



# Chilean Requirements and Practice for Hospital's Vulnerability Mitigation

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# Public Hospital's Vulnerability Mitigation

Design criteria require peer review for  
Hospital Vulnerability Mitigation, including:

- Seismic structural
- Seismic non-structural
- Strong winds
- Snow and ice
- Floodings due to rain
- Floodings due to pressurized pipes bursts
- Floodings due to broken sanitary sewers
- Storm lightnings
- Soils
- Flotation by elevation of the water table
- Electrical
- Fires

- Communications
- Security and vandalism
- Potable water supply
- Clinical gases
- Vertical transportation
- Emergency evacuation
- Air conditioning
- Fuel spills
- Accessibility
- Medical equipment
- Helipad

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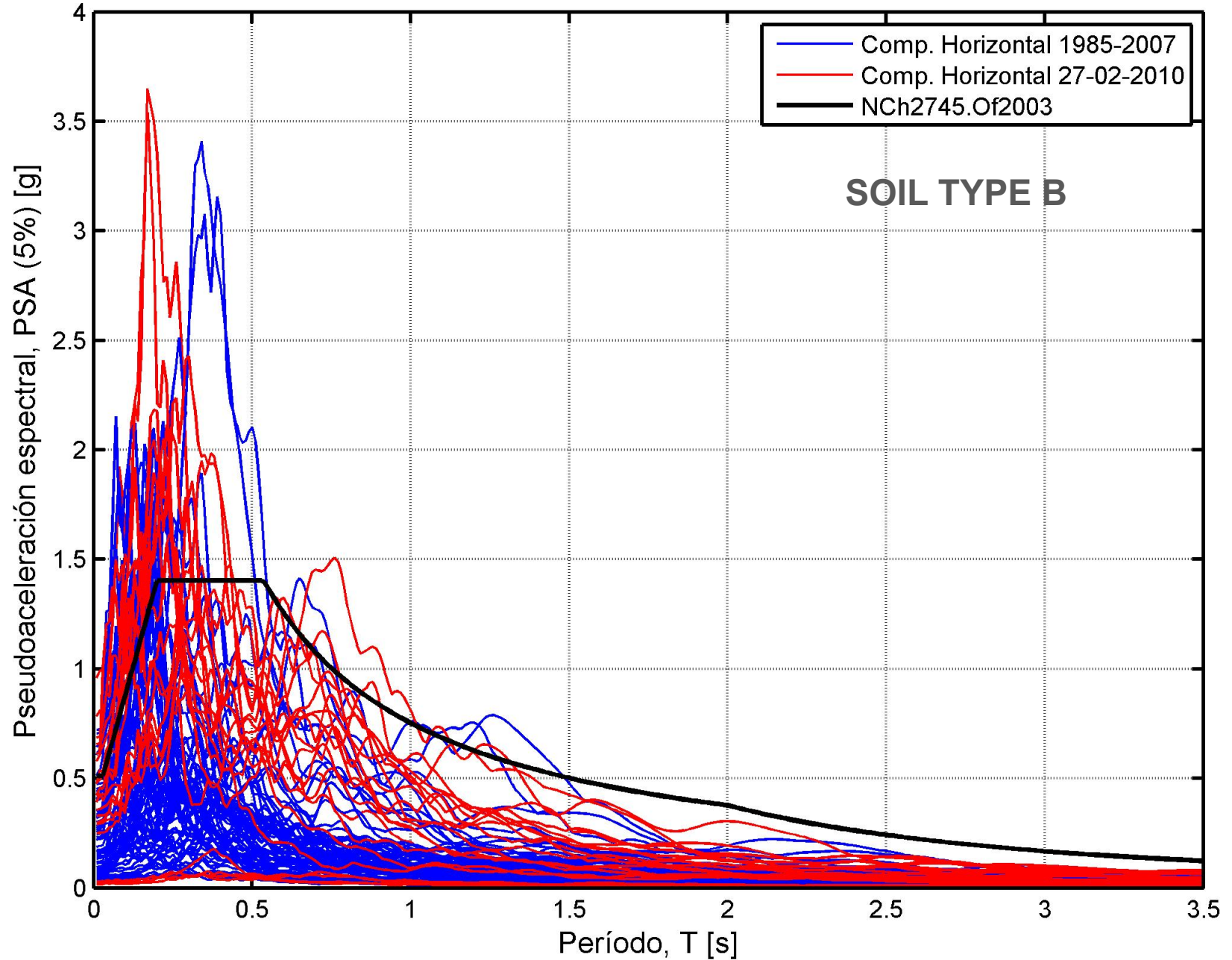
# Public Hospital's Vulnerability Mitigation

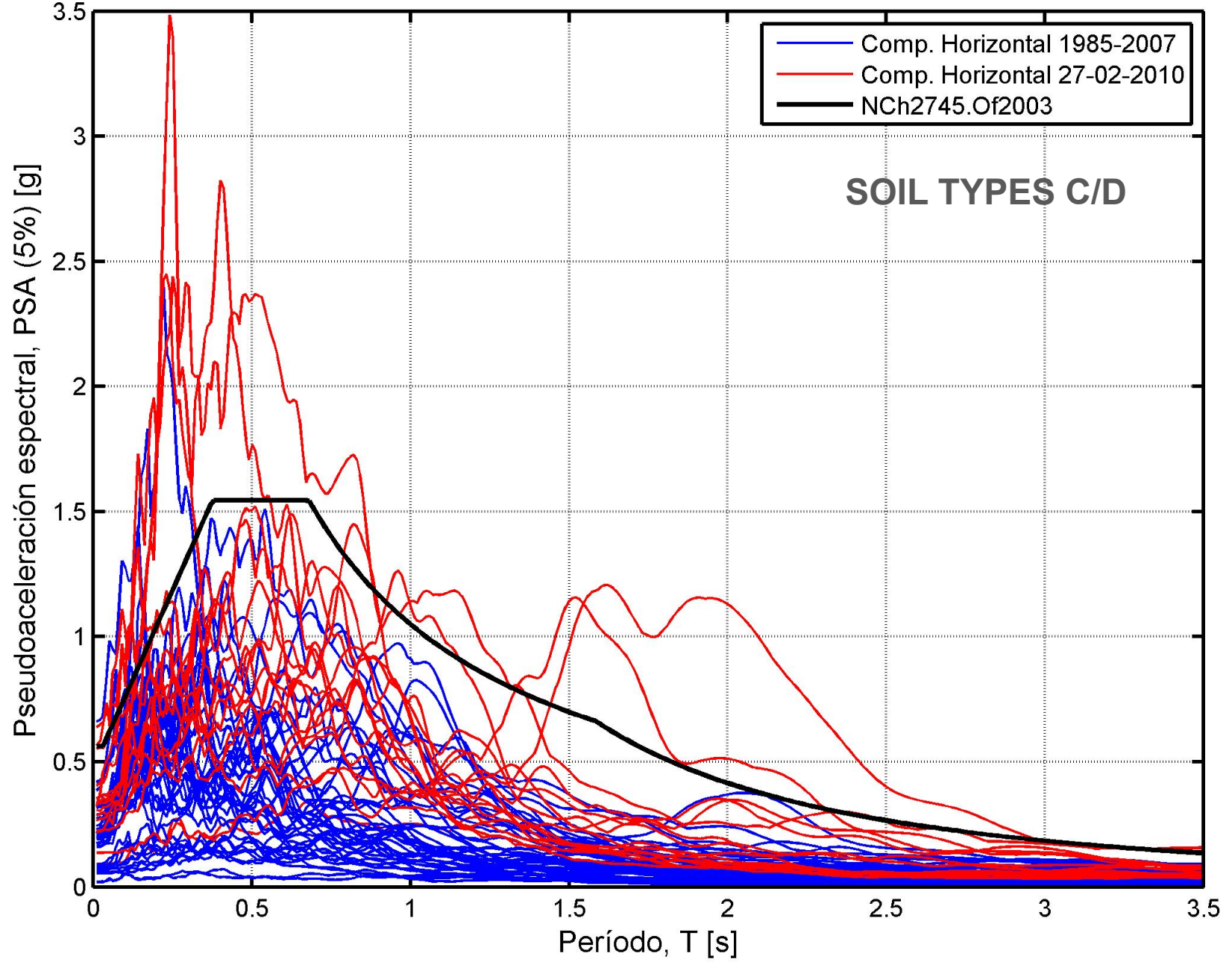
- Seismic isolation used in all facilities with 3 or more levels built
- Isolated structures designed using NCh2745: Analysis and design of buildings with seismic isolation
- Nonstructural components and systems designed using NCh3357

# Chilean Code for Seismic Isolation

Based on UBC 97 and ASCE/SEI 7-2010 provisions with some minor variations, including:

- PGA's for DBE and MCE determined probabilistically
  - ✓ 10% PE in 50 yrs for DBE
  - ✓ 10% PE in 100 yrs for MCE
- $PGA_{MCE}/PGA_{DBE}=1.2$
- Structure designed for DBE and seismic isolation designed for MCE
- Spectral shapes envelope all recorded ground motions



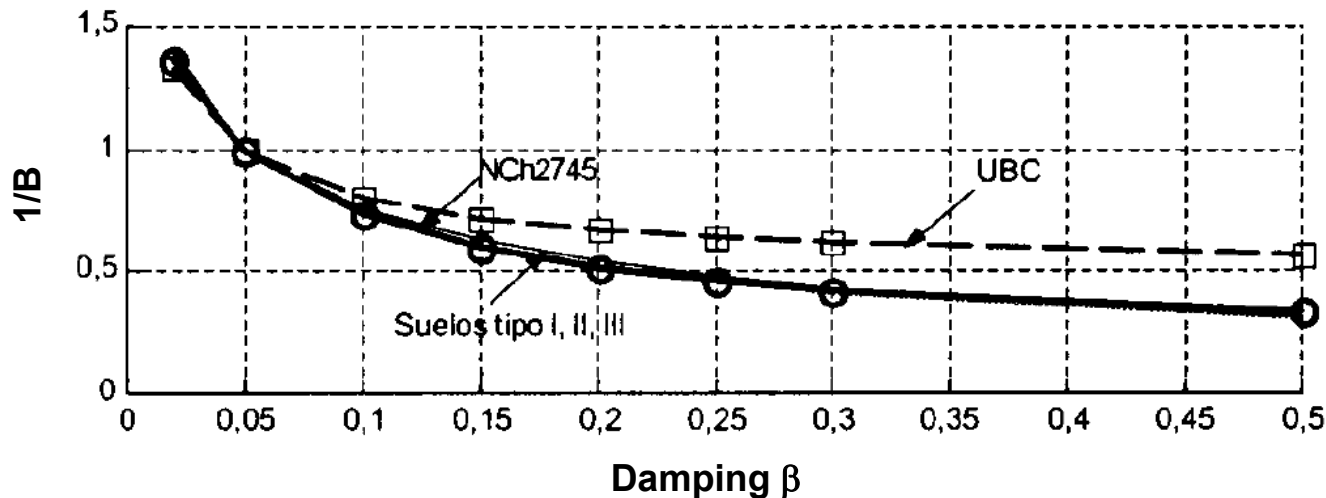




# Chilean Code for Seismic Isolation

Based on UBC 97 and ASCE/SEI 7-2010 provisions with some minor variations, including (Cont'd):

- $B_M$  and  $B_D$  damping reduction factors according to characteristics of Chilean earthquakes (wide frequency content and duration)





# Chilean Code for Seismic Isolation

Based on UBC 97 and ASCE/SEI 7-2010 provisions with some minor variations, including (Cont'd):

- Response modification factors for superstructures in the range 1-2 and equal to 1.5 for substructures
- Limit maximum normalized story drifts under DBE/R to  $\delta_{\text{Max}} < 0.0025$  (0.003 if NLTHA is used)
- Design base shear for the structure shall not be less than  $0.05 - 0.07 W_s$
- Seismic design forces shall be amplified by a 1.4 factor

# Chilean Code for Seismic Isolation

Based on UBC 97 and ASCE/SEI 7-2010 provisions with some minor variations, including (Cont'd):

- Superstructures can be detailed as intermediate moment resistant frames
- Resulting  $T_M$ 's typically in the range 3-4 sec
- Resulting  $D_{TM}$ 's typically in the range 35-45 cm
- Limit minimum isolation vertical frequency to  $f_v > 10$  Hz
- Testing 100% elastomeric bearings and 15% friction pendulums

# Additional requirements from Hospital's Design Criteria

In addition to code requirements, Hospital's design criteria requests:

- Probabilistic seismic hazard analysis shall be performed for all projects
- Lambda factors from ASCE/SEI 7-16 shall be considered
- Only elastomeric (NR or LRB) bearings are allowed, in combination with flat (non lubricated) sliders if needed
- The total service load on sliders shall not exceed  $0.25W_s$

# Additional requirements from Hospital's Design Criteria

In addition to code requirements, Hospital's design criteria requests (Cont'd):

- Maximum service load on a single slider shall not exceed 150 Tonf
- Bearings safety factors shall be greater than 3 for service loads and greater than 1 for seismic loads

- Rubber strains shall fulfill: 
$$\frac{D_{TM}}{h_r} + \frac{P_r}{GA_r S} \leq \frac{0.85\varepsilon_u}{1.5}$$

where  $\varepsilon_u$  shall be considered less or equal than 600%

# Additional requirements from Hospital's Design Criteria

In addition to code requirements, Hospital's design criteria requests (Cont'd):

- Capital's dimensions shall be greater than  $D_e + 90$  cm
- An initial 50 mm displacement due to eventual concrete shrinkage shall be considered
- The initial displacement shall be added to  $D_{TM}$
- Uplift or tension forces on bearings are not allowed
- Distributed nonstructural systems shall be placed 1.5 m away from the bearings

# Additional requirements from Hospital's Design Criteria

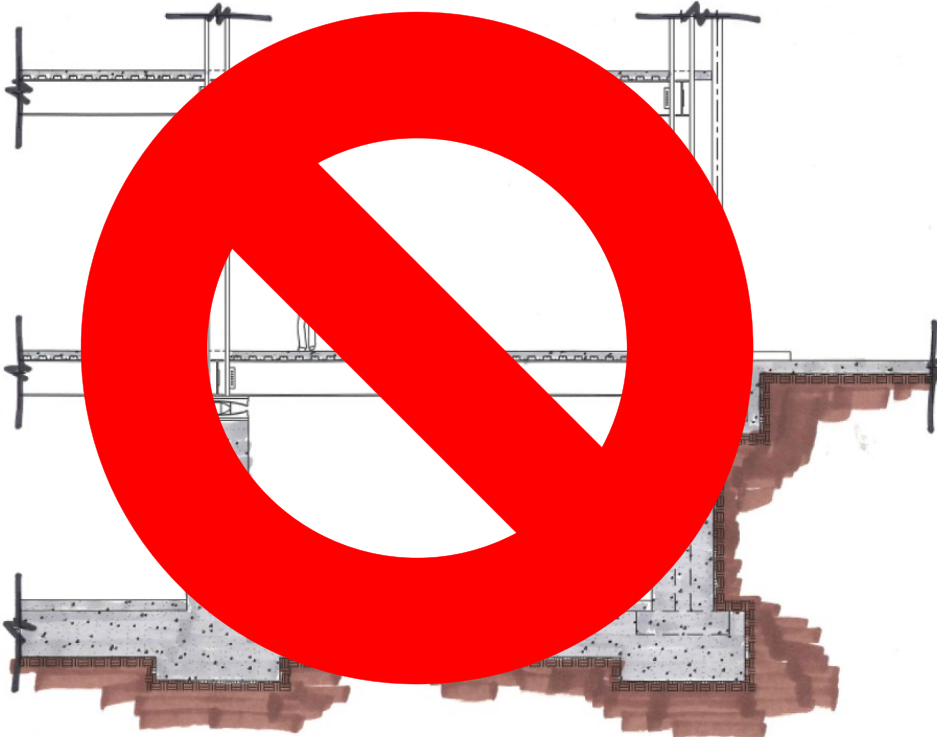
In addition to code requirements, Hospital's design criteria requests (Cont'd):

- Gap defined probabilistically to prevent impact
  - ✓ 10% probability of impact for MCE and
  - ✓ 5% probability of impact for DBE
- Gap defined considering  $\beta > 0.5$
- Using fire protection blankets (subjected to 10 displacement cycles at  $D_{TM}$  before fire tests) to keep superficial temperature in the bearings below 140 °C during 120-180 mins

# Additional requirements from Hospital's Design Criteria

In addition to code requirements, Hospital's design criteria requests (Cont'd):

- Beams shall be considered above and below the seismic isolation





**Thank You!**