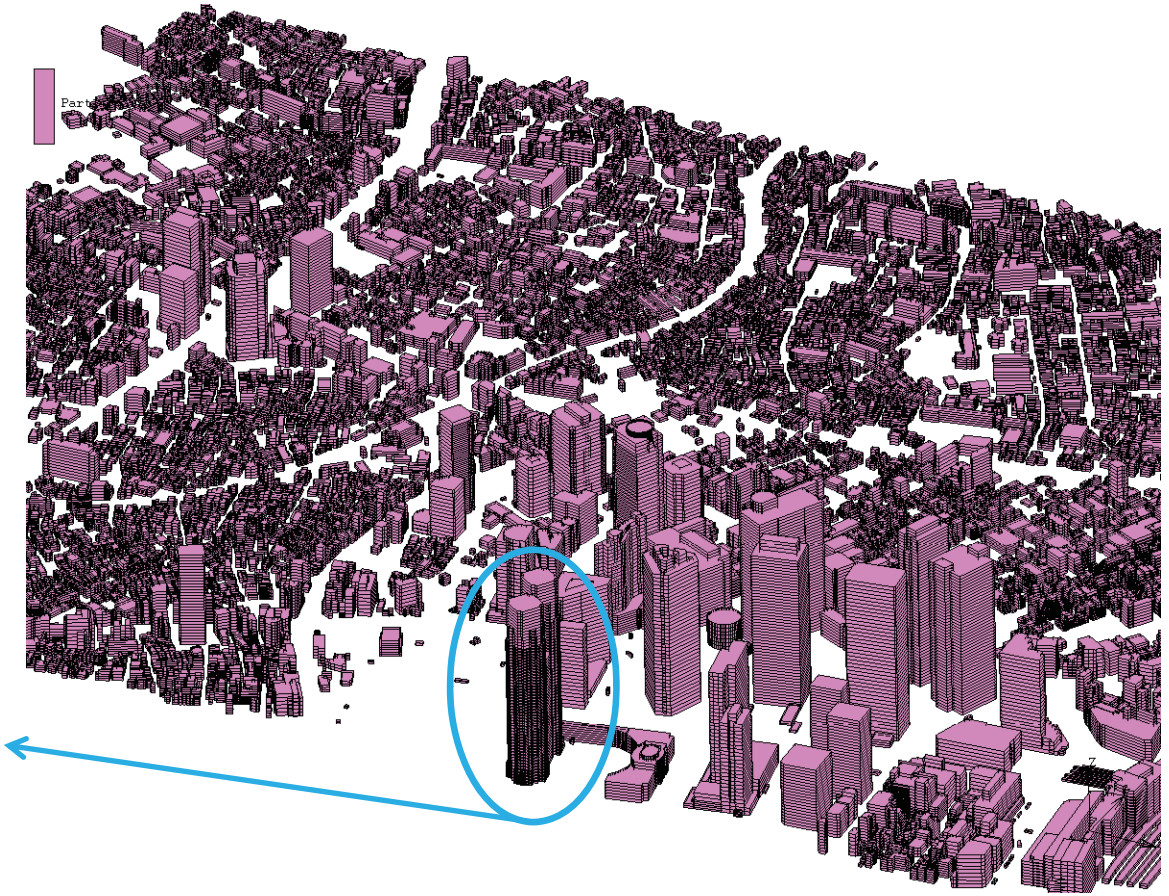


OVERVIEW



Improved building information

- 25 polygons
- horizontal polygons for external boundary of floor
- vertical line for boundary of polygons



Tokyo Metropolitan Government Building

single building with varying floor

IMPROVEMENT OF RELIABILITY

Meta-modeling

- Comparison of seismic response for SDOF and MDOF
- SDOF serve as reference

Simple criterion to choose unknown parameters

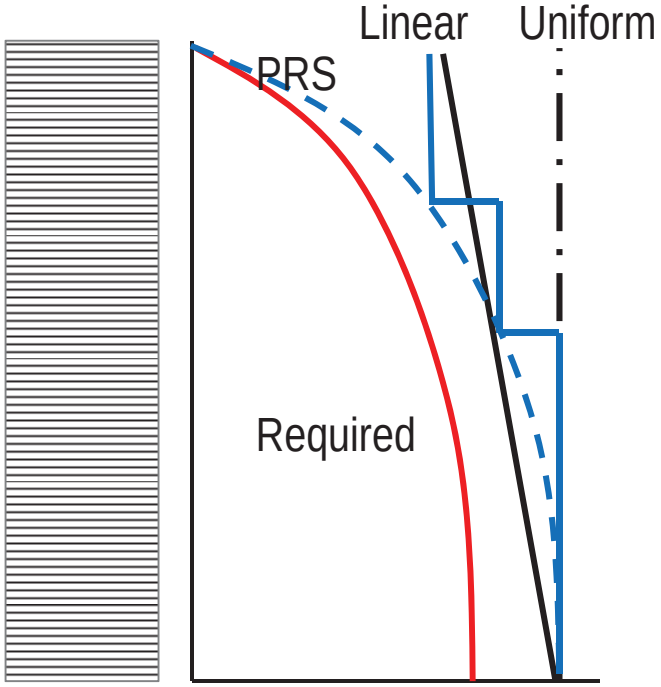
- Stochastic modeling for stiffness (natural frequency consideration)
- Stochastic modeling for uncertainty of strength

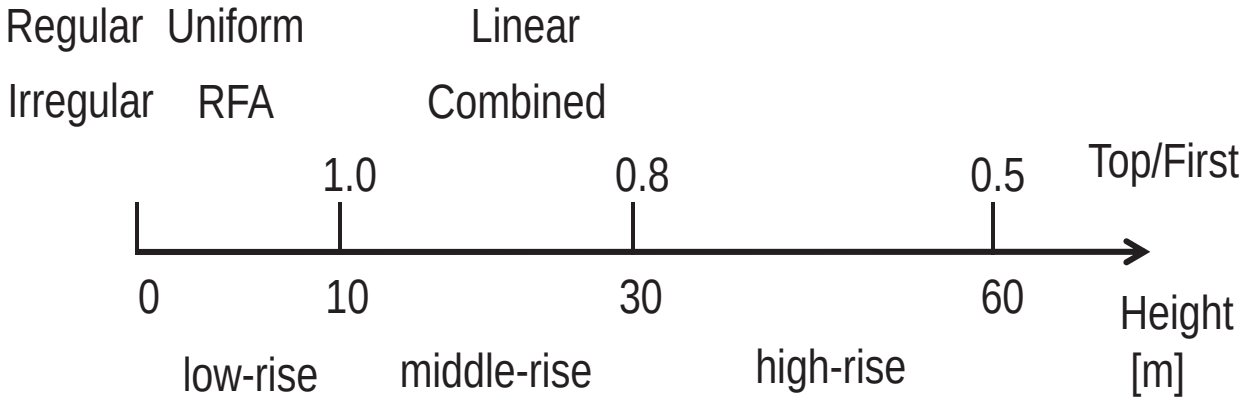
Parameter	Details
Number of story (DOFs)	Low-rise/Middle-rise/High-rise
Type of structure	RC/Steel/Wood
Type of ground motions	Golden set/Long-period set/K-NET set/MeSO-net set

Main research issues and parameters

Distribution of story-wise shear stiffness

- Linear/Uniform
- Related to floor area (RFA)/Combined
- Proportional to Required Shear Strength (PRS)
- Concentrated story deformation or damage (not available in SDOF) due to significant stiffness change through adjacent stories

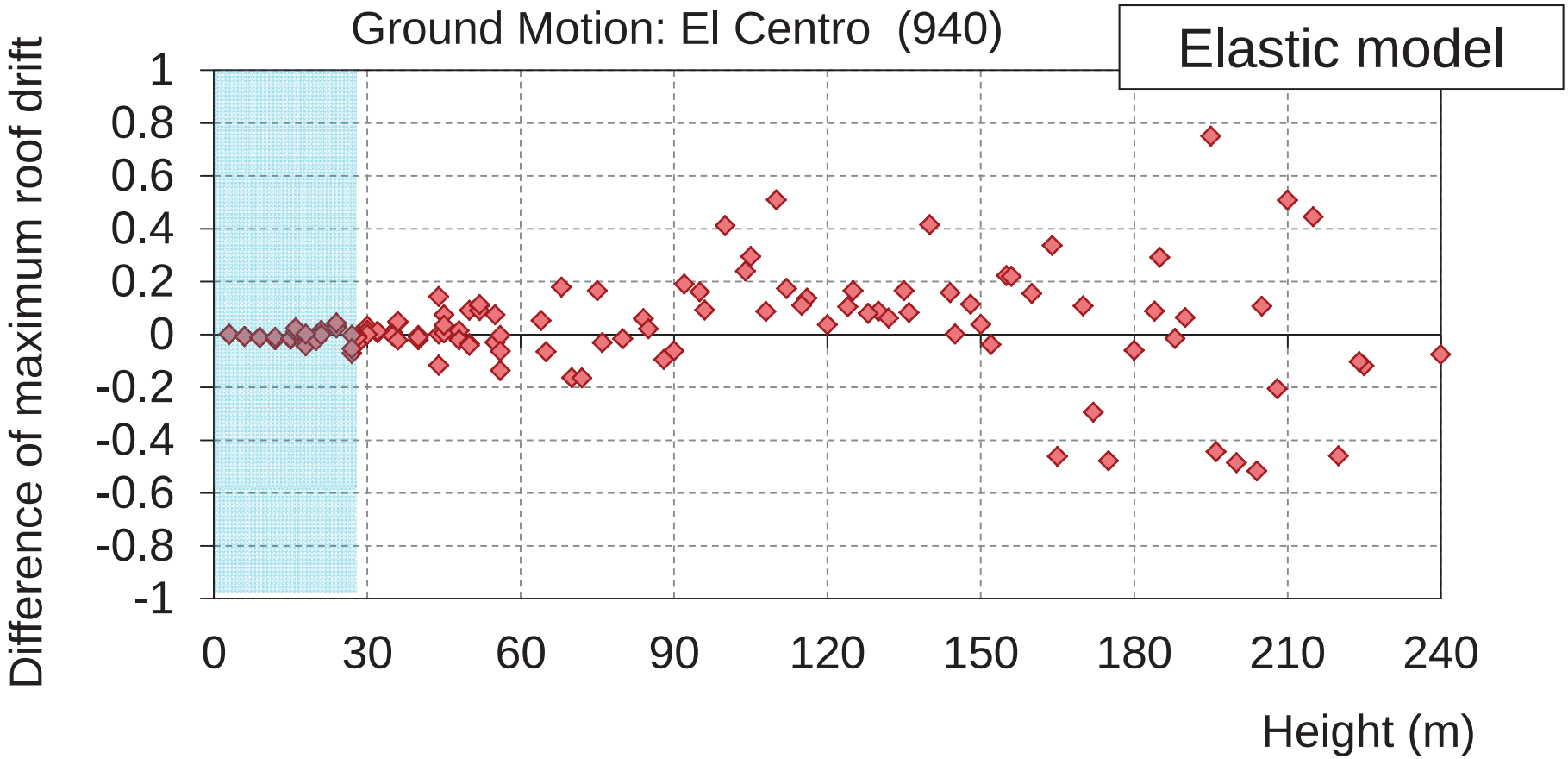




PROCEDURES

Step	Details
Selection of ground motion	Two sets: Conventional/Long-period At least five ground motions for each set
Selection of building	500~1000 from about 1.5 million by random Cover various characteristics of buildings
Analysis	SDOF & MDOF All selected buildings->all ground motions For each parameters
Evaluation	Indices: Roof drift, maximum story drift most damaged story, Base shear

SDOF versus MDOF (Max Roof Drift)

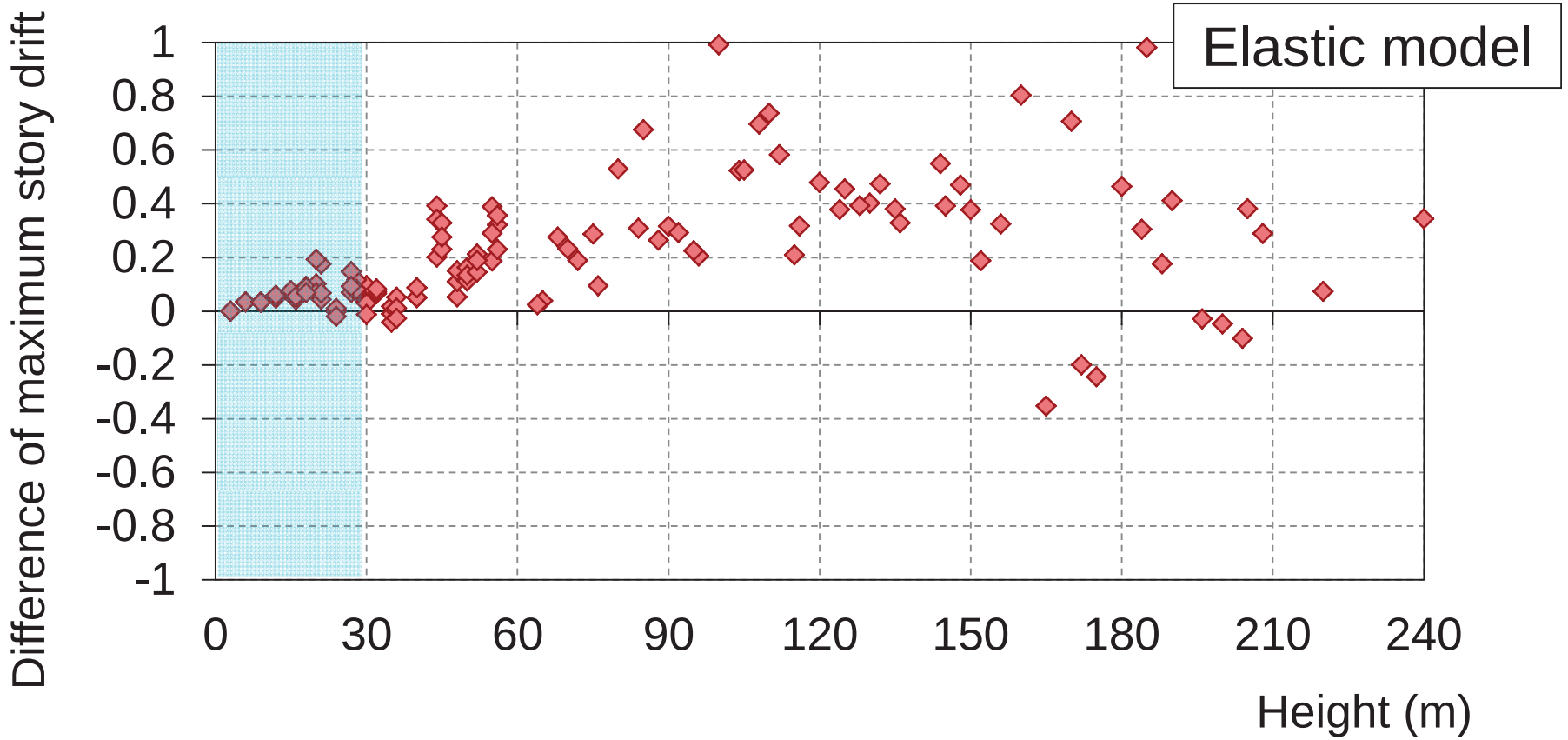


Evaluation of the Difference of Roof Drift:

$$DRD=(RD_{s,max}-RD_{m,max})/RD_{s,max}$$

The majority of the buildings (99%,<30m): within 10%

SDOF versus MDOF (Max Story Drift)

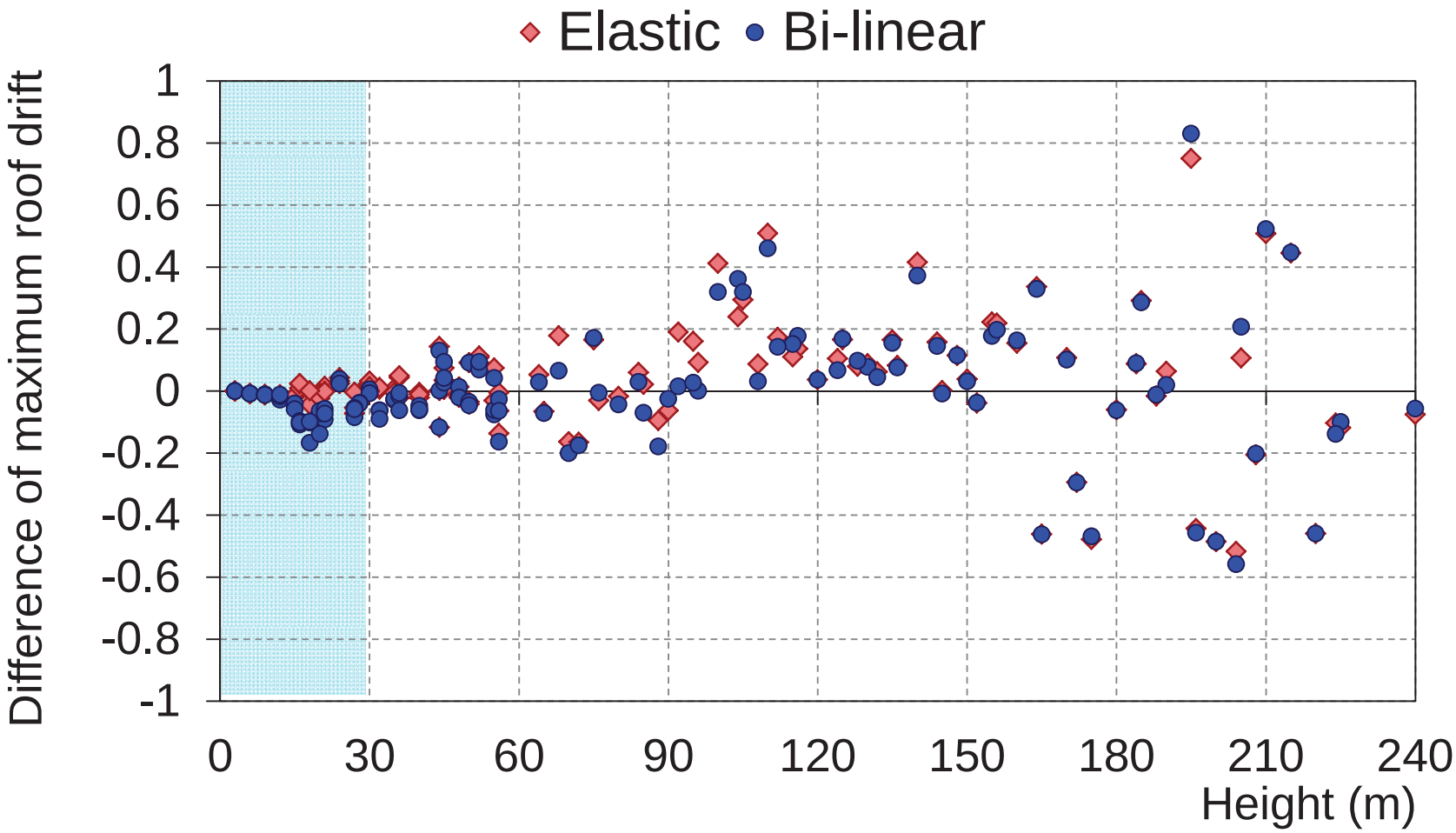


Evaluation of the Difference of Story Drift:

$$DSD=(SD_{s,max}-SD_{m,max})/SD_{s,max}$$

The majority of the buildings (99%,<30m): within 20%

SDOF versus MDOF (Max Roof Drift)



The majority of the buildings (99%,<30m): Difference between SDOF and MDOF is doubled using nonlinear model