FRENCH REGULATIONS FOR CIVIL ENGINEERING

IN REGIONS BROKEN BY SEISMISM.

Presentation Note

by A. BRENIER

The ORLEANSVILLE catastrophe of 9 September 1954, and the possibility of such destructions in case of further earthquakes in Algeria and possibly in certain regions of metropolitan France or the French Community, have led the Housing and Reconstruction Ministry to preconize particular technical recommendations aiming to make smaller, as far as possible, the effects of earthquakes on the stability of structures.

For that purpose the Housing and Reconstruction Ministry has established a technical commission which has had assemblies on October and November 1954, with M. RAYROLE, General Inspector, being President, and M. SALMON, Chief Engineer, his Assistant, with

- the Bureau Securitas, represented by

  MM. SUQUET, President,
  CAQUOT and LEBELLE, Vice-Presidents,
  LOSSIER and CHAMBAUD, Delegate Members of its Reenforced concrete Commission,
  BRENIER, General Delegate,
  BLEVOT, Assistant to General Delegate.

- the Society for Technical Control and Survey of Construction (SOCOTEC), represented by

  MM. MERCY, Chief of Technical Services,
  HIERHOLTZ, Engineer.

- the Bureau VERITAS, represented by

  MM. BUISSON, Chief of the Building Services,
  GUILLERAULT, Engineer.

(Reporters : MM. BRENIER, BLEVOT and MERCY.).

General Delegate of the Bureau SECURITAS.

Later on, this Commission included other members, especially
MM. BLACHERE, Commissary for ORLEANSVILLE Reconstruction,
GRENOT, Director of the Globe Physics Institute of Algiers,
GOURINARD, Professor of Applied Geology,
and delegates of the Administration and the Constructors.

The map of the regions broken by seismism has been drawn by MM. LAFFITE and GOURINARD, Geologists.

The worked out regulations have been issued on May 1955 under the title : "RECOMMENDATIONS RELATIVE TO CONSTRUCTIONS TO BE BUILT IN REGIONS SUBJECT TO EARTHQUAKES" and are known as "AS 55 RECOMMENDATIONS".

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French Regulations for protection against earthquake, have naturally taken into consideration the experience acquired in other countries broken by frequent earthquakes. In particular, the principle, which is nowadays universally approved, consisting in substituting to the dynamic calculation a static computation based on the intervention of horizontal forces proportional to masses, has been reconsidered. The allowable stains are considerably increased, and correspond approximately to the limit of elasticity of materials. Yield computing methods may be used.

Considering the circumstances, the values attributed to the seismic coefficients in the AS 55 Recommendations are certainly among the smallest in the world. It has to be explained that they have been fixed in function of several data, among which the seismicity of Algeria, normal regulations concerning constructions independantly from all ideas for protection against earthquakes, and finally the economical aspect of the problem.

France seismicity is weak. That of Algeria is rather well known nowadays thanks to the works of the Globe Physics Institute of Algiers, and professor ROTHE, Director of the Central International Bureau of Seismology of Strasbourg (1) to (6). Algeria is the scene of a rather intense seismic activity and has been struck by several destructive and grave earthquakes, but these have not worn, until now, a character of cataclysm as in certain other parts of the world, in sort that, safe in case of unforeseeable modifications of the seismicity of that region, it seems rather easy to take effective precautions against earthquakes. The correct application of normal regulations for constructions used in France (7) (8) (9) gives to the buildings planned in a simple and rational way, well calculated and well realized non-negligible chances to resist satisfactorily to medium intensity shocks. The rightness of this point of view has been confirmed by the Agadir earthquake of February 29th 1960 ;

with a few rare exceptions, buildings well studied and well realized have remained upright, though they have not been calculated with the hypothesis of an earthquake shock.

The authors of AS 55 Recommendations have consequently insisted on design questions, so as to make future constructions enter in the class of constructions to which normal regulations already confer non-negligible chances of survival. Other prescriptions aim to bring the indispensable complement of stability.

At last, the appreciation of seismic coefficients is part of an economic and human whole, and in this respect, positions may be totally different if we are in a strongly industrialized country or in an under-developped country. In the case of a medium seismicity country like Algeria, which is also not well fitted, industrially speaking, one may think that more human lifes can be saved by building hospitals or struggling against poverty than by increasing the value of antiseismic coefficients.

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AS 55 Recommendations have been strictly applicated in the whole regions destroyed by the ORLEANSVILLE earthquake of 1954, and under the Administrative Juridiction of the Commissariat for the Reconstruction of Orleansville.

BOUGAINVILLE village, at about 12 miles from ORLEANSVILLE, has been rebuilt according to the AS 55 Regulations, and has undergone two shocks on June 28th and August 15th 1957, the intensities of which, in the International Macroseismic scale, have been respectively VII and VIII. The new buildings have behaved perfectly well.

It is unfortunately deplorable that the application of the antiseismic regulations has worn an imperative character only in the destroyed zone of 1954. Everywhere else, they have remained till now but simple recommendations. We can be but satisfied of the decision taken recently to make them become obligatory by means of a governmental decree.

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Let us notice finally that these regulations are being reviewed to take into consideration the lessons from the Agadir earthquake and recent acquisitions in earthquake engineering.

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A. Brenier

RECOMMENDATIONS CONCERNING THE CONSTRUCTIONS TO BE BUILT IN SEISMIC REGIONS.

PREAMBLE

TERRITORIAL ZONES IN ALGERIA

For the whole of the Algerian territory two zones will be distinguished :

- A zone, with low seismicity ;
- B zone, with high seismicity.

These zones are delimited on the annexed map, which is taken from the report of November 28th 1954 by Mr. Laffitte and Mr. Gourinard, professor and Assistant at the Laboratory for Applied Geology of the Algiers Faculty of Sciences.

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1 - GENERAL RECOMMENDATIONS CONCERNING THE DESIGN.

In order to make constructions resist in good conditions to seismic movements such as they manifested themselves till now, without an inacceptable increase of costs, it is recommended to respect the following rules :

1.1 - GENERAL CONCEPTION OF BUILDINGS

1.11 - The height of buildings shall be diminished as much as possible, and especially the ratio of height to width (the width being the smallest lenghth between outer faces of façades); if this ratio exceeds :

- 2.5 for A zone ;
- 2 for B zone ;

special justifications must be furnished.

1.12 - Constructions not well equilibrated in their height or in their inertia are to be avoided.

1.13 - There is to be disposed, as far as possible, an all-over basement, or else, deep massives or reinforced foundations which anchor the construction in the soil.

1.14 - Vaults without tie-rods are to be avoided as well as generally the constructions or parts of constructions the stability of which is incompatible with small movements of supports.

1.15 - Cantilevers, brackets, cornices with important projections and generally all kind of constructional elements not well tied to the framework are to be avoided.

1.16 - In roofings or ceilings avoid the use of not well fixed elements, even if they are of small dimensions.

1.17 - Circulation area is to be disposed in a way to facilitate rapid exit in the case of an earthquake. Each flight of stairs shall form a whole as stiff as possible, well tied to the landing and the framework.

1.2 - FOUNDATIONS

1.21 - Solid ground is to be chosen preferably ; water-bearing soils, fills, falls, alluvions very recent or in thin layers are to be avoided.

1.22 - Deep foundations should be disposed, carefully tied and engaged in the resisting soil, especially in the view of their resistance to lifting forces due to earthquake.

1.23 - All heterogenous foundations are to be avoided.

1.24 - A very resistant tie is to be realized between the foundations and the superstructure.

1.3 - SUPERSTRUCTURE

1.31 - Vertical loads are to be diminished in the upper parts ; the center of gravity of the construction ought to be held as low as possible. Heavy roofing and terraces are to be especially avoided.

1.32 - In framework constructions, joints shall be made stiff. It is most important to make safe the indeformability of the whole structure by efficient wind-bracing in every direction ; for instance by means of cross walls disposed sufficiently near to one another and stiff window basements, these members being tied to one another and to the skeleton by carefully anchored reinforcements.

- The disposition of the reinforcement in framework joints shall allow a correct concreting.

- In columns, the overlaps length of reinforcing toothing bars shall be at least 50 times the diameter of the bars. Overlaps shall be executed without hooks.

1.33 - Efficient connection is to be made between different members of a structure by means of tie-beam or tie-rods (reinforced concrete or steel), horizontally, vertically and diagonally. These ties have to resist to tensile and shear stresses and to stresses resulting from a possible torsion of the whole structure.

- Reinforced concrete constructional members subject to shear shall always be reinforced transversally ; the spacing of that reinforcement shall not exceed the effective depth of the member considered (the depth refered to is the depth from compression face of beam or slab to the center of the longitudinal tensile reinforcement section, as used in bending computations). This does not apply to solid slabs and footing slabs.

1.34 - Special care shall be given to these connections when using precast elements. Proscribe floor constructions with joists running only in one direction without a reinforced concrete slab cast on the spot; precast concrete joists and slab cast on the spot are to be efficiently tied.

1.35 - In masonry construction it is expressly recommended to frame masonry panels by means of horizontal and vertical tie-beams. Spacing of such ties (between parallel members) should normally not exceed 5.00 meters.

- When no such ties are disposed and when masonry is built

in horizontal layers it could be sufficient in some parts of the structures to dispose tie-reinforcements in the masonry joints, on condition that such reinforcement is carefully anchored in the vertical skeleton members or in orthogonal walls. Such reinforcements are to be placed in deep horizontal joints (3 to 4 cm deep), put at most every 50 cm. Cross-sectional area of such reinforcement is to be about 1 cm^2 in each joint.

- Masonry is to be pugged with ciment mortar, made with clean sand not containing agregates the size of which is inferior to 0.4 mm. Masonry materials should be abundantly watered just before building them in.

- Isolated pillars and masonry walls between windows of small depth shall be avoided.

1.36 - Framings tied to the skeleton or the tie-beams are to be disposed around openings.

1.37 - Special precautions are to be taken for corner buildings (especially as to wind-bracing) and for transformations or heightenings where stability of both old and new structure has to be proved.

1.38 - It shall be avoided to transmit to small surfaces important efforts due to accelerations both horizontal and vertical ("punching" or "ramming" effects at the end of trusses, beams,...)

- Elastic tampons are to be disposed in expansion joints between blocks of same inertia or nearly same inertia. On the contrary, large joints are to be disposed between blocks of markedly different inertia.

1.39 - Not-fragile gas and water piping shall be used, as well as carefully protected electric lines.

1.40 -When planning the execution of works, it is to be avoided to have important breaks between the execution of the skeleton or bearing walls and that of front wall fillings and inner partitions which contribute efficiently to the wind-bracing of the structure.

2 - COMPUTATION RULES.

Stresses shall first be calculated under the effect of dead loads, live loads and climatic loads according to regulations in vigour at the time of the construction‡. Then earthquake

‡ Regulations to be applied at present are the codes edicted by the Ministry of Housing and Reconstruction and known as : Règles BA 1945 for reinforced concrete, CM 1946 for steel structures and NV 1946 for the computation of effects of wind and snow.

effects shall be calculated as indicated in the following :

2.1 - Earthquake forces.

The inertia forces, due to seismic movements of the ground, which develop in the structure, may act in any direction. It will be sufficient to consider simultaneously or successively the effects of a horizontal and vertical component, these components being defined as follows :

2.11 - Horizontal component.

For a determined element of the construction, this component acting in any horizontal direction and applied to the center of gravity of the considered element, will be σ P.

σ is a "seismic coefficient", equal to the product $\sigma_1 \sigma_2 \sigma_3$ (see annexed tables).

- σ_1 is a "zone coefficient" which, up to 10 m. height above ground level, will equal

0.035 in A zone (1)

0.070 in B zone (1)

Over 10 m. height above ground level, the values of σ_1 as given above shall be increased with 2% per meter of height.

Taking for an example 16.0 m. height, we will have :
0.070 (1+ 0.02 x 6) = 0.0784 in B zone.

- σ_2 is a "ground coefficient" wich depends on foundation conditions. This coefficient which will equal 1 in usual foundation cases, can vary between two extreme values :
0.75 for constructions founded on rock,
1.25 for constructions founded on loose and water bearing soils.

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(1) - These values correspond to the following base coefficient

0.05 in A zone
0.10 in B zone

multiplied by a reducing factor of 0.7. This reducing factor accounts for the fact that the seismic effects the intensity of which varies very rapidly with time, will be assimilated to statical forces liable to act during a considerable time.

- σ_3 is a "foundation depth coefficient" which will equal 1 when the construction has a over-all basement or deep massive reinforced foundations, and 1.25 in other cases.

P will be equal to :

1) dead loads only, corresponding to the member considered, for housing buildings.

2) dead loads plus half the live loads acting direcly on the member considered, for stores, warehouses and industrial buildings.

3) dead loads plus total live loads acting directly on the member considered, for reservoirs, tanks and silos.

2.12 - Vertical component :

This component will equal $\pm$ 2 σ P,
σ and P being calculated conforming to paragraphe 2.11 and being agreed that for σ_1 the value fixed above for height up to 10 metres, will be taken without any increase for greater height.

2.13 - In case of constructions having floors, computations will be made by applying the horizontal forces at each floor level, and by accounting in the evaluation of P dead loads and possibly the fraction of live loads defined above, corresponding to the floor presently considered.

2.14 - For isolated constructions (factory chimneys, tanks, fence walls, etc.) the seismic coefficient defined above should be doubled.

2.15 - For chimneys (beginning from last floor) and for structural elements jutting out from front or side walls of buildings (corbels, projecting elements of balconies, cornices) the seismic coefficient defined above shall be multiplied by 3 ; for balconies, verification shall be made for the parapet and for the whole balcony.

2.2 - Allowable unit stresses :

Stresses shall be calculated under the simultaneous action of :

- dead loads,
- service live loads,
- earthquake,

excluding climatic loads (wind, snow, temperature).

2.21 - In certain verifications it could be more defavorable to assume that live loads or some of them are null. One shall equally account for the fact that inertia forces of seismic origin can act upwards.

2.22 - It has to be proved for each member that the above defined effects on construction or part of it are inferior to ultimate strength capacity. This verification has to be made by means of an ultimate strength design method based on experiments of proved evidence.

Provisionally, for lack of an official method according to regulations for ultimate strength design, the classical methods, may be used i. e. those for elastic range.

In this case computations will be made by taking the following values for unit stresses allowable under these conditions :

- for the steel or steel constructions, or concrete reinforcements : the conventional limit of elasticity.

- for the concrete of flexural members of reinforced concrete skeletons : 8/10 of compressive strength, this being measured at 90 days of age on cubical specimens of 14.1 or 20 cm side length (tensile strength of concrete will be considered as null) ;

- for the concrete members of reinforced concrete skeletons, the section of the members being under compression on their whole area : 6/10 of compressive strength determined under above conditions ;

- for masonry and plain concrete : the triple of unit stress usually allowable ;

- for soils if they are plain rock : the triple of unit stress usually allowed ;

- for loose and water bearing soils : the unit stress usually allowable ;

- for soils that cannot be classified in the above two categories the double of unit stress usually allowable.

2.23 - Filling panels can be accounted for in computations relative to the stability of constructions on condition that those panels are wholly framed by skeleton members or are made of masonry treated as indicated in 1.35.

SEISMIC COEFFICIENTS TO BE ACCOUNTED FOR IN STATICAL COMPUTATIONS OF CONSTRUCTIONS TO BE BUILT IN EARTHQUAKE ZONES

	Heigth above ground level	Soils of average consistency		Rock soils		Loose and water bearing soils	
		Deep foundations	Superficial foundations	Deep foundations	Superficial foundations	Deep foundations	Superficial foundations
Horizontally	up to 10,00 m	0,0350	0,0437	0,0262	0,0328	0,0437	0,0547
	to 20,00 m	0,0420	0,0525	0,0315	0,0394	0,0525	0,0656
	to 30,00 m	0,0490	0,0612	0,0367	0,0459	0,0612	0,0765
	to 40,00 m	0,0560	0,0700	0,0420	0,0525	0,0700	0,0875
Vertically	any heigth	0,0700	0,0875	0,0525	0,0656	0,0875	0,1094

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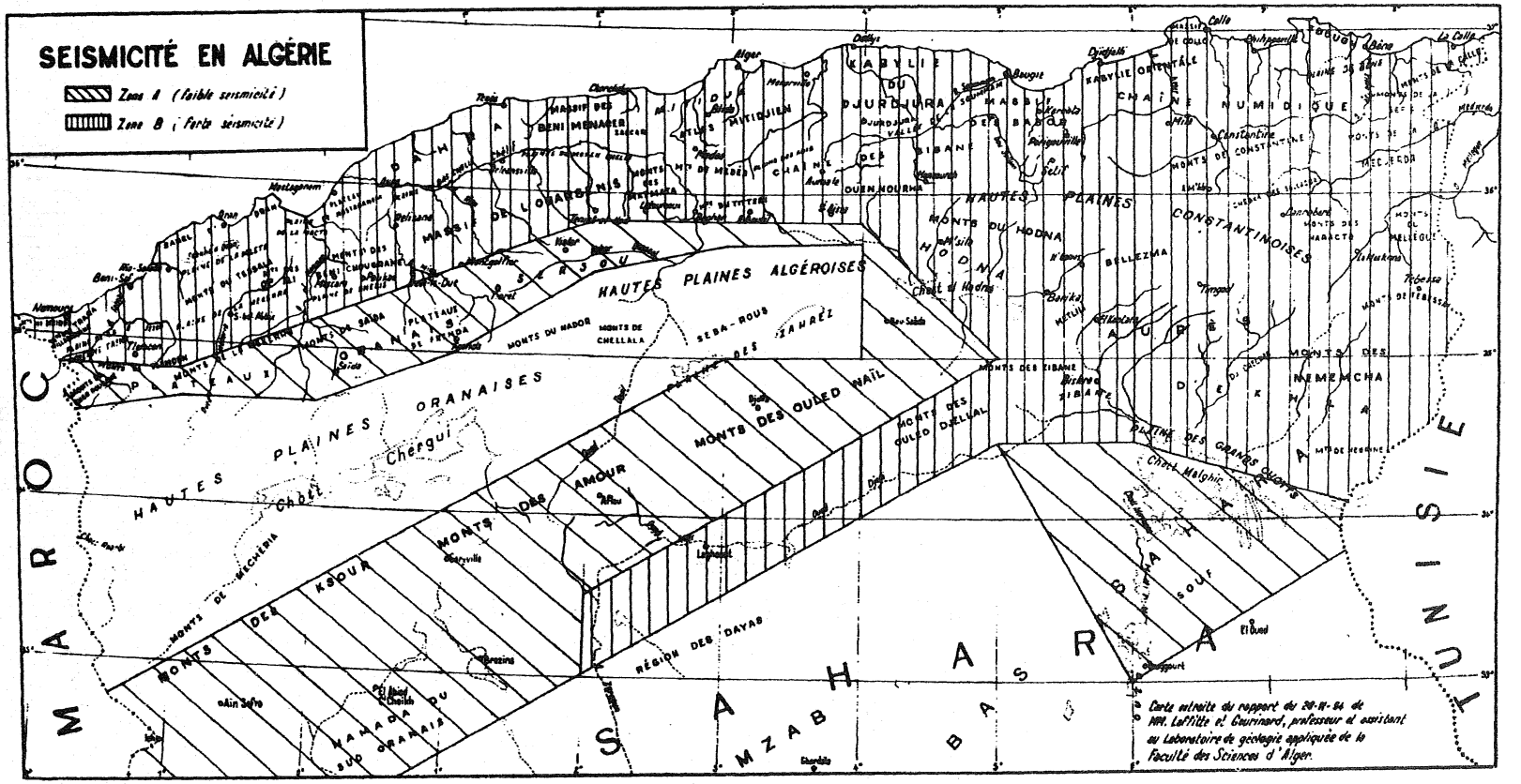
		Deep foundations	Superficial foundations	Deep foundations	Superficial foundations	Deep foundations	Superficial foundations
Horizontally	up to 10,00 m	0,0700	0,0875	0,0525	0,0656	0,0875	0,1094
	to 20,00 m	0,0840	0,1050	0,0630	0,0787	0,1050	0,1312
	to 30,00 m	0,0980	0,1225	0,0735	0,0919	0,1225	0,1531
	to 40,00 m	0,1120	0,1400	0,0840	0,1050	0,1400	0,1750
Vertically	any height	0,1400	0,1750	0,1050	0,1312	0,1750	0,2188

SEISMICITY IN ALGERIA A zone (low seismicity) B zone (high seismicity)



Map taken from report dated 28.11.54 by Mr. Laffitte and Mr. Gourinard, Professor and Assistant at the Laboratory for Applied Geology, at the Algiers Faculty of Sciences.

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