Present Status of Earthquake Preparedness Activities in Chile

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The present situation and status of the different activities related to Earthquake Preparedness activities in Chile are described. The activities are divided in three groups: Codes and Standards, Structural and Seismic Review procedures, and Building Permits procedures.

Codes and Standards:

In Chile, the codes related to earthquake engineering practice are divided into two major groups: the first defining the loads and actions, and the other dealing with materials behavior, strength, and detailing requirements. The overall characteristics of these codes are discussed. Special emphasis is given to the seismic design code provisions that define the expected level of earthquake action, depending on building characteristics and site soil conditions. A seismic zoning map (based on a given level of probability of exceeding maximum ground acceleration) is included in the codes. Two different analysis procedures are allowed: an equivalent lateral forces procedure where torsion is considered through an amplification of the static torsion in the building; and the standard response spectrum analysis method with a three degree of freedom per story model of the building. The maximum responses of the different modes are combined using the CQC combination rule. Additional restrictions are imposed to torsion effects, and to overall building deformations. Some ideas being discussed for the revision of the code are presented. A brief description of the main changes that the codes have undergone in the last 25 years is described and how these changes were prompted by significant earthquakes is briefly described.

Structural and Seismic Review:

Starting in 2003 and implemented in a gradual manner the local authorities required, with the support of the Chilean Association of Structural Engineers, that for all buildings the structural and earthquake engineering projects of the buildings shall be reviewed by an independent reviewer, from a rooster of authorized professionals kept under the authority of the Ministry of Housing.

This review has become a well established process and all projects need now to undergo the review before the actual construction permits can be issued.

Building Permits Procedures:

A brief description of the process that is required to obtain building permits is provided. Before construction can start, the project drawings (architectural and structural) and a set of construction specifications need to be submitted for approval to the local Municipality. This process is required for all buildings, but for public utility buildings (schools, hospitals, police stations, Fire fighting stations, communication centers, etc.) and for office and residential buildings of more than 5 stories the project has to include also the approval by an independent reviewer.

The estimated number of existing buildings which do not conforming to the current building code and their characteristics is briefly discussed, in particular for: schools, hospitals, public facilities, residential and office buildings and non-engineered buildings.

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Codes and Standards:

The different codes related to the practice of earthquake engineering can be grouped into three major groups:

1) Definition of Loads or Actions

2) Material Behavior, Design, and Detailing

3) Earthquake Codes

The actual names, the dates since their last revision, and their current status are shown in the following slide.

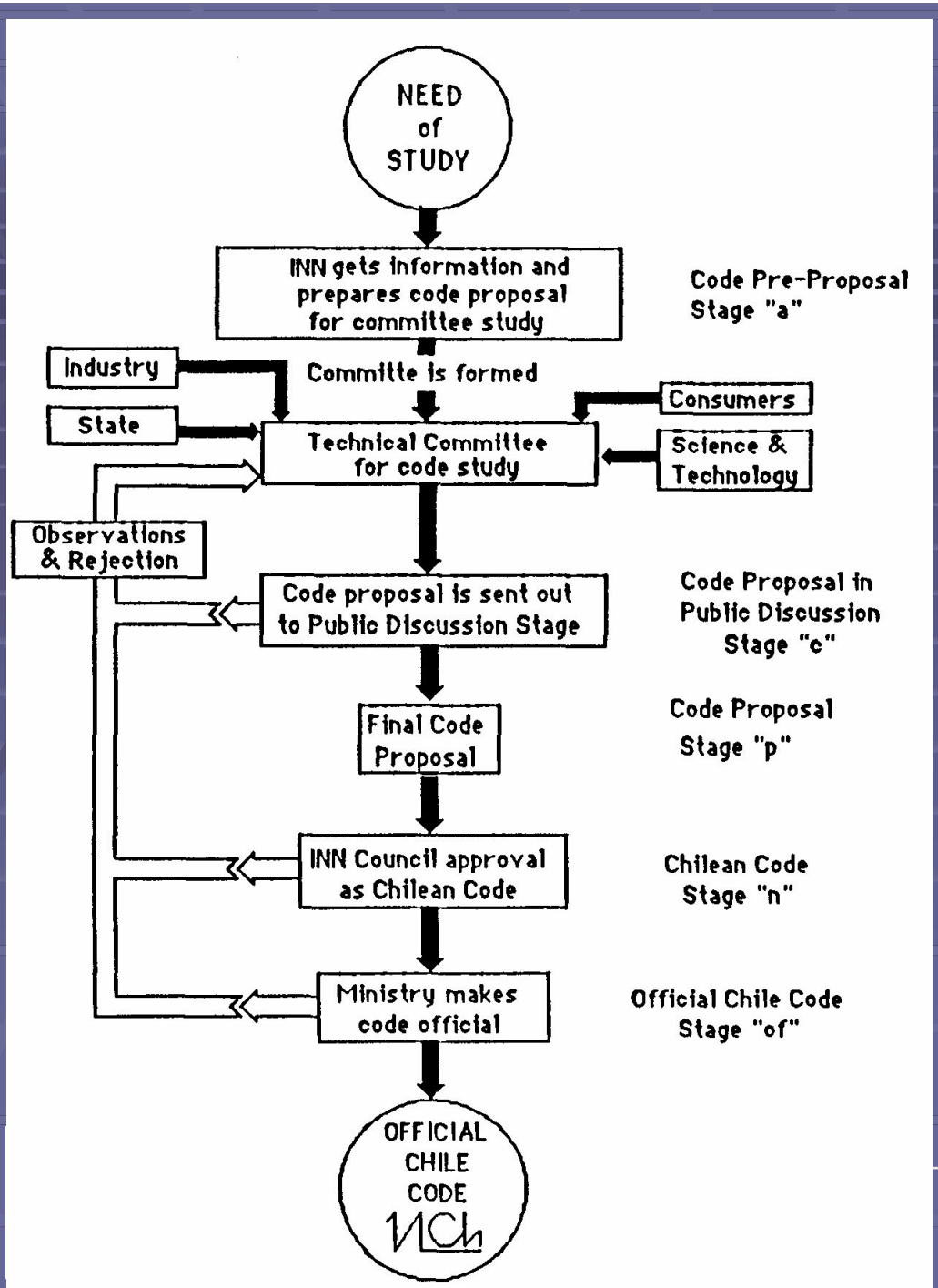
Codes and Standards:

	Number	Name	Date	Status
Actions	NCh431	Snow Loading	1977	Applicable
	NCh432	Wind Loading	1971	Applicable (*)
	NCh1537	Dead / Live Loads Specification	1986	Applicable (*)
Materials / Design	NCh427	Design of Steel	1977	Under review
	NCh430	Design of Reinforced Concrete (ACI 318)	2008	Applicable
	NCh1198	Design of Wood	2006	Applicable
	NCh1928	Design of Reinforced Masonry	2003	Applicable
	NCh2123	Design of Confined Masonry	2003	Applicable
Earthquake	NCh433	Earthquake resisting design of buildings	1996	Applicable (*)
	NCh2369	Earthquake resisting design of industrial structures and facilities	2003	Applicable
	NCh2745	Earthquake resisting design of base isolated buildings	2003	Applicable

(*) Modifications are being studied and are going to be proposed in the near future

Introduction:

- The present situation and status of the different activities related to Earthquake Preparedness activities in Chile are discussed.
- The activities are divided in three groups: Codes and Standards, Structural and Seismic Review procedures, and Building Permits procedures.
- Codes and Regulations are the key to adequate Earthquake Engineering and Construction practices. If they are properly done and adequately followed they should allow to provide a uniform level of safety and quality to different buildings.
- If the codes and regulations are strictly enforced there is an implicit warranty that the behavior of the buildings under the action of the loads that can occur during their service life will be that expected from them when the codes and regulations were made and put into effect.
- But this is only an ideal scenario. In real life, it is almost impossible to predict what the behavior of a building will be under the action of loading of different types; especially under the action of seismic loading.



Schematic of the Chilean Official Codes Approval Procedure

The code committees are joined by members coming from all the areas related to any given code, and normally include persons from the scientific and research community, from related industry companies, from private consulting offices, and from the government agencies.

Web Site for Chilean National Institute of Standards: www.inn.cl
(only Spanish, pdf files can be obtained at a price)

Periodic updating and revision of codes is a requirement; to keep up with improvements in construction technology, to include new developments in analysis and design techniques, and to take advantage of the always increasing knowledge on material properties and structural behavior.

The exchange of information between different countries related through a common situation like the occurrence of earthquakes should be improved.

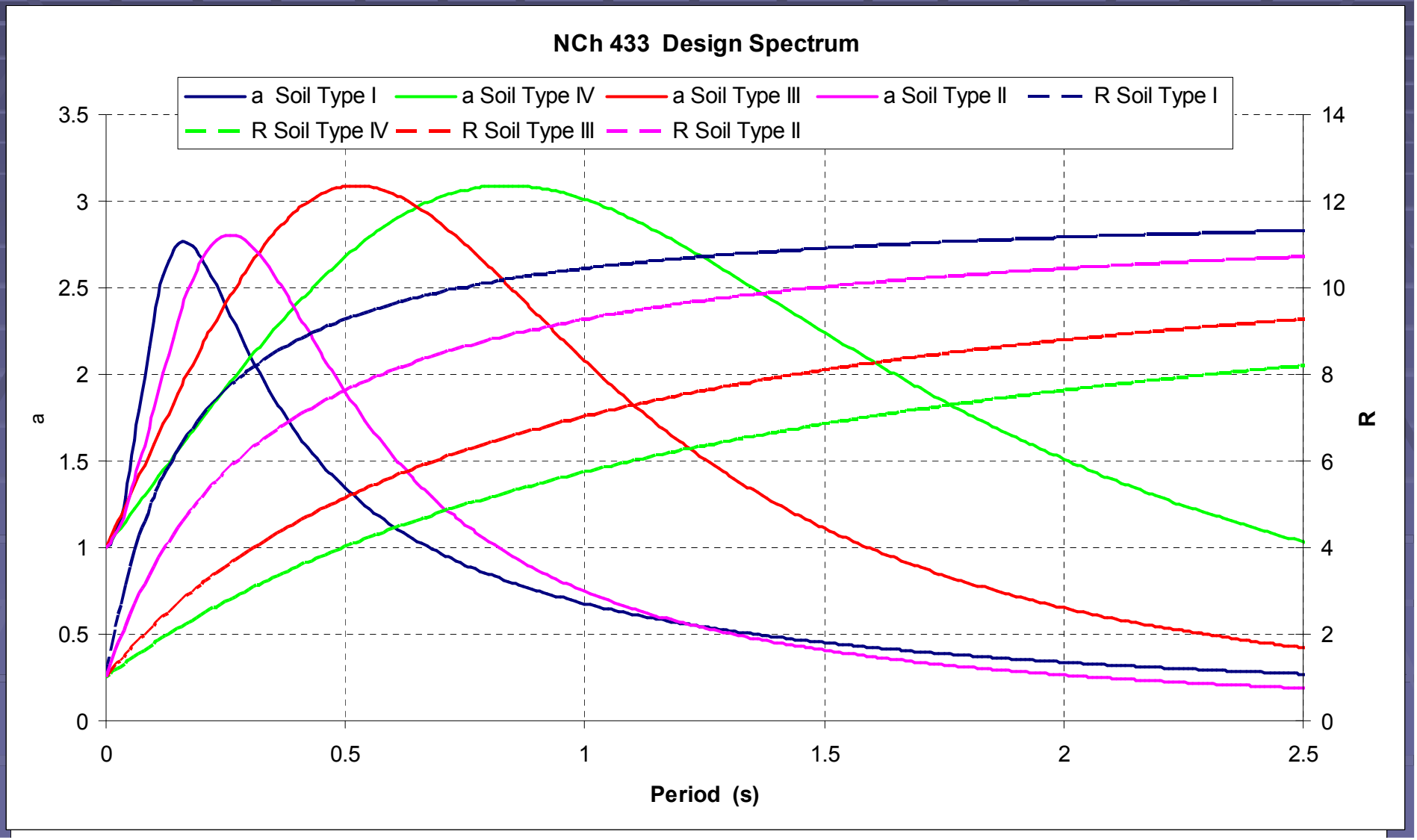
The benefits of such an effort start by recognizing that the experience of one country in the field of earthquake engineering can be readily used by others to improve their own analysis, design, and construction practices.

The benefits come not only from avoiding duplication of research efforts but also, and most importantly, from taking advantage of the real size laboratory experiments that the occurrence of large earthquakes generate.

In depth study of earthquake effects in real buildings provides valuable information for the appraisal of the adequacy of codes and regulations. Through the analysis of earthquake induced damage and in-depth knowledge of building characteristics, of material properties, and of earthquake ground motion (actual records) the important factors in building response can be identified and improvements to codes can be proposed.

Earthquake Codes:

The expected level of earthquake action, is determined depending on the building characteristics (R, ζ) and the site soil conditions (Soil type 1,2,3,4).



Earthquake Codes:

Two different analysis procedures are allowed:

An equivalent static lateral forces procedure where in plan torsion is considered through an amplification of the static torsion in the building.

The standard response spectrum analysis method with a three dimensional model of the building (at least 3 dof per story). The maximum responses of the different modes are combined using the CQC combination rule.

Restrictions are imposed to torsion effects, and to overall building lateral displacements and inter-story drifts.

For industrial buildings several specific requirements based on performance of typical design and detailing solutions observed in previous earthquakes are given. Anchoring systems details, bracing configurations, over strength in “non-ductile” elements, etc.

Earthquake Codes:

The M=7.8 earthquake in Central Chile in 1985, that affected two of the most densely populated areas (Santiago and Valparaiso) and the most important region of the country in terms of economic output prompted the revision of the building code; the previous version dated from 1972.

Main changes that the codes have undergone in the last 25 years:

- Seismic Zoning (A_0 = 0.4, 0.3, 0.2)
- Response Modification Factors (R depends on material and configuration)
- In dynamic analysis, the modal maxima combination rule was changed
- The restrictions to lateral displacements and story drifts were updated

Some ideas being discussed for the next revision of the codes:

- Load Combinations adjusted for new material codes (ASCE-7 type)
- Updating of Seismic Zoning maps and effect of site soil conditions
- Updating of detailing and special requirements on Industrial buildings code

Structural and Seismic Review :

Starting in 2003, but implemented in a gradual manner, the national building authorities require, with the full support of the Chilean Association of Structural Engineers, that the project of all the buildings shall be reviewed by an independent reviewer, from structural and earthquake engineering standpoints.

The reviewer must be chosen from a rooster of authorized professionals kept under the authority of the Ministry of Housing.

Three different levels can be assigned to the reviewers depending on the individual qualifications.

The level of the reviewer required for a given project depends on the complexity and importance of the building being considered.

This review procedure has become a well established process and all projects need now to undergo the review before the actual construction permits can be issued.

Building Permits Procedures:

Before construction can start, the project drawings (architectural and structural) and a set of construction specifications need to be submitted for approval to the building department of the Municipality (township) where the site is located.

This process is required for all buildings.

For public buildings (schools, hospitals, police stations, fire fighting stations, communication centers, etc.) and for office and residential buildings of more than 5 stories the project has to include also the approval by an independent structural / seismic reviewer.

This procedure is well defined and has been included since many years in the General Construction Ordinance (a law of the country) and therefore all the involved parties (owner, builder, construction company) and the administrative authorities must follow it. Failure to comply will result both in Civil and Penal sanctions imposed by the judiciary system.

Final Remarks:

The number of new buildings which are not conforming to the current building codes can be estimated to be less than 2 or 3%, and correspond to informal housing (dwellings) in highly rural areas (non-engineered buildings).

For schools, hospitals, public facilities, residential and office buildings this value is essentially zero, as strict enforcement of building permits procedures exists.

There is a significant stock of older buildings including not only housing but also public buildings that were built to the previous versions of the seismic codes, and therefore have larger vulnerability. Perhaps 25% of total building stock.

On the other hand, given the frequency of occurrence of large earthquakes in Chile, most of these older buildings have undergone a significant (M>7) earthquake with epicenter located within say 150 km, and therefore have been already "experimentally tested." Performance has been in general acceptable, and damage has been limited to mostly non-engineered buildings.

Thank you very much !

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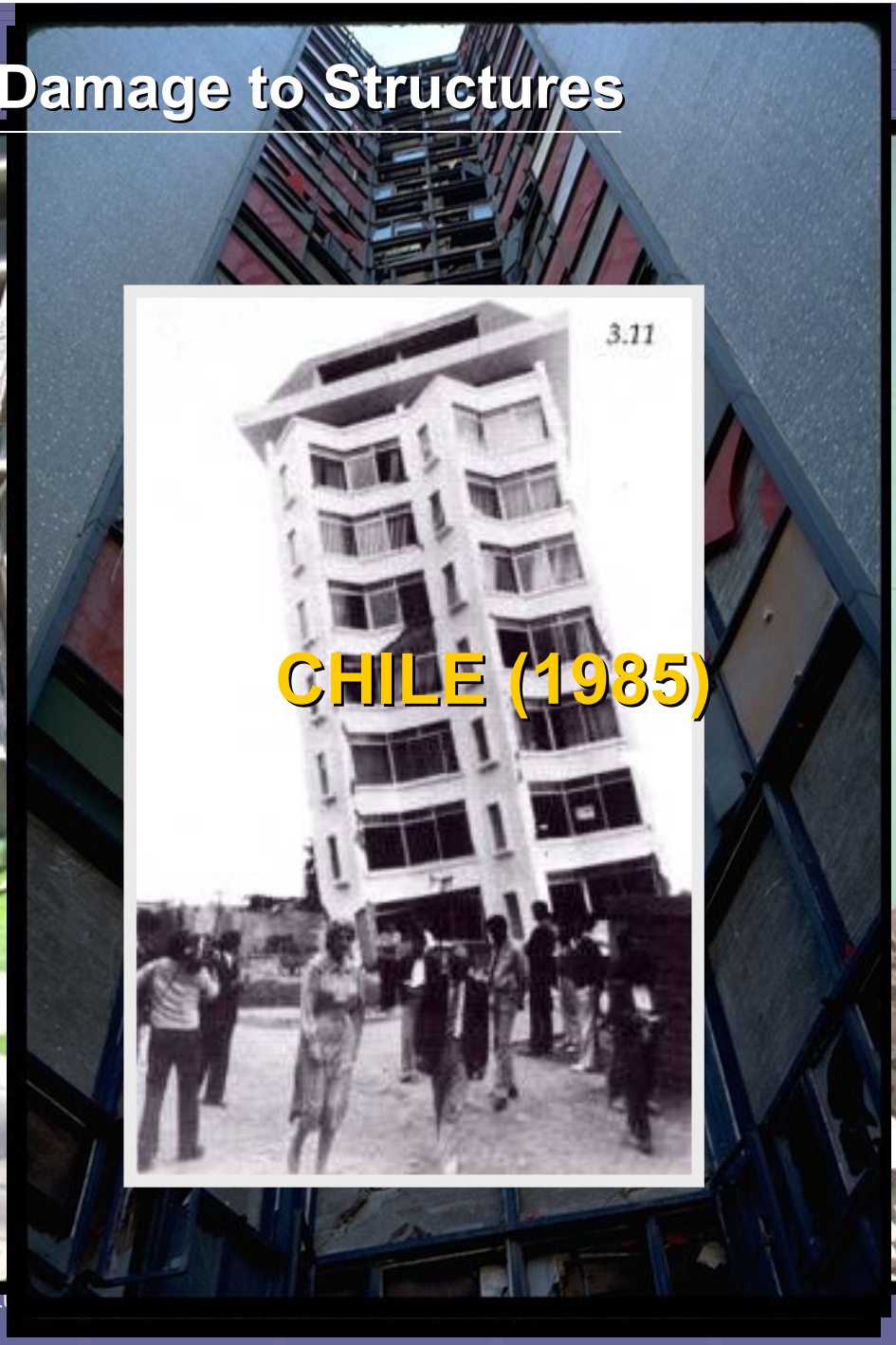
Muchas Gracias !

Earthquake Damage to Structures



CHILE (1985)

Earthquake Damage to Structures

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どうもありがとうございます

Thank you very much !

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çok teşekkürler !

Muchas Gracias !