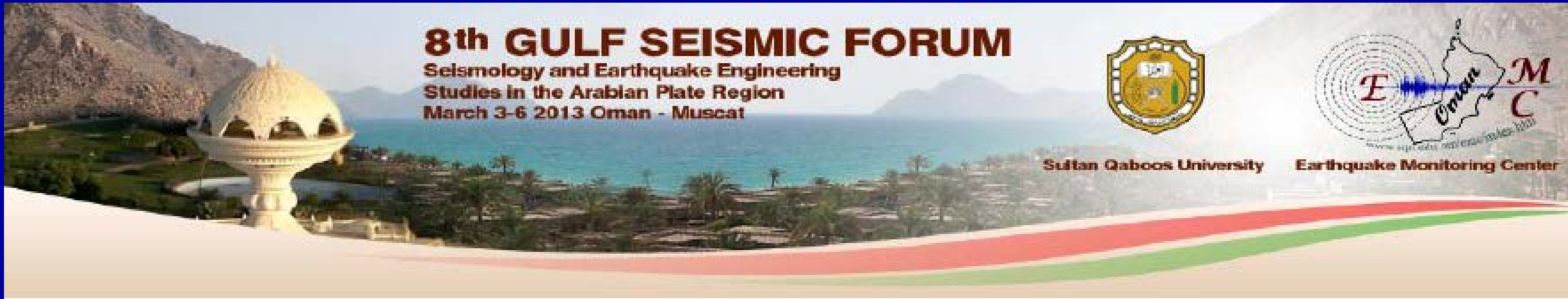

NEW OMAN SEISMIC DESIGN CODE FOR BUILDINGS

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ESSENTIAL FEATURES OF
OMAN SEISMIC DESIGN CODE

COUNTRY-SPECIFIC SEISMIC GROUND MOTION

The seismic ground motion considered in the
Oman Seismic Design Code
is based on a country-specific
Probabilistic Seismic Hazard Analysis
conducted by
Sultan Qaboos University.

Sultan Qaboos University

Earthquake Monitoring Center

Probabilistic and Deterministic Seismic Hazard Assessment for Sultanate of Oman

(Phase I)

Project # 22409017

By:

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2010

COMPLIANCE WITH EUROCODES

The main philosophy of the
Oman Seismic Design Code,
including specific design requirements for
reinforced concrete, structural steel, composite
and masonry buildings
are in full compliance with the relevant Eurocodes, namely
Eurocode 2, Eurocode 3, Eurocode 4, Eurocode 6,
Eurocode 7 and Eurocode 8.

EXPLICIT SEISMIC PERFORMANCE OBJECTIVES

1) PRIMARY SEISMIC PERFORMANCE OBJECTIVE:

Life Safety – Controlled Damage Performance Objective
is intended to be achieved for
normal occupancy buildings
under specified
design earthquake with a 475 years return period.

2) ENHANCED SEISMIC PERFORMANCE OBJECTIVE:

Immediate Occupancy – Minimum Damage Performance Objective
is intended to be achieved for
special occupancy buildings
under the same design earthquake.

SEISMIC ANALYSIS REQUIREMENTS

The seismic analysis requirements of the
Oman Seismic Design Code
are based on
equivalent static, semi-dynamic and fully dynamic analysis methods
specified for
low-rise, medium-rise and high-rise buildings.

SPECIFIC SEISMIC DESIGN AND DUCTILE DETAILING REQUIREMENTS

have been specified for

Reinforced Concrete Buildings
Structural Steel Buildings
Steel – Concrete Composite Buildings
Masonry Buildings
and their
foundations

CHAPTER 1
GENERAL REQUIREMENTS

SCOPE, NOTATIONS, REFERENCE CODES

SEISMIC PERFORMANCE OBJECTIVES

Life Safety Performance Objective
Immediate Occupancy Performance Objective

SEISMIC GROUND MOTION

Design earthquake
Representation of ground motion: Elastic Response Spectrum
Representation of ground motion in time domain

IDENTIFICATION OF LOCAL SOIL CLASSES FOR ELASTIC RESPONSE SPECTRUM

DESIGN RESPONSE SPECTRUM

Definition of Design Response Spectrum
Seismic Load Reduction Factors
Building Importance Factors

ELASTIC RESPONSE SPECTRUM

$$S_{AE}(T) = 0.4\,S_{SD} + 0.6\,\frac{S_{SD}}{T_o}T \qquad (T_o \le T)$$

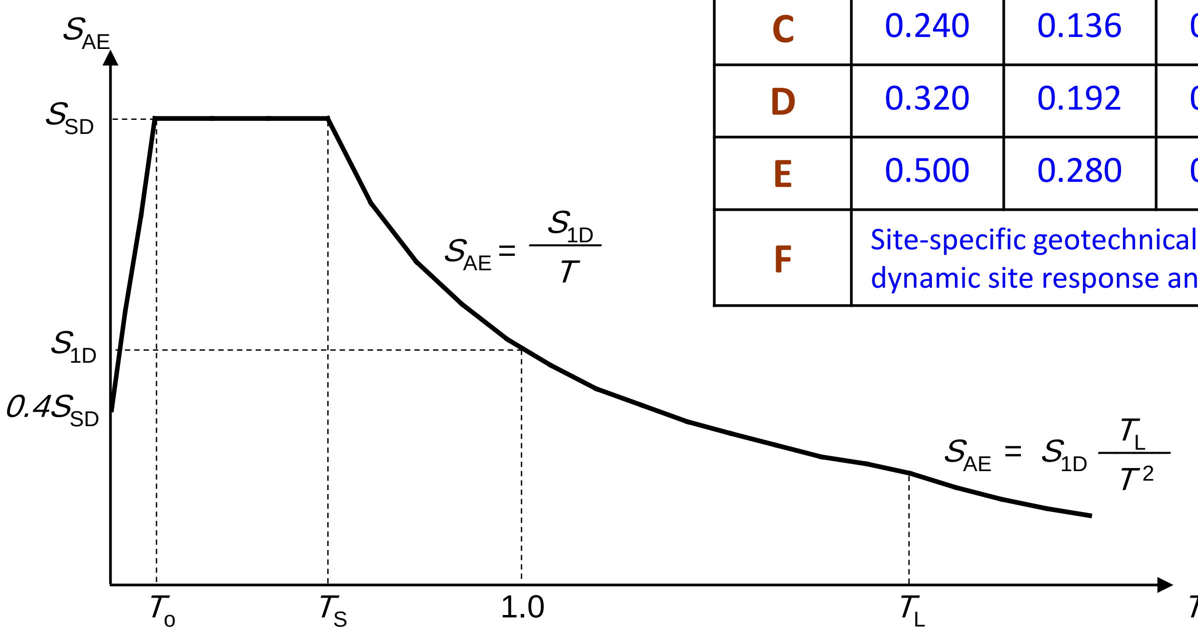
$$S_{AE}(T) = S_{SD} \qquad (T_o \le T \le T_S)$$

$$S_{AE}(T) = \frac{S_{1D}}{T} \qquad (T_S \le T \le T_L)$$

$$S_{AE}(T) = \frac{S_{1D}\,T_L}{T^2} \qquad (T_L \le T)$$

$$T_S = \frac{S_{1D}}{S_{SD}}$$

$$T_o = 0.2T_S$$



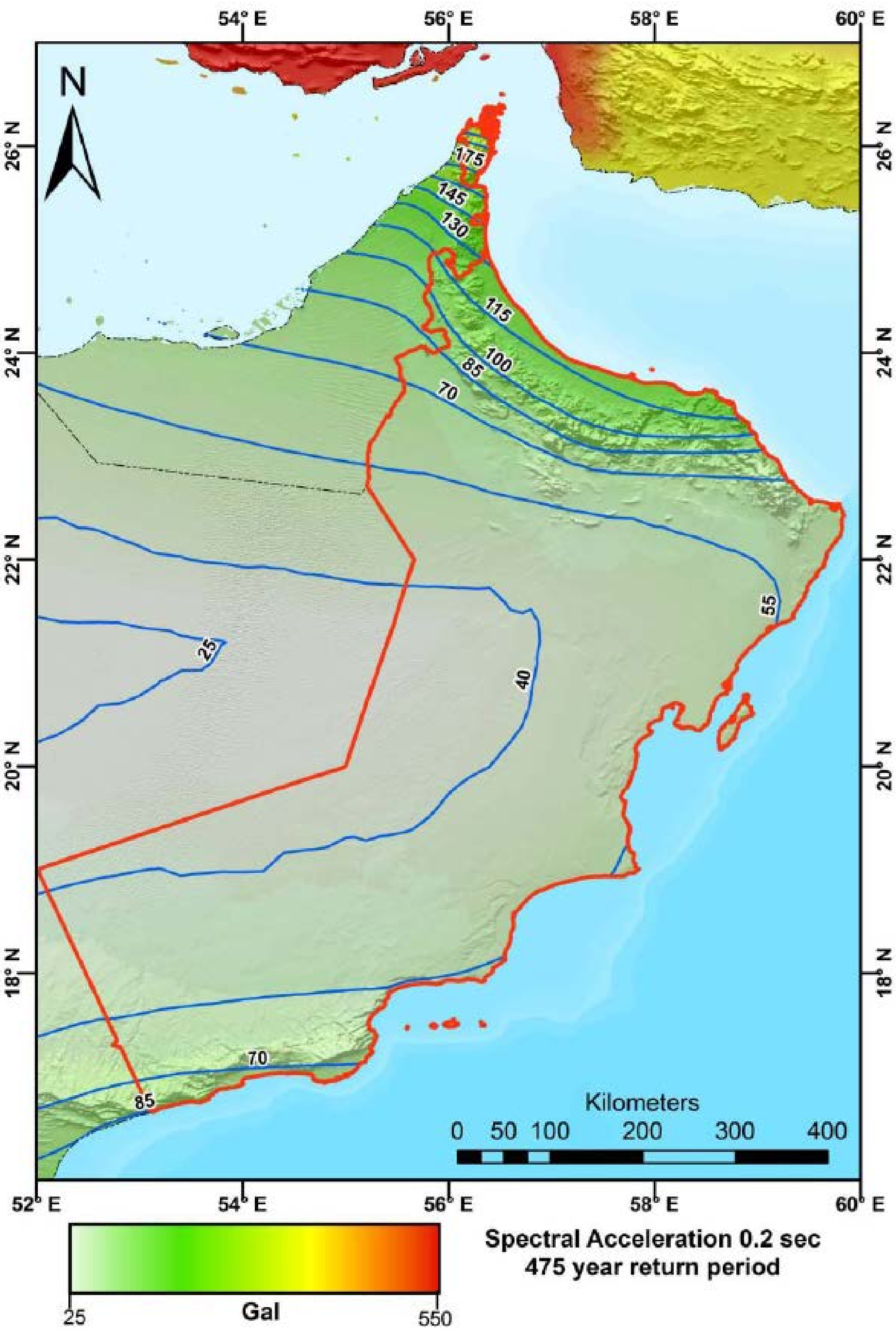
Short period and 1.0 second elastic spectral accelerations

Local Soil Class	Seismic Zone			
	Zone 1 Muscat, Sohar, Diba, Khasab		Zone 2 Nizwa, Sur, Salalah	
	S_{SD} / g	S_{1D} / g	S_{SD} / g	S_{1D} /g
A	0.160	0.064	0.080	0.032
B	0.200	0.080	0.100	0.040
C	0.240	0.136	0.120	0.068
D	0.320	0.192	0.160	0.096
E	0.500	0.280	0.250	0.140
F	Site-specific geotechnical investigation and dynamic site response analysis required			

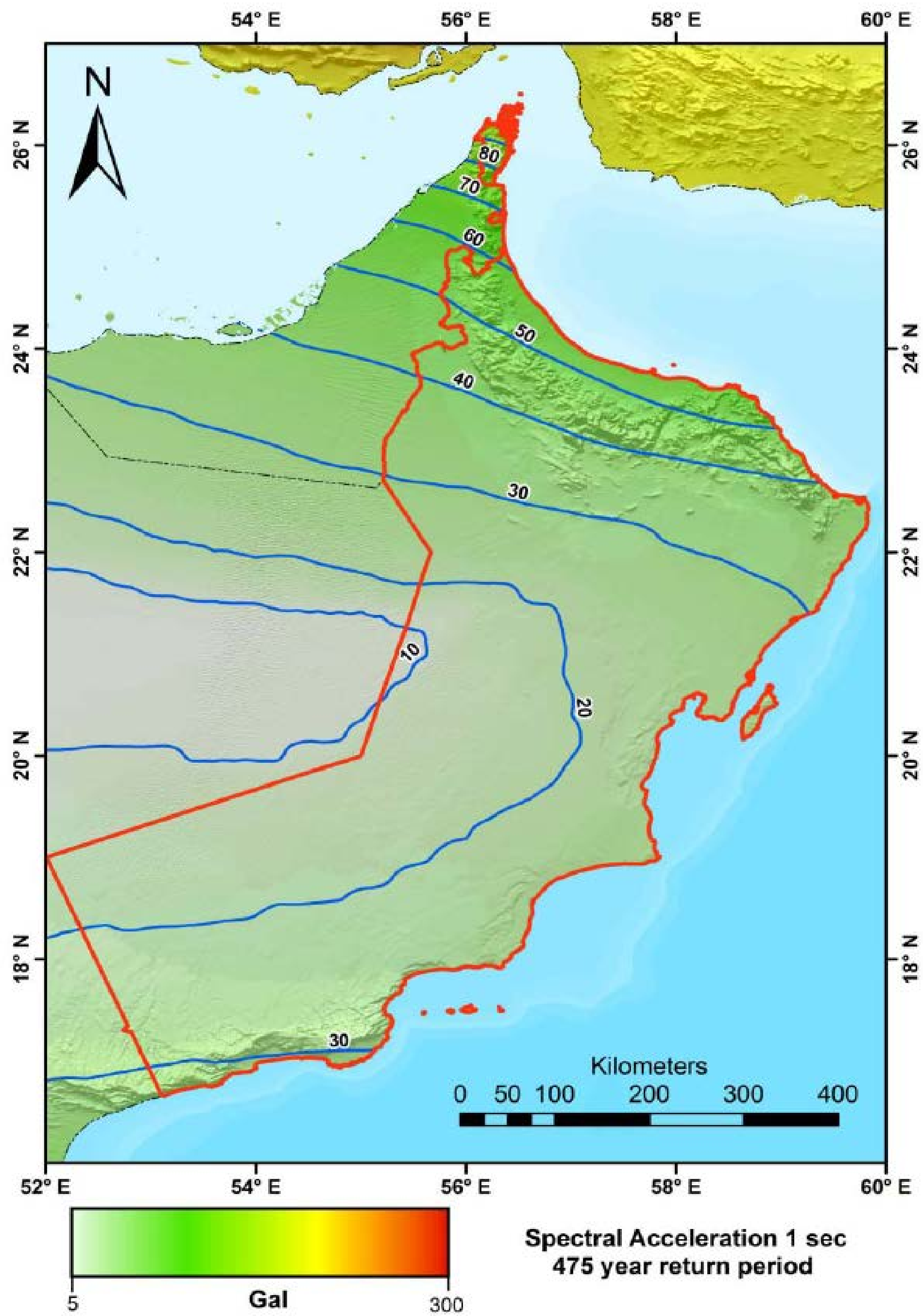
$$T_L = 8\ \text{s}$$

Table 1.2 – Soil classification parameters

Soil Class	$\bar{v}_s$ (m/s)	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$ (kPa)
A. Hard rock	> 1500	NA	NA
B. Rock	760 – 1500	NA	NA
C. Very dense soil and soft rock	360 – 760	> 50	100
D. Stiff soil	180 – 360	15 – 50	50 – 100
E. Soft clay soil	< 180	< 15	< 50
	or any profile with more than 3 m of soil with plasticity index: $PI > 20$, moisture content: $w \geq 50\%$, undrained shear strength: $\bar{s}_u < 25$ kPa.		
F. Soils requiring site response analysis	1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils 2. Peat and/or highly organic clays with more than 3 m. 3. Very high plasticity clays with more than 7.5 m and $PI > 75$ 5. Very thick, soft/medium stiff clays with more than 35 m and $s_u < 50$ kPa		



Spectral Acceleration 0.2 sec
475 year return period



Spectral Acceleration 1 sec
475 year return period

DESIGN RESPONSE SPECTRUM

$$S_{AR}(T) = \frac{S_{AE}(T)}{q_R(T)}$$

Seismic Load Reduction Factor

$$q_R(T) = 1 + \left(\frac{q}{I} - 1\right)\frac{T}{T_S} \qquad (0 \le T \le T_S)$$

$$q_R(T) = \frac{q}{I} \qquad (T_S < T)$$

Behaviour Factors (q) for reinforced concrete structural types

Structural type	q
Moment resisting frame system	3.5
Coupled structural wall system	3.5
Uncoupled structural wall system	2.5
Frame-dominant dual system	3.0
Wall-dominant dual system (coupled walls)	3.0
Wall-dominant dual system (uncoupled walls)	2.5
Inverted pendulum system	1.5

Behaviour Factors have been given as well for structural steel, steel-concrete composite and masonry buildings.

Building Importance Factors (I)

Occupancy Category	Purpose of Occupancy of Building	(I)
I	**(a)** Buildings required to be occupied immediately after an earthquake (Hospitals, dispensaries, health wards, fire fighting buildings and facilities, PTT and other telecommunication facilities, transportation stations and terminals, power generation and distribution facilities, governorate, county and municipality administration buildings, first aid and emergency planning stations) **(b)** Schools, other educational buildings and facilities, dormitories and hostels, military barracks, prisons, etc. **(c)** Museums **(d)** Buildings containing or storing toxic, explosive and/or flammable materials etc	1.5
II	Sport facilities, cinema, theatre and concert halls, etc.	1.2
III	Buildings other than above-defined buildings (Residential and office bldgs, hotels, building-like industrial structures).	1.0

CHAPTER 2
ARRANGEMENT OF BUILDING STRUCTURAL SYSTEMS FOR SEISMIC DESIGN

GENERAL GUIDELINES

Structural simplicity
Uniformity, symmetry and redundancy
Adequate resistance and stiffness
Diaphragm action
Adequate foundation

REGULARITY REQUIREMENTS

Definition of Irregular Buildings
Conditions for Irregular Buildings

PRIMARY AND SECONDARY MEMBERS

Primary members
Secondary members

CHAPTER 3
SEISMIC ANALYSIS REQUIREMENTS OF BUILDINGS

SEISMIC ANALYSIS METHODS

1) EQUIVALENT SEISMIC LOAD METHOD

2) MULTI-MODE RESPONSE SPECTRUM ANALYSIS METHOD

3) RESPONSE HISTORY ANALYSIS METHOD (linear or nonlinear)

SAFETY VERIFICATION

DAMAGE LIMITATION

ANALYSIS REQUIREMENTS FOR NONSTRUCTURAL SYSTEMS

CHAPTER 4
SEISMIC DESIGN REQUIREMENTS FOR REINFORCED CONCRETE BUILDINGS

SCOPE AND DESIGN CONCEPTS

Scope
Design Concepts
Structural types and Behaviour Factors
Design actions
Capacity Design rules
Material requirements
Local ductility requirements

SEISMIC DESIGN REQUIREMENTS FOR REINFORCED CONCRETE BEAMS

Geometrical requirements
Design shear forces of beams
Seismic detailing of beams

SEISMIC DESIGN REQUIREMENTS FOR REINFORCED CONCRETE COLUMNS

Geometrical requirements
Design shear forces of columns
Seismic detailing of columns
Seismic detailing of beam-column joints

SEISMIC DESIGN REQUIREMENTS FOR REINFORCED CONCRETE STRUCTURAL WALLS

Geometrical requirements
Design bending moments and shear forces of structural walls
Seismic detailing of structural walls

REQUIREMENTS FOR ANCHORAGE AND SPLICING OF REBARS

General
Anchorage of rebars
Splicing of rebars

DESIGN AND DETAILING OF SECONDARY SEISMIC ELEMENTS

DESIGN CONCEPTS

ADEQUATE ENERGY DISSIPATION CAPACITY (DUCTILITY CAPACITY)

ADEQUATE STRUCTURAL RESISTANCE

Design of earthquake resistant reinforced concrete buildings shall provide the structure with an adequate energy dissipation capacity without substantial reduction of its overall resistance against horizontal and vertical loading.

Adequate resistance of all structural elements shall be provided, and non-linear deformation demands in critical regions should be compatible with the overall ductility assumed in calculations.

BUILDINGS OF LOW DUCTILITY CLASS (DCL)

Reinforced concrete buildings, excluding Occupancy Category I and Category II buildings specified in **Table 1.3**, may alternatively be designed for low dissipation capacity and low ductility, by applying only the rules of EN 1992-1-1:2004 for the seismic design situation, and neglecting the specific provisions given in this chapter.
The class of such buildings is identified as *Low Ductility Class* (DCL).

BUILDINGS OF NORMAL DUCTILITY CLASS (DCN)

Reinforced concrete buildings, other than those defined above, shall be designed to provide energy dissipation capacity and an overall ductile behaviour. Overall ductile behaviour is ensured if the ductility demand involves the different elements and locations of all its storeys. To this end, ductile modes of failure (e.g. flexure) should precede brittle failure modes (e.g. shear) with sufficient reliability.

The class of such buildings is identified as *Normal Ductility Class* (DCN), for which reinforced concrete seismic design requirements are given in the remainder of **Chapter 4**.

CAPACITY DESIGN RULES

Brittle failure or other undesirable failure mechanisms (e.g. concentration of plastic hinges in columns of a single storey of a multi-storey building, shear failure of structural elements, failure of beam-column joints, yielding of foundations or of any element intended to remain elastic) shall be prevented, by deriving the design action effects of selected regions from equilibrium conditions, assuming that plastic hinges with their possible over-strengths have been formed in their adjacent areas.

Example:

In moment resisting frame systems, including frame-dominant dual systems, the following *capacity design condition* should be satisfied at all beam-column joints:

$$\sum M_{\mathrm{Rc}} \geq 1.3 \sum M_{\mathrm{Rb}}$$

CHAPTER 5
SEISMIC DESIGN REQUIREMENTS FOR STRUCTURAL STEEL BUILDINGS

SCOPE AND DESIGN CONCEPTS

Scope
Design Concepts
Structural types and Behaviour Factors
Material requirements

GENERAL DESIGN CRITERIA AND DETAILING RULES

Design rules for ductile elements in compression or bending
Design rules for ductile elements in tension
Design rules for connections

DESIGN AND DETAILING RULES FOR MOMENT RESISTING FRAMES

Design criteria
Beams
Columns
Beam-column connections

DESIGN AND DETAILING RULES FOR FRAMES WITH CONCENTRIC BRACINGS

Design criteria
Analysis
Diagonal members
Beams and columns

DESIGN AND DETAILING RULES FOR FRAMES WITH ECCENTRIC BRACINGS

Design criteria
Seismic links
Members not containing seismic links
Connections of seismic links

DESIGN RULES FOR INVERTED PENDULUM STRUCTURES

CHAPTER 6
SEISMIC DESIGN REQUIREMENTS FOR STEEL – CONCRETE COMPOSITE BUILDINGS

SCOPE AND DESIGN CONCEPTS

Scope
Design Concepts
Structural types and Behaviour Factors
Material requirements

GENERAL DESIGN CRITERIA AND DETAILING RULES

Design criteria for dissipative structures
Plastic resistance of dissipative zones
Detailing rules for composite connections in dissipative zones

RULES FOR MEMBER DESIGN

Steel beams composite with slab
Fully encased composite columns
Partially-encased members
Filled composite columns

DESIGN AND DETAILING RULES FOR COMPOSITE MOMENT RESISTING FRAMES

Specific criteria
Analysis
Rules for beams and columns
Beam to column connections
Condition for disregarding the composite character of beams with slab

DESIGN AND DETAILING RULES FOR FRAMES WITH CONCENTRIC BRACINGS

Specific criteria
Analysis
Diagonal members
Beams and columns

DESIGN AND DETAILING RULES FOR FRAMES WITH ECCENTRIC BRACINGS

Specific criteria
Analysis
Seismic links
Members not containing seismic links

DESIGN AND DETAILING RULES FOR STRUCTURAL SYSTEMS MADE OF REINFORCED CONCRETE STRUCTURAL WALLS COMPOSITE WITH STRUCTURAL STEEL ELEMENTS

Specific criteria
Analysis
Detailing rules for composite walls
Detailing rules for coupling beams

DESIGN AND DETAILING RULES FOR COMPOSITE STEEL PLATE STRUCTURAL WALLS

Specific criteria
Analysis
Detailing rules

CHAPTER 7
SEISMIC DESIGN REQUIREMENTS FOR MASONRY BUILDINGS

SCOPE

SEISMIC REQUIREMENTS FOR MASONRY STRUCTURAL SYSTEMS

Types of masonry buildings
General requirements
Requirements for Unreinforced Masonry Buildings
Requirements for Confined Masonry Buildings
Requirements for Reinforced Masonry Buildings

DESIGN CRITERIA AND ANALYSIS REQUIREMENTS

Material strengths
Behaviour Factors
Analysis requirements

CHAPTER 8
SEISMIC DESIGN REQUIREMENTS FOR FOUNDATIONS

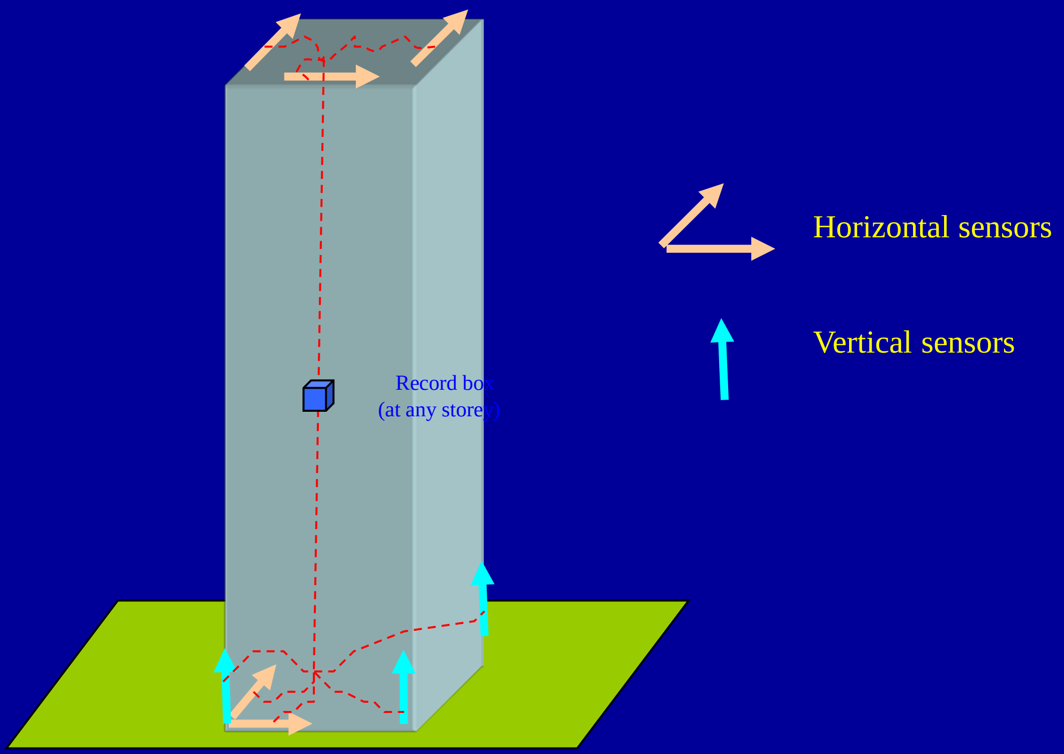
SCOPE

DESIGN ACTION EFFECTS FOR FOUNDATIONS

CONNECTIONS OF VERTICAL ELEMENTS WITH FOUNDATION BEAMS AND WALLS

CAST-IN-PLACE CONCRETE PILES AND PILE CAPS

CHAPTER 9
STRUCTURAL HEALTH MONITORING SYSTEMS FOR HIGH-RISE BUILDINGS



THANK YOU