PART 1-GENERAL

1.1 SCOPE

1.1.1 These regulations apply to the general structural design and construction of buildings and parts of buildings.

1.1.2 These regulations do not apply for construction which, in the opinion of the Engineer, are sufficiently unusual for the provisions of these regulations (e.g., nuclear power plants, pressure vessels,...etc). Special studies shall be made for such constructions.

1.1.3 These regulations shall not be interpreted to prevent the use of new materials or methods of design or construction not specifically referred to herein.

1.1.4 All buildings designed in accordance with these regulations shall be so supervised as to ensure that the requirements of the design are achieved in the construction.

1.2 INTERPRETATION

1.2.1 In these regulations the word "shall" indicates a requirement that is to be adopted in order to comply with these regulations. While the word "should" indicates a recommended practice.

1.2.2 Where any other standard named in these regulations has been declared then reference to the named standard shall be taken to include any current amendments.

1.3 FUNDAMENTAL QUANTITIES

1.3.1 Physical and mechanical quantities are expressed in terms of the System International (SI) units whose basic units are meter , kilogram and second.

1.3.2 Seismic Intensities

1.3.2.1 Macroseismic intensity scale :
Seismic intensities are evaluated with references to the International Macroseismic Intensity Scale. Grading of this scale is designated by Roman numbers (I,II,.......etc.)

1.3.2.2 Decimal scale :
For a precise definition of earthquake intensities to be considered in engineering projects a decimal scale is associated with

the Macroseismic intensity scale defined as follows (see Fig.1.1) :

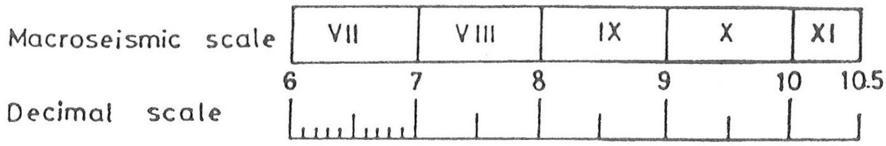

Fig.1.1 Relation Between Macroseismic and Decimal Scales.

a) integer divisions coincide with the upper limit of the same degree in the macroseismic scale.
b) each interval is then divided into decimal divisions.

1.4 DEFINITIONS

The terms generally used in these regulations are defined as follows :

ANALYSIS :

EQUIVALENT STATIC FORCE ANALYSIS means a method of analysis using static forces to simulate the effects of earthquake ground motion.

SPECTRAL MODAL ANALYSIS means a method of dynamic analysis in which a given earthquake design spectrum is applied to a building and the response of several modes is determined.

NUMERICAL INTEGRATION RESPONSE ANALYSIS means a method of dynamic analysis in which a mathematical model of the structure is subjected to time histories of actual or synthetic earthquakes.

BASE means the level at which the earthquake motions are considered to be imparted to the structure, or the level at which the structure as a dynamic vibrator is supported.

CENTER OF MASS means the point through which the resultant of the masses of a system acts. This corresponds to center of gravity of the system.

CENTER OF RIGIDITY means the point through which the resultant of the restoring forces of a system acts.

CRITICAL DAMPING means the damping beyond which the motion will not be oscillatory.

DAMPING means the effect of internal friction, imperfect elasticity of material, slipping, sliding, etc., in reducing the amplitude of vibration and is expressed as a percentage of critical damping.

DEAD LOAD means the weight of all permanent components of a building including walls, partitions, columns, floors, roofs, finishes and fixed fittings that are integral part of the structure.

DESIGN means the use of rational computational or experimental methods in accordance with the established principles of structural mechanics.

DIAPHRAGM means a member composed of a web (such as a floor or roof slab), or a truss which distributes forces to the horizontal force resisting system.

DUCTILITY means the ability of the building or member to undergo repeated and reversing inelastic deflection beyond the point of the first yield while maintaining a substantial proportion of its initial maximum load capacity.

ELEMENTS include primary and secondary elements.

PRIMARY ELEMENTS means elements forming part of the basic load resisting structure, such as beams, columns, diaphragms, or shear walls necessary for the building's survival when subjected to the specified loadings.

SECONDARY ELEMENTS means elements such as partition walls, panels, or veneers not necessary for the survival of the building as a whole but subject to stresses due to loadings applied directly to them or to stresses induced by the deformation of the primary elements.

EPICENTER means the geographical point on the surface of earth vertically above the focus of the earthquake.

FRAME means a system composed of interconnected members functioning as a complete self-contained unit with or without the aid of horizontal diaphragms or floor bracing systems.

DUCTILE FRAME means a frame in which seismic energy is dissipated by flexural yielding of a significant number of beams.

MOMENT RESISTING FRAME means a load carrying frame in which the members and joints are capable of resisting horizontal forces by bending moments.

FOCUS means the originating source of the elastic waves which cause shaking of ground.

HORIZONTAL FORCE RESISTING SYSTEM means that part of the structural system to which the horizontal forces prescribed by these regulations are assigned.

INTENSITY OF EARTHQUAKE means a measure of the effects of the earthquake at a particular site.

LIVE LOADS means the load assumed or known to result from the occupancy or use of a building and includes the loads on floors, loads on roofs other than wind or rains, loads on balustrades and loads from movable goods, machinery, and plant that are not an integral part of the structure and may be changed during the life of the building with a resultant change in floor or roof loading.

OVERTURNING MOMENT at any given level means the moment of the horizontal forces acting on the structure as a whole above that level.

SET-BACK means any offset horizontally in from the plane of an exterior wall of a structure.

SHEAR WALL means a wall designed to resist horizontal forces in the plane of the wall.

DUCTILE CANTILEVER SHEAR WALL means a wall with no openings having a significant effect on the behaviour of the wall, and which will not fail in a non-ductile manner (such as buckling or shear) before some of the vertical reinforcement yields in tension due to the applied moment. The height - to - width ratio of such a wall shall be not less than 2 and the wall width not less than 1.5 m.

DUCTILE COUPLED SHEAR WALL means two or more ductile cantilever shear walls interconnected by beams having a span-to-depth ratio of less than 4.

CANTILEVER SHEAR WALL OF LIMITED DUCTILITY means a shear wall not complying with the two categories above.

STATIC ECCENTRICITY means the distance from the center of rigidity to the center of mass at the level considered, measured perpendicular to the direction of loading.

STORY-SHEAR means the sum of all the horizontal forces acting on the levels above the level under consideration.

1.5 SYMBOLS

In these regulations symbols shall have the following meanings, provided that other symbols, or other meanings, for symbols listed below, that are defined immediately adjacent to formulae or figures shall apply in relation to these formulae or figures only :

A	Design load for the working stress design method.
A	Standard value for horizontal acceleration ratio.
b	Maximum horizontal dimension of the building at that level measured perpendicular to the direction of loading.
C	Coefficient of the standardized response spectrum for average damping of 5% .

C_p	Seismic design coefficient for a part or portion of a building.
C_s	Seismic design coefficient.
D	Dead loads or their related internal moments and forces
D_i	Total dead load for the ith floor.
d	Dimension of the building in a direction parallel to the applied seismic forces, in meters.
E	Earthquake loads or their related internal moments and forces.
e	Distance from center of rigidity to the center of mass at the level considered measured perpendicular to the direction of loading.
e_d	Torsion design eccentricity.
F	Foundation soil factor.
F_i	Horizontal force assigned to the i th floor.
F_t	Horizontal force assigned to the n th floor.
F	Liquid pressures or their related internal moments and forces.
F_p	Horizontal force on a part or portion of a building.
g	Ground acceleration, in meters per second squares.
H	Total height of building , in meters.
h_i	Height over the base to the level of the i th floor.
h_p	Height at which a part or portion of a building is located.
I	Importance factor.
L_i	Total live load for the i th floor.
L_R	Reduced live loads.
M	Structural material factor.
n	Total number of stories above the base.
P_p	Position factor for a part or portion of a building.
p	Incidence factor for live loads.
Q	Construction quality factor.
Q	Earth pressure or their related internal moments and forces.
R	Risk factor.
R_p	Risk factor for a part or portion of a building.
S	Structural system type factor.
T	Fundamental period of vibration of the building in the direction under consideration, in seconds.
V	Total horizontal seismic force or shear at the base in the direction under consideration.
W	Wind loads or their related internal moments and forces.
W_i	Portion of W_t that is located or assigned to the ith floor.
W_t	Total reduced gravity loads above the level of imposed lateral ground restraint.
W_p	Weight of a part or portion of a building.
Z	Seismic zoning factor.
δ_i	Elastic horizontal deflections of the ith story.

1.6 GENERAL DESIGN REQUIREMENTS

1.6.1 Methods of Analysis

1.6.1.1 Except as provided by clause 1.7.2, buildings and parts of buildings shall be designed (see definition of "design" in clause 1.4)

1.6.1.2 When the effect of any element on the structural behaviour of the building can not be assessed with confidence, then the element shall not be considered as contributing to the basic load-resisting structure of the building. However, the effect of the design loads on the element itself shall be assessed and allowance shall be made for the effect of the element on the distribution of loads and on building ductility.

1.6.2 Loading Tests

1.6.2.1 Buildings or parts of buildings not fully amendable to analysis and design may be tested to demonstrate that the construction is adequate for its intended purpose.

1.6.3 Design Methods

1.6.3.1 In the design of structures, members shall be proportioned for adequate strength in accordance with the appropriate Egyptian standard.

1.6.3.2 Load combinations to be used with the working stress method of design shall be as those given in clause 1.7.2.3.

1.6.4 Distribution of Horizontal Forces

1.6.4.1 The total horizontal force at any level imposed by wind or earthquake loads shall be considered to be resisted by the various resisting elements in proportion to their stiffnesses.

1.6.5 Stability

1.6.5.1 All buildings and parts of buildings shall be designed against the adverse effects arising from uplift or overturning moments.

1.7 STRENGTH REQUIREMENTS

1.7.1 Design Loads

1.7.1.1 Stuctures shall be designed to resist all applicable loads as specified in these regulations.

1.7.2 Design load combinations

1.7.2.1 Structures and members designed by the working stress method shall be designed in accordance with the allowable stresses given in the relevant material code to resist the load combinations specified in clause 1.7.2.3 as applicable. However, earthquake load, wind load and transient dynamic effects need not be taken as acting simultaneously.

1.7.2.2 The most unfavourable distribution of live loads shall be considered, and provision shall be made for the load combinations resulting from the method of sequence of construction.

1.7.2.3 The design loads A for the working stress method shall not be less than whichever of the following load combinations is applicable and gives the greatest effect:

$A = D + L_R$ ....(1)

For wind loads:

$A = D + L_R + W$ ....(2)

$A = 0.85D + W$ ....(3)

For earthquake loads:

$A = D + L_R + E$ ....(4)

$A = 0.85D + E$ ....(5)

For earth pressure loads :

$A = D + L_R + Q$ ....(6)

$A = D + Q$ ....(7)

For liquid pressure :

$A = D + L_R + F$ ....(8)

$A = D + F$ ....(9)

1.7.2.4 Impact effect, if any, shall be included in the live load L.

1.7.2.5 Where the structural effects of differential settlement, creep, shrinkage , or temperature change may be significant this shall be included with the dead load D in equations (1) to (9) inclusive. Estimation of these effects shall be based on a realistic in-service assessment.

1.8 BUILDING DEFORMATION

1.8.1 Provision shall be made for the effects of relative movement, differential settlement ,creep, vibrations, shrinkage or temperature change on the deformation of buildings or parts of buildings. Structural members shall be designed for acceptable deflections and vibrations under service loads .

1.8.2 Under the most adverse loading conditions, other than earthquakes, the deflections of the structure as a whole, and of any of its parts, shall not be such as to impart the strength or serviceability of the structure or any of its parts, or lead to damage of other building components.

PART 2-EARTHQUAKE PROVISIONS

2.1 SYMMETRY

2.1.1 The main elements of a building that resist seismic forces shall, as nearly as is practicable, be located symmetrically about the center of mass of the building.

2.2 METHODS OF ANALYSIS

2.2.1 Buildings shall be analyzed by the equivalent static force method specified in section 2.3. In addition a dynamic analysis as specified in section 2.4 shall be approved for any building and may be required by the Engineer for any building where, in his opinion, special circumstances exist, for example where a building is of particular importance to the community, or where a special study is required by these regulations.

2.3 EQUIVALENT STATIC FORCE ANALYSIS

2.3.1 General

2.3.1.1 The horizontal seismic forces specified in this section shall be applied simultaneously at each floor and roof level.

2.3.1.2 For buildings symmetrical about at least one axis and for buildings with seismic resisting elements located along two perpendicular directions, the specified force may be assumed to act separately along each of these two horizontal directions. For other buildings, different directions of application of the specified forces shall be considered so as to produce the most unfavourable effect in any structural element.

2.3.2 Total horizontal seismic force

2.3.2.1 Every building shall be designed and constructed to withstand a total horizontal seismic force (V) in each direction under consideration in accordance with the following formula :

$$V = C_s W_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

where :

C_s is the seismic design coefficient and shall be determined according to clause 2.3.2.2

W_t is the total weight and shall be as specified in clause 2.3.2.5

2.3.2.2 The seismic design coefficient C_s shall be determined from :

$$C_s = Z\ I\ S\ M\ R\ Q \qquad (11)$$

where :

Z is the seismic zoning factor and shall be determined according to clause 2.3.2.6.

I is the importance factor and shall be as given in Table 1.

S is the structural system type factor and shall be as given in Table 2 or rationally deduced. The value of S shall be determined separately for each direction.

M is the material factor and shall be as given in Table 3 or rationally deduced therefrom.

R is the risk factor and shall be as given by Table 4. Where two values of R apply, the higher shall be used.

Q is the construction quality factor and shall be determined according to clause 2.3.2.4.

2.3.2.3 The value of C_s need not be taken greater than 4.8 ZIMQ and shall in no case be taken less than 0.02 for non-zero seismic zone.

Table 1 IMPORTANCE FACTOR (I)

Class	Description	I
I	a) Structures and buildings to be used during or immediately after an earthquake (such as hospitals, fire stations,broadcasting buildings, power stations, terminals , etc.). b) Buildings housing valuable and important items (museums, etc.).	1.50
II	Buildings and structures of high occupancy (such as schools, stadiums, theatres, cinemas, worship buildings, etc.)	1.30
III	Buildings and structures of low occupancy (such as residential buildings, hotels, office buildings, restaurants , etc.)	1.00

Table 2 STRUCTURAL SYSTEM TYPE FACTOR (S)

Structural System	Type	Description	S
Frames	1	Moment-resisting frame.	1.00
	2	Ductile moment-resisting frame.	0.67
Shear Walls	3	Two or more parallel and approximately symmetrically arranged ductile cantilever shear walls.	1.00
	4	Ductile coupled shear walls.	0.80
	5	Single ductile cantilever shear walls.	1.20
	6	Shear walls not designed for ductile flexural yielding but having the ability to dissipate a significant amount of seismic energy. (This includes walls other than listed above).	1.60
Diagonal Bracing	7	Buildings with diagonal bracing capable of plastic deformation in tension only : a) Single-story b) Two or three stories c) More than three stories	 2.0 2.5 *
	8	Buildings with diagonal bracing capable of plastic deformation in both tension and compression.	*
Box System	9	Both horizontal and gravity forces resisted by wall system.	1.33 in each direction
Shared Force Resisting Systems	10	Buildings with a dual bracing system consisting of a ductile moment resisting frame plus shear walls conforming with the following conditions : a) The frames and shear walls shall resist the total lateral force in accordance with their relative rigidities considering the interaction between the shear walls	0.80

Table 2 (cont.) STRUCTURAL SYSTEM TYPE FACTOR (S)

Structural System	Type	Description	S
		and frames ; b) The shear walls acting independently shall resist the total lateral force. c) The ductile moment - resisting frame shall have the capacity to resist at least 25% of the total lateral force.	
	11	Shear walls plus a ductile moment-resisting frame which do not satisfy the conditions of Type 10.	1.33
	12	Buildings in which bracings of Type 7 plus a frame of Type 2.	*
Miscellaneous	13	Small tanks on the ground.	2.00
	14	Free-standing elevated tanks with full contents, on four or more cross-braced legs and not supported by a building.	2.50
	15	Free-standing structure of an inverted pendulum type, including elevated tanks on three or less cross-braced legs, or on unbraced legs.	3.20
Other Structural Concepts	16	Structural systems other than those included as Types 1 to 15 above may be accepted where evidence shows that equivalent ductility and energy absorption are available sufficiently to relate behaviour of such alternative structural systems to any of Types 1 to 15 above.	*

* by special study.

Table 3 MATERIAL FACTOR (M)

Item	Material	M
1	Reinforced concrete	1.0
2	Structural steel	0.8
3	Prestressed concrete	1.2
4	Reinforced masonry	1.2

Table 4 RISK FACTOR (R)

Item	Description	R
1	Buildings other than those given below and presenting no unusual risk.	1.0
2	Distribution facilities for natural gas, coal gas or petroleum products.	2.0
3	Structures and installations for the direct containment of toxic liquids or gases, spirits, acids, alkalis, molten metal, or poisonous substances, including substances that could form dangerous gases if released.	3.0 or by special study

2.3.2.4 The construction quality control factor (Q) is taken to be 1.0 when there is provision within the contract documents for the performance of inspection at the important stages of construction. Inspection shall include material testing. Where this provision does not exist (Q) is taken to be 1.2.

2.3.2.5 The total weight (W_t) may be evaluated from :

$$W_t = \sum_{i=1}^{n} W_i \qquad \text{.....................(12)}$$

and,

$$W_i = D_i + pL_i \qquad \text{.....................(13)}$$

in which :

D_i = total dead load for the ith floor.
L_i = total live load for the ith floor.
p = incidence factor for live loads, given in Table 5.

Table 5 INCIDENCE FACTOR FOR LIVE LOADS (p)

Type of Structure	Incidence Factor (p)
Residential buildings, hotels, offices, hospitals, public buildings, etc.	0.25
Storage areas and warehouses*.	0.50

* Tanks, reservoirs, silos and the like shall be considered to contain their full contents.

2.3.2.6 The seismic zoning factor (Z) shall be determined from :

$$Z = A\ C\ F \qquad (14)$$

in which :

A is a standard value for horizontal acceleration ratio and shall be determined from Table 6 in accordance with seismic zoning map shown in Fig.2.1.

C is the coefficient of the standardized response spectrum for average damping of 5% as shown in Fig.2.2.

F is the foundation soil factor and shall be determined from Table 7.

Table 6 HORIZONTAL ACCELERATION RATIO (A)

Zone	Intensity	A
0	≤ V	0
1	VI	0.02
2	VII	0.04
3	VIII	0.08

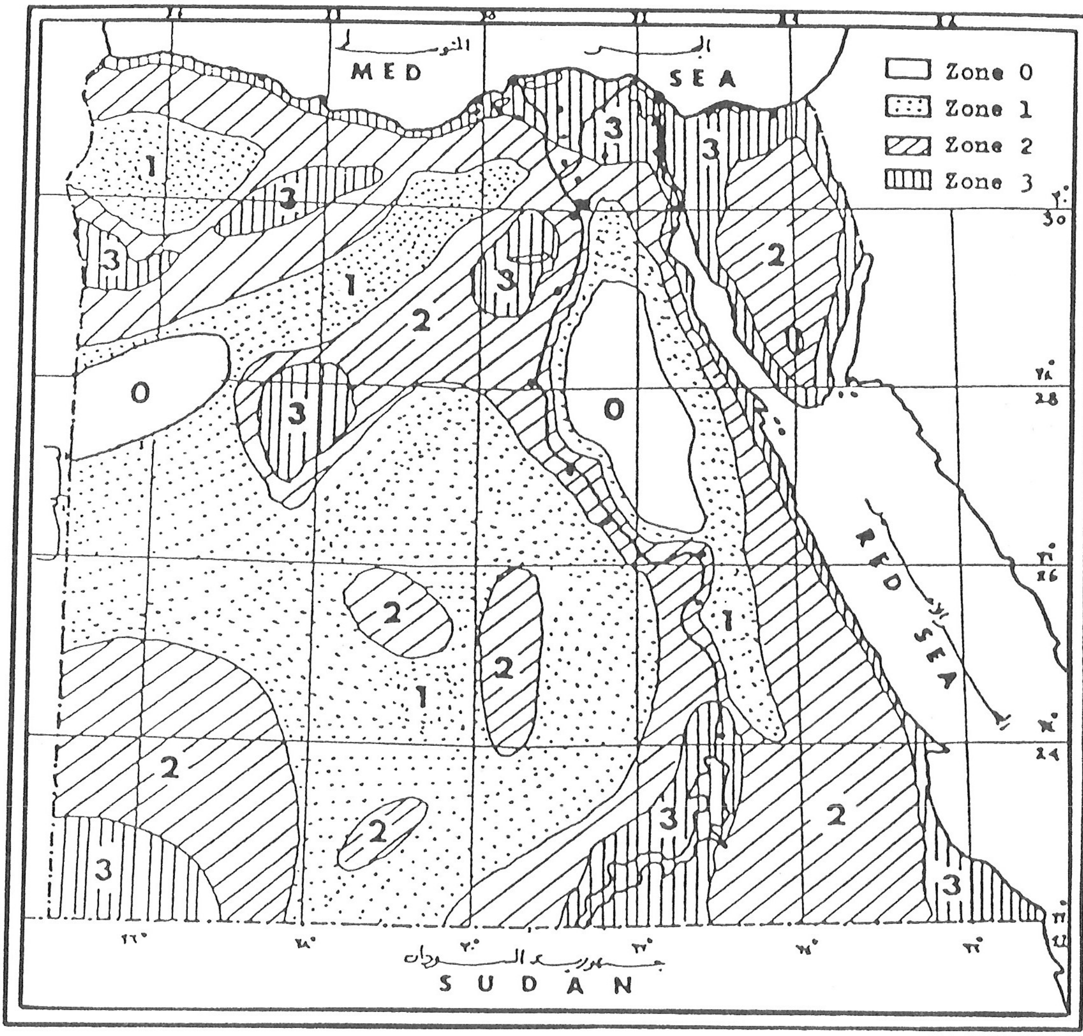

Fig. 2.1 Seismic Zoning Map for Egypt

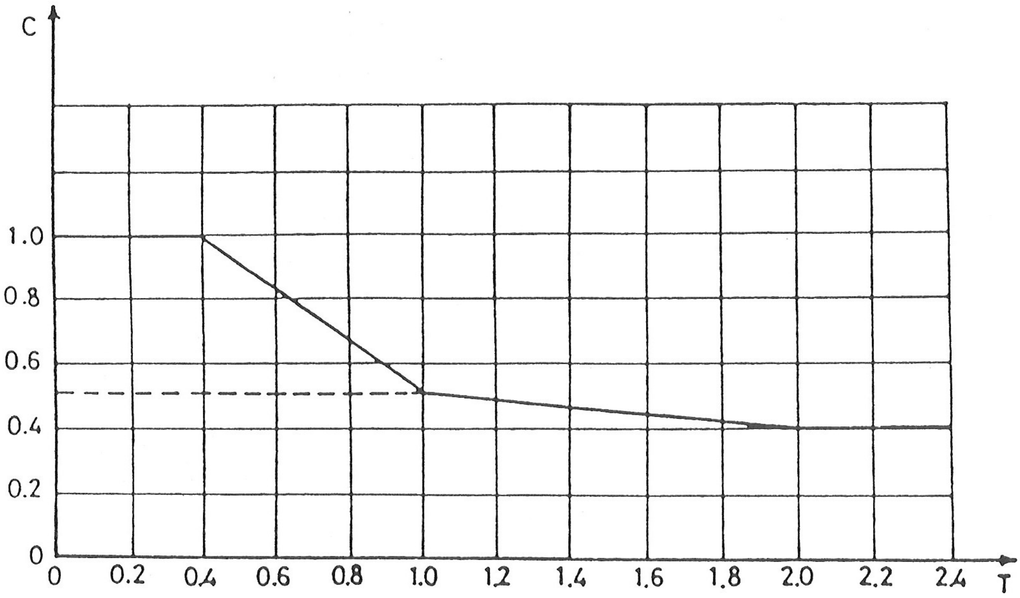

Fig. 2.2 Coefficient of Standardized Response Spectrum for Average Damping of 5%

Table 7 FOUNDATION SOIL FACTOR (F)

Soil Type	Description	F
1	Rock, dense and very dense coarse-grained soils, very stiff and hard fine-grained soils, compact coarse-grained soils and firm and stiff fine-grained soils with a depth of less than 15 m.	1.0
2	Compact coarse-grained soils , firm and stiff fine-grained soils with a depth greater than 15 m. Very loose and loose coarse-grained soils and very soft and soft fine-grained soils from zero to 15 m deep.	1.3
3	Very loose and loose coarse-grained soils , and very soft and soft fine-grained soils with depth greater than 15 m.	1.5

2.3.3 Building period

2.3.3.1 The fundamental period of the building (T) in seconds for use in calculating the total horizontal seismic force (V) shall be determined in accordance with one of clauses 2.3.3.2 and 2.3.3.3.

2.3.3.2 Simple determination : The value of (T) may be given by :

$$T = \frac{0.09\ H}{\sqrt{d}} \qquad \text{.....................(15)}$$

where :

H is the total height of building in meters.

d is the dimension of the building in a direction parallel to the applied seismic forces , in meters.

For buildings in which the total horizontal force is resisted by a moment resisting space frame the value of (T) may be given by :

$$T = 0.1\ n \qquad \text{.....................(16)}$$

in which n is the total number of stories above the base.

2.3.3.3 The value of (T) may be established using the structural properties and deformational characteristics of resisting elements in a properly substantiated analysis. One such method is to use the following expression :

$$T=2\pi \sqrt{\left(\sum_{i=1}^{n} W_i \delta_i^2\right) \Big/ g \left[\left(\sum_{i=1}^{n-1} F_i \delta_i\right) + (F_t + F_n)\delta_n\right]} \quad ..(17)$$

where :

δ_i (i=,....,n) are the elastic horizontal deflections in stories i,due to the forces F which represent that part of the total horizontal force (V) assigned to the i th floor according to clause 2.3.4.

g is the gravity acceleration (meters per second squares).

F is that part of the horizontal force (V) according to clause 2.3.4.

2.3.4 Distribution of horizontal seismic forces

2.3.4.1 For a regular building the total horizontal seismic force (V) shall be distributed over the height of the building in accordance with the following formula :

$$F_i = \left(\frac{W_i h_i}{\sum_{i=1}^{n} W_i h_i}\right) V \quad ....(18)$$

where :

F_i is that part of the total horizontal seismic force assigned to the i th floor.

h_i is the height over the base to the level of the i th floor.

W_i is the total load on the i th floor determined according to equation (13).

provided that :

(a) For buildings having height-to-width ratio (H/d) is equal to or greater than 3, then 0.1V shall be considered concentrated at top story and the remaining 0.9V shall be distributed in accordance with equation (18).

(b) For chimneys and smoke-stacks resting on the ground, 0.2V shall be considered as concentrated at the top and the remaining 0.8V shall be distributed in accordance with equation (18).

(c) For buildings with set-backs the load distribution shall comply with clause 2.3.7.

2.3.4.2 The distribution of horizontal seismic forces in major buildings that have highly irregular shapes, large differences in lateral resistance or stiffness between stories, or other unusual structural features shall be determined in accordance with the dynamic analysis procedure of section 2.4.

2.3.4.3 At each level designated as i, the force F shall be applied over the area of the building in accordance with the mass distribution at that level.

2.3.4.4 Total shear in any horizontal plane shall be distributed to the various elements of the system which resist the horizontal forces in proportion to the rigidities of the elements.

2.3.5 Horizontal torsional moments

2.3.5.1 For structures not more than five stories high or for reasonably regular structures more than five stories high with moderate eccentricity (as defined in clause 2.3.5.4.) ,the horizontal torsion effects shall be taken into account either by :

(a) the static method of clause 2.3.5.5.
(b) the two-dimensional modal analysis method of clause 2.4.2.2.1.
(c) the three - dimensional modal analysis method of clause 2.4.2.2.2.

2.3.5.2 For reasonably regular structures more than five stories high with a high degree of eccentricity (as defind in clause 2.3.5.4) , horizontal torsional effects shall be taken into account either by :

a) the static method of clause 2.3.5.5.
b) the two-dimensional modal analysis method of clause 2.4.2.2.1. However, it is recommended that the three-dimensional modal analysis of clause 2.4.2.2 be used for such buildings.

2.3.5.3 For irregular structures more than five stories high, horizontal torsional effects shall be taken into account by the three-dimensinal modal analysis method of clause 2.4.2.2.2.

2.3.5.4 Structures of moderate eccentricity are structures for which the average eccentricity between the center of mass and the center of rigidity is not greater than one fifth the plan dimension perpendicular to the direction of loading. When this value of eccentricity is exceeded it shall be considered high eccentricity.

2.3.5.5 So as to provide for shear resulting from torsional motion, the horizontal force at the level considered shall be applied at a point at distance e_d (torsion design eccentricity) from the center of rigidity at that level. This eccentricity is measured perpendicular to the direction of loading and shall be computed from the following two equations, whichever is more critical :

$$e_d = 1.5e + 0.1b \quad \text{..................(18a)}$$

or

$$e_d = e - 0.1b \quad \text{...................(18b)}$$

where:

- e is the distance from the center of rigidity to the center of mass at the level considered, measured perpendicular to the direction of loading.
- b is the maximum horizontal dimension of the building at that level, measured perpendicular to the direction of loading.

2.3.6 Overturning moments

2.3.6.1 The seismic overturning moments shall be derived from the horizontal seismic forces and the distribution of horizontal seismic forces according to clauses 2.3.2, 2.3.4 and 2.3.5 without reduction.

2.3.7 Set-backs

2.3.7.1 For buildings with set-backs where the plan dimension of the tower portion in each direction is at least 75 percent of the corresponding plan dimension of the lower part, the effect of the set-back may be neglected for the purpose of determining seismic forces by the equivalent static force method.

2.3.7.2 For other conditions of set-backs the distribution of horizontal seismic forces shall be determined in accordance with the dynamic analysis procedure of section 2.4.

2.3.8 Parts or portions of buildings

2.3.8.1 Any part or portion of a building shall be designed for a seismic force F_p applied at its center of mass in each direction under consideration as given by :

$$F_p = C_p \; W_p \qquad \text{.........................(19)}$$

where:

C_p is the seismic design coefficient for a part or portion of a building and shall be determined according to clause 2.3.8.2.

W_p is the weight of a part or portion of a building and is determined in the same manner as W_t (see clause 2.3.2.5).

2.3.8.2 The seismic design coefficient for a part or portion of a building C_p is determined from :

$$C_p = C_s \; P_p \; R_p \qquad \text{.....................(20)}$$

where:

C_s is the seismic design coefficient determined according to clause 2.3.2.2.

P_p is the position factor for a part or portion of a building and is determined according to clause 2.3.8.3.

R_p is the risk factor for a part or portion of a building and is determined according to clause 2.3.8.4.

2.3.8.3 The position factor P_p reflects the amplification of the ground motion by the structure supporting the particular component and is determined from :

$$P_p = 1.0 + h_p / H \qquad \text{......................(21)}$$

where:

h_p is the height at which a part or portion of a building is located.

H is the total height of the building.

2.3.8.4 The risk factor R_p for a part or portion of a building is an allowance for its performance during and immediately following an earthquake. Values for R_t are given in Table 8.

Table 8 RISK FACTOR FOR PART OR PORTION OF A BUILDING (R_p)

Item	Description	R_p
1	Walls and partitions : (a) Adjacent to an exit-way, street, public place or required to have a fire resistance rating; (b) Cantilevered walls and parapets; (c) All walls not specified in items 1(a), 1(b) or 2.	 1.1 1.5 1.0
2	Stairs and their enclosing shaft walls, and shaft walls for lifts.	2.0
3	Horizontally cantilevered floors, beams, etc. (the force acts vertically upward or downward).	2.0

2.4 DYNAMIC ANALYSIS

2.4.1 General

2.4.1.1 Dynamic analysis shall be done by the spectral modal analysis in accordance with clause 2.4.2 which may be , if deemed necessary by an experienced structural engineer, supplemented by numerical integration response analysis in accordance with clause 2.4.3.

2.4.2 Spectral modal analysis

2.4.2.1 Design spectrum

2.4.2.1.1 The structural design spectrum shall be given by the expression Z A' for each mode where Z shall be determined in accordance with clause 2.3.2.6 and Fig.2.2, and A' is a scaling factor as given in clause 2.4.2.4 and is the same for all modes.

2.4.2.2 Torsional effects

2.4.2.2.1 For symmetrical or moderately unbalanced building for which torsional effects are calculated by the static method of clause 2.3.5 account shall be taken of not less than the first three modes for each direction under consideration.

2.4.2.2.2 Where the dynamic torsional effects are included in the spectral modal analysis, account shall be taken of not less than four modes for each direction under consideration , two of them predominantly translational and two predominantly torsional. The model shall include the effects of accidental eccentricities of ± 0.1b. For moderately unbalanced buildings the torsional effect shall be not less than that calculated by the static method of clause 2.3.5.

2.4.2.3 Shear

2.4.2.3.1 The shear at any level shall be taken as the square root of the sum of the squares of the modal shears at that height.

2.4.2.4 Scaling factor

2.4.2.4.1 The value of the scaling factor A'shall be selected such that the computed base shear, in accordance with clauses 2.4.2.1 to 2.4.2.3 inclusive, is scaled upwards so that it is not less than 0.90 the base shear calculated by section 2.3.

2.4.2.5 Minimum shear values

2.4.2.5.1 At any level the shear derived in accordance with clause 2.4.2.3 shall be taken as not less than 80 percent of the values computed by the equivalent static force method in section 2.3.

2.4.2.6 Horizontal forces and overturning moments

2.4.2.6.1 The horizontal forces and overturning moments shall be derived from the shears given by clauses 2.4.2.1 to 2.4.2.4 inclusive.

2.4.3 Numerical integration response analysis

2.4.3.1 Numerical integration response analysis may be used to obtain additional information on building behaviour, particulary in the post-elastic range, to supplement that obtained by the spectral modal analysis.

2.5 ALLOWABLE STRESSES

2.5.1 Whenever earthquake forces are considered along with other normal design forces, the allowable stresses in materials, in the elastic design method, may be increased by one-third, except otherwise mentioned in the following clauses.

2.5.2 For steels having a definite yield stress the stress will be limited to the yield stress ; for steels without a definite yield point, the stress will be limited to the proof stress or 80 percent of the ultimate strength whichever is smaller.

2.5.3 In reinforced concrete structures an increase in bond stresses shall not be permitted.

2.5.4 In prestressed concrete members, the tensile stress in the extreme fibers of the concrete may be permitted so as not to exceed 2/3 of the modulus of rupture of concrete.

2.5.5 The allowable bearing pressures for subsoils composed of soft clays or loose sands shall not be increased.

2.5.6 In foundations bearing directly on soils such as those mentioned in clause 2.5.5 no increase in allowable stresses for concrete and reinforcing steel shall be permitted.

2.6 SPECIFIC REQUIREMENTS FOR PARTICULAR ELEMENTS

2.6.1 All parts of a building, including floors, roofs , partitions, ornamentations, machinery, tanks, veneers, precast elements, and the like, unless specifically designed to act otherwise, shall be tied and interconnected by adequate fixings designed to resist earthquake loads. Connections shall have sufficient strength to preclude fracture or brittle failure.

2.6.2 Nonstructural components shall be designed so as not to transfer to the structural system any force unaccounted for in the design. Any interaction of rigid elements such as walls and the structural system shall be designed so that the capacity of the structural system is not impaired by the action or failure of the rigid elements.

2.6.3 Individual foundations of a building shall be inter-connected in two directions generally at right angles by members designed for a horizontal force equal to 10 percent of the vertical load on the foundations under seismic conditions averaged between the columns concerned. Alternatively, foundations may be restrained by other means against differential lateral movement during an earthquake.

2.7 DEFORMATION DUE TO EARTHQUAKE LOADS

2.7.1 Computed deformations

2.7.1.1 Structural deformations shall be calculated from the application of the horizontal loads specified in section 2.3 or 2.4 multiplied by a factor of 3.0 to give realistic values of anticipated deflections or drifts.

2.7.2 Building separations

2.7.2.1 Each building separated from its neighbour shall have a minimum clear space from the property boundary, other than adjoining a public space, either by 2.0 times the computed deflections as given in clause 2.7.1 or 0.002 times its height, whichever is the larger, and in any case, not less than 2.5 cm.

2.7.2.2 Parts of buildings or buildings on the same site which are not designed to act as an integral unit shall be separated from each other by a distance of at least 2.0 times the sum of the individual computed deflections or 0.004 times their height, whichever is larger, and in any case not less than 5.0 cm.

2.7.2.3 Separation spaces need not extend into the foundations except where the Structural Engineer may direct.

2.7.2.4 Seperation spaces shall be detailed and constructed to remain clear of debris or other obstructions. Construction tolerances shall make allowance for the clear space provisions.

2.7.3 Inter-story deflections

2.7.3.1 Inter-story deflections between two successive floors shall be computed in accordance with clause 2.7.1 between two successive floors. The inter-story deflection of any point on the floor shall be taken as the horizontal displacement of that point relative to the corresponding point on the floor below.

2.7.3.2 The inter-story deflection shall not exceed 0.005 times the story height nor shall exceed 2.0 cm.

2.8 STRUCTURAL ALTERATIONS

2.8.1 The Structural Engineer shall make the contractor or owner aware of the dangers that can arise when structural elements, details, use or expansion of buildings are changed without the specific approval of the Structural Engineer. Any variations approved by the designer shall comply with the requirements of these regulations.