EL SALVADOR NATIONAL SEISMIC CODE.

SELECTION OF ANALYSIS METHOD FOR LATERAL FORCES.

1. ***Static Lateral Force Method can be used for:***
   - Regular structures lower than 70 m of height, except those which are located in S4 soil type and their fundamental period is higher than 0.7 seconds.
   - Irregular structures not having more than 5 stories or lower than 20 m of height. Structures with irregularities A, B, or C according to table 4, or any other irregularity not defined in table 4 or 5, should also comply with section 3.8.1 to use the static lateral force method.

2. ***Dynamic Analysis of Force Method can be used for:***
   Any structure can be designed using this method. It has to be used specially for the cases in which the static lateral force method can not be used.

STATIC LATERAL FORCE METHOD FOR LATERAL FORCES.

The base shear should be calculated using the following equation:

$$V = C_s W$$

Where Cs needs to be computed using:

$$C_s = \frac{AIC_o}{R}\left(\frac{T_o}{T}\right)^{2/3}$$

The fundamental period (T) of the structure needs to comply with: $T_o < T < 6T_o$

Where: A: Area factor (see table 1)
I: Building importance factor (see table 3)
Co and To: Site coefficients (see table2)
T: Period of structure
R: Reduction factor (see table 6)

Period of the structure.

- ***Method A:***

$$T = C_t h_n^{3/4}$$

With: Ct = 0.085 for ductile steel frame structure.
Ct = 0.073 for ductile RC frame structure.
Ct = 0.049 for every other structure.

- ***Method B:***

$$T = 2\sqrt{\frac{\sum_{i=1}^{n} W_i \delta_i^2}{g \sum_{i=1}^{n} F_i \delta_i}}$$

With: Fi = Any appropriate approximation of force distribution.
* T using this method should not be less than 80% of T using method A.

Vertical Distribution of Lateral Force.

The force acting in every floor, including the top floor is evaluated using:

$$F_x = \frac{(V - F_t) W_x h_x}{\sum_{i=1}^{n} W_i h_i}$$

Where the value of the extra force at the top Ft is:

$$F_t = 0.07TV$$

Where: T = Using Method A
Ft = 0 when T < 0.7 sec
Ft < 0.25V

Horizontal Distribution of Lateral Force.

- ***Accidental Torsion Moment.***

Mt = (Fx)x * e

Where: (Fx)x = Seismic force for story x
e = 0.05 * Building dimension perpendicular to x axis.

- ***Increasing of Accidental torsion due to irregularities listed in table 5***

When Torsional irregularities are present we need to increase:

The accidental torsion using factor Ax.

$$A_x = \left(\frac{\delta_{máx}}{1.2\delta_{prom}} \right)^2 \leq 3.0$$

The Base shear in the analysis direction using Bx:

$$B_x = 3.0\frac{\Delta_{máx}}{\Delta_{prom}} - 2.6 \leq 1.4$$

Story drift calculation and limits.

Δ = (Total displacement of story n+1) – (Total displacement of story n)

The total displacement of a story is calculated using:

$$\delta_x = C_d \delta_{xe}$$

Where: δ_{xe} = Elastic displacement of a story.

C_d = Increasing Displacement Factor.

* The story drift calculated by this equation should not be larger than the allowable story drift Δa listed in table 7. For this calculation the fundamental period can only be estimated using the B method, and the limitation of only taking the 80% of the period calculated using method A should not be taken into account.

Vertical component of seismic Forces.

- Horizontal cantilever members should be designed to resist a net upward force equivalent to 0.5 A times the dead load, in addition to the other combinations of applicable loads.
- Horizontal prestressed members should be designed, in addition to all the combinations of applicable loads, using no more than the 50 percent of dead load for gravitational loads, alone or in combination with the effect of lateral forces.

DYNAMIC ANALYSIS FOR LATERAL FORCES.

$$Si\ \ T_m < \frac{T_o}{3}$$

$$C_{sm} = \frac{IA}{R}\left[1 + \frac{3(C_o - 1)T_m}{T_o}\right]$$

$$Si\ \ \frac{T_o}{3} \leq T_m \leq T_o$$

$$C_{sm} = \frac{IAC_o}{R}$$

$$Si\ \ T_o < T_m \leq 4.0\ seg.$$

$$C_{sm} = \frac{IAC_o}{R}\left(\frac{T_o}{T_m}\right)^{2/3}$$

$$Si\ \ T_m > 4.0\ seg.$$

$$C_{sm} = \frac{2.5IAC_o\ T_o^{\ 2/3}}{R\ T_m^{\ 4/3}}$$

Response Spectrum Analysis.

1. Number of Modes to use: As much as needed to achieve 90 % of participant mass.
2. Mode combination: Most danger combination should be used.
3. Results evaluation:

- Irregular st.: 100 % of static base shear.
- Regular st.: 90% of static base shear using T from Method A. But greater than 80% of static base shear using Method B.

4. Directional Effects: Take into account the ortogonal effects.
5. Torsion: Take into account torsion effects.

Diaphragms.

The story deck for every floor should resist a force equal to:

$$F_{px} = \frac{F_t + \sum_{i=1}^{n} F_i}{\sum_{i=1}^{n} W_i} W_{px}$$

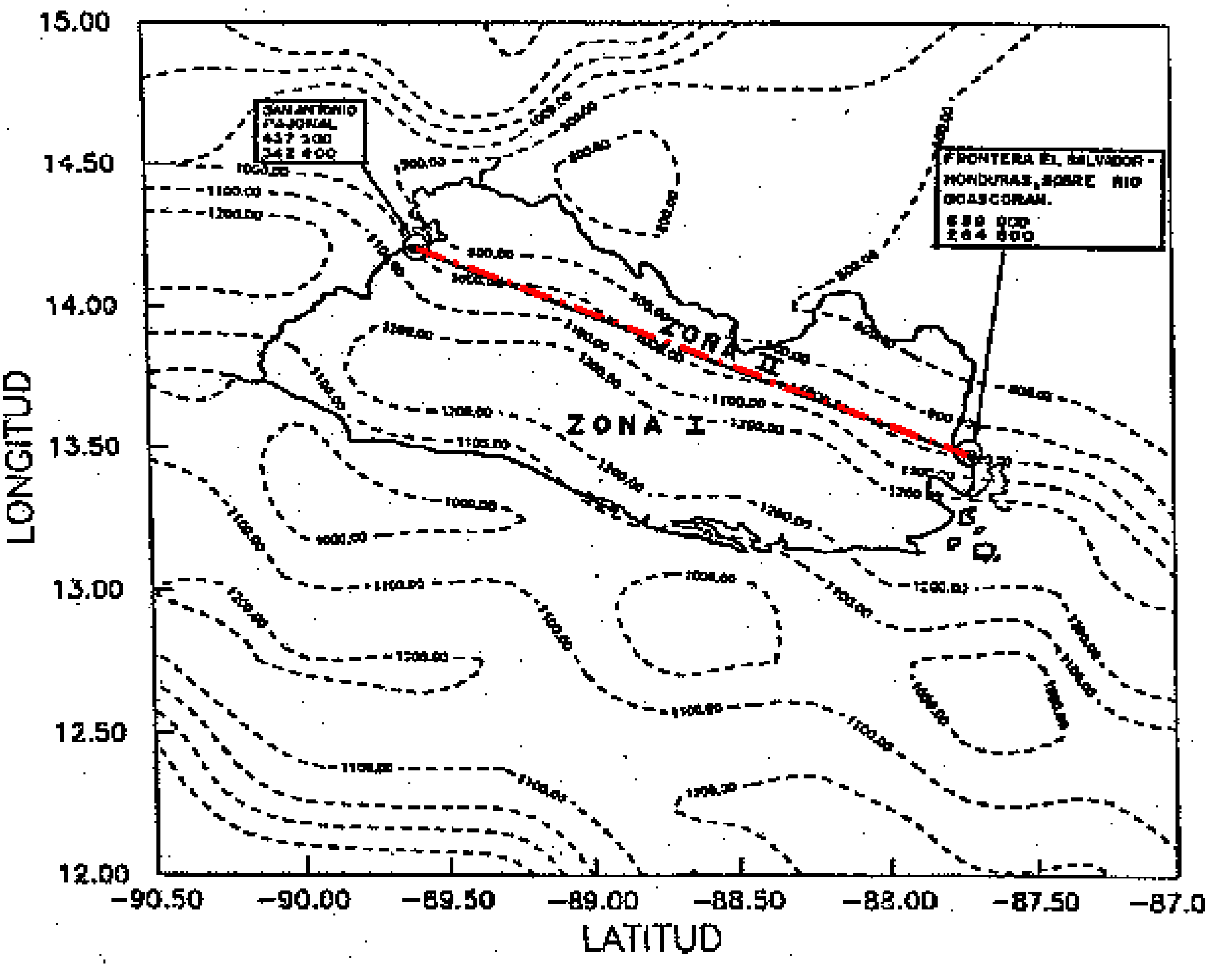
Where: 0.35 A I Wpx < Fpx < 0.75 A I Wpx

Ortogonal Effects.

To take into account the effect of seismic forces acting perpendicular to the analysis direction we can use:

(Mtx)t = 100% Mtx + 30 % Mty

TABLE 1. SEISMIC ZONE FACTOR A.



ZONA *	FACTOR A
1	0.40
2	0.30

TABLE 2. SITE COEFFICIENTS.

Type	Description	C_o	T_o
S_1	Soil profiles with the following characteristics: (a) Rock with V_s>500m/s (b) Rigid soils, thickness<30m	2.5	0.3
S_2	Soil profiles with the following characteristics: (a) Rigid soils, thickness>30m (b) Compact or medium dense soil, thickness<30m	2.75	0.5
S_3	Soil profile with a cumulative thickness from 4 to 12m of cohesive soft soil or cohesive medium compact soil or non-cohesive loose soil	3.0	0.6
S_4	Soil profile with more than 12m of cohesive soft soil or non-cohesive loose soil and V_s<150m/sec.	3.0	0.9

Note: (1) At the sites where the soil properties are not known in detail as to characterize it according the table above, the soil type S_3 must be used. (2) It is implicit that below the soil profile specified for each type of soil there is just rock of the S_1 type.

TABLE 3. IMPORTANCE FACTOR.

CATEGORY OF OCCUPANCY	IMPORTANCE FACTOR I
I essential or dangerous buildings	**1.5**
II special buildings	**1.2**
III normal buildings	**1.0**

TABLE 4. VERTICAL IRREGULARITIES.

A) Stiffness irregularity. Flexible Story
B) Mass irregularity
C) Vertical geometric irregularity
D) Plan discontinuity of vertical elements resisting lateral loads
E) Capacity discontinuity. Soft story

TABLE 5. HORIZONTAL IRREGULARITIES.

A) Torsional irregularity
B) Entering corners
C) Diaphragm discontinuity
D) Outside plan dealignment
E) Non parallel systems

TABLE 6. STRUCTURAL SYSTEMS.

Basic structural system	Description	R
System A	1. Steel or concrete frames with special detailing	12
	2. Concrete frames with intermediate detailing	5
	3. Steel frames with ordinary detailing	7
System B	1. Walls:	
	a. Concrete	8
	b. Masonry	7
	2. Braced steel frames	
	a. Eccentrically	10
	b. Concentrically	8
System C	1. Concrete walls combined with	
	a. Concrete or steel frames with special detailing	12
	b. Concrete frames with intermediate detailing or steel frames with ordinary detailing	8
	2. Masonry walls combined with	
	a. Concrete or steel frames with special detailing	7
	b. Concrete frames with intermediate detailing or steel frames with ordinary detailing	6
	3. Braced steel frames combined with:	
	a. Eccentric bracing	12
	b. Concentric bracing	10
System D	1. Walls	
	a. Concrete	7
	b. Masonry	6
	2. Braced steel frames	6
System E	1. Systems with the mass concentrated at the top of the structure	3
	2. Systems with the mass distributed along its height	4

TABLE 7. ALLOWABLE STORY DRIFT Δa.

Building type	**Category of occupancy**		
	I	**II**	**III**
1 story steel building without any equipment joined to the structure nor fragile finishing	0.015 h_{sx}	0.020 h_{sx}	NO LIMITATION
Building with 4 stories or less and without any fragile finishing	0.010 h_{sx}	0.015 h_{sx}	0.020 h_{sx}
The rest of buildings	0.010 h_{sx}	0.015 h_{sx}	0.015 h_{sx}