GROUND MOTION PREDICTION EQUATIONS FOR INELASTIC RESPONSE OF STRUCTURES

Rajesh Rupakhety,

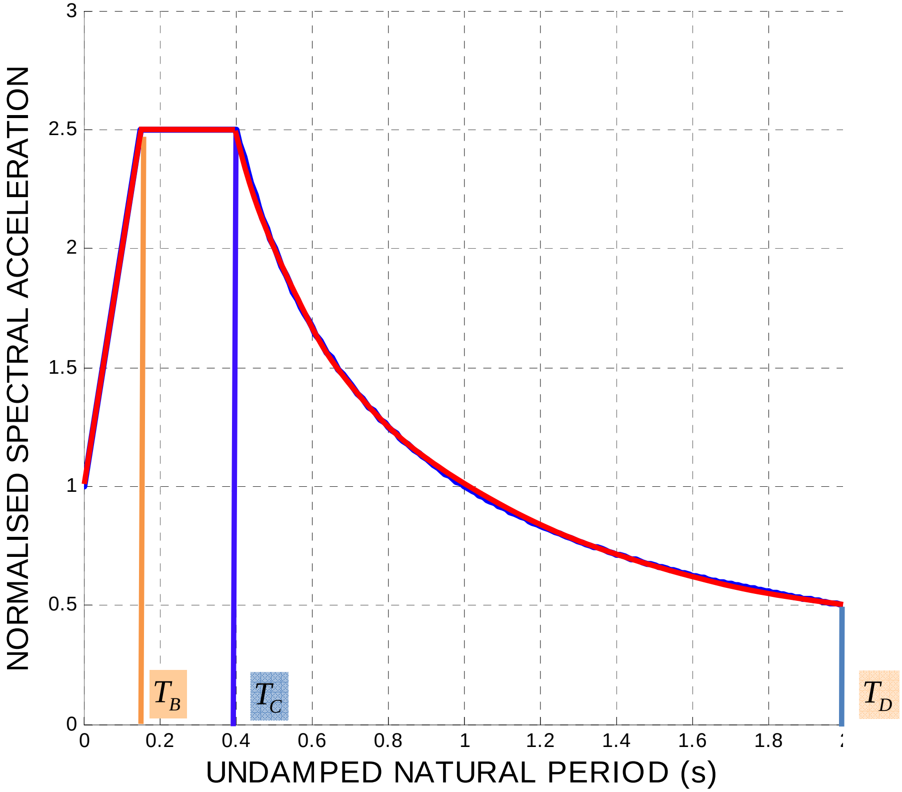
Ragnar Sigbjörnsson

EARTHQUAKE ENGINEERING RESEARCH CENTRE
UNIVERSITY OF ICELAND

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

Eurocode 8 Acceleration Spectra

Predefined shape scaled to PGA



$$S_e(T) = a_g S\left[1 + \frac{T}{T_B}(2.5\eta - 1)\right] \text{ for: } 0 \leq T \leq T_B$$

$$S_e(T) = 2.5 a_g S \eta \text{ for: } T_B \leq T \leq T_C$$

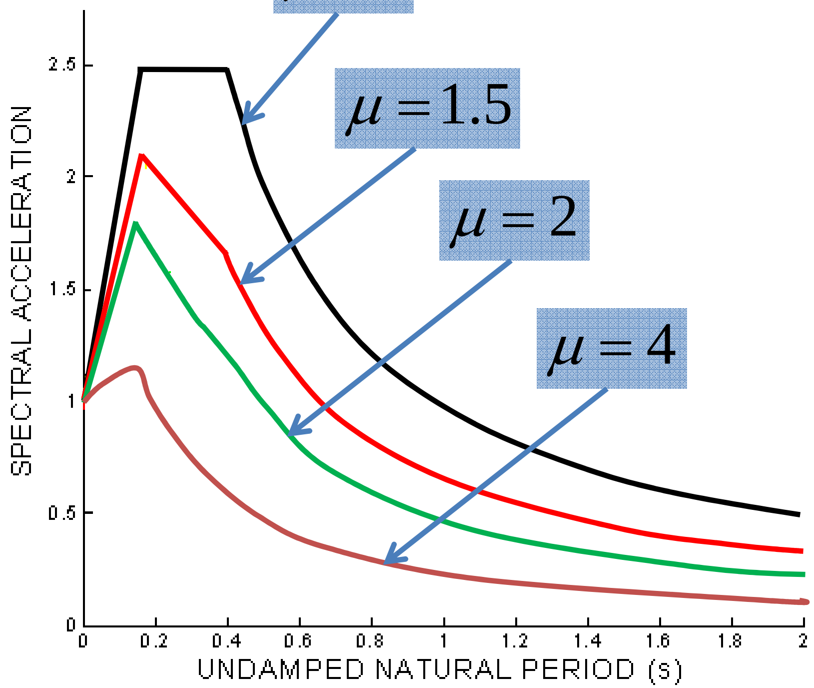
$$S_e(T) = 2.5 a_g S \eta \left(\frac{T_C}{T}\right)$$

Ground type	S	T_B(s)	T_C(s)	T_D(s)
A	1.0	0.15	0.4	2.0
B	1.2	0.15	0.5	2.0
C	1.15	0.20	0.6	2.0
D	1.35	0.20	0.8	2.0
E	1.4	0.15	0.5	2.0

Eurocode 8 : Inelastic effects

Inelastic design is required due to safety and economic reasons

Design for reduced forces allow inelastic deformation



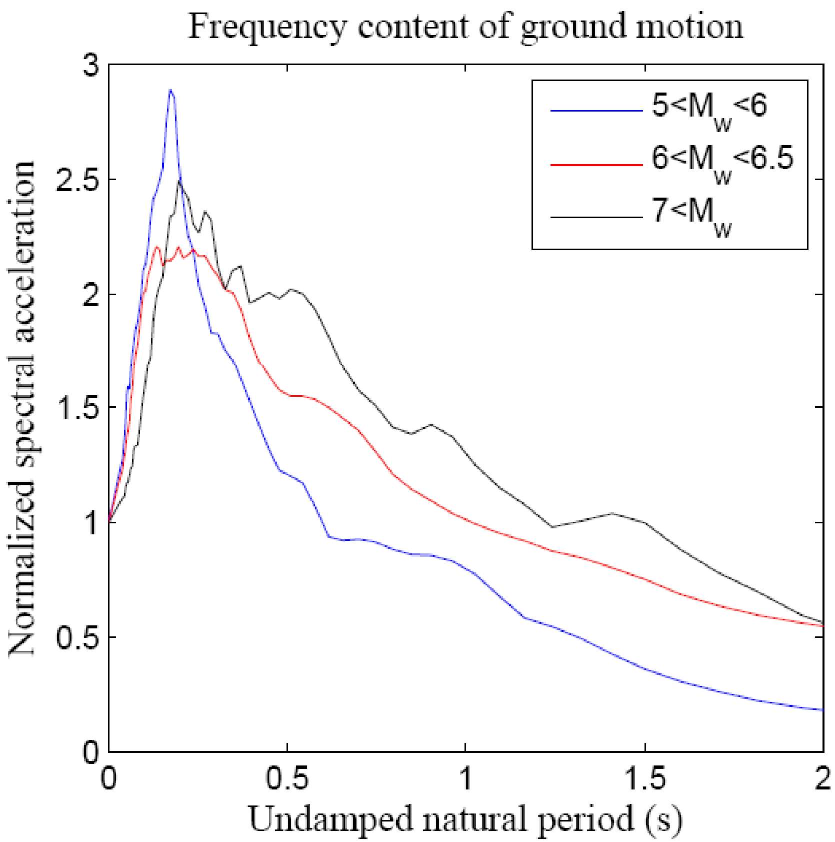
$$S_d(T,\zeta,\mu) = \frac{S_e(T,\zeta)}{q(T,\mu)}$$

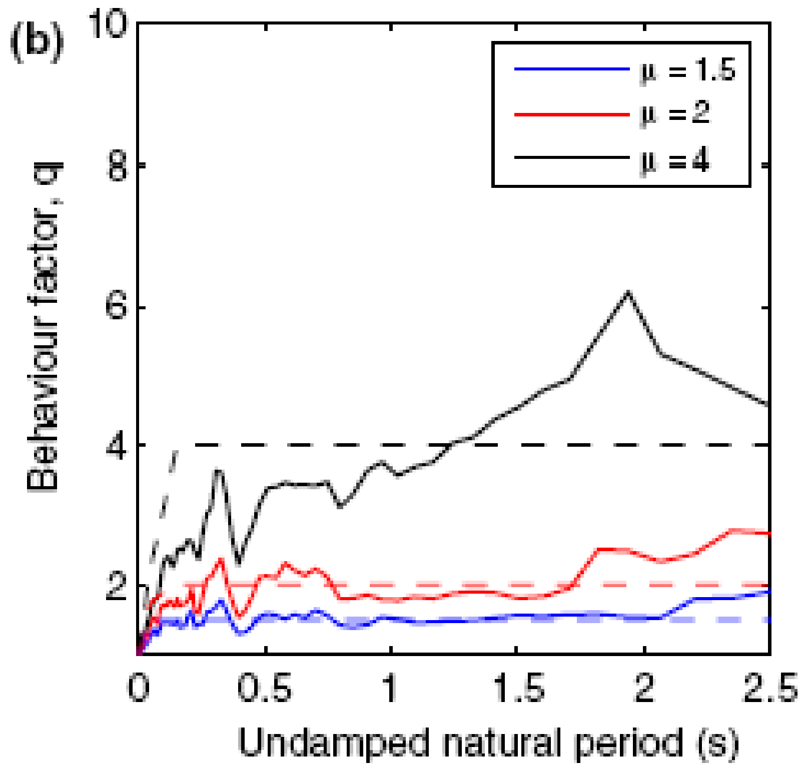
Structural behaviour factor

$q = \mu$ for $T \geq T_C$

$q = 1 + \frac{q-1}{T} T_C$ for $T < T_C$

Two basic problems





Very strong earthquakes induce the greatest response in the long-period range, while moderate earthquakes induce the greatest response in the short -period range.

Structural behaviour factor can not be described as simply as is done in Eurocode 8

The solution ?

Ground Motion Prediction Equations (GMPEs) for inelastic response of SDOF systems

Constant ductility systems

- Empirical equations to estimate capacity demand
- Incorporate in Probabilistic Seismic Hazard Assessment (PSHA)
- Useful results for designing structures

Constant strength systems

- Empirical equations to estimate ductility demand
- Incorporate in Probabilistic Seismic Demand Assessment (PSDA)
- Useful results for evaluating existing structures or verifying design

Methodology

Functional form

$$\log_{10}(S_a) = b_1 + b_2 M_w + b_3 \log_{10}\sqrt{d^2 + b_4^2} + b_5 S$$

Site factor
S = 0 for ground type A
S= 1 for ground type B and C

Normalized yield strength

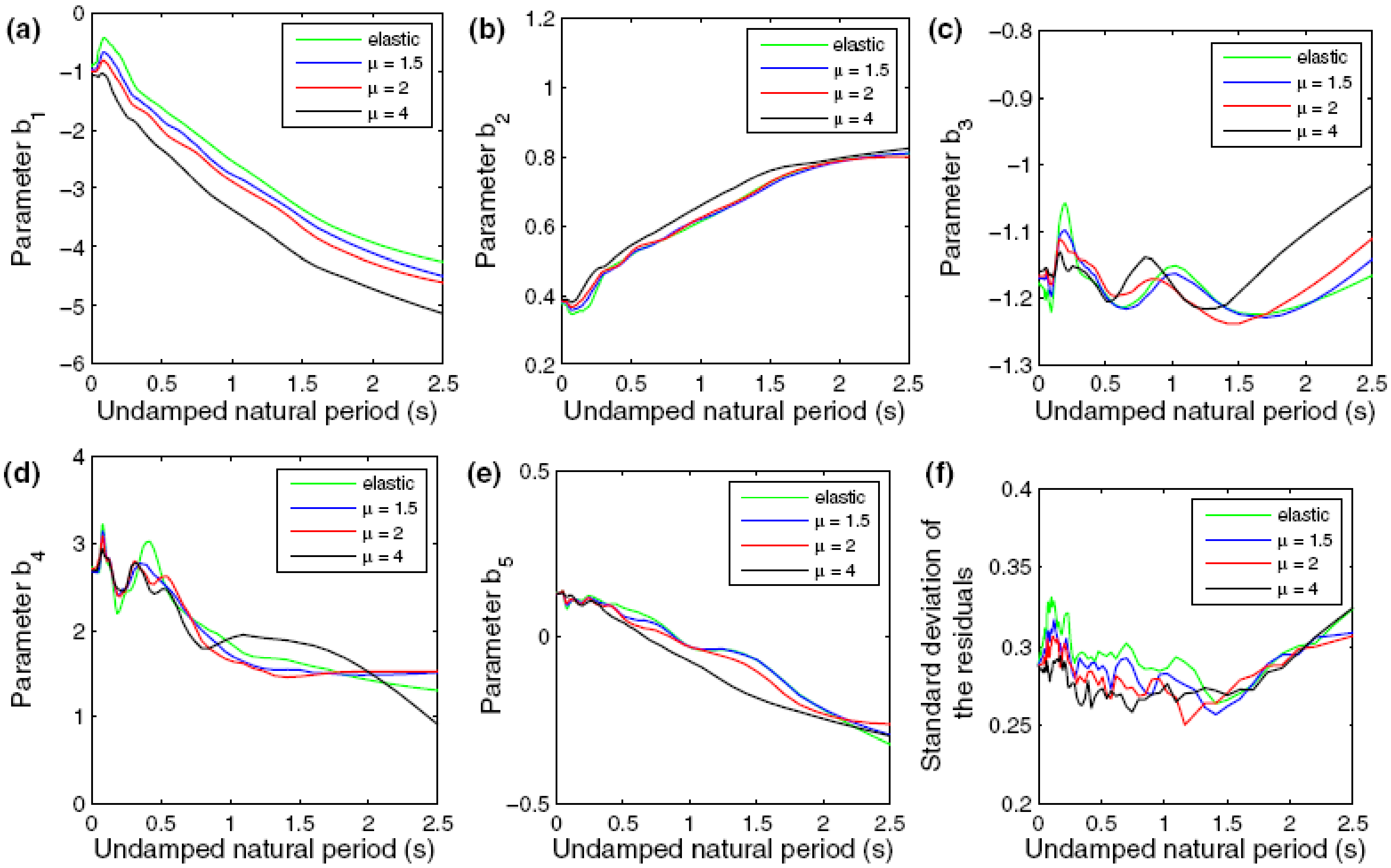
Moment magnitude

Distance from site to surface projection of fault

Data applied

- ❖ 182 acceleration records obtained from Iceland, continental Europe and the Middle East
- ❖ The component which gives higher spectral acceleration is chosen
- ❖ Shallow crustal earthquakes with strike slip mechanism
- ❖ Magnitude range from 5 to 7.7 and distance range from 1 to 97 km

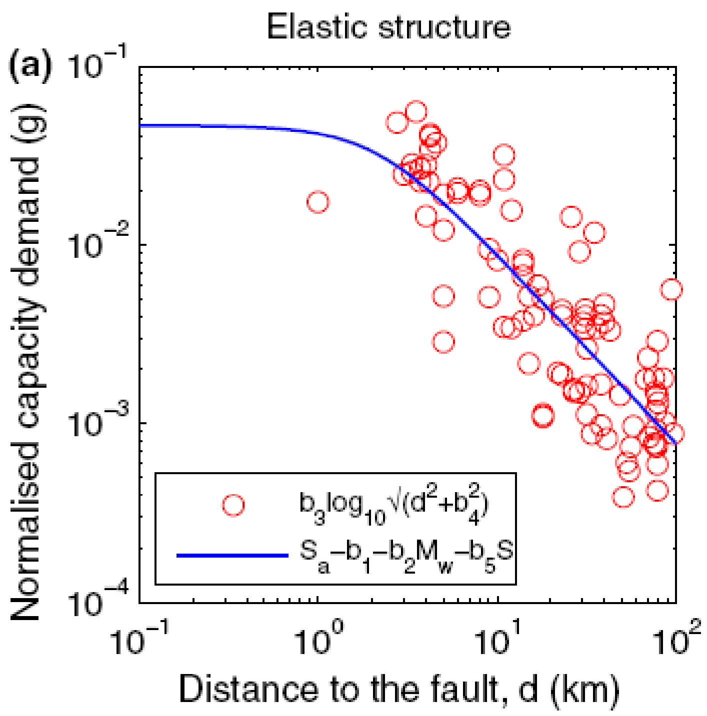
Results : Constant ductility systems

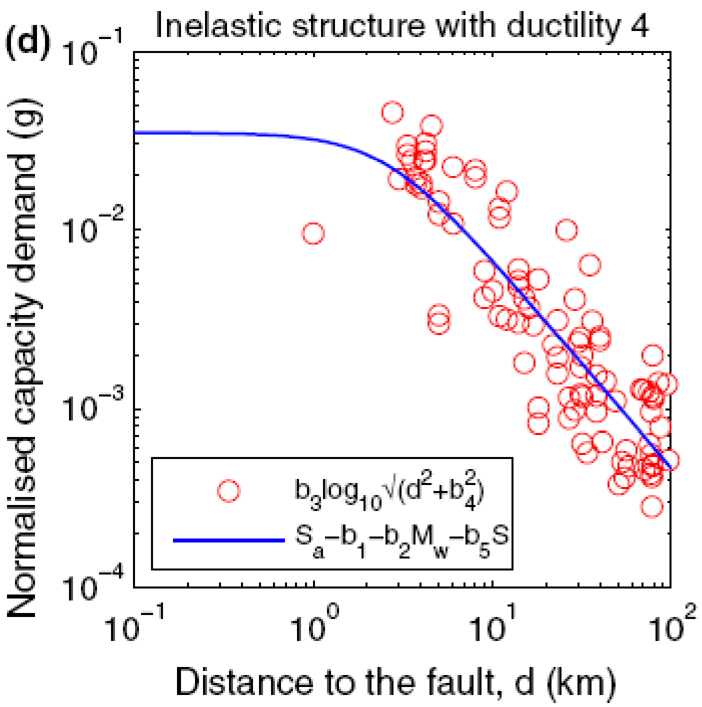


Results : Model parameters

Results : Constant ductility systems

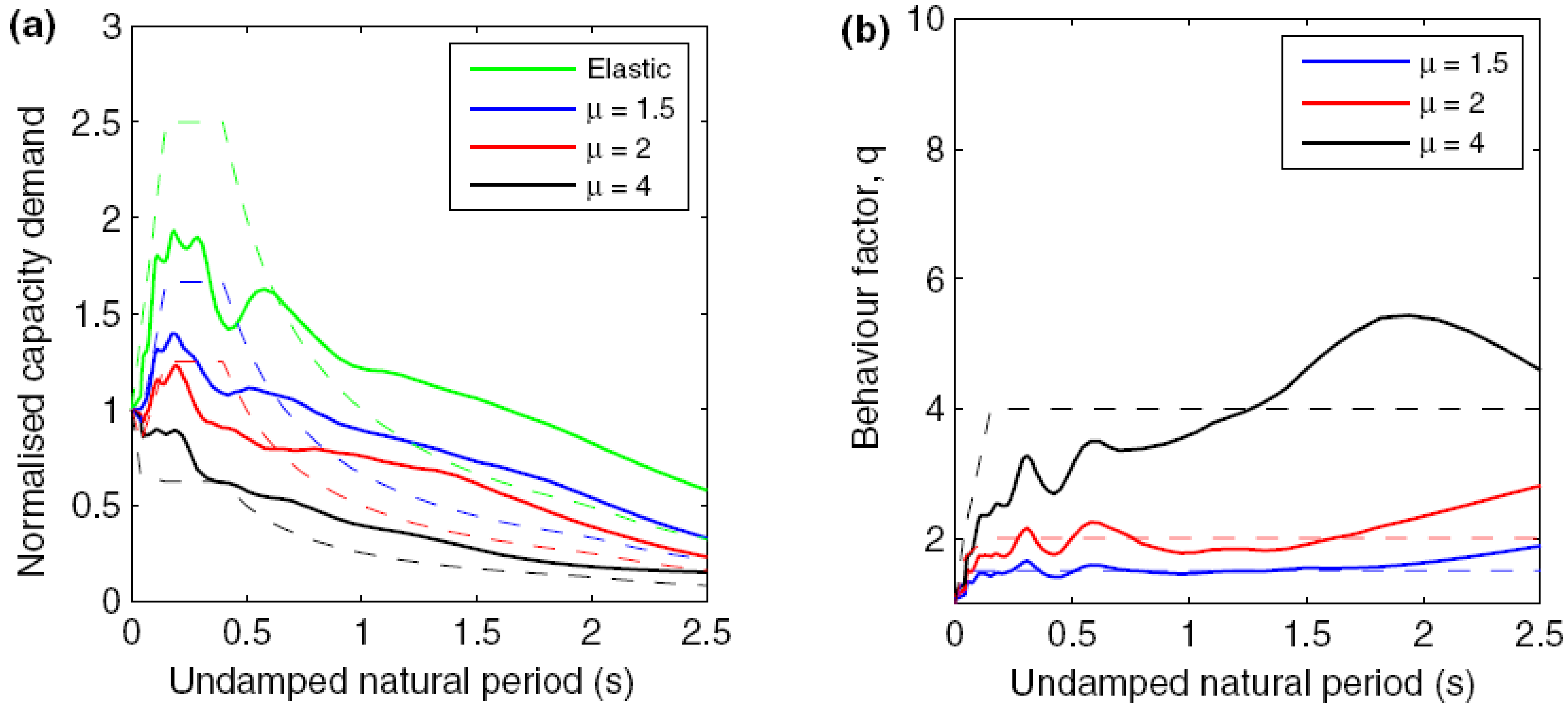
Results : Comparison of data and the model.





Results : Constant ductility systems

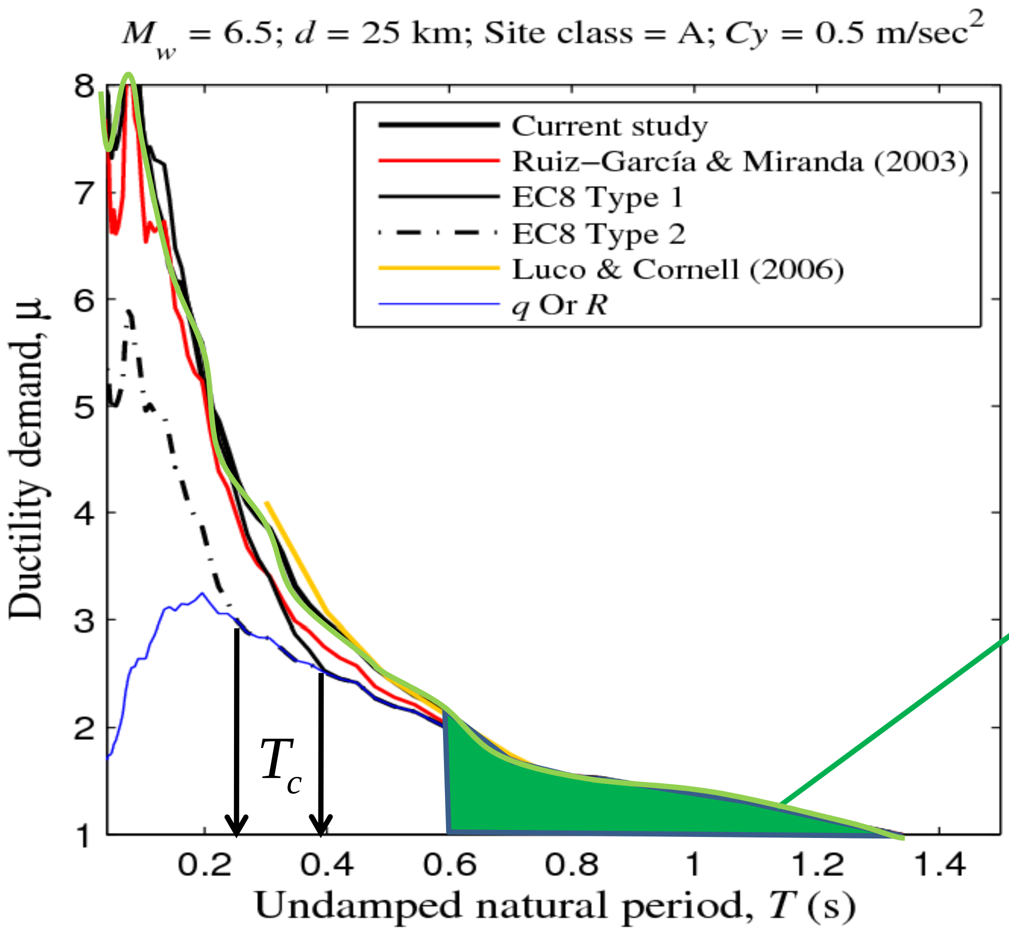
Results : Capacity demand and structural behaviour factors



Moment magnitude = 6.5 ; d = 1 km and rock site

Results : Constant strength systems

Results : comparison with Eurocode 8 and results of other Researchers



Equal displacement rule

Conclusions

❖ Predictive equations are proposed to compute the strength and ductility demands of inelastic structures

❖Inelastic response is modelled as a function of earthquake magnitude, source-to-site distance and ground type, thus avoiding the use of the two step procedure including elastic spectra and structural behaviour factors

❖Inelastic response can be predicted at similar level of uncertainty as their elastic counterparts

Future works

❖ Incorporating the proposed models in PSHA to produce uniform hazard spectra and probabilistic seismic zoning maps for Iceland

❖Using the proposed model in PSDA to perform strucutral evaluation.

❖Extending the proposed models with an extensive dataset for application in the European region and modelling of directivity effects.

Thank you for your attention.