THE NEW PORTUGUESE SEISMIC CODE

by

J. Ferry Borges (I) and Artur Ravara (II)

Synopsis

This paper presents the main provisions included in the chapter on seismic actions of the draft of the portuguese "Safety and Loading Code for Building and Bridge Structures" {1}.

The draft, issued in January 1976, is circulating for criticism and suggestions until the end of 1976. Then the final version will become official through a Decree. This Decree will revocate the present code {2}, which dates from 1961.

The main problem met with in preparing the new code was how to insert in it the modern (and quick changing) concepts of earthquake engineering and yet keep it simple enough. The criteria adopted to overcome this difficulty are presented and briefly discussed.

1. BASIC CRITERIA

Structures were classified according to their complexity and importance. For simple structures, similar to single or multi degree of freedom systems, the seismic coefficient has been used, its value been determined by means of simplified dynamic analysis taking into account the seismicity, the soil characteristics, the dynamic properties and the ductility of the structures.

For complex and/or important structures the ground motion is prescribed by means of power spectra and by equivalent response spectra of acceleration. The basic rules for dynamic linear and nonlinear analysis are indicated.

2. SEISMIC ZONING

As in the previous code the territory is divided in three zones A, B and C, having high, medium and low seismicity, their limits being indicated in fig. 1. Azores Islands belong to zone A but Flores and Corvo islands are in zone B, together with Madeira. In the previous code the three islands belonged to zone C. These minor changes were made as a result of seismic events recently felt in those three islands.

I) Director, Laboratório Nacional de Engenharia Civil (LNEC), Lisbon

II) Head Structures Department, LNEC, Lisbon

Recent studies on the seismicity of Portugal { 3,4 } allowed to estimate the extreme values of horizontal acceleration, velocity and displacement of the ground as a function of return periods in zones A, B C and C as indicated in Table 1.

3. SEISMIC COEFFICIENTS

For simple structures, similar to single or multi-degree of freedom systems, the seismic (horizontal) forces acting at the center of gravity of each member of the structure can be determined by means of a seismic coefficient given by

$$C = \alpha\, C_o / \mu$$

where:

- α - seismicity factor equal to 1.0 for zone A, 0.6 for zone B. and 0.3 for zone C
- C_o - response spectra factor, depending on the type of soild and fundamental frequency of the structure as shown in Fig. 2 and Table 2.
- μ - ductility factor, depending on the material and on the type of structure, with values ranging from 1.0 to 4.0 (Table 3).

As mentioned the factors C_o are values of acceleration response spectra; they correspond to a relative viscous damping of 0.05; in all cases the spectra have a constant acceleration and a constant velocity branch.

The tipification of soils is the following:

Type I - rock and stiff soils ($v > 2000$ m/s)

Type II - hard and medium cohesive soils ($1000 < v < 2000$ m/s), compact cohesionless soils, with sands and well graded mixtures of sands and gravel ($1000 < v < 2000$m/s). For the case of direct foundations these soils must be considered in type III if the distance between the lower face of the footings and the water level is smaller than the footing side.

Type III - loose cohesionless soils and soft cohesive soils ($v < 1000$m/s).

In all cases v is the longitudinal wave propagation velocity in the soil.

The seismic coefficient thus determined can be reduced by 20% in constructions with a considerable reserve of strength due to non-structural bracing members, such as brick-infilled walls, etc.

Lower bounds of 0.06 in zone A and 0.03 in zone B are to be taken for C.

In special cases where vertical seismic forces are to be considered, the value of the seismic vertical coefficient will be two thirds its value for the horizontal direction.

4. PROFILE OF HORIZONTAL SEISMIC FORCES

In multi-degree of freedom systema, namely in multi-storey buildings where the mass is usually supposed to be lumped at floor levels, the distribution law of horizontal seismic forces along the building height depends on the fundamental mode profile. So, for usual strutures forces are distributed according to

$$F_i = C\, h_i\, P_i \frac{\Sigma\ P_i}{\Sigma\ h_i\ P_i}$$

where C is the seismic coefficient and P_i and h_i, are respectively, the weight lumped at and the height of floor i. Horizontal torsional moments are accounted for in the horizontal distribution of seismic forces.

For unusual structures a dynamic analysis is mandatory.

5. SEISMIC ANALYSIS OF SPECIAL STRUCTURES

In special studies of complex and/or important structures (analytical) studies and model tests) seismic actions must be taken as an ensemble of horizontal and vertical ground motions, with the following characteristics:

- each motion is a sample of a stationary Gaussian process, with 30 seconds duration
- Orthogonal components are uncorrelated
- Horizontal motion is isotropic
- power spectra of acceleration of the type shown in fig. 3, and Table 4, function of the soil properties, as referred before.

If the maximum base dimension is less than 50 m, the effects of the space variability of the motion, may be substituted by the effects of a rotational motion about one vertical and two horizontal axis.

The response spectra of acceleration (horizontal) that correspond to these power spectra are the ones shown in Fig. 2, for 0.05 relative viscous damping. Relationship between both kinds of spectra has been the subject of recent studies {5}.

6. SAFETY RULES

The checking of safety for ultimate limit states is based on characteristic values of the actions (having a probability of 0.05 of being exceeded during the reference period of 50 years). When considering the combination of actions where seismic actions are principal they have to be combined with permanent loads and reduced superimposed loads. In this combination the seismic actions are multiplied by a factor 1.5.

The resulting design action effects are compared to design resistances.

The checking of serviceability limit states to seismic actions is not compulsory.

BIBLIOGRAPHY

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Table 1 - Characteristics of horizontal ground motion in zones A,B and C

Return period, years	Zone A			Zone B			Zone C		
	accel, gal	vel, cm/s	displ, cm	accel, gal	vel, cm/s	displ, cm	accel, gal	vel, cm/s	displ, cm
100	75	6	2.5	50	4	1.5	25	1.8	0.8
1000	150	15	6	100	9	3	50	4	1.5

Table 2 - Response spectra factor, C_o

TYPE OF SOIL	FUND. FREQ. f(Hz)	Co
I	f < 3.5	0.14 f
	f > 3.5	0.49
II	f < 2.5	0.16 f
	f > 2.5	0.40
III	f > 2.0	0.18 f
	f 2.0	0.36

Table 3 - Ductility factor, μ

Material and type of structure	μ
Steel frames, with very high ductility	4.0
r.c. frames, with high ductility	3.0
r.c. combined structures (shear walls associated with frames), with medium ductility	2
r.c. wall structures (shear walls), with small ductility	1.5
Isolated elements, such as small chimneys, balconies, with very low ductility	1.0

Table 4 - Values of the parameters f(Hz) and S(gal^2 Hz^{-1})

	Soil I	Soil II	Soil III
f_1	0.04	0.03	0.02
f_2	2.0	1.5	1.0
f_3	4.0	3.0	2.0
f_4	7.0	6.0	5.0
f_5	11.0	10.0	9.0
f_6	20.0	20.0	20.0
S_1	350	325	300
S_2	150	125	100
S_3	65	50	35

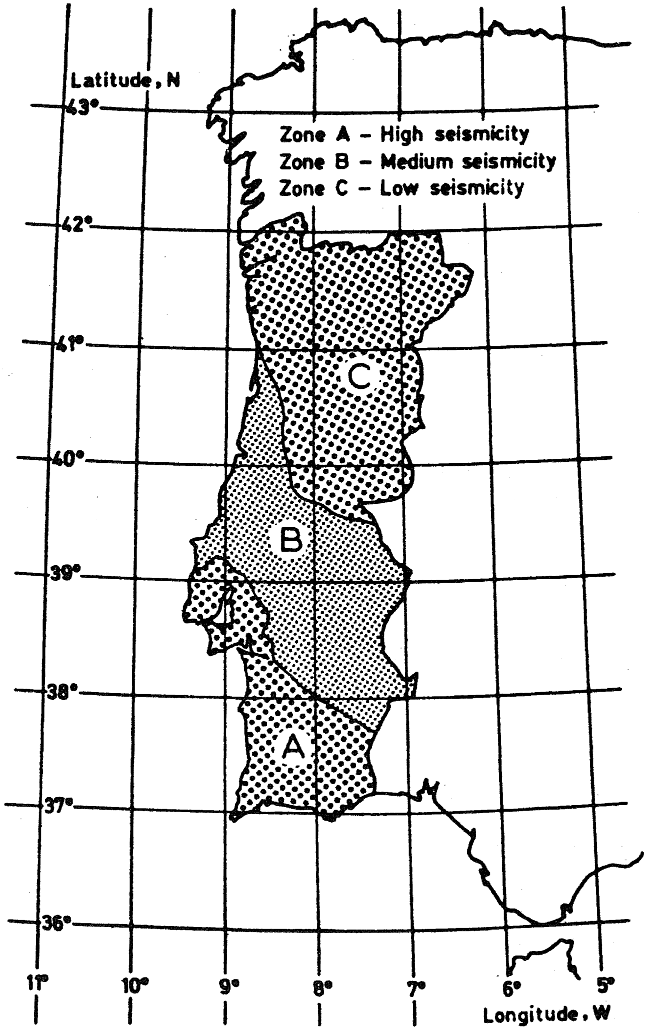

Fig. 1 - Seismic zoning of Portugal

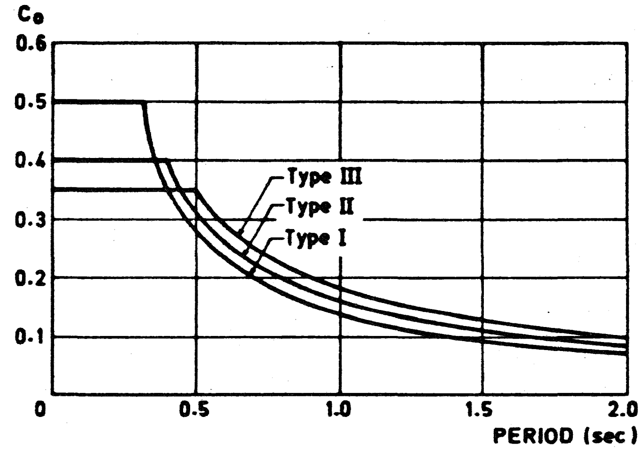

Fig. 2 - Response spectra factor, C_o

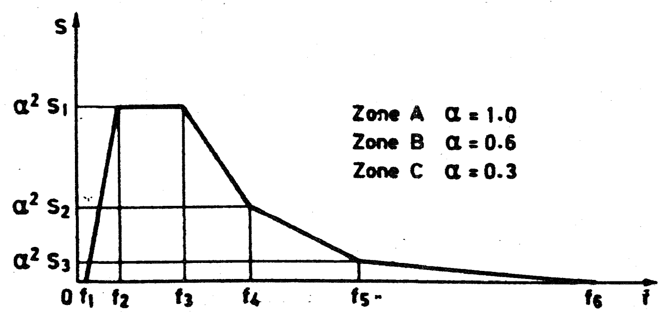

Fig. 3 - Power spectra of acceleration