UNIVERSITY OF ICELAND
SCHOOL OF ENGINEERING AND NATURAL SCIENCES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

# ISSEE 2009

# INTERNATIONAL SYMPOSIUM ON STRONG-MOTION EARTHQUAKE EFFECTS

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# Response of inelastic Steel Moment Resisting Frames (SMRFs) to near-fault ground motions.

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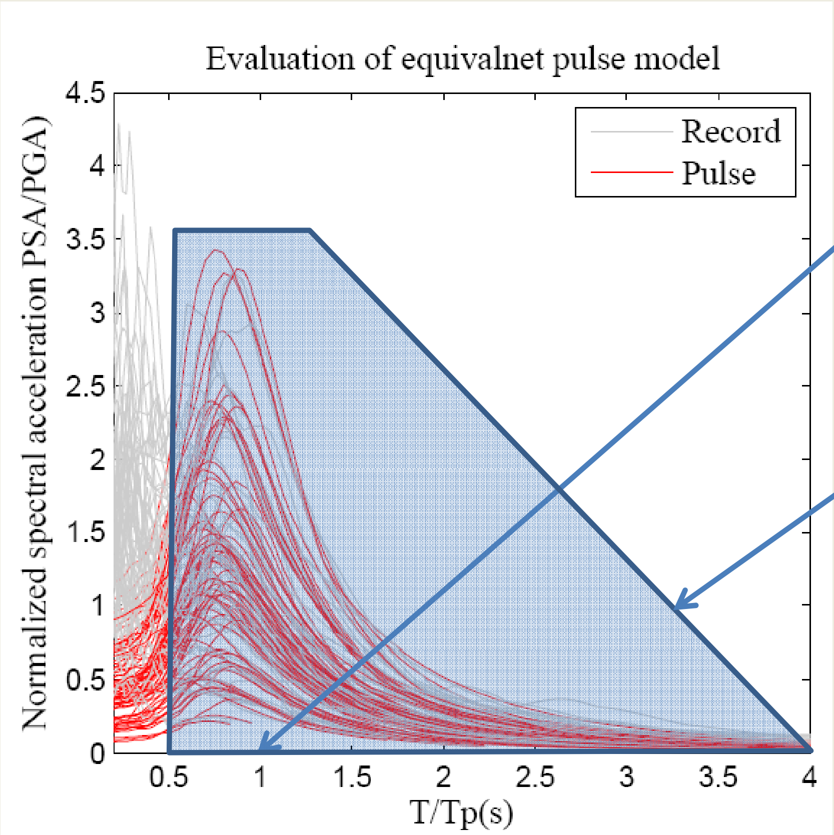
# Peculiar characteristics of near-fault ground motions

- ❖ Intense long-period velocity pulse
- ❖ Magnitude scaling of pulse period and structural response




72 near-fault ground motions

Peak response around pulse period

Good prediction by a simple pulse for normalized period greater than half the pulse period

COHERENT NATURE !

# STRUCTURAL SYSTEMS: Geometry and inertia

❖ Material : Steel

❖ Load resisting system : Moment Resisting Generic Frames

❖ Inertial properties : Equal lumped mass at each storey

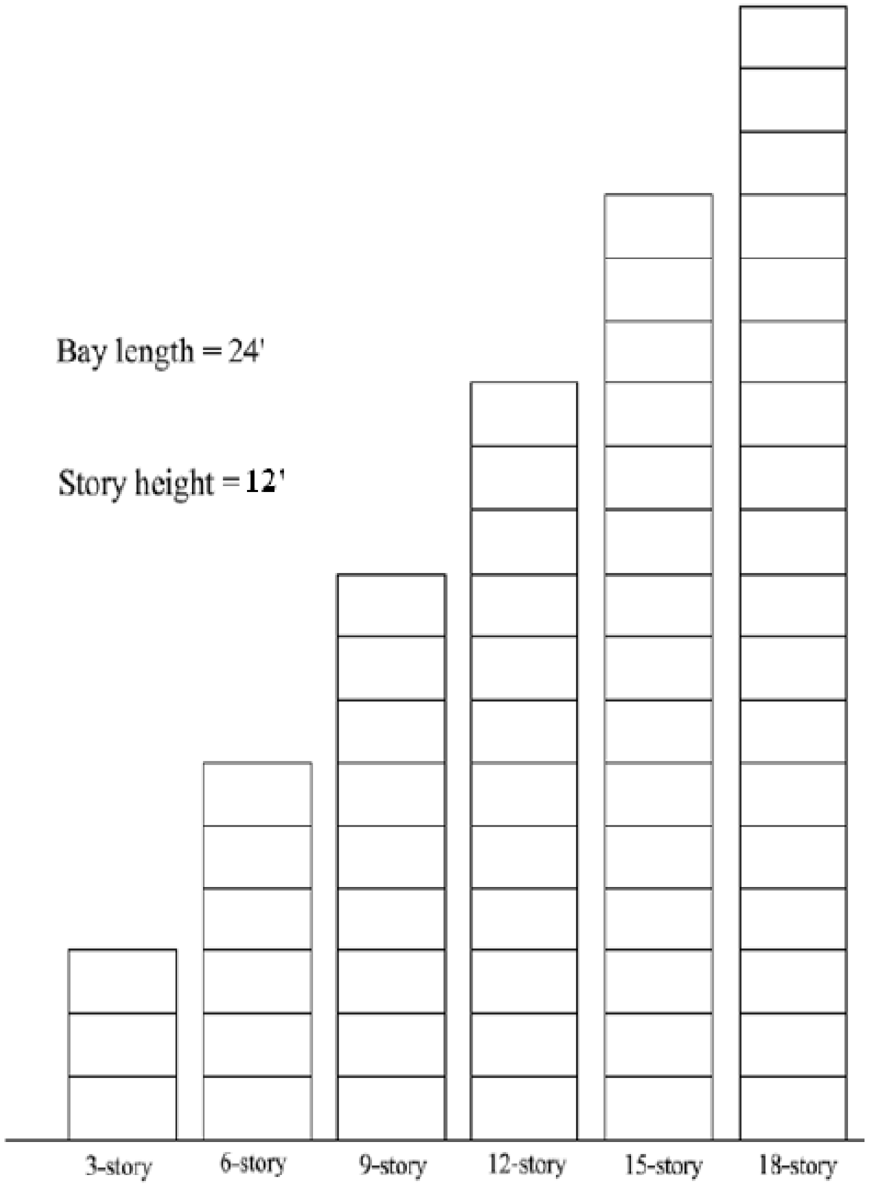
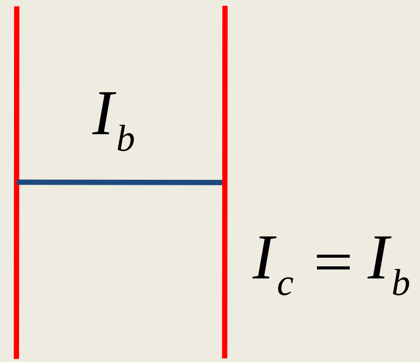


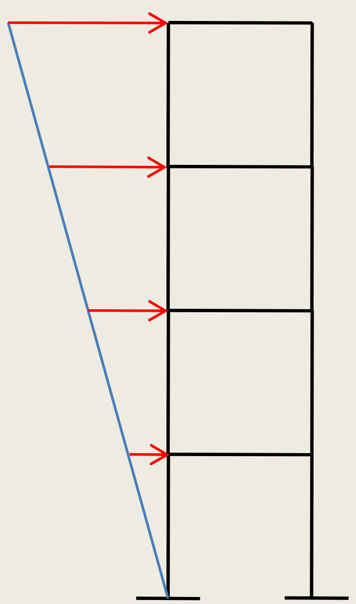

Figure 3-1: Generic 1-bay 3,6,9,12,15, 18-story frames used in this study.

# STRUCTURAL SYSTEMS: Stiffness

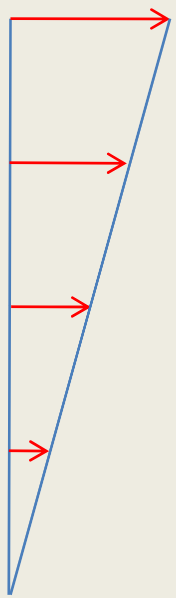
In each storey, the moment of inertia of the beam and the supporting columns is kept equal




The relative values of moment of inertia of beams at different stories is tuned so as to have linear first mode shape under the application of code specified lateral forces



*Distribution of lateral forces*



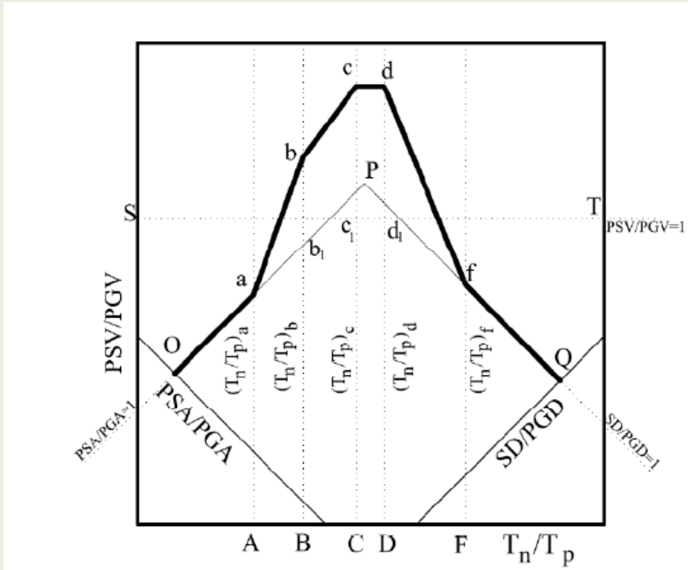
*First mode of vibration*

The absolute values of stiffness is scaled so as to have a
First mode vibration period given by the following equation (Chopra and Goel 1997)

$$T = 0.045H^{0.8}$$

# STRUCTURAL SYSTEMS: Strength

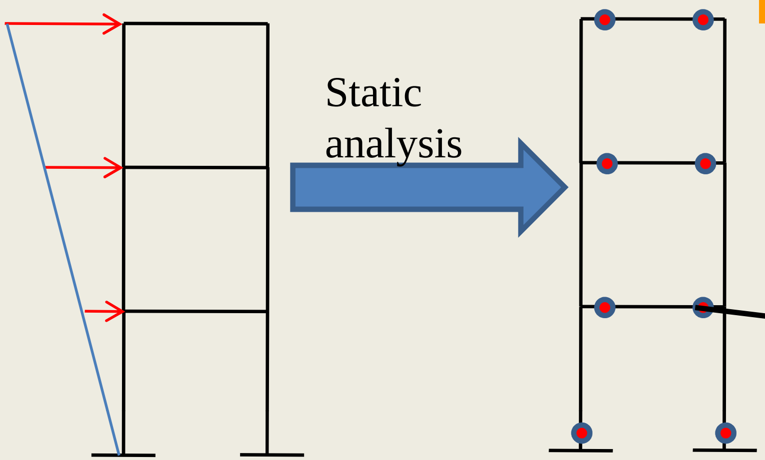
Elastic Response Spectra
: Mavroeidis et. al. 2004



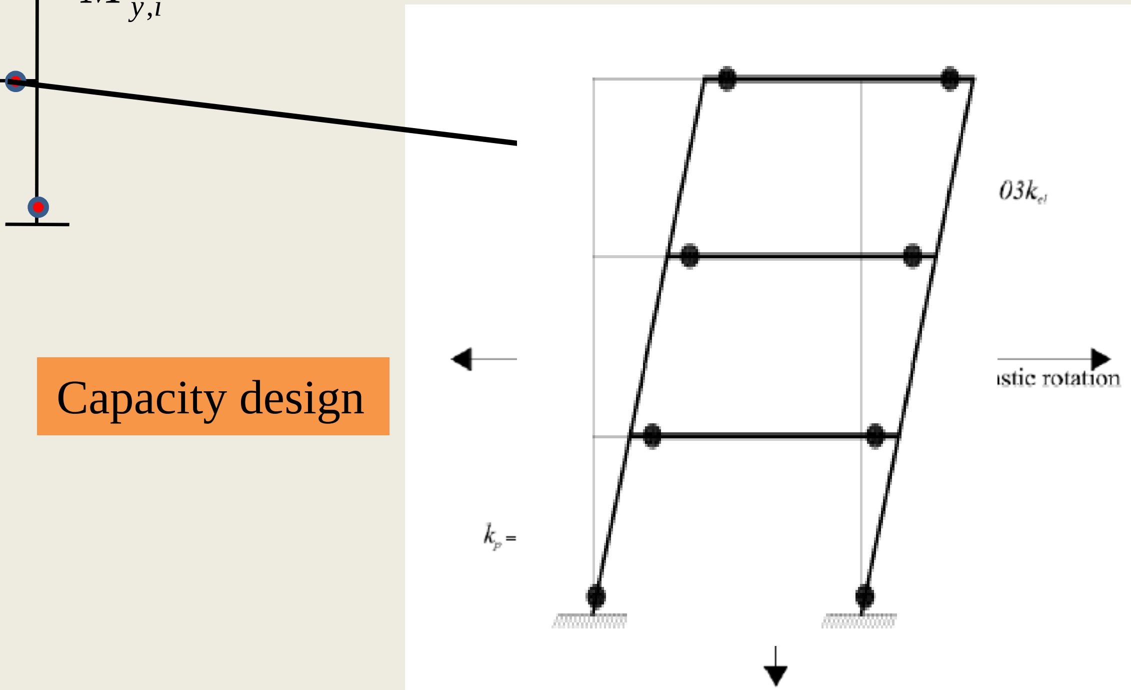

$$PSA = \frac{1.174}{T} g$$

$$V_b = PSA \times m$$

$$V_{by} = \frac{V_b}{\mu}$$




$M_{y,i}$

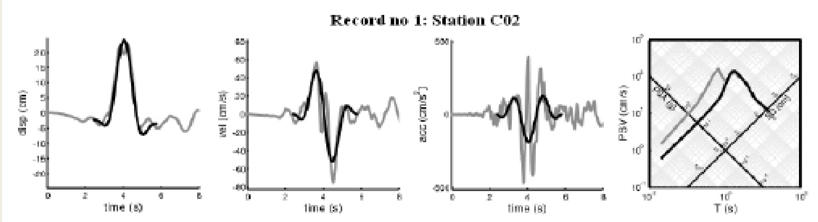


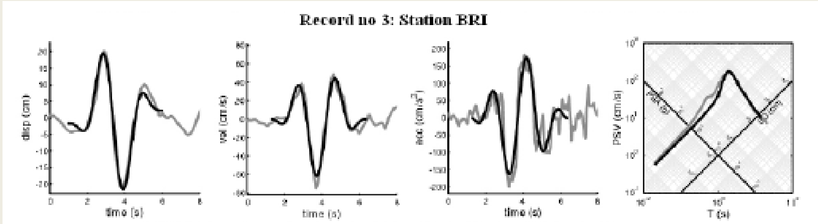

Capacity design

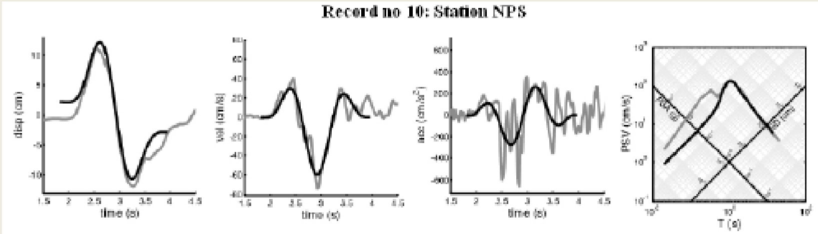
# Ground motions

20 ground motions records and the corresponding pulses fitted to them are used in structural analysis

| SN | Location | Station | $A$(cm) | $g$ | $\nu$(°) | $f_p$(Hz) |
|---|---|---|---|---|---|---|
| 1 | Parkfield,CA,U.S.A. | C02 | 60.00 | 1.70 | 100.00 | 0.50 |
| 2 | SAN Fernando, CA, U.S.A. | PCD | 115.00 | 1.60 | 180.00 | 0.68 |
| 3 | Bucharest, Romania | BRI | 62.00 | 2.40 | 200.00 | 0.47 |
| 4 | Tabas, Iran | TAB | 104.00 | 2.20 | 180.00 | 0.19 |
| 5 | Coyote Lake, CA, U.S.A. | GA6 | 48.00 | 1.55 | 315.00 | 1.00 |
| 6 | Imperial Valley, CA, U.S.A. | E04 | 71.00 | 1.90 | 305.00 | 0.23 |
| 7 | Imperial Valley, CA, U.S.A. | EMO | 78.00 | 2.30 | 0.00 | 0.34 |
| 8 | Mexicalli Valley, Mexico | VCT | 80.00 | 1.50 | 270.00 | 0.27 |
| 9 | Morgan Hill, CA, U.S.A. | HAL | 38.00 | 1.75 | 130.00 | 1.15 |
| 10 | Palm Springs, CA, U.S.A. | NPS | 60.00 | 1.70 | 170.00 | 0.80 |
| 11 | Superstition Hills, CA, U.S.A. | ELC | 46.00 | 1.65 | 210.00 | 0.43 |
| 12 | Superstition Hills, CA, U.S.A. | PTS | 112.00 | 1.80 | 237.00 | 0.45 |
| 13 | Loma Prieta, CA, U.S.A. | LGP | 60.00 | 3.00 | 280.00 | 0.31 |
| 14 | Loma Prieta, CA, U.S.A. | STG | 47.00 | 1.90 | 150.00 | 0.27 |
| 15 | Erzincan, Turkey | ERZ | 67.00 | 2.50 | 210.00 | 0.41 |
| 16 | Northridge, CA, U.S.A. | JFA | 87.00 | 2.30 | 100.00 | 0.33 |
| 17 | Northridge, CA, U.S.A. | RRS | 142.00 | 1.70 | 20.00 | 0.80 |
| 18 | Northridge, CA, U.S.A. | SCG | 93.00 | 2.50 | 0.00 | 0.34 |
| 19 | Aigion, Greece | AEG | 61.00 | 1.20 | 205.00 | 1.48 |
| 20 | Izmit, Turkey | ARC | 41.00 | 1.38 | 225.00 | 0.14 |

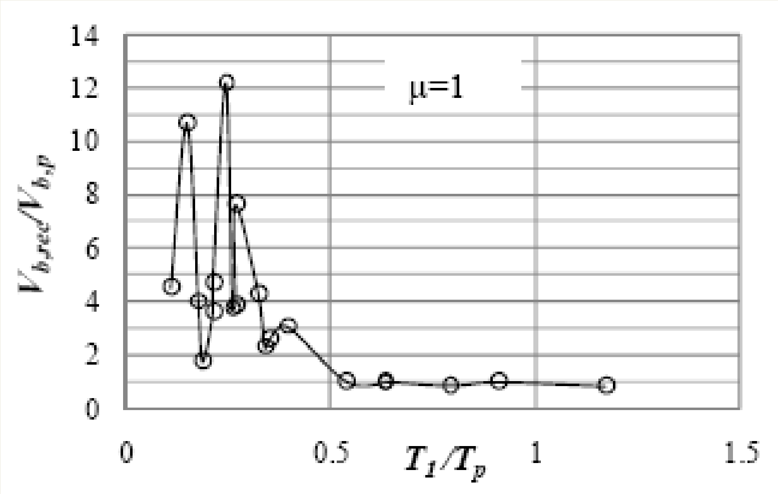


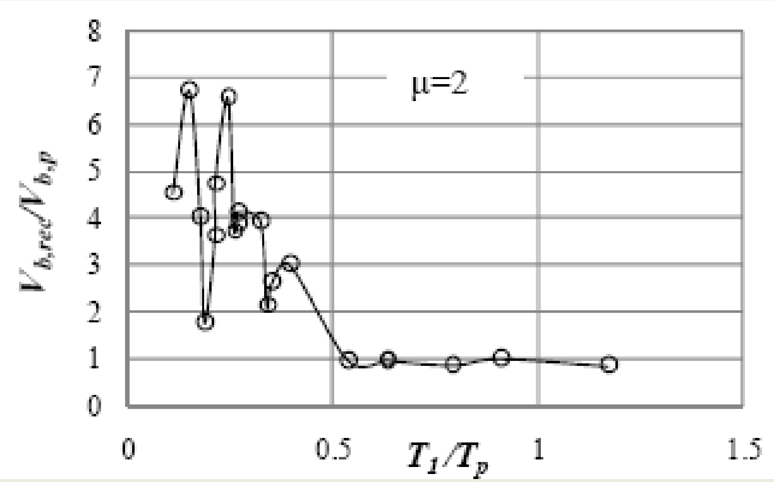



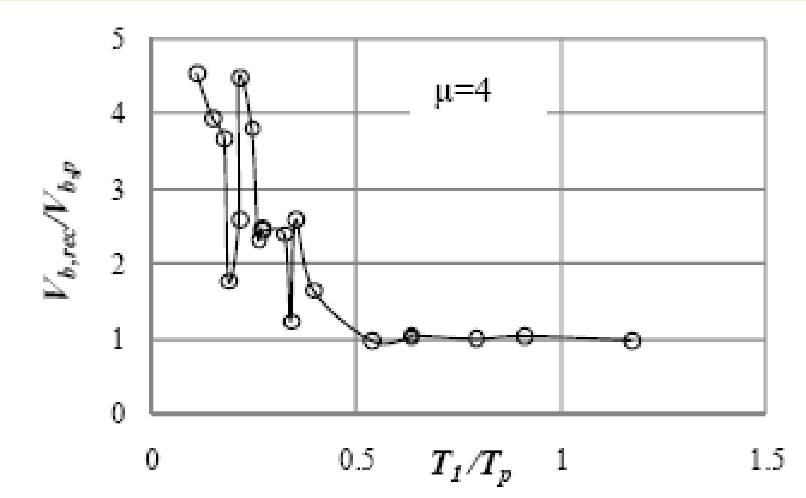



# Results : Prediction of base shear

3- storey building

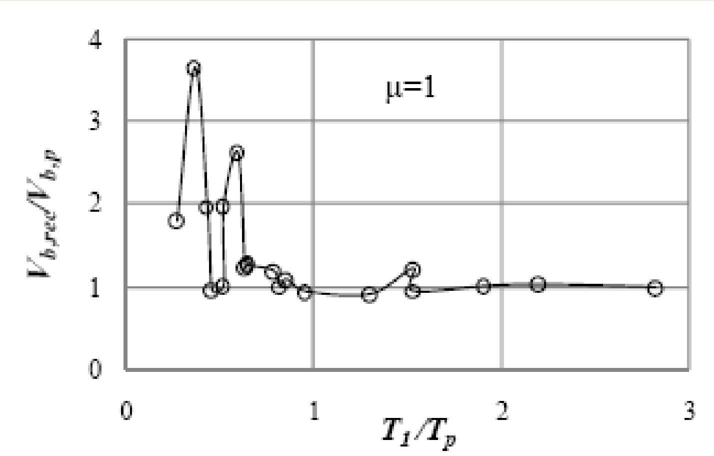


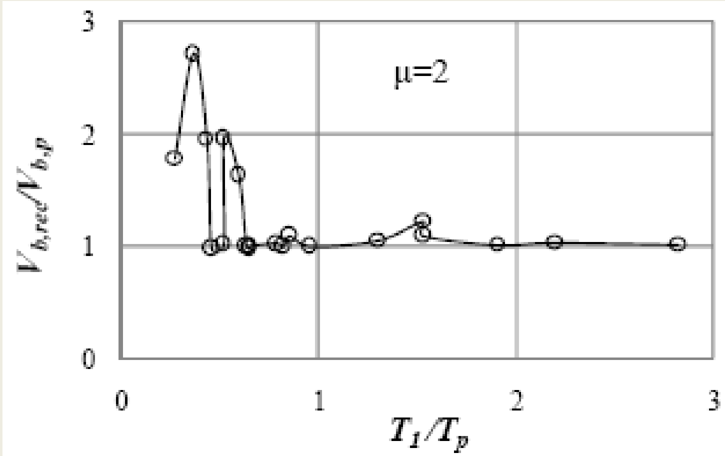



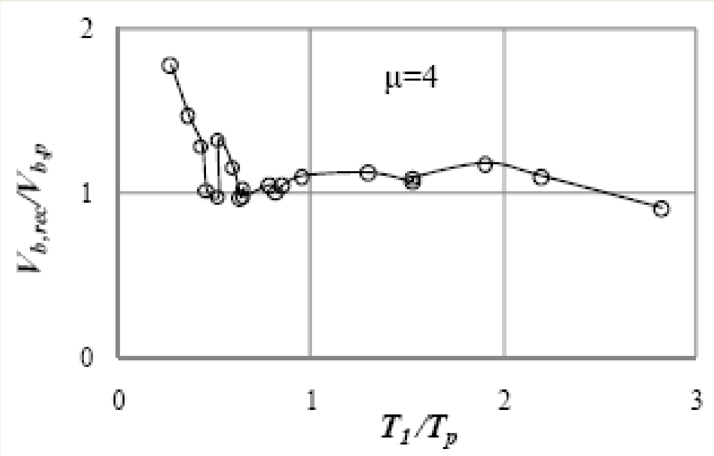



# Results : Prediction of base shear

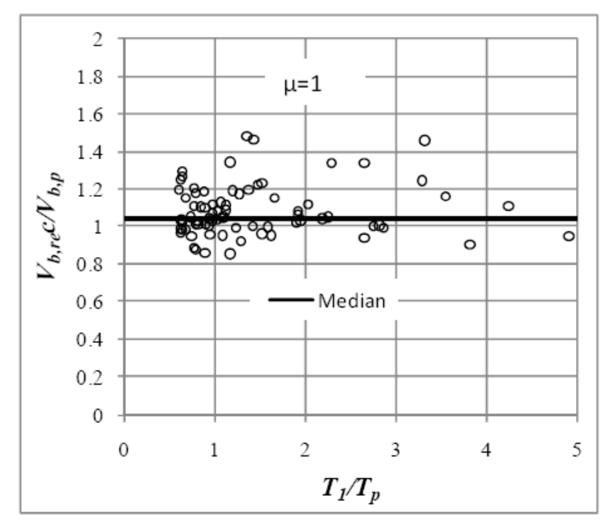
15- storey building

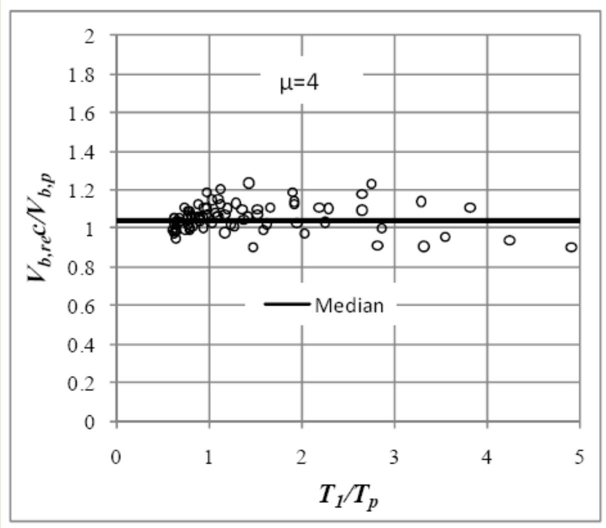


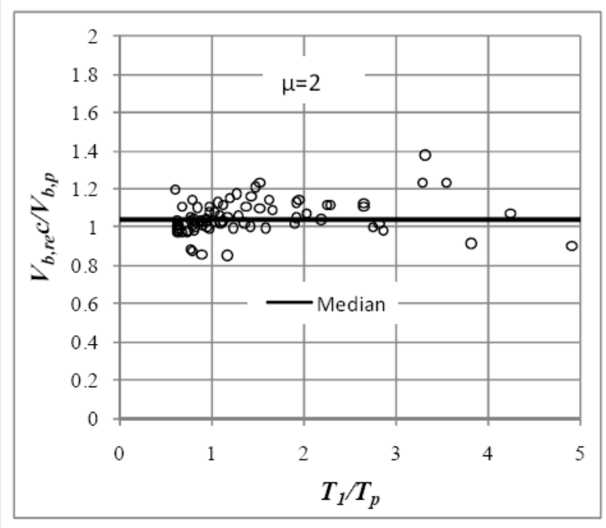



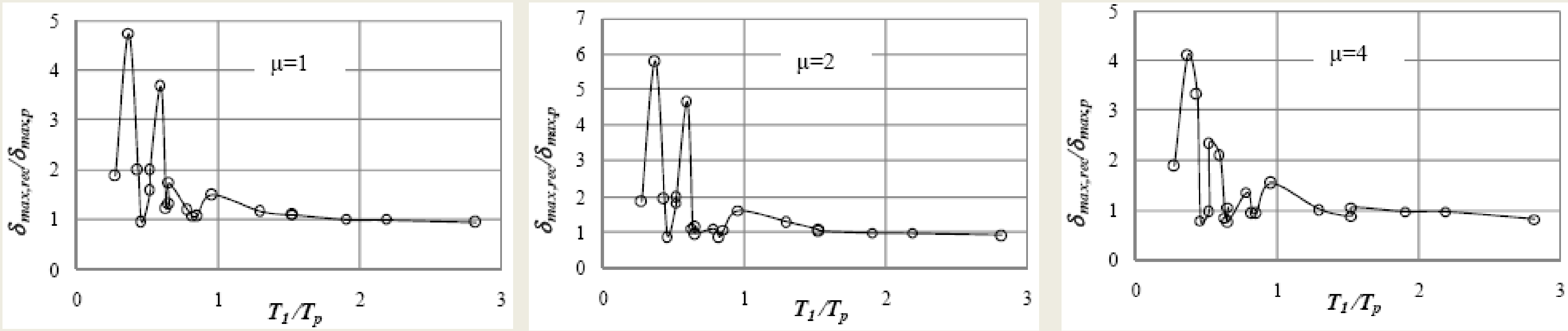
# Results : Prediction of median base shear



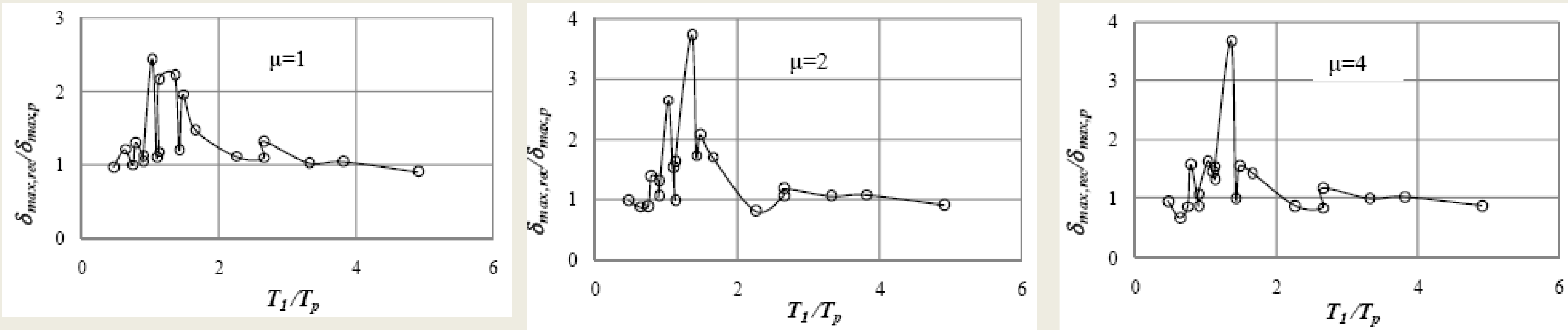



# Results : Prediction of maximum inter-story drift




9 Storey Generic frame




18 Storey Generic frame

# Conclusions

❖ The equivalent pulse model can efficiently predict the base shear demand of regular structures

❖ Prediction of maximum drift demand is also fairly accurate.

❖ It can predict well the distribution of drift along the height of the structure for frames up to 12 stories high, however higher mode effects can not be simulated by such narrow band deterministic models.

❖The equivalent pulses can be used in structural design verification resulting in a great saving of computational time

# Future work

❖ Analysis of structures with irregularities in stiffness and strength distribution.

❖ Incorporation of larger database of ground motions.

❖Development of simplified procedure to estime the base shear demand and inter-story drift as a function of pulse parameters and structural properties.