Construction Regulation that will govern in the National Territory

The Ministry of Housing and Human Settlements, of the Government of National Reconstruction of the Republic of Nicaragua, in use of its faculties and especially the one that confers to it the Decree 504, in the article five in its reform in may 12 1983.

Agreement:

The following Construction Regulation governs the National territory.

Notation

P_o (Kg/m2)	=	Wind pressure.
F_i (Kg)	=	Horizontal seismic force applied to the floor i of the building.
F_n (Kg)	=	Horizontal seismic force applied to the floor n of the building.
P_i^{cm} (m)	=	Coordinate of the mass center of the floor i, in the analysis axis.
P_i^{cr}t (m)	=	Coordinate of the rigidity center of the floor i, in the analysis axis.
R (%)	=	Reduction factor of gravitational live load according to defined, in Article 19.
S (Kg)	=	Horizontal shear force acting on the base of the building.
S_i (Kg)	=	Horizontal shear force acting on the i-th floor of the building.
T (sec.)	=	Fundamental period of vibration of the building in the analysis direction.
W (Kg)	=	Total weight of the building (CM + CVR).
W_i (Kg)	=	Weight of the floor i of the building(CM + CVR)
Gamma (dimensionless)	=	Reduction factor of the overturning moment.
θ (degrees)	=	Angle of slope of the ceiling or wall with respect to the horizontal direction of the wind, or among load direction with fibers direction.
c (dimensionless)	=	S/W = Seismic design coefficient to determine the shear stress in the base level of the construction.
D (dimensionless)	=	Dynamic amplification factor taking into account the soil effect.
e_{ti} (m)	=	Eccentricity of the floor i, or separation among the shear force action line of the floor i, and the rigidity center.
F_f (dimensioless)	=	Shape factor to increase the wind pressure.
H (m)	=	Maximum dimension in plant of the building.
h_i (m)	=	Height of floor i measured from the base level of the building.
h_n (m)	=	Height of floor n measured from the base level of the building.
K(dimensioless)	=	Shape and type factor of structure.
k(dimensioless)	=	Reduction factor of wind pressure.
M_u (Kg. m)	=	Twisting moment of the floor i
M_{vi} (Kg. m)	=	Overturning moment of the floor i
M_v (Kg. m)	=	Overturning moment of the base of the building.
n	=	Total number of floors of the building.

TITLE I
GENERAL ARRANGEMENTS

Chapter I
Generalities and Definitions

Objectives:

Article 1. These Regulatory Procedures establish the applicable requirements to the design and new constructions, as well as to the repair and reinforcement the already existing ones, in order to:

a) To avoid the loss of lives and to reduce the possibility of physical damages to persons.
b) To resist smaller earthquakes without damages.
c) To resist moderate earthquakes with mild structural damages and moderate non structural damages.
d) To avoid the collapse by earthquake effects of great intensity, reducing the

damages at economically admissible levels.

e) To resist wind effects and other accidental actions without damage.

Article 2. Correspond to the Ministry of Housing and Human Settlements that in forward will be designated MINVAH, the application of the Procedures here contained those which will govern in the National territory.

Article 3. The projects presented to the MINVAH to obtain the authorization that establishes the bylaws of Construction Permission of the different regulatory plan have to fulfil the present arrangements.

Article 4. This Regulation shall be able to be revised when necessary in order to incorporate the last advances of the seismic, structure and soils engineering.

Article 5. Following tables and figures contained are approved and incorporated in the present Regulation:

A) Table No. 1. Requirements for the determination of quality and category.
 Table No. 2. Requirements of quality for grade of the structure.
 Table No. 3. Weight of walls with 1cm of revetment in both faces.
 Table No. 4. Specific weight of construction materials.
 Table No. 5. Characteristic of materials stored in warehouse.
 Table No. 6. Specific weight of liquids.
 Table No. 7. Uniformly distributed live loads.
 Table No. 8. Wind pressures.
 Table No. 9. Seismic coefficient in zone 1 "C".
 Table No. 10. Seismic coefficient in zone 2 "C".
 Table No. 11. Seismic coefficient in zone 3 "C".
 Table No. 12. Seismic coefficient in zone 4 "C".
 Table No. 13. Seismic coefficient in zone 5 "C".
 Table No. 14. Seismic coefficient in zone 6 "C".

B) Figure Numbers: 1, 2, 3, 4.

C) Appendix
 Table A-1
 Table A-2 Factors for design.
 Figure A-1

Article 6. *Arrangement General*
All the constructions shall possess a structural system able to resist the specified loads, maintaining within the indicated limits; in shear as well as in deformations, for this, the present Regulation establishes for the calculation of the seismic solicitations in buildings, three methods, two static and one dynamic; assuming that the horizontal seismic forces act independently according to two principal axes of the structure, except specified it in the Article 25.
The action of the seismic forces and wind do not need to be considered simultaneously.

Article 7. *Definitions*
Each symbol employed in the Regulation will be defined where is employed for the first time. The following definitions are established.

a) *Loads*
 1) Dead Load (permanent load): Vertical load caused by the selfweight of the structure including ceilings, floors, walls, partitions, all machinery put in permanent form, lamps etc.
 2) Live Load (accidental load): The vertical load that resists the building due to its fate, including the weight of the occupants, furniture, all machinery and movable equipment, etc. These loads will not be less than specified in Table 7.
 3) Reduced Live Load: The vertical load that resists the structure according to its fate against seismic solicitations.
 4) Wind Load: It is produced by effect of the wind in any horizontal or vertical directions and determined according to table No. 8.
 5) Ash Load: The weight accumulated by effect of the volcanic ash, that shall be considered as is indicated in the Article 21.
 6) Seismic Load: Caused by earthquake in the form of horizontal and vertical accelerations. The force or seismic load will be determined as is indicated in the Article 24.

b) *Eccentricity*

1) Static Eccentricity: It is the distance between the mass center and the rigidity center of each floor
2) Accidental Eccentricity: It is an additional eccentricity, that incorporates approximately, the effects of the irregularities in the distribution masses and the rigidity, as well as the effects of the rotational excitement by the ground.

c) *Rigidity Center:* It is that point of the floor where upon applying a horizontal shear force, only produces translation.

d) *Response Spectrum:* It is the maximum value of response, of an oscillatory system of a degree of freedom system.

e) *Systems and structural terms.*

1) *Diaphragm*
It is understood by diaphragm any ceiling system or slab able of transmitting lateral earthquake forces or wind to the vertical elements that form the resistant system to such loads.

2) *Flexible Diaphragm*
It is that ceiling diaphragm or slab that only has capacity to transmit direct shear forces to the plane of the diaphragm.
As examples of flexible diaphragm can be considered: The systems of wood and ceilings floor with inferior lining of plywood that are duly united in all their length to the resistant vertical element to the lateral load. Also they are considered the braced ceilings with steel elements, either rod or laminated profiles.

3) *Rigid Diaphragm*
Diaphragm, either of ceiling or slab that could distribute the horizontal forces according to the rigidity of support the resistant elements . As examples of rigid diaphragms can be considered:
Solid slab of reinforced concrete cast in site; or slabs formed by joists of prefabricated elements without monolithic boards among them, but with an additional solid slab of reinforced concrete cast on the elements prefabricated and, duly anchored to them.
This plate or additional slab shall have not less than 5 cms of thickness and it shall be reinforced in each direction; according to the analysis requirements or by temperature, anyone that is greater.
The prefabricated beams, will have to be well anchored in their extreme to a cord or monolithic girder of reinforced concrete, duly calculated to avoid cracking. The floors or ceilings that do not comply with these conditions shall not be considered as rigid diaphragms and they shall not be employed in constructions of prefabricated walls greater than one floor
In anyone of the cases, the rigid diaphragm should fulfill the following condition:

$$F = \frac{\Delta W \times 10^6}{2.2qL} \leq 1$$

F = Rigidity factor of the diaphragm web.

Δw= Deflection by shear of diaphragm web in cm

q = Average shear force of the diaphragm in kilogram by meter on the length L

For concrete slabs can be applied the following formula:

$$F = \frac{28.4 \times 10^6}{\sqrt[t]{W^3 f'c}} \quad \text{less or equal than 1}$$

t = Slab thickness in cm.

W = Weight of the concrete in kg/m^3
The smaller value of W shall be 1.450 kg/m^3

f'_c = Compression strength of the concrete to 28 days in kg/cm^2.

F = Rigidity factor in micro centimeters by meter of clear and by unitary shear force of 1 kg/m.

4) *Bearing Wall*
Calculated wall and built to resist mainly vertical loads.

5) *Shear Wall*
Calculated wall and built to resist, so much vertical loads as horizontal ones parallel to itself

6) *Ductile Wall*
Calculated and built shear wall in such a way that could suffer inelastic deformations (from reversible and cyclical nature from a greater order than the elastic range), without sensitive loss of their resistance.

7) *Rigid Framework (not ductile frame)*
Structural system formed by girders and columns or trust and columns united in rigid way in joints and that resists the loads mainly flexion couple.

8) *Ductile Framework*
Structural system with its members and joints calculated so that could suffer inelastic deformations (from reversible and cyclical nature from a greater order than the elastic deformation), without loss of its resistance.

9) *Vibration and oscillation Modes*
They are geometric configurations of the structure to be displaced it harmonically in external load absence
The oscillation modes are taken linearly independent and orthogonal (with respect to the inertia and rigidity properties of the structure).

10) *Periods and Frequencies*
They are the periods and frequencies associated with the oscillation modes; the fundamental period is the natural period of greater value.

11) *Dynamic Analysis*
Linear systems analysis that is effected uncoupling the structure dynamic equations, in base to the orthogonallity.properties of the oscillation modes.

Chapter II
Requirement of the Seismic Resistant Design

Article 8 *General Requirement*
All structure shall be designed and built, to resist as minimal, the seismic loads determined according to what was established in the Article 24.

Article 9. *Considerations of Geological Character*
In order to minimize the risk due to the geological faults, the projects shall be adjusted to the specific requirements of the Matrix of planning and the Geological Maps for seismic risks by superficial faulting.

Article 10. *Structural Conception*
In the planning of the buildings, to improve the seismic behavior of the building, the following considerations are taken:

a) Symmetry in the masses distribution as well as in the rigidities.
b) To avoid sudden changes of structuring.
c) Smaller weight in the upper floors.
d) to avoid balconies, cantilevers, etc.
e) Selection and adequate use of construction materials.
f) Good constructive practice and rigorous inspection.
g) Design with emphasis in the ductility for a better behavior of the structure.

Chapter III
Classification of the Structures

Article 11. Groups.
Taking into account its objective, the structures are classified in three groups:

GROUP 1.
Public service buildings, such as Hospitals, Sanatoriums, Health Centers, Markets, Water Station Plants, (including Supply and Station Tanks of Pumping), Plants for Black Waters Treatment, Power Stations,(including sub-stations and structures for high voltage transmission), Airports, Terminal of Passengers, Central of Communication (including antenna towers), Broadcasting Station,
Buildings of public use with high occupation factor, Centers and Buildings of Government and Municipal, Fireman Stations, of Policeman Stations, Educational Centers, Jails, Stadiums, Buildings with content of great value (museums, Libraries, greater medicine deposits), Industrial Facilities with Toxic or Explosive Matter deposits, Centers that use Radio-active Material.

GROUP 2.
Buildings of public use with high occupation factor (Churches, Cinemas, Auditory, Markets) or where it does not exist

frequent agglomeration of persons as: Hotels, Offices, Trades, Industries, Clubs, Banks, Restaurants, Housings, Gas stations, External Clinics. All structure whose collapse could put in danger those of this group or of the group 1.

GROUP 3.

Isolated constructions not classified in the previous groups as: Warehouses, Posts of sale whose surface covered will be minor of 100 m2, repair Shops, stables, silos, posts, walls, structures whose collapse could not cause damages to constructions of the two first groups.

Article 12. Types

Taking into account the structural characteristics is made the following classification by TYPES:

Type 1

K= 0,67

Buildings able to resist all the lateral forces in its analysis direction, by mean of ductile frames.

For zone 6 the concrete frames will have to comply with the ductility requirements in each member and joints, in the calculation, detailing, as well as in the constructive phase. The plans will have to carry note in the one which is specified that the SUPERVISOR will not accept no other alternative of construction that is not indicated in the plans.

The construction shall be effected by a duly registered competent Engineer, and master of work class "A". It should be carried a strict control of quality of the materials and they shall be made tests of quality of the steel.

It should be provided of joints of separation to the walls to avoid behavior interference of the frameworks and to avoid damages of the non structural elements in smaller intensity earthquakes

It will not be accepted as ductile any structure that goes to be repaired.

They are included within this type the rigid steel frames of one story, without requiring of diaphragms in the ceiling level. Also they fit in this type the buildings until of 3 plants with flexible diaphragms at floors and ceilings level, designing it the frameworks, ductile, for the lateral forces that correspond to it by broad tributary.

Type 2

K= 0,80

Buildings composed by ductile frames and shear walls that comply with the following conditions: a) the diaphragms at floors and ceilings level will be sufficiently rigid to distribute the lateral forces of all the building in proportion to the rigidity of the resistant elements; b)walls shall have capacity to absorb the whole these forces, having the DUCTILE frames by itself capacity to resist at least 25% of the whole these forces

They can be included within this type the buildings until of 3 floors with diaphragms flexible at floors and ceilings level, should exist at least a resistant wall connected to the frameworks in each axis of the building floor, designing the elements for the shear force that corresponds to it by broad tributary.

Type 3

K= 1,00

Buildings composed by RIGID frames and shear walls that comply with the following conditions: 1) The diaphragms at floors and ceilings level shall be sufficiently rigid to distribute the lateral forces of all the building in proportion to the rigidity of the resistant elements; 2)Walls shall have capacity of absorbing all these forces, having the RIGID frames by itself capacity to resist at least 25% of whole these forces.

They are included in this type: a) The buildings up to two stories able to resist the total lateral forces in its analysis direction by means of rigid frames of any material or "hybrid", (frames with columns of a material and girders or beams with a different material from first), b) Buildings until 3 stories located in zones 1, 2 or 3 compounds in its direction analysis by means of rigid steel frames and/or reinforced concrete. When the floors and ceiling systems constitute rigid diaphragms, the frameworks will receive the lateral forces in proportion of its rigidity or when they constitute flexible diaphragms the frameworks will be designed for the lateral forces that correspond to it by broad tributary.

Type 4

K= 1,17

Structures of one story, compounds in its direction analysis by walls able to resist the total lateral forces that correspond to it by broad tributary. The walls that are connected perpendicularly to it, should be able to resist in flexion the total perpendicular lateral forces to its plane that corresponds to them, provided that the deflection of its wreath girders are within the permissible values. The ceilings of these structures do not need to constitute a structural diaphragm

They are included in this type structures up to two stories with flexible diaphragm at floor level.

Type 5

K= 1,33

Any structural systems that depend, in its principal analysis direction of shear walls or braced frameworks to resist the total vertical and lateral forces. At ceiling and/or floors level exist rigid diaphragms able to transmit the lateral forces in proportion to its rigidity of the resistant elements.

Type 6

K= 1,67

Structures without functional reservation that they do not gather the conditions of the types 1 to the 5, such as: towers, tanks whose contents begins from the level of its foundations and elements sustained by only columns row perpendicular to the analysis direction, including the structures type 4 in those which the slenderness of the wreath girders permits greater horizontal deformations than the admissible.

Type 7

K= 2,0

Tanks whose content is found in the top of its tower.

Article 13. General arrangement to the Types:

It will be able to establish the hypothesis that is wished to locate the structure in any one of the indicated TYPES, provided its final design will be consistent with this analysis and is guaranteed that the construction will be executed accordant to its design.

The type of structure could be different according to each direction, except for the buildings that classify within type 5

Buildings that classify within different structural TYPES among its floors, will be analyzed in its whole using the coefficient K that corresponds to its more critical type.

Article 14. Grade

Taking into account the quality and category in the symmetry, stability of the structure, reliability of the construction system, inspection and control of the materials, such as is established in Table 1, the structures are classified according to the degrees shown in Table 2.

TABLE No. 1

REQUIREMENTS FOR THE DETERMINATION OF QUALITY AND CATEGORY

CATEGORY	TYPES	QUALITY: EXCELLENT	QUALITY: REGULAR	QUALITY: POOR
I	$K_1 = 0,67$	4 or more frameworks with 3 or more spans each one symmetrical.	4 or more frameworks. Regular symmetry.	Everything else
I	$K_2 = 0,80$	4 or more frameworks with 3 or more spans and 4 or more ductile shear walls of concrete or confined masonry.	4 or more frameworks. Regular symmetry.	
I	$K_3 = 1,00$	Symmetrical. Without braced frameworks For the type 3, the height limit will be 16 floors		Everything else
I	$K_4 = 1,17$	4 or more ductile shear walls of reinforced concrete or confined masonry.	4 or more reinforced masonry walls, reinforced concrete or confined masonry.	
I	$K_5 = 1,33$	Symmetrical. Without braced frameworks		Everything else
I	$K_6 = 1,67$	For the Type 5, the height limit will be 16 floors.	Without braced frameworks . Regular symmetry. Height limit will be 16 floors.	
II	All the TYPES	Traditional system of high reliability and ductility emphasis. Without prefabricated elements in the resistant lateral systems. Floors and ceilings with diaphragm action. Dynamic analysis. Static analysis until max. height 4 floors.	Traditional system of regular reliability. Without prefabricated elements in the resistant lateral systems. Equivalent static analysis. Floors with diaphragm action and ceilings with or without diaphragms.	New structural systems of few reliability Simplified Analysis Method
III	All the TYPES	Supervisory Engineer assigned to the work. Labor with vast experience. Material approved and of controlled production.	Occasional inspection or remote inspection. Labor with regular experience. Material approved and of controlled production.	Remote inspection or no inspection. Not qualified labor. Material of not controlled production.

Symmetrical = Eccentricity is equal to or less than 10% ---------- Regular symmetry = Eccentricity is between 10% and 20%.

NOTE: To See Table 2 for the determination of GRADE.

TABLE 2

REQUIREMENTS OF QUALITY FOR DEGREE OF THE STRUCTURE.

Grade	
A	Requires excellent quality in three categories
B	Requires at least Regular quality in three categories.
C	It requires as minimal quality to regulate in any two combination categories and poor in the third.

Chapter IV
Design Load

Article 15. *General Arrangement*

In addition to the loads originated by selfweight of the building, the stored liquid and material loads, live load, wind load, seismic loads and the volcanic ash loads shall be considered. If they might have special loads to support, these shall be established by the Responsible Engineer of design.

Article 16. *Dead Loads*

In estimation of dead loads for design purposes, material weight listed in table 3, 4, 5 and 6 will be used as a minimum loads.

TABLE 3

WEIGHT OF WALLS WITH 1 Cm OF REVETMENT IN BOTH FACES

MATERIAL	DIMENSIONS cm	WEIGHT (Kg/m^2)
BLOCK OF CEMENT	10 x 20 x 40	166
	15 x 20 x 40	231
	20 x 20 x 40	253
BLOCK OF CLAY	10 x 15 x 30	196
	15 x 15 x 30	202
	30 x 15 x 30	174
HOLED BLOCK OF CLAY	5 x 15 x 30	255
	6 x 12,5 x 25	227
SOLID BLOCK OF CLAY	15.28 x 5.24 x 30.33	258
CANTERA	15 x 40 x 60	333

NOTE: - The weight of the 1cm of revetment is 20 kg/ m^2 for each face. In walls with fine, add the same quantity.

TABLE 4

SPECIFIC WEIGHT OF CONSTRUCTION MATERIALS

MATERIAL	APPARENT SPECIFIC WEIGHT (kg/m^3)
A. ROCKS	
Sandstone	2600
Porous limestone and porous sandstone	2400
Basalt, diorite	3000
Compact limestone and marbles	2800
Granite,syenite,diabase, porphyry	2800
Gneiss	3000
Shale	2800
B. WOODS	
Pochote	561
Pine	626
Genizaro	513
Cedar	577
Female laurel	561
Almond-tree	642
Oak	658
Mahogany	706
Goyabe tree	738
Male laurel	850
Guapinol	930
Medlar	1010
C. VARIOUS MATERIAL	
Tar	1200
Asphalt	1300
Rubber in plate	1700
Paper	1100
Plastic in plate	2100
Flat glass	2600

TABLE 5

CHARACTERISTIC OF STORABLE MATTERS

MATERIAL	APPARENT SPECIFIC WEIGHT (Kg/m^3)	INTERNAL FRICTION ANGLE
A. CONSTRUCTION MATERIAL		
Sand	1500	30*
Pumice Sand	700	35*
Lime in powder	1000	25*
Lime in lump	1000	45*
Cement in sacks	1600	----
Cement in powder	1200	25*
Gravel	1700	40*
B. AGRICULTURAL PRODUCTS		
Oats	450	30*

TABLE 5

CHARACTERISTIC OF STORABLE MATTERS

MATERIAL	APPARENT SPECIFIC WEIGHT (Kg/m³)	INTERNAL FRICTION ANGLE
Sugar	750	35*
Fed	650	25*
Rye	800	35*
Flour and bran	500	45*
Corn	750	25*
Wheat	750	25*
Rice	860	----
Frijol	792	---
C. OTHER MATTERS		
Artificial fertilizer	1200	40*
Carbide	900	30*
Fish flour	800	45*
Ice	900	30*
Common salt	1200	40*

TABLE 6

WEIGHT OF LIQUIDS

MATERIAL	SPECIFC WEIGHT Kg/m³
Oil of creosote	1100
Linseed oil	940
Castor Oil	970
Mineral Oil	930
Acetone	790
Acid hydrochloric to the 40%	1200
Acid nitric to the 40%	1250
Sulfuric Acid to the 50%	1400
Water	1000
Ethylic alcohol	800
Aniline	1040
Benzene	700
Benzol	900
Beer	1030
Gasoline	750
Milk	1030
Petroleum	800
Carbon sulfur	1290

Article 17. *Live loads*

Depending on the objective of each construction, the higher live loads that probably occur shall be considered in the design, but in no case less than the uniformly distributed live loads listed in table 7.

TABLE 7

LIVE LOADS UNIFORMLY DISTRIBUTED.

OBJECT	LIVE LOAD Kg/m²	REDUCED LIVE LOAD Kg/m²
Residential (houses, apartments and room of hotels)	200	80
Schools (class room)	250	100
Hospitals (rooms) Asylums, Centers of Health and Clinics	200	100
Operation rooms	300	150
Offices	250	100
Libraries::		
Reading rooms	300	150
Books' rooms	600	300
Places of Meeting:		
Dance salons, gymnasiums, restaurants, rooms of games and similar.	400	200
Auditory, Cinemas,		
Temple: Fixed chairs	300	120
Mobile chairs	500	250
Theaters: vestibules	200	80
Floor of the stage	700	350
Places of Communication of public use (corridors, staircases, ramps and passages of free access to the public) stadiums and places for provided spectacle of gradin (devoid of seats or arm-chairs)	500	250
Laboratories	250	125
Trade: Light	350	250
Middle weighted	450	340
Weighted	550	410
Factory and Work shops:		
Light	400	300
Middle weighted	500	375
Weighted	700	625
Warehouses: Light	450	340
Middle weighted	550	415
Weighted	650	490
Slab ceilings with slopes not greater than 5%	100	40
Slab ceilings with slopes greater than 5%	50	20
Garages and parking (only for cars)	250	150

Scaffoldings and centering for concrete	150	60
Cantilever in public route (marquees, balconies and similar)	400	200

Article 18. *Lives loads in lightceilings.*

For the case of light ceilings of waved covers (including the tile of mud), the resistant structural elements (such as perlines of wood or metallic), they can be designed for the effects that result from the overlapping with a concentrated load from 100 kg. in half of the clear of the resistant member, plus a uniformly distributed load of 10 kg/m^2.

For the case of principal structural elements (such as beams, frameworks and principal girders) that sustain light ceilings of waved covers, shall be considered a concentrated load of 200 kg. that will be applied in half of the clear span of the resistant element, independently of the position of the ridge when possesses two slopes. It will be added a uniformly distributed load of 10 kg/m^2.

For earthquake effect, the reduced live loads to be employed will be of 10 kg/m^2.

Article 19. *Live loads canbe reducedin attention to:*

I.- Live Loads less or equal than ≤500 kg/m^2

The values of the live loads, can be reduced for the vertical design of structural elements when its corresponding area would exceeds 14m^2 in a 0,86% by square meter of supported area by the structural element except in places of meeting, it will not be greater than 60% neither it shall not exceed the value of R determined by the following formula:

$$R=23\left(1+\frac{CM}{CV}\right) \quad \text{Eq. 1}$$

Where: R= Reduction in percentage

CM: Dead Load per square meter supported by the structural element.

CV: Design Live Load per square meter supported by the structural element.

The specified reduction shall not be valid when is applied the Article 18.

II.- Live Loads greather than 500 kg/m^2

For live loads exceeding 500 kg/m^2, it will not be able to make reductions, except that design live loads in columns could be reduced in 20%.

Article 20. Wind loads-concerning the wind loads should be considered:

I.- Wind effects

Wind effects shall be calculated for the buildings and structures to resist the pressures of the wind in any horizontal direction, as well as the horizontal and vertical suction effects. The pressures of the wind assumed for the structural design will be the highest than they could be presented in the zone, but not less than listed in Table 8.

In special cases of very exposed situation, for example: in defiles, in steep, etc., they can be required greater values, that will be determined through special study.

Table 8

WIND PRESSURES

HEIGHT (Mts)	P_0(kg/m^3) Zone 1	Zone 2
0 < H ≤ 10	40	70
10 < H ≤ 15	55	100
15 < H ≤ 30	80	135
30 < H ≤ 150	105	160
150 < H ≤ 375	135	200

ZONE1-will comprehend the Pacific Strip and the Northern part

ZONE2-will comprehend the Atlantic Zone populations

II- Wind forces

Structures shall be studied under the performance of the wind in the direction to its main axes in both senses.

Pressure of the wind against the building varies according to the slope of the walls or the slopes of the ceiling and produces on each superficial element of a construction, so much guided to windward as lee, an over-load P(Kg/m^2) in its normal positive direction (pressure) or negative (suction) a value given by the expression:

P= K P_0 (Eq. 2)

P_0= Equivalent pressure of the wind, according to Table 8.
K= Factor of pushes (dimensionless)

In walls, when the wind acts normally to the exposed surface, will be taken
K= 0,75 of the windward side (pressure) and k=-0,68 of the lee side (suction). The stability of the isolated walls, such as bards, will be analyzed with the sum of the pressure and suction effects, that means K= 1,43.

In buildings with rectangular elevation and plant, shall be used for the normal walls to the wind action, the values of K that indicates the previous paragraph. In walls parallel to the action of the wind, as well as in the ceiling, if it is horizontal, shall be distinguished three zones:
In the first, that is extended from the windward edge until an equal distance distance to a third of the height of the construction K=-1,75. In the second, that it encompasses until one and half times the height of the construction measured from the same edge, K=-1; and the rest, K=-0,40. The same specification will govern in covers with ridges and parallel edges to the action of the wind (cylindrical or inclined ceilings). In this case it will be considered as height of the construction its highest point
In two slope covers, with wind action normal to the ridges, it will be considered in the windward surface three equal ways to the described for the horizontal covers. For this purpose, it will be taken as height of the construction, its highest point. (See figure 1).
They are employed the factors of pushes specified in following table:

Slope	Windward Surface			Leeward Surface
	Windward Zone	Central Zone	Leeward Zone	
Less than 65°	-1.75 + 0,054θ	-1,0 + 0.027 θ	-0.4 + 0,018 θ	-0.68
If D/H less than 0,3				
If D/H= 1,0	D/B, but not greater than 0.75	0.8D/B but not greater than 0.75	0.5D/B but not greater than 0.75	-0.68
Greater than 65°	0.75	0.75	0.75	-0.68

θ =Slope of the cover in degrees
D/H =Relationship among the over elevation of the cover and height of the Construction.
B =Width of the construction
For values of D/H comprised among 0,3 and 1,0, interpolate linearly.
When the wind acts parallel to the ridges, will be supposed the zones and pressures established for horizontal covers. For this purpose it shall be taken as height of the construction, its highest point.
Action of the wind acting normal to the ridges of two slopes cover.

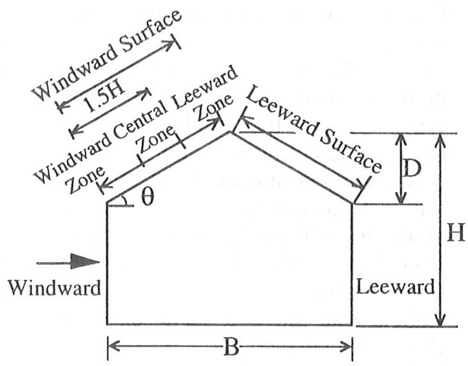


Fig 1

In covers of one slope and when the wind is acting normally to the horizontal ridges and the cover is oriented toward the windward side, they will be applicable the coefficients of table for two slope covers.

If the cover is oriented toward the lee side and its slope exceeds of 15°, will be taken K=-0.68.

If its slope is less than 15°, to analyze the wind effects acting parallel to the ridges, it will be supposed the zones and pressures established for horizontal covers.

It could be made use also of any other generalized method.

III - *Arrangements for special structures.*

a) Truss Structures.
In opened truss structures, constructions with toothed faces or with oblique structure to the faces, will be studied furthermore its action in the biased directions that result unfavorable.

b) Opened Structures.
For the case of ceilings on opened structures (without walls) it will be taking into account the suction effects on the ceiling.

c) Chimneys, tanks and similar structures.
The chimneys, tanks and other similar structures will be held to a special study, established by the Responsible Engineer for design.

d) Labels, cartels and similar structures;
The labels, cartels and any type of announcement that is put in highways or on the public route in commercial buildings, the same as posts with announcements and the support structures of said labels shall multiply pushes of wind calculated in the Eq. 2 for the following form factor:
Labels that have a 70% or more than solid surface F_f= 1,5
Labels that have less than 70% of solid surface F_f= 2,0

Article 21. Load caused by volcanic ash.

In localities as Leon, Carazo, Masaya and in any other zone that exposed to receive volcanic ash shall be taken in account this load for design effects, additional to live load and to any other present load. It is recommended a load due to ash in wet state of 20 kg/m^2 in local documentation absence.

In the corner gutters and zones of the cover, in which could be accumulated anormally the ash by sliding of the confluent ceilings or by effect of the wind or rain, shall be calculated the load due to the foreseeable accumulations.

It is considered the possibility of the fact that the ash load gravitates with different value on partial zones of the cover caused by unequal deposits, drags of wind or other causes.

TITLE II
STRUCTURAL ANALYSIS AND DESIGN

Chapter I
Structural Analysis

Article 22. Design seismic resistant coefficients .

Tables 9 to the 14 list the coefficients "C" to obtain the seismic force that acts on the structures and that is determined according to the Article24.

This coefficient" C "varies in 6 seismic zones in which it has been divided the country (fig. 3) according to GROUP, TYPE and GRADE of the structures.

Alternatively, the coefficient can be calculated according to what was established in the observations.

Article 23. Influence of the soil and of the period of the building.

The values of the coefficients "C' of tables 9 to the 14 can be modified according to the condition of the soil and the period of the building, affecting it for a reduction factor" D "in the following way:

a) For midium and hard soil condition, when T is greater than 0.5 seconds.

$$D=\sqrt{\frac{0.5}{T}}$$

b) For soft soil conditions when T is greater than 0,8 seconds.

$$D= \sqrt{\frac{0.8}{T}}$$

The conditions of soft, midium and hard soil conditions, can be defined as:

SOFT SOIL

Soil deposit of 10 mts. or more of depth composed of:

--- Cohesive material from soft to midium consistence (2 to 8 N) with or without intercalating sandy strata or cohesive material.

--- Material not cohesive (sandy and/or granular) of lossen compactness to firm (0 to 20 N).

MEDIUM SOIL

Soil deposit of more than 60 mts. of depth integrated by:

--- Sands and average gravel to high compactness (21 to 50 N).

--- Lime and/or clay of firm consistenceness to hard (9 to 30 N).

--- A mixture of they

HARD SOIL

--- Rock of any characteristic, either hardy and heals or soft and meteorized.

--- Soil deposit of less than 60 mts. of depth composed of sand and very dense gravel (N greater than 50) and/or clay very hard (N greater than 30).

Where N= number of knocks per foot of penetration

In case of do not have sufficient information the conditions of the subsoil, or if the profile can not be included in none of the previous cases, it will be used soil condition middle.

Soils proned to be liquefied are not included in none of the previous cases.

The fundamental period of the building can be calculated based in the strength properties of the system against the seismic forces, in the analysis direction and trough methods based on mechanics principles generally accepted.

To obtain an approximation of the period of the building, are recommended the following formulas:

$T= C_t h_n^{3/4}$ for the type 1

$T= 0.09 h_n / \sqrt{L}$ for the types 2.3.4, 5 and 6 Where:

C_t = 0,085 for steel frames

C_t = 0,061 for concrete frames

h_n = Height in meters from the base until the highest level of the construction.

L = Length of the building, in the direction under consideration.

The fundamental period T, can be calculated using procedures of Structural Dynamics.

TABLE 9

COEFFICIENTS FOR THE OBTAINMENT OF SEISMIC FORCES IN ZONE 1

"C"

TYPE	GRADE	GROUPS 1	2	3
1	A	0,037	0,026	0,023
1	B	0,045	0,031	0,028
1	C	0,052	0,036	0,033
2	A	0,054	0,037	0,034
2	B	0,063	0,043	0,039
2	C	0,072	0,049	0,045
3	A	0,067	0,046	0,042
3	B	0,079	0,054	0,049
3	C	0,090	0,062	0,056
4	A	0,079	0,054	0,049
4	B	0,092	0,063	0,057
4	C	0,105	0,072	0,065
5	A	0,090	0,062	0,056
5	B	0,105	0,072	0,065
5	C	0,120	0,082	0,075
6	A	0.108	0.074	0.067
6	B	0,125	0,086	0.078
6	C	0,143	0,099	0,090
7	C	0,104	0,072	0,066

TABLE 10

COEFFICIENTS FOR THE OBTAINMENT OF SEISMIC FORCES IN ZONE 2 " C "

		GROUPS		
TYPE	GRADE	1	2	3
1	A	0,064	0,050	0,042
1	B	0,077	0,060	0,050
1	C	0,090	0,070	0,059
2	A	0,092	0,072	0,061
2	B	0,108	0,084	0,071
2	C	0,123	0,096	0,081
3	A	0,115	0,090	0,076
3	B	0,135	0,105	0,088
3	C	0,154	0,120	0,101
4	A	0,134	0,105	0,088
4	B	0,157	0,122	0,103
4	C	0,179	0,140	0,117
5	A	0,154	0,120	0,101
5	B	0,180	0,140	0,118
5	C	0,205	0,160	0,134
6	A	0,185	0,144	0,121
6	B	0,216	0,169	0,141
6	C	0,246	0,195	0,161
7	C	0,180	0,140	0,118

TABLE 11

COEFFICIENTS FOR THE OBTAINMENT OF SEISMIC FORCES IN ZONE 3 "C"

		GROUPS		
TYPE	GRADE	1	2	3
1	A	0.122	0.097	0.086
1	B	0.146	0.116	0.103
1	C	0.171	0.135	0.120
2	A	0.176	0.139	0.123
2	B	0.205	0.162	0.144
2	C	0.235	0.185	0.165
3	A	0.220	0.174	0.154
3	B	0.256	0.203	0.180
3	C	0.293	0.232	0.206
4	A	0.256	0.203	0.180
4	B	0.300	0.237	0.210
4	C	0.342	0.271	0.241
5	A	0.293	0.232	0.206
5	B	0.342	0.271	0.240
5	C	0.391	0.309	0.275
6	A	0.353	0.280	0.245
6	B	0.412	0.325	0.286
6	C	0.470	0.372	0.327
7	C	0.342	0.270	0.240

TABLE 12

COEFFICIENTS FOR THE OBTAINMENT OF SEISMIC FORCES IN ZONE 4 " C "

		GROUPS		
TYPE	GRADE	1	2	3
1	A	0,140	0,117	0,098
1	B	0,168	0,140	0,118
1	C	0,196	0,163	0,137
2	A	0,202	0,168	0,141
2	B	0,235	0,196	0,165
2	C	0,269	0,224	0,188
3	A	0,252	0.210	0.176
3	B	0,294	0,245	0,206
3	C	0,336	0,280	0.235
4	A	0,294	0,246	0,206
4	B	0,343	0,287	0,240
4	C	0.392	0,328	0,275
5	A	0,336	0.280	0,235
5	B	0,392	0,327	0,274
5	C	0,448	0,373	0,314
6	A	0,403	0,319	0,289
6	B	0,470	0,372	0,337
6	C	0,538	0,425	0,385
7	C	0,392	0,326	0,274

TABLE 13

COEFFICIENTS FOR THE OBTAINMENT OF SEISMIC FORCES IN ZONE 5 "C"

		GROUPS		
TYPE	GRADE	1	2	3
1	A	0,157	0,124	0,110
1	B	0,190	0,149	0,132
1	C	0,220	0,173	0,153
2	A	0,226	0,178	0,158
2	B	0,263	0,208	0,185
2	C	0,301	0,237	0,210
3	A	0,282	0,223	0,197
3	B	0,329	0,260	0,231
3	C	0,376	0,297	0,263
4	A	0,329	0,261	0,231
4	B	0,384	0,304	0,269
4	C	0,439	0,348	0,308
5	A	0,376	0,297	0,263
5	B	0,439	0,347	0,307
5	C	0,502	0,395	0,351
6	A	0,453	0,356	0,316
6	B	0,529	0,415	0,369
6	C	0,604	0,475	0,421
7	C	0,440	0.346	0.306

TABLE 14
COEFFICIENTS FOR THE OBTAINMENT OF SEISMIC FORCES IN ZONE 6 "C"

TYPE	GRADE	GROUPS 1	2	3
1	A	0,202	0,161	0,137
1	B	0,244	0,192	0,164
1	C	0,286	0,226	0,191
2	A	0,293	0,230	0,198
2	B	0,342	0,272	0,233
2	C	0,391	0,310	0,263
3	A	0,366	0,290	0,248
3	B	0.429	0,337	0,290
3	C	0,488	0,386	0,328
4	A	0,429	0,341	0,290
4	B	0.499	0,395	0,336
4	C	0,568	0,452	0,385
5	A	0,488	0,387	0,328
5	B	0,568	0,452	0,382
5	C	0,652	0,514	0,439
6	A	0,588	0,463	0,386
6	B	0,686	0,541	0,451
6	C	0,784	0,618	0,515
7	C	0,572	0,452	0,382

Article 24. Evaluation of the horizontal seismic force.

The horizontal seismic force to be resisted will be determined according to the following expression:

S= c W

where:

S=Base shear Force

c= Design Coefficient for seismic forces, content in tables 9 to the 14. This value can be different for the two directions in which is considered the action of the seismic forces, if the type of structure is different according to each direction.

W=Load or total weight of building and that is defined in the Inc. I of the Article 32.

Chapter II
Analysis criteria

Article 25 *General Criterion.*

It will be supposed the seismic action as a rule, acting independently according to two principal axes of the construction.

For the structural systems type 1, 2 and 3, the vertical elements and their foundations shall be designed for 100% of the effects in one direction plus 30% with the axial load for earthquake of the orthogonal axis.

In the structures type 7 (including similar structures), will be considered the effect of one direction plus the 50% of the effect of the other direction.

In all the cases, will be used the load values that produce the more critical effect combinations.

Article 26. Considerations for elements composed.

In constructions with structural elements of mixed materials, it could be consider the combined action of them as long as is assured the combined work of the composed element.

Article 27. Verification.

It will be verified that the deformations of all the structural elements will be compatible mutually, as well as the verification that the diaphragms or roof systems will be able to resist and transmit the induced forces.

Chapter III
Analysis methods

Article 28. *Election of the Method.*

They are presented 3 structural analysis methods, but the selection of the method will be held to the following:

1st. In buildings with smaller height or equal to 12 meters, it will be able to use the simplified analysis method when fulfil simultaneously with the following requirements:

a) In each structure, at least 75% of the vertical loads will be supported by walls mutually tied by means of rigid diaphragms. Those walls shall be of reinforced concrete, confined masonry, reinforced masonry, that satisfy the requirements established in the corresponding Technical Procedures;
b) In each level and in each analysis axis, will exist at least two boundary bearing walls, those which can be parallel or that form mutually an angle not greater than 20 degrees, being each wall bound by the rigid diaphragm in a length of at least 50% of the building dimension, measure in the direction of those walls.

These walls will have to keep among their lengths a relationship not less than 70%, to be of the same material and be put in opposite sides;

c) The relationship of height to minimal dimension of the building base will not exceed to 1,5;
d) The relationship of long/width of the plant of the building shall not exceed of 2,0, unless for seismic analysis end, could be supposed this plant split into independent blocks whose relationship of long to width that satisfies this restriction and each section resists according to the criterion specified in the Article 29;
e) Are included in this method, wood constructions with equal or less than 6 meters height, with flexible diaphragms and that satisfy the minimal requirements established in the Technical Procedures.

2nd. In buildings with height less than 45 meters shall be used the equivalent static method or the dynamic method taking into account the lateral displacement, twist effects and overturning as is established in the Article 30.

3rd. In buildings with height greater than 45 meters, it shall be employed the dynamic analysis method.

Article 29. *Simplified analysis Method.*

To apply this method it shall be made remiss case of the horizontal displacement, twist effects and overturning moment , verifying only that in each floor the total shear forces determined as is established in the Article 30 Inc., a) do not exceed the sum of the bearing walls shear resistance, projected in the analysis direction, verifying in the construcion two principal directions.

Article 30. *Equivalent static method.*

The equivalent state of loads to the seismic forces originates in the construction shear stress, twist and overturning moment. The loads or masses acting in the construction could be replaced by a set of masses concentrate at level of floors, slabs and covers. In effect of the distributions, the shear force at base level shall be distributed to the height of the building according to the Inc., a) of this Article. (Figure 2).

For constructions less than 3 floors, the force acting in each floor will be determined according to the mass distribution in that floor and of uniform way in the height of the building. For analysis the bards and walls in cantilever, will be supposed that the seismic action exercises on that element a horizontal seismic force calculated as is defined in Article24 and acting at 2/3, of the height of the element measured from the base level.

The shear effects, twist and overturning moment can be obtained in the following way:

a) Shear Force.

The shear force in the different levels, it will be referred to the horizontal forces system, equivalent to the seismic effect in the following way:

For Level i, $F_i = \alpha \dfrac{W_i H_i}{\sum_{i=1}^{n} W_i h_i} S$

For the last level n,

$$F_n = \frac{W_n h_n}{\sum_{i=1}^{n} W_i h_i} \alpha S + (1-\alpha) S$$

$\alpha = 1$ for $T \leq 0.5$ sec.

$\alpha = 0.95$ For $0.5 < T < 1.0$ sec.

$\alpha = 0.90$ For $T \geq 1.00$ sec.

$$S_i = \sum_{j=i}^{n} F_j$$

where:

α = coefficient for shear distribution in the height of the building.

F_i= horizontal forces applied at floor level i

hi=Height of the floor i, measured from the base level of the building.

W_i= Weight of the floor i calculated according to it specified in load and their combinations.

b) Twist Effect.

For each analysis axis, the eccentricity "e_{ti}" in the level i, will be determined according to:

$$e_{ti} = P_i^{cm} - P_i^{cr}$$

But not less than:

$$e_{ti} = 0.05\ H$$

Where:

e_{ti} = Eccentricity in the level i

P_i^{cm} = Coordinate of the Mass Center of each analysis axis in the level i.

P_i^{cr} =Coordinate of the Center of rigidity of each axis of analysis in the level i.

H =Maximum length of the building of the level i, normal to the analysis direction.

The moment of twist in the level i, will be determined by means of

$$M_{ti} = \sum_{i=1}^{n} F_i \bullet e_{ti}$$

c) Overturning Moment.

All structure shall be calculated to resist the effects of the overturning moment, either due to the wind or to horizontal forces generated by earthquakes.

The overturning moment in the level i, will be determined by means of

$$M_{vi} = \sum_{j=i+1}^{n} F_j (h_j - h_i)$$

It will be permitted a reduction factor "gamma" of the overturning moment, which is given in table that follow, in function of the type of structure.

TYPE	FACTOR "K"	REDUCTION FACTOR "gamma"
1	0,67	1,00
2*	0,80	0,83
3*	1,00	0,66
4	1,17	1,00
5*	1,33	0,50
6	1,67	1,00
7	2,00	1,00

* For grade " C ", the reduction factor shall be equal to 1.

Article 31. *Dynamic method.*

It is admissible the evaluation of the horizontal seismic force through dynamic analysis procedures, in those which shall be admitted the following

I -- Simplification hypothesis

a) The acting mass in the construction shall be replaced by a set of concentrated masses at level of the floors, slabs and covers;

b) The vertical translating inertia of the floor and the rotational inertia around horizontal axis can be despised;

c) The rigidity of the frames is null against transverse loads and only take load in its plane;

d) The eccentricity "e_{ti}" in each level, it will be calculated according to what is established in the Article 30 Inc. b);

e) If the modal analysis is used, for each one of the two directions, it should be determined as minimal, 3 vibration modes or all the vibration modes with greater periods of 0,4.

f) An acceleration spectrum for modal dynamic analysis is given in figure 4 for two types of soils, being the spectral acceleration:

A= f (c, T)

f= function

where:

c = seismic design Coefficient given in tables 9 to 14 those which include the effect of the structural damping, therefore should not be permitted reductions by that concept.

T = Modal periods of the building.

g) The modal vibration periods will be determined according to established mechanics methods, considering the mass and rigidity characteristics of the building.

II - Dynamic Shear force

The Shear force in the different levels, will be referred to the horizontal forces system in the following way:

For each mode:

a) The lateral force in the level i, and mode m.

$$F_{im} = \frac{A_m}{g} \alpha_m W_i \phi_{im}$$

b) The Shear force in the level i results from:

$$V_{im} = \sum_{j=i}^{n} F_{jm}$$

c) The basal shear force in mode m will be revised according to the following formula:

$$S_m = \frac{A_m}{g}\,\bar{\alpha}_m \sum_{i=1}^{n} W_i$$

being

$$\alpha_m = \frac{\left|\sum_{i=1}^{n} W_i\,\phi_{im}\right|}{\sum_{i=1}^{n} W_i\,\phi_{im}^2}$$

$$\bar{\alpha}_m = \frac{\left(\sum_{i=1}^{n} W_i\,\phi_{im}\right)^2}{\sum_{i=1}^{n} W_i\,\phi_{im}^2} \bullet \frac{1}{\sum_{i=1}^{n} W_i}$$

Where:

A_m= Spectral Acceleration corresponding to the modal vibration period T_m as is defined in the I point Inc. g of this articulate.

α_m = modal participation factor

$\bar{\alpha}_m$ = participation factor for mass in "m" mode

ϕ_{im} = normalized amplitud of the floor i in m mode

W_i= Weight of the floor i, considering (CM + CVR)

The modal displacement of each floor will have to determine according to the following expression:

$$\delta'_{im} = dt\ A_m \frac{1}{W_m^2}\,\alpha_m \phi_{im}$$

where:

dt = deformation Factor given in the Art, 34

III- Design Forces

The shear forces, overturning moments and lateral displacement in each floor shall be determined for design effects, in the following way:

The shear in the floor i

$$V_i = \sqrt{\sum_m V_{i_m}^2}$$

The overturning moment of i-th floor

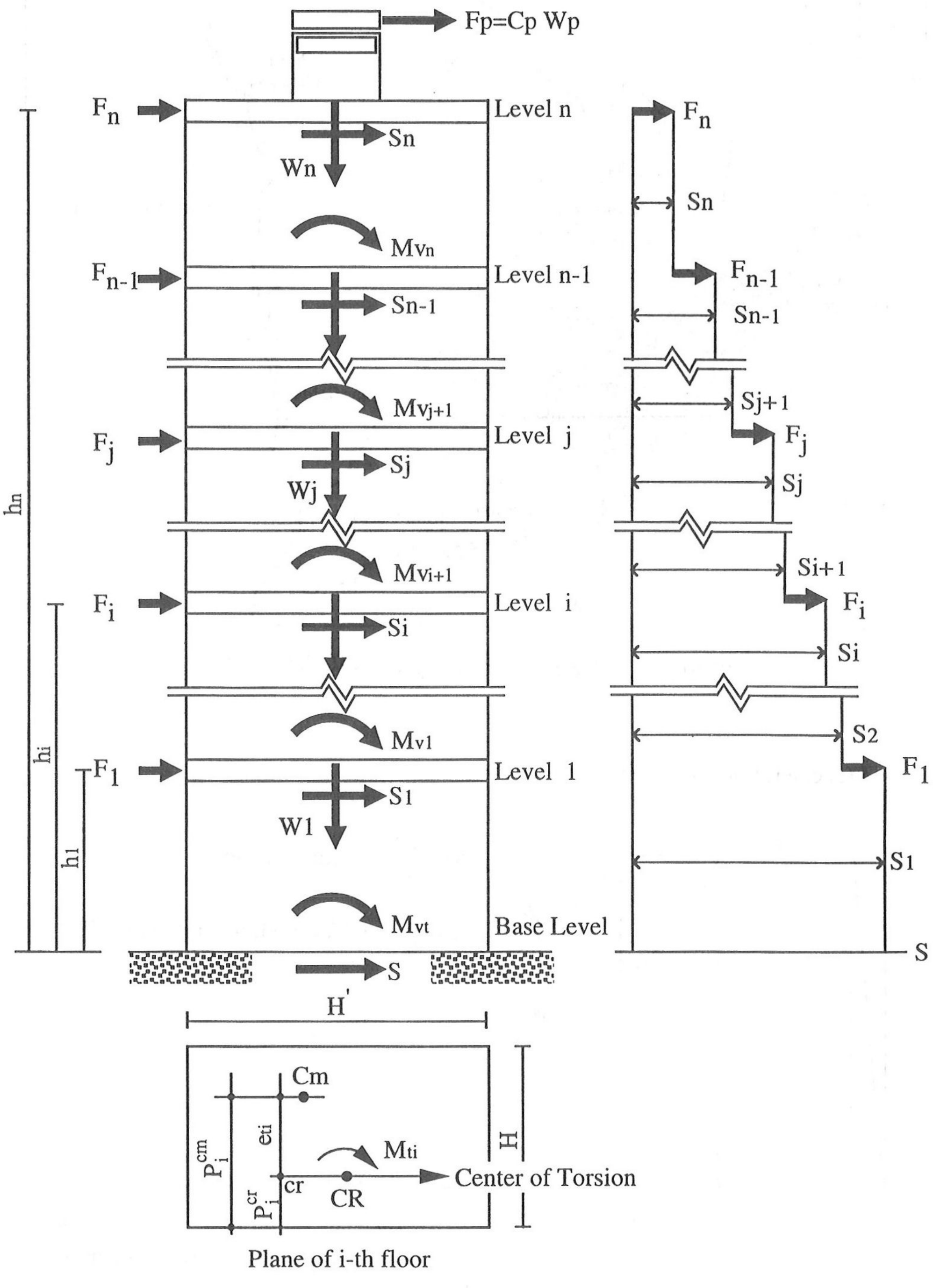
$$M_{vi} = \sqrt{\sum_m M_{i_m}^2}$$

and the displacement of i-th floor

$$\delta'_i = \sqrt{\sum_m \delta'^2_{i_m}}$$

In any level, the shear forces determined as is indicated here could not be less than 60% from the obtained with the application of the equivalent static method.

EQUIVALENT STATIC METHOD



Plane of i-th floor

Figure 2

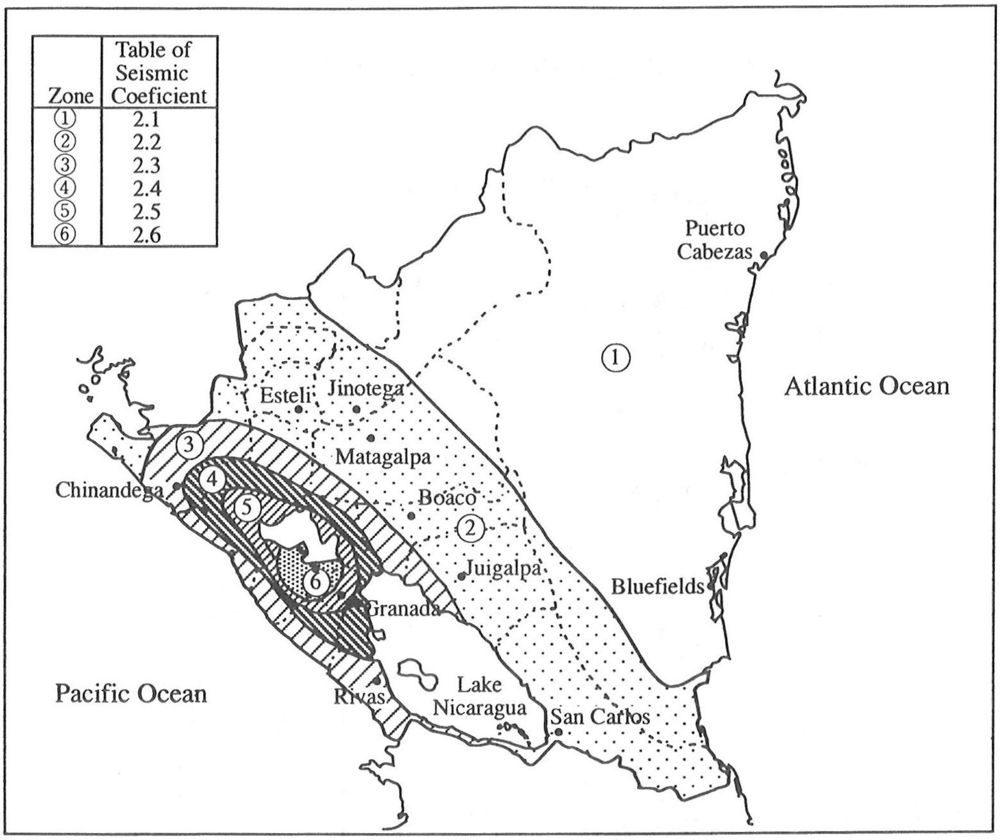
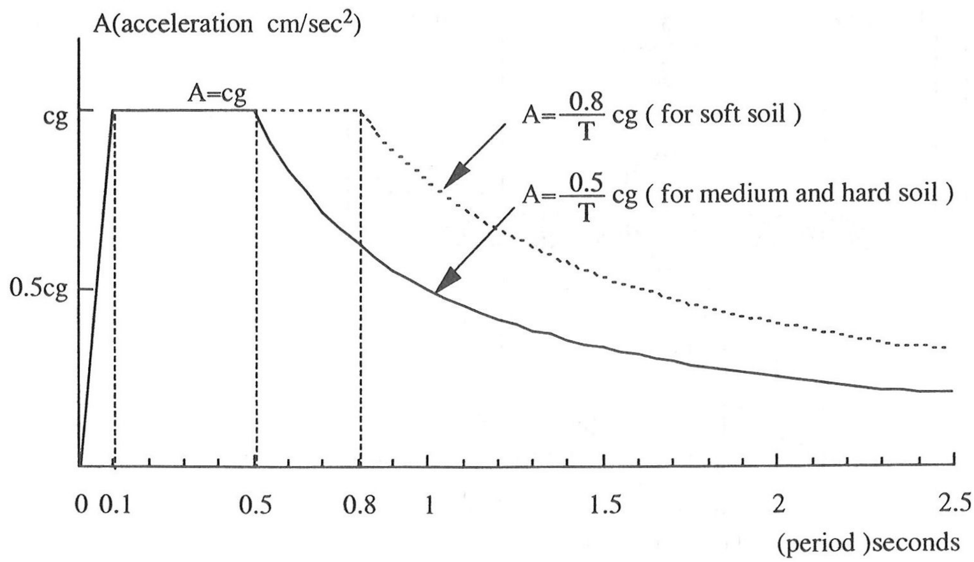


Figure 3. Seismic Zoning of NICARAGUA



c = seismic design coefficient given in Table 9 to 14

Figure 4 Accerelation Spectra

Editorial Notes This is an authorized English translation prepared by Dr. Armand Hernandez, the national delegate of Nicaragua in collaboration with the editorial members.
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