IN THE NAME OF GOD

ISLAMIC REPUBLIC
OF IRAN
Ministry MINISTRY OF HOUSING
AND URBAN DEVELOPMENT

Building & Housing
Research Center

IRANIAN CODE OF PRACTICE FOR SEISMIC RESISTANT DESIGN OF BUILDINGS

(Standard No. 2800)
3rd Edition

**permanent Committee for Revising
The Iranian Code of Practice for
Seismic Resistant Design of Buildings
(Standard 2800)**

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Permanent Committee of Revising the Code of Practice for Seismic resistant Design of Buildings

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Foreword

Nowadays in symbiosis of human's community, to supporting against natural phenomenon as earthquake's destructives, the progressing and developing on Science and Information Technology have been extended.
Scientific achievements in basic science studying, engineering knowledge and technical skills, also executive managements in standards, codes and enforceable instructions, caused possibility for this symbiosis.
As Iran is located in a seismic region, many earthquakes on different area have been recorded through thousands of years. Beside each desolation, a new built has created.
Increasing knowledge on earthquake's fields, with scientists and researchers efforts, may do controlling and prevention of earthquake effects.
The first step on this way was compiling "Iranian code of practice for seismic resistant design of buildings" in decade 60, which is in chapter of Iran's standard 519. Iranian code of practice for seismic resistant design of buildings "standard 2800" on 1988 has been approved and endorsed by Islamic Republic of Iran's government and became state of being official.
These provisions caused discipline for all construction activities in different part of the country. Trying for general executive and prevention from offends, were so effective in reduction of damages due to earthquake.
Experiences and executed reaction in practice and in engineering comments, also studying and considering lessons learned from different earthquakes around the world as Iran (Mangil, Roodbar,), showed that revising the Iranian code of practice for seismic resistant design of buildings is very important.
On 17 March 1989, Islamic Republic of Iran's government, bounded Ministry of Housing and Urban Planning to revise "Iranian code of practice for seismic resistant design of buildings" once each 5 years.
On 1993, Building and Housing Research Center, revised this Code of Practice by Iranian professors, researchers and expert engineers in depended majors as specialist committee. On 1996, the main committee named "the permanent committee for revising the Iranian code of practice for seismic resistant design of buildings" has been established. This committee has to describe further improved Code of Practice.

At 5 December 1999, Islamic Republic of Iran's government has approved the second edition of "Iranian code of practice for seismic resistant design of buildings". As expectation, in this edition, appreciate more technical points and standard safety level comparing with the first edition.
The revision of the 3rd edition for "Iranian code of practice for seismic resistant design of buildings" has started from 12 December 2000. In this period of revision, for fluency and quickness and also accuracy in specialized Code of Practice in each field, after numerous meeting, the permanent committee for revising the Iranian code of practice for seismic resistant design of buildings, which contains 36 people of the scientists and experts, had decided to distribute its duty to 3 following groups.

- Executive committee, contains 15 people
- Preparation and edition draft committee, contains 3 people
- Activated groups and real person

Therefore, the 3rd revision edition program for Code of Practice is based on the following fields:

1. To remove doubts, clearing and replying to questions from all designers and engineers who are cooperating and working with the second edition of the Code of practice to analyze, calculate and design the resistance structures against earthquake.
2. To exert necessary changes in different discussion noticed based on new knowledge and information in earthquake engineering and seismology. Also according to world creditable Seismic Codes of Practice.
3. Using scientific research and studying achievements by Iranian researchers and scholars in special occasions for seismic and construction in Iran.

One of the programs in short and middle period was gathering and arranging the improved proposals and ideas. The permanent committee for revising the Iranian code of practice for seismic resistant design of buildings studied these proposals carefully in each field, with considering on executive and studying timetable, and then approved them.
The processing to revise the third edition for Code of Practice is as follow:
Based on the programs in short and middle periods, the proposal and new

subject first in the preparation and editing draft committee will perusal. Then it will be propounded in executive committee and exert necessary changes in third edition draft. The final draft and conclusion from executive committee reported to the permanent committee for revising the Iranian code of practice for seismic resistant design of buildings.

In the third revision edition for Code of Practice, besides exerting necessary changes and new subjects in different discussion to removing all doubts from Code of Practice text, logical argument process in chaptering the Code of Practice was considered too.

Hope that these efforts and perseverance in revision and preparation new editions from Code of Practice to reach in updating goal, be useful and have effects on construction activity in different part of the country. Never see any other overtaken by calamities and irreparable damages again, like those, which happened in Bam and Zarand earthquakes.

G. Heidarinejad
BHRC President

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It is herewith desired to appreciate and acknowledge late Dr. H. Sarvi for his great contribution to the compilation of this code during his fruitful period of membership in the committee. May god bless his great soul.

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Definitions

P- Delta Effect:
Secondary effect on shears and moments of frame elements induced by the vertical loads acting on the deformed structure.
Khorjini Connection:
A beam-to-column connection type in which the beams are connected, each to one side of the column, in such a manner that each beam sits on one lower angle and is held in position by another upper angle.
Base Shear:
Total design lateral forces or shear at the base level of a structure.
Essential Buildings:
Those group of buildings that remain serviceable after occurrence of earthquake.
Story Shear:
Sun of design lateral forces above the story level under consideration.
Base Level:
The level at which it is assumed that the ground movement is transmitted to the structure, or the level which is considered to act as structural support during dynamic vibrations.
Story Drift:
Lateral displacement of one level relative to the next lower level.
Diaphragm:
A horizontal or semi-horizontal structural member transmitting lateral forces to the Vertical load resisting members. The term “diaphragm” may be also considered as the horizontal bracing system.
Shear Wall:
A wall designed to resist lateral in plane forces. It is also referred to as vertical diaphragm.
Liquefaction:
An earthquake-generated state of distortion and displacement accompanied with intense strength degradation of the ground composed of uncondensed saturated sandy soil.
Story Stiffness:
The sum of lateral stiffness of all lateral force resisting vertical members at story level.

To compute such stiffness, unit lateral displacement is applied to floor level of the specified story while all lower floors remain stationary.

Bearing Wall System:

An structural system without a complete vertical load bearing space frame. Load carrying walls or main bracing systems support vertical loads. Resistance to lateral loads is provided by shear walls or braces frames.

Building Frame System:

A system in which, vertical loads are mainly supported by simple space frames, and resistance to lateral forces is provided by shear walls or braced frames.

Dual System:

A system consisting of special or intermediate moment resisting frames composed with shear walls or braces frames designed to resist lateral forces, a significant portion of vertical loads in this system is carried by frames. Lateral force resistance is provided by shear walls, bracings, and frames, according to their lateral stiffness.

Horizontal Bracing System:

A horizontal truss system that serves the same function as a diaphragm.

Lateral Force Resisting System:

That part of the entire structure designed to resist lateral forces.

Ductility:

The ability to absorb and dissipate energy and to maintain load carrying capacity of the structure while its non-linear behavior and hysteresis loops are observed during an earthquake.

Story:

The vertical distance between floor levels. Story i is located below the level i.

Soft Story:

The story in which, lateral stiffness is less than 70 percent of that of the story above or less than 80 percent of the average stiffness of the three above stories.

Weak Story:

The story in which, lateral strength is less than 80 percent of that of the above story.

Braced Frame:

A vertical truss system of the concentric or eccentric type utilized to resist lateral forces.

Concentric Braced Frame:

A braced frame in which, the members are mainly subject to axial forces.

Eccentric Braced Frame:
A steel braced frame in which the members are not convergent, and it is designed according to valid codes' specifications.

Moment resisting Frame:
A frame in which, members and joints are mainly moment resisting members.

Intermediate Moment Resisting Frame:
A concrete or steel frame, designed according to the clause 4-20 of the Iranian code for concrete (Structures with medium ductility).

Ordinary Moment Resisting Frame:
A moment resisting frame not meeting special detailing requirements for ductile behavior.

Special Moment Resisting Frame:
A moment resisting frame specially detailed to provide ductile behavior.

Center of Rigidity:
The rigidity centers of a multi-level structure (assuming linear elastic behavior), are those points in story levels that when the resultant of seismic lateral forces is assumed at those points, there would be torsion in none of the stories of the structure.

Strength:
Ultimate capacity of a member to resist factored loads.

Story Drift Ratio:
Story drift divided by story height.

Symbols

A: Design base acceleration ratio
B: Building response factor.
B_p: a factor set forth in Table-7.
C: The seismic coefficient.
D: Width of the building.
d: Depth of projection of a building, according to figure 3 in chapter 3.
d_i: Thickness of the i^{th} layer of soil.
e_{aj}: Accidental eccentricity at level j determined in accordance with Clause 2-3-10-3.
e_{ij}: Eccentricity between the lateral force at level j and the center of stiffness at level i.
F_j: The lateral force at level j.
F_p: Lateral Force on non-structural elements of Building
F_{pi}: The lateral load in the diaphragm, at level i
F_t: A concentrated force at the roof level.
F_v: The vertical seismic load.
g: Acceleration due to gravity.
H: Total height of building from the base level.
H_m: Maximum allowable building height from the base level.
h_i: Height of the story of level i, from the base level.
I: Importance factor, as given in Section 2-3-7.
L: Length of building.
l: Extent of projection in masonry buildings, according to figure 3 in chapter 3 .
M_i: The torsional design moment at a given story, i.
n: Total number of stories above the base level.
R: Building behavior factor, as given in Section 2-3-8.
S: The parameter determined from the soil profile type and level of seismicity.
T: Fundamental period of vibration of the structure in the direction under consideration, in second.
T_s: The parameter determined from the soil profile type and level of seismicity.
T_o: The parameter determined from the soil profile type and level of seismicity.
V: The shear force at base level. This level is defined in Section 2-3-2.
V_{min}: The minimum of the total design lateral force or shear at the base level.

$\overline{V}_s$: The average shear wave velocity in the top 30 meters of site layer.
V_{ser}: The equivalent static base shear for service level earthquake.
V_{si}: Shear wave velocity in i^{th} layer.
W: The total seismic weight of building.
W_i: The seismic weight of level i, that is equal to the dead plus a percentage of live load at this level as defined in Table-1.
w_i: Weight of diaphragm and its attachments, plus a portion of its live load, as set in section 2-3-1, at level i.
W_p: The weight of the element plus total live load.
w_p: Weight of the element or component.

Chapter One

General

1-1 Purpose

The purpose of this code is to provide minimum provisions and regulations for the design and construction of buildings to resist the earthquakes effects. By these provisions, it is expected that:

a) In major seismic ground motions the loss of life is minimized while the stability of the building is maintained, and in moderate and low seismic ground motions the building is left without major structural damage,

b) In moderate and low seismic ground motions, buildings designated as "high importance" in section 1-7 maintain their serviceability, and for buildings designated as "intermediate importance" in section 1-7 the structural and non-structural damage shall be minimized,

c) In major seismic ground motion, buildings designated as "Very High Importance" in section 1-7 shall maintain their operational level without major structural damage.

NOTE- Major seismic ground motion or "Design Level Earthquake" is the ground motion with a 10 percent probability of not being exceeded in 50 years, the lifetime of the building.
Low and moderate seismic ground motions or "Service Level Earthquake" is the ground motion that has a 99.5 percent probability of not being exceeded in 50 years, the lifetime of the building.

1-2 Scope

1-2-1 This code is applicable for the design and construction of buildings with reinforced concrete, steel, wood and masonry structures.

1-2-2 The following structures are not included in the scope of this code:

a) Special buildings such as dams, bridges, offshore structures and nuclear power plants.

Design of special Buildings shall be done in accordance with specific provisions as set forth in the respective code to withstand seismic effects. However, the design base acceleration, A, shall in no case be taken less than the values given in this code. Whenever a site-specific investigation is conducted for such buildings, the results may be used for design purposes provided that the resulting site-specific response spectrum do not fall below the two third of the “standard design spectrum”, according to section 2-4-1-2, without considering importance factor, “I”, and behavior factor, “R”.

b) Mud and Adobe Buildings

These buildings do not have adequate seismic resistance due to the inherent weakness of their constituting materials. Special provisions shall be observed to ensure relative safety of such buildings against seismic actions. For buildings constructed in remote areas where suitable material may not be easily available, special provisions and technical guidelines shall be developed and implemented to ensure the relative safety of these buildings such as use of wood, steel or concrete resisting elements or any combinations of them or any other suitable material.

1-2-3 Reinforced masonry buildings shall conform to the provisions of Chapter 2 of this Code. The design of such buildings shall be based on reliable international codes until a national code is developed in this regard. Otherwise the general provisions and regulations of Chapter 3, for unreinforced masonry buildings, shall be observed for these buildings.

1-3 Geotechnical Considerations

1-3-1 Building construction is not allowed on top or in the vicinity of active faults that may cause surface rupture during an earthquake. However, if buildings are to be constructed in the vicinity of a fault, special technical consideration shall be observed in addition to the regulations of this Code.

1-3-2 Site specific studies are recommended for construction in sites susceptible to geotechnical instabilities due to earthquake such as liquefaction, excessive settlement, land slide or rock fall during an earthquake and where the soil consists of sensitive clay mainly. However, such studies shall be mandatory for buildings designated as “High Importance” and “Very High Importance”.

1-3-3 In sites susceptible to liquefaction, the possibility of instability, geotechnical movement, lateral soil displacement, reduction in soil bearing capacity or excessive settlements shall be investigated. However, if necessary, appropriate methods for improving soil behavior shall be utilized to ensure the safety of the building foundation.
A site is considered as liquefaction-prone if any of the following conditions exist:
a- A liquefaction history record exists for the site
b- The site soil consists of low density sand, either clean or with less than 20% clay, or contains silt and gravel while the water table level is within 10 meters depth of the ground level.
A low density sand is a sand with a “Standard Penetration Number, $(N_1)60$” less than 20.

1-3-4 For construction on a slope, soil excavation or backfilling shall be done by subsequent stability analysis of the slope and if necessary implementing sufficient provisions to ensure its overall stability. The soil bearing capacity and local and global slope stability of the building foundation shall be ensured.

1-3-5 Building foundation at the top or on the slope of any ground shall preferably be constructed on a horizontal level. However, if it is not possible, each part of the foundation shall be placed on a horizontal level.

1-4 Architectural Considerations

1-4-1 In order to avoid or decrease the damage due to pounding, buildings shall be separated from each other by “isolation joints” or shall be constructed with a minimum distance from the adjacent building’s property land. The width of the isolation joint shall conform to the provisions of Clause 1-6-3.

1-4-2 Buildings plan shall be as simple and symmetrical as possible, in two orthogonal directions, without excessive projection or setback. Vertical asymmetry shall also be avoided to the extent possible.

1-4-3 Cantilever projections longer than 1.5 meters shall be avoided to the extent possible.

1-4-4 Large adjacent openings in floor diaphragms shall be avoided.

1-4-5 Placing of heavy construction components and equipments over cantilevers, slender and long span elements shall be avoided.

1-4-6 Using lightweight and high strength structural material with appropriate ductility, and lightweight non-structural materials, to minimize the weight of the building, is recommended.

1-4-7 Split floor levels shall be avoided to the extent possible.

1-4-8 Any change in floor area over the elevation of the building, that leads to considerable variation in floor masses, shall be avoided.

1-5 Structural Configuration Considerations

1-5-1 Vertical load carrying elements shall be aligned vertically, to the extent possible, in order to avoid the transfer of loads by means of horizontal elements.

1-5-2 Elements that carry the horizontal earthquake loads shall be configured in such a way that loads are transfered to the foundation as directly as possible, and the relevant lateral load resisting elements be located in one vertical plane.

1-5-3 Lateral load resisting elements shall be configured in a manner that the torsion resulting from earthquake loading is minimized. For this purpose, it is recommended that the eccentricity between the center of mass and center of stiffness, at each floor level, be less than 5% of the building dimension in that level in the direction under consideration.

1-5-4 The building and its elements shall be designed in such a way that adequate ductility and strength in each of them is ensured.

1-5-5 Buildings with moment resisting frames system shall be designed in such a way that any damage in the beams occurs prior to columns, to the extent possible.

1-5-6 Non-structural components such as partition walls and façades in buildings shall be detailed in such a way that they do not impose any restraint for the displacement of structural systems during earthquake. Otherwise, their interaction with structural system shall be considered.

1-5-7 Short columns, especially in basement openings, are to be avoided to the extent possible.

1-5-8 Use of different structural systems in various directions, in plan and elevation, shall be avoided to the extent possible.

1-6 General Requirements

1-6-1 All the lateral load resisting elements shall be adequately connected to each other to ensure the integrity of the structure as a whole during earthquake. In this regard, floors shall be connected appropriately to the vertical load bearing elements, frames or walls; so that they can transfer the earthquake loads to the lateral load resisting elements as a diaphragm.

1-6-2 The structure shall be able to resist horizontal earthquake loads in both orthogonal directions. Moreover, these loads shall be transferred appropriately to the foundation in both directions.

1-6-3 The minimum width of the isolation joint, as defined in Clause1-4-1, at each story level shall be equal to 1/100 of the height of that level from the base level. For this purpose, the minimum clear distance between any floor level to the property line shall be equal to 5/1000 of the height of that story from the base level.

For buildings designated as "High Importance" and "Very High Importance" and in building with 8 stories or taller, the minimum width of the isolation joint, at any story level, shall not be less than the design story drift of that level multiplied by the behavior factor, R. Each adjacent building shall provide a clear gap equal to the design story drift multiplied by 0.5R at each story level. The behavior factor is defined in Clause 2-3-8.

The isolation joint may be filled with low strength material that are easily crushed during an earthquake and may be easily refilled and repaired.

1-7 Building Classification according to Importance

Buildings are grouped into four categories based on their importance:

Group1- Buildings with "Very High Importance"

This group includes buildings that their post-continuous earthquake operation is of special importance and any discontinuity in this regard leads to an indirect increase in casualties and damages. Hospitals, clinics, fire stations, water supply and power plants, aviation control towers, communication centers including radio and TV , police stations, rescue centers and, in general, all buildings that are involved in rescue and help operation are in this category. Buildings and structures supporting toxic and hazardous material whose failure may causes widespread important environmental damage in short and long term are also considered in this group.

Group2- Buildings with "High Importance"

This group consists of the following:

a- Buildings whose damage results in great loss of life such as: schools, mosques, stadiums, cinemas and movie theatres, assembly halls, departmental stores, terminals or any enclosed area with a capacity greater than 300 people under one ceiling.

b- Buildings whose damage results in loss of national heritage. These include: museums, libraries and other places where national documents and valuable items are preserved.

c- Industrial buildings and facilities whose failure, may result in environmental pollution or widespread fire, such as refineries, fuel storage tanks and gas supply centers.

Group3- Buildings with "Moderate Importance"
All buildings that are within the scope of this Code, except those included in other categories, fall in this group. These include: residential, office and commercial buildings, hotels, multistory parkings, warehouses, workshops, industrial buildings, etc.

Group4- "Buildings with Low Importance"
This group consists of the following:

a- Buildings with low risk of damage and loss of life due to their failure such as agricultural warehouses and poultry farms.

b- Temporary buildings with an operational life of less than two years.

1-8 Building Classification according to Configuration

Buildings are classified as "Regular" or "Irregular", base on their configuration as follows:

1-8-1 Regular Buildings:
Buildings are "Regular" if they conform to all of the following criteria:

1-8-1-1 Plan Regularity:

a- The plan of the building shall be symmetric or almost symmetric about its principle axes, where the lateral load resisting elements are generally aligned with. In case there is any setback or projection, their dimension in each direction shall not exceed 25% of the respective building dimension in that direction.

b- In each story, the distance between the centers of mass and stiffness in each orthogonal direction shall not exceed 20% of the building dimension in that direction.

c- Abrupt variation in diaphragm stiffness relative to the adjacent stories shall not exceed 50%. Moreover, the total area of openings in each diaphragm shall not be greater than 50% of the total area of the diaphragm.

d-There shall be no discontinuity in the lateral load path toward the base, such as out-of-plane offsets of the lateral load resisting elements.

e- In each story the maximum drift, including accidental torsion, at one end of the structure shall not exceed 20% of the average of the story drifts of the two ends of the structure.

1-8-1-2 Vertical Irregularity

a- Distribution of mass over the height of the building shall be approximately uniform such that the mass of no story, except the roof and loft differ more than 50% of the mass of the story located below.

b- The lateral stiffness of each story shall not be less than 70% of that in the story above or 80% of the average stiffness of the three stories above. The story not complying with these, is considered a "flexible story".

c- The lateral strength of each story shall not be less than 80% of that in the story above. The story strength is the total strength of all elements resisting the story shear in the direction under consideration. The story not complying with this, is considered a "weak story".

1-8-2 Irregular Buildings

An irregular building is a building not conforming to one or more of the provisions of Section 1-8-1.

1-9 Building Classification according to Structural System

Buildings shall be classified as one of the following, according to their structural systems:

1-9-1 Bearing Wall System: A structural system without a complete vertical load-carrying space frame. In this system, bearing walls or braced frames provide support for all or most of the gravity loads. Resistance to lateral load is provided by shear walls or braced frames.

1-9-2 Building frame system: A structural system with an essentially complete space frame with simple connections, providing support for gravity loads. Resistance to lateral load is provided by shear walls or braced frames. Frame systems with so called “Khorgini” connections and vertical braces shall be considered in this category.

In this system, braced frames may be used as concentric or eccentric.

1-9-3 Moment- Resisting Frame System: A structural system with an essentially complete space frame providing support for gravity and lateral loads. Structures with complete moment-resisting frames, and structures with moment-resisting frames at the perimeter or part of the plan and simple frames in other locations, shall be considered in this category.

The concrete and steel frames used in this system may be ordinary, intermediate or special, according to their ductile behavior.

1-9-4 Dual System: A structural system with the following features:

a- An essentially complete space frame that provides support for gravity loads.

b- Resistance to lateral loads is provided by shear walls or braced frames, and moment-resisting frames. Story shear for each group at each story is evaluated according to their lateral stiffnesses.

In this system, braced frames and moment-resisting frames may be of the types defined in 1-9-2 and 1-9-3, and reinforced concrete shear walls may be of Intermediate or special type.

c- Moment-resisting frames shall be capable of carrying at least 25% of the design base shear, independently.

Note-1: For buildings lower than 8 stories or 30m, in lieu of distributing lateral loads according to the relative stiffness of lateral load-resisting elements, shear walls or braced frames may be designed for 100% of the lateral load, while the moment-resisting frames shall be designed for 30% of the lateral load.

Note-2: Ordinary steel or reinforced concrete moment-resisting frames shall not be used in this system. Otherwise the system shall be classified as building frame system, as defined in Section 1-9-2.

Note-3: When a system fails to conform to criteria (c) above, the system shall be classified as building frame system, as defined in Section 1-9-2.

1-9-5 Other Structural System: A structural system that does not conform to the provisions of 1-9-1 to 1-9-4. The lateral and vertical load bearing elements characteristics of this system shall be determined by recognized codes, technical research or laboratory tests.

Chapter Two

Design of Building for Earthquake Loading

2-1 General Provisions

2-1-1 All structures except masonry buildings that conform to the provisions of Chapter 3 of this Code shall be designed in accordance with the provisions of this chapter.

2-1-2 Structures shall be analyzed independently for earthquake and wind loads. Each structural element shall be designed for the most critical action. However, detailing requirements and limitations of seismic design prescribed in this chapter shall be considered for all elements.

2-1-3 The effect of vertical component of earthquake load shall also be considered together with the horizontal components, as required in Section 2-3-12.

2-1-4 The structure shall be designed for earthquake load in two orthogonal directions. In general, this may be done independently for each direction, except for the following cases:

a- The structure with plan irregularity

b- A column that is a common member of two or more intersecting lateral-force-resisting systems.

For these cases, the earthquake load shall be applied at a direction that results in the maximum effect. Alternatively, the effect of the two orthogonal directions may be satisfied by designing such elements for 100 percent of the prescribed seismic forces in one direction plus 30 percent of the prescribed seismic forces in the perpendicular direction. For design purposes, the most critical case in terms of internal seismic forces sign shall be considered.

Note-1: If the axial load in the column due to seismic forces in either direction is less than 20 percent of the column axial load capacity, the above requirement need not be considered.

Note-2: When 100 percent of seismic load in one direction is considered with 30 percent of seismic load in the orthogonal direction, the accidental eccentricity, as per Section 2-3-10, need not be considered for the seismic load applied to the direction with 30 percent load.

2-1-5 The seismic forces in either orthogonal direction shall be considered to act reciprocally in opposite directions.

2-1-6 The mathematical model of the structure shall include all elements in the lateral-load-resisting system and represent the spatial distribution of the mass and stiffness of the structure. The model shall also include the stiffness and strength of the non-structural elements, which are significant to the distribution of forces. In this regard, stiffness properties of reinforced concrete elements shall consider the effects of cracking of the sections. This may be accounted for in accordance with the provisions of Section 2-5-6.

2-2 Horizontal Seismic load

2-2-1 The horizontal seismic load acting on a structure shall be determined by either "Equivalent Static" or "Dynamic" procedures, according to the criteria and limitations of this Section. These procedures are addressed in detail in Sections 2-3 and 2-4. The horizontal seismic load acting on non-structural elements shall be determined in accordance with the criteria of Section 2-8.

2-2-2 The equivalent static procedure shall be used only for the following structures:

a- Regular structures Shorter than 50 m in height from the base level.

b- Irregular structures not more than five stories, or Shorter than 18 m in height from the base level.

c- Structures having a flexible upper portion supported on a rigid lower portion where:

1-Both portions can be classified as regular structures separately.

2-The average story stiffness of the lower portion is at least 10 times the average of the upper portion

3- The fundamental period of the entire structure is not greater than 1.1 times the period of the upper portion, considered as a separate structure with fixed base.

2-2-3 The dynamic procedures may be used for all structures; however, they shall be used for any structure that is not conforming to the criteria of Section 2-2-2.

2-3 Equivalent Static Procedure

The equivalent static lateral force shall be determined in accordance with the criteria of this section and shall be applied in opposite directions to the structure.

2-3-1 Base Shear, V

The minimum base shear or the sum of the horizontal seismic loads, in each direction of the structure, shall be determined from:

$$V=CW \qquad (2\text{-}1)$$

Where:
V= The shear force at base level. This level is defined in Section 2-3-2.
W= The total seismic weight of building, that is equal to the total dead load plus a percentage of live and snow loads as defined in Table-1.
C= The seismic coefficient, that is determined from the following formula:

$$C = \frac{ABI}{R}$$

Where:
A= Design base acceleration ratio (ratio of seismic acceleration to gravity acceleration, g) as given in Section 2-3-3
B= Building response factor determined from the design response spectrum, as given in Sections 2-3-4 to 2-3-6
I=Importance factor, as given in Section 2-3-7

R= Building behavior factor, as given in Section 2-3-8.
The design base shear shall not be considered less than:

$$V = 0.1AIW \quad (2\text{-}2)$$

Table 1: Percentage of live and snow loads in the seismic weight of the building

Location	Percentage of live load
Sloped roofs with a slope equal to or greater than 20%(1)	----
Flat roofs or roofs with a slope less than 20%	20
Residential buildings, Offices, hotels and garages	20
Hospitals, schools, shopping centers and public buildings	40
Storages and Libraries	60
Water tanks and other liquid storage tanks and silos	100

(1)- If there is a high possibility that snow remain on these roofs, then they shall be treated as flat roofs.

2-3-2 Base level

Base level is defined as the level below which the structure does not move relative to the ground during an earthquake. This level is generally taken as the top of foundation level. However, when most of the basement levels are surrounded by peripheral reinforced concrete retaining walls, monolithically cast with the structure, then base level may be taken as the level of the story closest to the peripheral consolidated soil level of the ground, provided that the retaining walls are extended up to this story.

2-3-3 Design Base Acceleration Ratio, A

The design base acceleration ratio shall be determined for various region of the country from Table-2, according to their level of seismicity. The levels of seismicity of different part of Iran are given in Appendix-1.

Table 2: Design base acceleration ratio for various seismic zones

Zone	Description	Design base acceleration(/g)
1	Very high level of relative seismic hazard	0.35
2	High level of relative seismic hazard	0.30
3	Intermediate level of relative seismic hazard	0.25
4	Low level of relative seismic hazard	0.20

2-3-4 Building Response Factor, B

The building response factor represents the building response to the ground motion. This factor shall be determined from the following formulae or from Figure-1(a) and Figure-1(b):

$$
\begin{aligned}
B &= 1 + S\left(\frac{T}{T_0}\right) && 0 \le T \le T_0 \\
B &= S + 1 && T_0 \le T \le T_s \qquad (2\text{-}3) \\
B &= (S+1)\left(\frac{T_s}{T}\right)^{2/3} && T \ge T_s
\end{aligned}
$$

Where:

T= Fundamental period of vibration of the structure in the direction under consideration, in second, as determined in Section 2-3-6.

T_0, Ts and S= are parameters determined from the soil profile type and level of seismicity, as set forth in Table-3. Various soil types are described in Section 2-3-5.

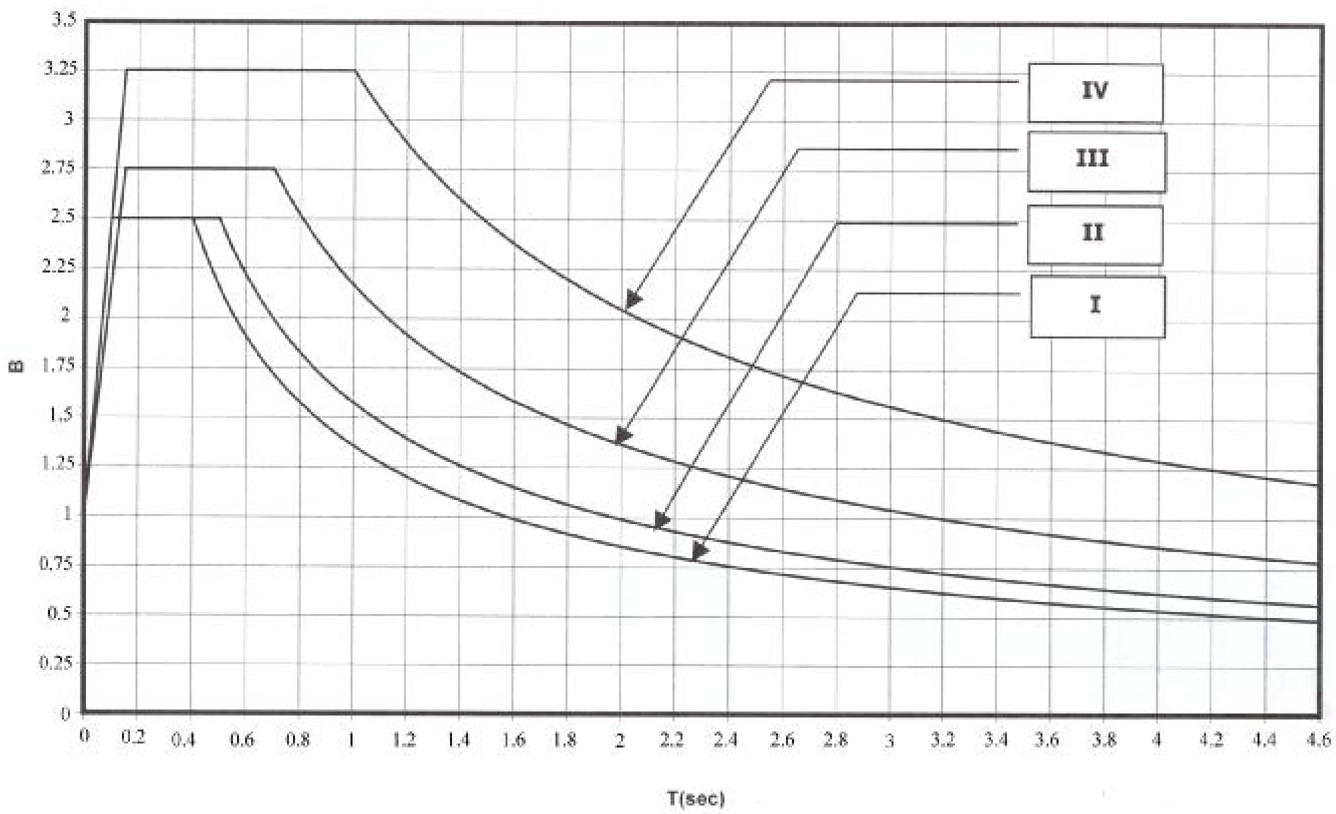

Figure 1-a: Building response factor for zones of “Moderate” and “Low” levels of seismicity. (Soil types are as defined in Section 2-3-5)

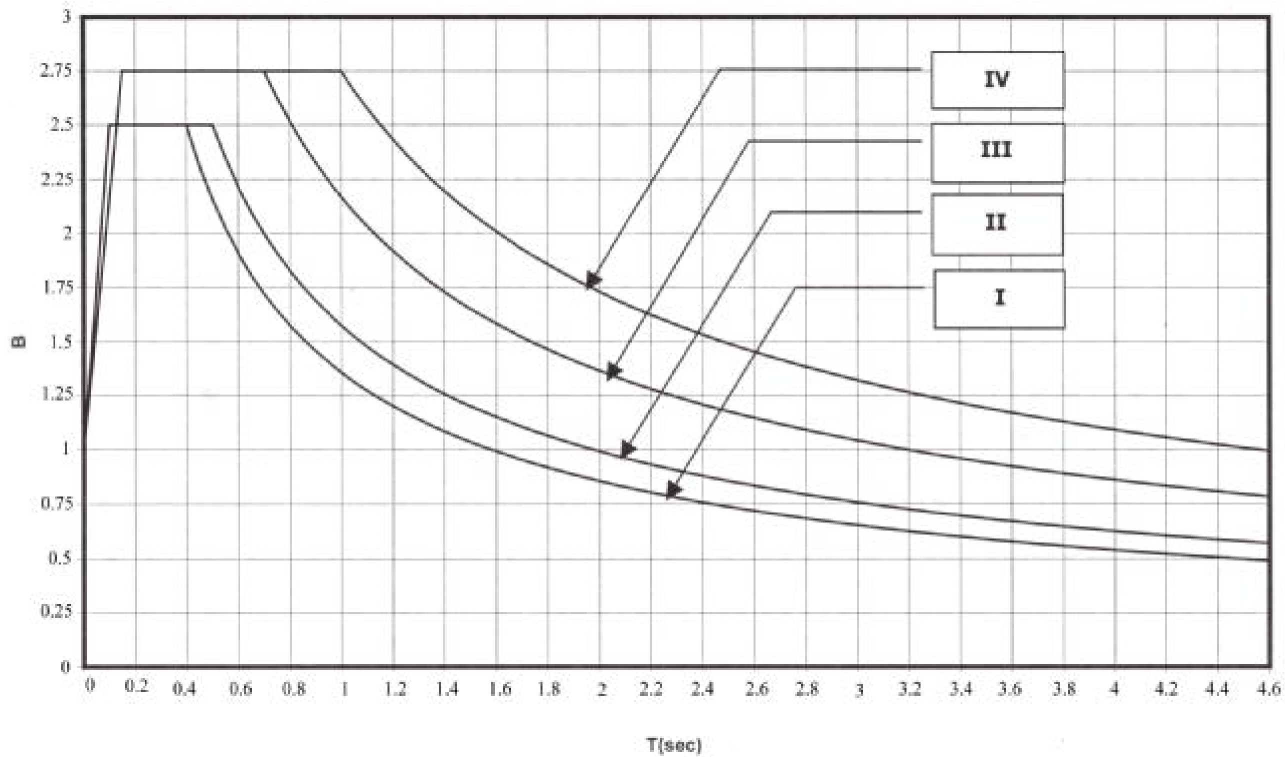

Figure 1-b: Building response factor for zones of "Very High" and "High" levels of seismicity. (Soil types are as defined in Section 2-3-5)

Table 3: values for S,T_0 and T_s

Soil profile type	T_0	T_s	"Moderate" and "Low" seismicity	"High" and "Very high" seismicity
			S	S
I	0.1	0.4	1.5	1.5
II	0.1	0.5	1.5	1.5
III	0.15	0.7	1.75	1.75
IV	0.15	1.0	2.25	1.75

2-3-5 Soil Profile Type Classifications

Soil profile types are classified according to Table-4:

Table 4: Soil Profile classification

Soil Profile Type	Description	$\bar{V}_s$ (m/sec)
I	a)Igneous rocks(with coarse and fine grade texture), stiff sedimentary rocks and massive metamorphic rocks (Gneiss, crystal layers silicate rocks) and conglomerate. b) Stiff soils (compact sand and gravel, very stiff clay) with a thickness more than 30 meters above bed rock.	>750 $375 \le \bar{V}_s \le 750$
II	a)Loose igneous rocks (e.g. tuff), loose sedimentary rocks, foliated metamorphic rocks and in general rocks that have become loose and decomposed due to weathering b)Stiff soils (compact sand and gravel, very stiff clay) having a thickness more than 30 meters above bed rock.	$375 \le \bar{V}_s \le 750$ $375 \le \bar{V}_s \le 750$
III	a)Rocks that are disintegrated due to weathering b) Soils with medium compaction, layers of sand and gravel with medium intragranular bond and clay with intermediate compaction.	$175 \le \bar{V}_s \le 375$ $175 \le \bar{V}_s \le 375$
IV	a)Soft deposits with high moisture content due to high level of water table b) Any soil profile containing clay with a minimum thickness of 6 meters and a plastic index and moisture content exceeding 20 and 40 percent respectively.	<175

$\overline{V}_s$ Is the average shear wave velocity in the top 30 meters of site layer that may be determined in accordance with the thickness and shear wave velocity of various soil layers by the following formula:

$$\overline{V}_s = \frac{\sum d_i}{\sum (d_i / V_{si})} \qquad (2\text{-}4)$$

Where d_i and V_{si} are the thickness and shear wave velocity in each layer respectively.

When soil profile type can not be determined by the qualitative descriptions of Table-4, laboratory or in-situ tests shall be used to determine the value of V_{si} directly. Alternatively, reliable experimental relationship as well as physical and mechanical properties of soil may be used to evaluate V_{si}. The soil type shall be classified based on the value of $\overline{V}_s$.

In cases that the soil properties are not known in sufficient detail to determine the soil profile type according to Table-4, a soil profile type that gives the higher response factor shall be used.

2-3-6 Fundamental Period of Vibration

The fundamental period of vibration, T, shall be determined from the following formulae:

a) For buildings with moment resisting frame system;
   1- If infill walls does not impose restraint on frame displacements:
      - For steel frame: $T=0.08H^{3/4}$ (2-5)
      - For reinforced concrete Frame: $T=0.07H^{3/4}$ (2-6)

   2- If infill walls impose restraint on frame displacements, T shall be taken as 80 percent of the value calculated from the above formulae.

b) For buildings with other systems: $T=0.05H^{3/4}$ (2-7)

In the above formulae, H is the height of the building in meters, measured from the base level. If the weight of the loft is greater than 25 percent of the roof, its height shall be considered as well.

Note-1: In lieu of the above empirical formulae, the fundamental period may be calculated using structural properties of the resisting elements in a properly substantiated analysis or by using the following formula:

$$T = 2p\sqrt{(\sum_{i=1}^{n} w_i d_i^2) \div (g\sum_{i=1}^{n} F_i d_i)} \qquad (2\text{-}8)$$

The values of F_i represent any lateral force distributed approximately in accordance with the distribution of Formula (2-9) or any other rational distribution. d_i is the deflection due to applied lateral forces, F_i, on the building. The seismic weight of the story, w_i, shall be determined in accordance with the definition of Section 9-3-2 and g is the gravity acceleration.

The value of T from these methods, however, shall not exceed a value 25 percent greater than the value obtained from the empirical Formulae (2-5) to (2-7).

Note-2: In calculating the fundamental period, T, for reinforced concrete structures, the effective stiffness of the cracked sections shall be considered. This may be done by considering the moment of Inertia for beam equal to $0.5I_g$ and for columns and walls equal to I_g. I_g is the gross moment of inertia for the member's cross-section neglecting its reinforcement. These values are 1.5 times the values prescribed in Section 2-5-6 for calculation of drift.

2-3-7 Building Importance Factor, I

The building importance factor shall be determined in accordance with the classification of Section 1-7, from Table 5:

Table 5: Building Importance Factor

Building Classification	Importance Factor
Group 1	1.4
Group 2	1.2
Group 3	1.0
Group 4	0.8

2-3-8 Building Behavior Factor, R

2-3-8-1 The building behavior factor, R, represents the global characteristic of the structure such as ductility, redundancy and the inherent overstrength capacity. This factor shall be determined in accordance with the type of lateral-force-resisting system, from table 6. However in determining this factor, limitations of section 2-3-8-8 and 2-3-8-9 shall be considered. The values

presented in this Table conform to the Allowable Stress Design method and the resulting forces shall be appropriately amplified when other design philosophies such as the Limit State or Strength Design methods are used.
In cases that a structural system other than the ones listed in Table 6 is used, its corresponding R value shall be determined from reliable codes.

2-3-8-2 Construction of buildings exceeding the height limits, H_m, indicated in Table 6 is not allowed, in all parts of the country. For special buildings such as communication towers, monuments and so on, where the height exceeds these limits, the ratification of the Technical Committee of this Code is mandatory.

2-3-8-3 For buildings classified as "Very High importance", in zone of very high seismicity, only structural systems designated as "Special" shall be used.

2-3-8-4 For buildings with 15 story and more or exceeding 50 meters in height, special moment resisting frame or dual systems shall be used. In these buildings, shear wall or braced systems shall not be individually used to resist the entire lateral load.

2-3-8-5 Use of flat slabs and column system, as moment resisting frames shall be limited exclusively for buildings not more than three stories or 10 meters height. This limit may be exceeded when the lateral earthquake loads are resisted by shear walls or braced frames.

2-3-8-6 For reinforced concrete structures with joist and block floor systems, where beams depths are taken equal to the floor thickness, if beams depths are less than 30 cm, the floor shall be considered as Flat slab type, and the provisions of Clause 2-3-8-5 shall be applied.

2-3-8-7 Steel frames with conventional "Khorjini" connections may be regarded as simple building frame system, provided that they satisfy the special technical requirement.

2-3-8-8 Combinations of Structural Systems in Plan

In cases that a structure has two different lateral-load-resisting systems along two axes in plan, each system shall be designed for its corresponding R factor.

Exception: Where a structure has a bearing wall system in one direction, the value of R used for the design in the orthogonal direction shall not be greater than that used for the bearing wall system.

2-3-8-9 Combinations of Structural Systems in Height

For buildings that combine two different structural systems in height, the value of R used for design of lower system shall not be greater than the value of R used for the system above. The structure may be designed using Procedure (1) below. In special cases where the structure conform to Clause 2-2-2-c, any one of the Procedures (1) or (2) may be used.

Procedure (1)- In this procedure, the seismic load is determined based on the lower R factor in the direction under consideration for total height of the structure. The fundamental period of the structure shall be determined according to the provisions of Section 2-3-6. The empirical formula that results in the lower fundamental period for two systems shall be used.
Procedure (2)- This procedure consists of the following two-stages:
a- The flexible upper portion shall be designed as a separate structure with rigid supports based on an R factor corresponding to its structural system.

b- The rigid lower portion shall be designed as a separate structure using the corresponding R factor. The reactions from the upper portion shall be modified by the ratio of the R of the upper portion over R of the lower portion and be super-imposed to the loads acting on the lower portion.

Table 6: Building Behavior factor, R, and maximum permissible building height, H_m

Structural System	Lateral-Force, Resisting System	R	H_m (m)
A- Bearing Wall System	1- Special reinforced concrete shear walls	7	50
	2- Intermediate reinforced concrete shear walls	6	50
	3- Ordinary reinforced concrete shear walls	5	30
	4- Reinforced masonry shear walls	4	15
B- Building frame System	1- Special reinforced concrete shear walls	8	50
	2- Intermediate reinforced concrete shear walls	7	50
	3- Ordinary reinforced concrete shear walls	5	30
	4- Reinforced masonry shear walls	4	15
	5- Steel eccentric braced frame	7	50
	6- Steel concentric braced frame[1]	6	50
C-Moment-	1-Special reinforced concrete moment-	10	150

resisting frame system	resisting frame[2]		
	2- Intermediate reinforced concrete moment-resisting frame[2]	7	50
	3- Ordinary reinforced concrete moment-resisting frame[2],[3]	4	---
	4-Special steel moment-resisting frame[1]	10	150
	5- Intermediate steel moment-resisting frame	7	50
	6- Ordinary steel moment-resisting frame[3],[4]	5	---
D-Dual systems	1-Special moment-resisting frame(steel or concrete)+special reinforced concrete shear walls	11	200
	2- Intermediate concrete moment-resisting frame+ intermediate reinforced concrete shear walls	8	70
	3- Intermediate steel moment-resisting frame+ intermediate reinforced concrete shear walls	8	70
	4- Special steel moment-resisting frame+ Steel eccentric braced frame	10	150
	5- Special steel moment-resisting frame+ Steel concentric braced frame	9	150
	6- Intermediate steel moment-resisting frame+ Steel eccentric braced frame	7	70
	7- Intermediate steel moment-resisting frame+ Steel concentric braced frame	7	70

Notes:

[1]- Refer to Appendix (2) for special provisions on steel structures

[2]- Ordinary, intermediate and special reinforced concrete moment-resisting frames are identical to the low, intermediate and high ductility moment-resisting frames defined in Iranian Concrete Code (ABA) respectively, except that for intermediate moment-resisting frames, the tie spacing in the “L_o” region of columns shall not be taken greater than 15 cm.

[3]- This system shall not be used for buildings designated as “Very High or High Importance” in all seismic zones and “intermediate importance” in seismic zones 1 and 2. The maximum height limit for this system for buildings designated as “intermediate importance” in seismic zones 3 and 4 shall be limited to 15 meters.

[4]- This system may be used for one-story buildings or industrial structures designated as “intermediate or low importance” in all seismic zones provided that their height does not exceed 18 meters.

2-3-9 Vertical Distributions of Seismic Forces

The Design Base Shear, V, determined from the provisions of Section 2-3-1, shall be distributed over the height of the structure in accordance with Formula (9-2):

$$F_i = (V - F_t)\frac{W_i h_i}{\sum_{j=1}^{n} W_j h_j} \qquad (2\text{-}9)$$

Where:

F_i = The lateral force at level i

W_i = The seismic weight of level i, that is equal to the dead plus a percentage of live load at this level as defined in Table-1, and half of walls and columns weight located immediately above and below this level.

h_i = Height of the story of level i, from the base level

n = Total number of stories above the base level

F_t = A concentrated force at the top level that is determined from the following formula:

$$F_t = 0.07TV \qquad (2\text{-}10)$$

F_t need not exceed 0.25V and may be considered as zero where T is 0.7 second or less.

Note: If the weight of the loft is greater than 25 percent of the roof, the concentrated force F_t, shall be applied at loft level. Otherwise, it shall be applied at roof level.

2-3-10 Horizontal Distributions of Seismic Forces

2-3-10-1 The design story shear, determined from the vertical distribution of seismic forces as above, shall be distributed among the various vertical lateral-force-resisting systems in proportion to their rigidities. The shear due to horizontal torsion resulting from eccentricities of the applied design lateral forces at levels above any story, shall also be included. Where diaphragms are not rigid, the effect of their deformations shall also be considered in horizontal distribution of shears.

2-3-10-2 The torsional design moment at a given story, i, shall be determined from the following formula:

$$M_i = \sum_{j=1}^{n} (e_{ij} + e_{aj}) F_j \qquad (2\text{-}11)$$

Where:

e_{ij} = Eccentricity between the lateral force at level j and the center of stiffness at level i (the horizontal distance between the center of mass at level j and center of rigidity at level i)

e_{aj} = Accidental eccentricity at level j determined in accordance with Clause 2-3-10-3

F_j = The lateral force at level j

All structural elements shall be designed for the torsional moment that induces the maximum effect.

2-3-10-3 The accidental eccentricity at any floor level, e_{aj}, accounts for the possible variations in mass and stiffness distributions and also the forces due to the torsional component of earthquake. This eccentricity shall be considered in both directions with a minimum value equal to 5 percent of the building dimension perpendicular to the direction of the force under consideration at that level. Where torsional irregularity exists, Clause 1-8-1-1-c, this effect shall be accounted for by increasing the accidental eccentricity at each level by amplification factor, A_j, determined from the following formula:

$$A_j = \left(\frac{\Delta_{\max}}{1.2\Delta_{ave}} \right)^2 \qquad 1 \le A_j \le 3 \qquad (2\text{-}12)$$

Where:

$\Delta_{\max}$ = the maximum displacement at level j

Δ_{ave} = the average of the displacements of the extreme points of the structure at level j.

2-3-10-4 For buildings up to 5 story or less than 18 meters in height, when the eccentricity of the lateral story shears in levels above the level under consideration are less than 5 percent of building dimension at that level, perpendicular to the direction of the force under consideration, the torsional moments need not be considered in design.

2-3-11 Overturning

Structures as a whole, shall be designed to resist the overturning effects. The overturning moment at foundation level is equal to the sum of the lateral story force at each level multiplied by its height from foundation bottom level. The factor of safety for overturning, defined as the ratio of the resisting moment to the overturning moment, shall not be less than 1.75. The resisting moment shall be determined from the vertical loads that are considered for determination of lateral seismic load. The weight of foundation and the soil on its top are added to these vertical loads. The resisting moment shall be calculated at the foundation bottom level with respect to its outer edge.

2-3-12 Vertical Seismic load

2-3-12-1 The vertical seismic load shall be considered for design in the following cases:

a- Beams with spans exceeding 15 meters. The adjacent columns and supporting walls shall also be considered.

b- Beams with considerable concentrated loads, with respect to other applied loads. The adjacent columns and supporting walls shall also be considered. A considerable concentrated load is a load with magnitude of at least half of the sum of all other applied loads.

c- Balconies and cantilevers

2-3-12-2 The vertical seismic load for cases (a) and (b), above, shall be determined from Formula (2-13). For the case (c), above, this load shall be doubled. Moreover, for this latter case the load shall be considered in both upward and downward directions, ignoring the reducing effect of gravity loads.

$$F_v = 0.7AIW_p \qquad (2\text{-}13)$$

Where:
A and *I* are as defined in Sections 2-3-3 and 2-3-7.
W_p = The weight of the element plus total live load.

2-3-12-3 The vertical and horizontal seismic loads shall be considered in the following load combinations:

1- 100 percent of horizontal seismic load in any direction, plus 30 percent of the horizontal load in the perpendicular direction and 30 percent of the vertical seismic load.

2- 100 percent of the vertical seismic load plus 30 percent of the horizontal seismic load in any two perpendicular directions.

In these load combinations, the exception 2 of clause 2-1-4 may be considered.

2-4 Dynamic Analysis Procedures

In dynamic analysis procedures, the horizontal seismic load is determined from the dynamic response of building subjected to an appropriate "Ground Motion". These procedures include the "Response Spectrum" method and the "Time History" method, defined in Sections 2-4-2 and 2-4-3. The use of either method is arbitrary.

The appropriate ground motion shall be chosen in accordance with the provisions of Section 2-4-1.

Note: The parameters used in dynamic procedure such as mass, design base acceleration ratio etc. are identical to those defined for static procedure.

2-4-1 Ground Motion

2-4-1-1 The ground motion properties shall, as a minimum, conform to the "design earthquake level" defined in Section 1-1. The ground motion effects may be defined either by an "Acceleration Response Spectrum" or an "Acceleration Time History". The "Acceleration Response Spectrum" may be the "Standard Design Spectrum" or the "Site-specific Design Spectrum" as set in Sections 2-4-1-2 and 2-4-1-3 respectively. The "Acceleration Time History" shall conform to Section 2-4-1-4.

The use of either spectrum is arbitrary for all buildings. However, for buildings in which the dynamic analysis is compulsory, Section 2-2-3, and buildings conforming to any of the following criteria, the site-specific design spectrum is compulsory.

a- Very High and High Importance buildings on Soil Profile Type IV, Table4.

b- Buildings higher than 50 meters on Soil Profile Type IV.

c- Buildings higher than 50 meters on Soil Profile Type II-b and III-b, with a thickness exceeding 60 meters.

2-4-1-2 Standard Design Spectrums

This spectrum shall be based on the provisions of Section 2-3, which reflects the effects of ground motion for design earthquake level. The spectrum shape shall be taken as $\frac{ABI}{R}$, in which A, B, I and R parameters are defined in Section2-3-1. The lower-bound value of Formula 2-2 shall also be observed. The damping ratio in this spectrum is 5 percent.

2-4-1-3 Site-specific Design Spectrum

The Site-specific Design Spectrum shall be based on the geologic, tectonic, seismologic and soil characteristics of the site. The spectrum shall be developed for a damping ratio of 0.05, unless a more appropriate value, consistent with the behavior of structure and the level of earthquake, is established. The developed spectrum, however, shall be multiplied by I and 1/R.

The Site-specific Design Spectrum values, in no cases, shall be taken less than two-third of the Design Response Spectrum values.

2-4-1-4 Acceleration Time-history, Accelerograms

2-4-1-4-1 The acceleration time histories representing the ground motion effects shall reflect the expected earthquake acceleration at the site. Further more a minimum of three pairs of appropriate horizontal ground motion time history components, with the following characteristics, shall be used:

a- Time histories shall have magnitudes, fault distances and source mechanisms that are consist ant with those that control the design-basis earthquake.

b- Time histories shall belong to the sites with geologic, tectonic, seismologic and particularly soil characteristics, similar to site under consideration.

c- The time duration of the strong ground motion accelerograms shall be at least 10 seconds or three times the fundamental period of vibration of the structure, whichever is greater. This duration may be evaluated by recognized methods such as the cumulative energy distribution method.

Where three appropriate recorded ground motion time history pairs are not available, appropriate simulated ground motion time history pairs may be used.

2-4-1-4-2 The selected time history pairs shall be scaled as follows:
a- Each accelerograms shall be scaled to its maximum value, so its peak value will be equal to the gravity acceleration, g.

b- For each pair the 5 percent-damped response spectrum shall be developed and combined, using the square root of the sum of the squares (SRSS) method, so that a unique spectrum is constructed for each pair.

c- The motions shall be scaled such that the average value of their SRSS spectra does not fall below 1.4 times the Standard Design-Spectra for periods of 0.2T second to 1.5T seconds, where T is the fundamental period of vibration, as set forth in section 2-3-6.

d- The resulting scale factor shall be applied to the scaled accelerograms in Item(a) to be used in dynamic analysis.

2-4-2 Response Spectrum Analysis Method

2-4-2-1 In this method a linear dynamic analysis is performed and the vibration modes of the building is determined. The maximum modal response is then obtained from the design spectrum and combined by a statistical method to get the total response of the building. In this procedure the provisions of sections 2-4-2-2 to 2-4-2-4 shall be met.

2-4-2-2 Numbers of Modes

In each orthogonal direction, a minimum number of three first modes, or all the modes with periods higher than 0.4 seconds or all the modes that include at least 90 percent of the participating mass of the structure, whichever is the greatest, shall be considered in the analysis.

2-4-2-3 Combining Modes

The maximum member forces, displacements, story forces, story shears and base reactions for each mode shall be combined by recognized methods such as the square root of the sum of the squares (SRSS) or the Complete Quadratic Combination (CQC). For structures with plan irregularity or where torsional effects are considerable, the modal combination method shall include the interaction of modes. For these cases, the Complete Quadratic Combination (CQC) method may be used.

2-4-2-4 modifications of Response Values

2-4-2-4-1 When the base shear determined from the response spectrum analysis is less than the corresponding value derived from the equivalent static method, the former value shall be modified in accordance with the following items. The equivalent static base shear is the value determined from Formula (1-2), based on standard design spectrum.

a- For all irregular structures, the above response parameters may be modify such that the corresponding design base shear is not less than 100 percent of the base shear determined from Formula (1-2).

b- For all regular structures, where the ground motion representation complies with the standard design response spectrum, the above response parameters may be modified such that the corresponding design base shear is not less than 90 percent of the base shear determined from Formula (1-2).

c- For all regular structures, where the ground motion representation complies with the site-specific response spectrum, response parameters may be modified such that the corresponding design base shear is not less than 80 percent of the base shear determined from Formula (1-2).

2-4-2-4-2 When the base shear determined from the response spectrum analysis is greater than the corresponding value derived from the equivalent static method, elastic response parameters may be modified such that the corresponding design base shear is not less than 100 percent of the base shear determined from Formula (1-2).

2-4-2-5 Torsional effects

The analysis shall account for torsional effects, including accidental torsion effects as prescribed in Section 2-3-10. Where three-dimensional models are used for analysis, effects of accidental torsion may be accounted for by displacing the center of mass of each story by a distance equal to the accidental eccentricity.

2-4-2-6 Directional Effects

Directional effects for horizontal ground motion shall conform to the requirements of Section 2-1-4 for response spectrum analysis. The effects of vertical ground motions shall conform to the requirements of Section 2-3-12 using equitably of the static analysis. Alternatively, vertical seismic response may be determined by dynamic response methods, but in no case shall the response used for design be less than that obtained by the static method.

2-4-2-7 Dual Systems

Where the lateral forces are resisted by a dual system, the moment-resisting frame shall be capable of resisting 25 percent of the base shear determined from the response spectrum analysis in accordance with the provisions Section 1-9-4, Item c. The base shear shall be distributed in height in accordance with the Response Spectrum Analysis or the Equivalent Static Analysis, Section 2-3-9.

2-4-3 Time History Analysis

2-4-3-1 Time history analysis is a method in which the dynamic response of a structure is determined at each increment of time, when the base is subjected to a specified ground motion time history. The analysis shall be performed using accepted principles of dynamic. The ground motion representation shall conform to the provisions of Section 2-4-1-4.

Each pair of accelerograms shall be applied simultaneously in both principal, orthogonal directions and the response parameters are determined at each time increment. The final response of the structure at each time increment shall be the maximum response obtained from the analysis of each of the three-accelerogram pairs.

In lieu of the above provision, seven pair of accelerograms conforming to the provisions of Section 2-4-1-4 may be used. In this case the average value of the parameter of interest may be used for design.

The structure may be assumed to be linear or nonlinear in accordance with the provisions of Sections 2-4-3-2 and 2-4-3-3.

2-4-3-2 Linear Time History Analysis

2-4-3-2-1 In linear time history analysis a 5 percent damping ratio may be assumed, unless a different value is shown to be consistent with the anticipated structural behavior.

2-4-3-2-2 Linear time history analysis shall conform to the provisions of Section 2-4-2-4 for modification of response parameters, Section 2-4-2-5 for torsional effects and to Section 2-4-2-7 for dual systems. In these sections the term response spectrum analysis is substituted by time history analysis.

2-4-3-3 Nonlinear Time History Analysis

2-4-3-3-1 Nonlinear characteristics of structural elements including strength, stiffness and ductility shall be modeled consistent with test data or substantiated analysis.

2-4-3-3-2 Damping ratio shall be determined based on the nonlinear characteristics of structural elements. In the absence of reliable data, a 5 percent damping ratio may be used.

2-4-3-3-3 When nonlinear time history analysis is used, a design review shall be performed by an independent engineer(s) licensed in the appropriate disciplines and experienced in seismic analysis methods. The review shall include the following:

a- appropriateness of the ground motion time-histories

b- suitability of structural characteristics of members with respects to those in the analytical model.

c- investigation of demand to capacity ratio of structural components.

2-5 Story Drift

2-5-1 The story drift at each story level is defined as the difference between the displacements at centers of masses in the stories above and below that level. These displacements are calculated for the design or service level earthquakes and are named accordingly.

2-5-2 The story drift at each story level is the displacement due to the applied lateral earthquake load, assuming a linear behavior for the structure. This parameter is named “Design story drift” and “Service story drift” for the design or service level earthquakes respectively. These values shall be determined considering the parameters that affect structural stiffness, such as cracking in reinforced concrete members as addressed in Section 2-5-6.

2-5-3 The actual relative displacement or the inelastic drift, at each story level is the displacement that will be obtained if the actual nonlinear behavior of the structure is considered in the analysis. This behavior is noticeable only for the design earthquake level. If linear analysis is performed, the actual relative displacement may be determined using the following Formula:

$$\Delta_M = 0.7R.\Delta_w \qquad (2\text{-}14)$$

Where:

Δ_M = The actual design story drift

Δ_w = The design story drift

R = Building behavior factor

2-5-4 The actual design drift at the center of mass of each story shall not exceed the following values. The analysis used to determine Δ_M shall consider $P-\Delta$ effect in accordance with Section 2-6.

For structures with T<0.7 second: $\overline{\Delta}_M < 0.025$ h

For structures with $T \geq 0.7$ second: $\overline{\Delta}_M \leq 0.02$ h

Where T is the fundamental period, and h is the story height of the structure.

$\overline{\Delta}_M$ is the actual design story drift including $P-\Delta$ effect.

Exception: The design lateral forces used to determine Δ_w, Formula (1-2), may disregard the limitations of Exception 1 in Section 2-3-6 for determination of T.

2-5-5 The Service story drift at each story level shall not exceed 0.005 times the story height. This limitation may be increased to 0.008 times the story height where the type, material and connection of nonstructural elements are such that they can withstand greater drift without considerable damage.

2-5-6 In calculating the design drift for reinforced concrete structures, the cracked moments of inertia may be taken according to the recommendation of Iranian Concrete Code (ABA). These values are $0.35I_g$ and $0.7I_g$ for beams and columns, respectively. For walls a value of $0.35I_g$ or $0.7I_g$ may be considered based on the amount of expected cracking. For Service level earthquake, these moments of inertia may be increase 1.5 times. At service level earthquake the $P-\Delta$ effects may be disregarded.

2-6 *P-Δ* Effect

$P-\Delta$ effect is the effect of axial forces in vertical members undergoing lateral displacement. This effect induces additional shears and bending moments in structural members, and consequently increases lateral deflection. This effect is also known as the secondary effect.

$P-\Delta$ effect shall be considered when the stability index, q_i, as determined by Formula (2-15), is greater than 10 percent.

$$q_i = \left(\frac{P\Delta_w}{Vh}\right)_i \qquad (2\text{-}15)$$

Where:

P_i = Total sum of dead and live loads from level i to the last level, n

Δ_{wi} =Initial drift at level i

V_i =Sum of shear forces at level i

h_i = Story height at level i

In no cases the stability index, q_i, shall exceed $q_{\max}$ as determined from the following Formula. In such cases the structure may be unstable and its design shall be revised.

$$q_{\max} = \frac{1.25}{R} \le 0.25 \qquad (2\text{-}16)$$

For calculation of $P-\Delta$ effect it may either be incorporated in the analysis of the structure together with other forces, or be taken into consideration by one of the approximate methods specified in "Material Design codes". The method set forth in Appendix (5) of this Code may also be used. In all cases, the lateral story displacements, that are used in determination of internal actions, shall be the amplified story drifts, $\overline{\Delta}_{wi}$ as given by formula:

$$\overline{\Delta}_{wi} = \frac{\Delta_{wi}}{1-q} \qquad (2\text{-}17)$$

The actual design story drift, $\overline{\Delta}_{Mi}$, including the $P-\Delta$ effect, may be determined from the following Formula:

$$\overline{\Delta}_{Mi} = 0.7R\overline{\Delta}_{wi} \qquad (2\text{-}18)$$

2-7 Framing Below the Base Level

The strength and stiffness of the framing between the base and the foundation level shall not be less than that of the superstructure above the base. Where the plan and geometry below the base does not differ considerably from the superstructure, structural properties below the base, including sizes of beams, columns, shear walls and braces, shall be taken at least, the same as the superstructure.

2-8 Lateral Force on non-structural elements of Building and Their Attached Components

Non-structural elements of building and their attachments shall be designed to resist the total design seismic force as fallow:

$$F_p = AB_pIw_p \qquad (2\text{-}18)$$

Where:

A and *I* are as defined in Sections 2-3-3 and 2-3-7.

w_p = Weight of the element or component. For tanks, shelves in warehouses and storage areas and libraries w_p shall be taken as the dead plus full live loads.

B_p = a factor set forth in Table-7.

Table 7: B_p factor

Elements of building or attached component	Direction of Horizontal Load	B_p
Internal and external walls of the building and partition walls	Perpendicular to the wall plane	0.7
Parapets and cantilever walls	Perpendicular to the wall plane	2
Ornamental and Internal components or attachments	Any Direction	2
Tanks, towers, chimneys, false ceilings, equipment and machineries if attached to the structure or be a part of it	Any Direction	1
Connections of pre-fabricated structural elements	Any Direction	1

Note1: The allowable tensile strength for attached elements made of masonry and sand-cement mortar may be taken up to 15 percent of their compressive strength, as set forth in Iranian Standard Code No.519.

2-9 Lateral Forces in Diaphragms

2-9-1 Diaphragms are generally the structural floors that carry the gravity loads. They also transmit the lateral loads induced in them to the vertical load-resisting elements, during an earthquake. Diaphragms shall have adequate strength and stiffness to resist the in-plane horizontal deformations. These elements shall be designed to resist the lateral seismic forces determined by the Formula:

$$F_{pi} = \frac{\left(F_t + \sum_{j=i}^{n} F_j\right)}{\sum_{j=i}^{n} W_j} W_i \qquad (2\text{-}19)$$

Where:

F_{pi} = The lateral load in the diaphragm, at level i

W_i = Weight of diaphragm and its attachments, plus a portion of its live load, as set in section 2-3-1, at level i.

F_j and W_j are the story farce and story weight as defined in section 2-3-9.

F_{pi} Shall not be taken less than $0.35AIW_i$, and its maximum value need not exceed $0.7AIW_i$. When a diaphragm transfers the lateral load of discontinuous vertical elements, their loads shall be superimposed to the load determined by the Formula (2-19).

2-9-2 Internal actions and deformations induced in diaphragms shall be determined by a recognized structural analysis method. In conventional diaphragms with relatively regular plan and without large adjacent openings, these actions and deformations may be determined by modeling the diaphragm as a deep beam on elastic supports. This method is described in appendix-6.

2-9-3 Diaphragms shall be designed for the in-plane shear and bending moments induced in them under the action of lateral loads. The strength of reinforced concrete diaphragms shall be evaluated by the provisions of Iranian Concrete Code (ABA). For diaphragms made of other materials, reference shall be made to their relevant codes.

2-9-4 Diaphragms shall be considered rigid when their maximum lateral deformation under applied load is less than half of the average story drift. For rigid diaphragms, the story shear may be distributed in accordance with relative stiffness of vertical lateral-load-resisting elements. When a diaphragm is flexible, its deformation shall be considered in distribution of the story shear.

2-10 Increasing the Design Load of Columns

In cases, where a lateral-load-resisting element, such as shear wall or braced frame is not continuous up to the foundation level, the columns that support them shall be designed for the following load combinations in addition to the combinations used in common design practice.

1.0 (Dead Load) +0.8 (Live Load) ± 2.8(Earthquake Load)
0.85(Dead Load) ± 2.8(Earthquake Load)
(2-20)

The strength of such columns need not exceed the maximum load transmitted to them by their connecting elements.

The above-mentioned strength is the ultimate column strength. Where Allowable Stress method is used for design, column design strength shall be taken as 1.7 times of their allowable strength.

2-11 Structural Elements That Are Not Part of the Lateral Load-Resisting System

For buildings higher than five stories, all structural elements that are not part of the lateral load-resisting system but are connected to them through floor diaphragms, shall be designed for the effects of the actual design story drift as set forth in Section 2-5-3. The $P-\Delta$ 13

2-12 Façade and Other Nonstructural Components Attached to the Building

2-12-1 For buildings designated as “Very High and High Importance” and buildings more than eight stories, where interior partition walls or façades are not part of the lateral load-resisting system, their connections to the structural elements shall be detailed in such a way that structural movements in the direction of wall plane is not prevented. These connections shall be capable of transferring the induced lateral seismic loads to the structure. It is recommended that these walls be constructed of light and flexible materials. However, if these walls impose restrictions on structural movements in the direction of wall plane, their stiffness shall be considered in the lateral load analysis. In this case, walls and their connections shall be designed for the resulting actions.

2-12-2 Pre-fabricated and glass- façade components of buildings designated as “Very High and High Importance”, and buildings more than eight stories, shall be designed for the lateral seismic loads set forth in Section 2-8. Moreover, these components shall be capable of accommodating the story displacements due to seismic loads without restricting the structural movements. These components shall be supported on structural elements or be connected to them with mechanical connectors in accordance with the following provisions:

a- Façade connection for glass and pre-fabricated components and the joint width between façade panels shall be capable of accommodating the actual design story drift or 1.5 centimeters which ever is greater.

b- Connections shall allow the relative movements of two adjacent stories along component’s plane. This can be taken care of sliding connection using bolt and slotted devices or connections in which the steel elements deformation or any similar mechanism provides for story drift.

c- Connections shall have adequate ductility and rotational capacity to avoid brittle failure in the vicinity of weld locations.
d- The attached component shall be designed for 1.33 times the earthquake load as set forth in Section 2-8.

e- All parts of the connection including bolts, welds and anchors and attached components shall be designed for 4 times the earthquake load as set forth in Section 2-8.

f- Dowels and anchors that are connected to concrete elements are recommended to be anchored or hooked to the reinforcement of the concrete elements, so that they are capable of transferring the induced loads to the structural elements.

2-12-3 Buildings other than those addressed in Clauses 2-12-1 and 2-12-2, shall conform to the provisions of Sections 3-7 and 3-12 for conformance to attached components and façades minimum requirement, regardless of their number of stories.

2-13 Structural Provisions for Service Level earthquake

2-13-1 Buildings designated of “Very High and High Importance” or buildings higher than 50 meters or more than 15 stories shall be checked for the service level earthquake so that their serviceability, as set in section 1-1-b and 1-1-c be, maintained. For this purpose the structural design shall be such that under load conditions at service level, without load factor, the following requirements are met.

a- In steel structures, the member’s stresses shall not exceed their yield strength.

b- In reinforced concrete structures, the member’s internal forces shall not exceed their nominal ultimate strength.

c- The elastic story drifts, corresponding to service level earthquake, shall conform to the limitations of Section 2-5-5.

2-13-2- The ground motion characteristic for service level earthquake shall be similar to the design base earthquake, Section 2-3, except that the design base acceleration ratio, A, shall be reduced by a factor of 6 and the building behavior factor, R, is taken as unity. Therefore, the equivalent static base shear for service level earthquake is determined from the following formula:

$$V_{ser} = \frac{1}{6} ABIW \qquad (2\text{-}21)$$

A, *B*, *I* and *W* are as defined in section 2-3-1.

2-14 Non-building Structures

2-14-1 The lateral seismic load acting on nonbuilding structures listed in Table-8, shall be determined by any methods of Section 2-1, and conform to the following provisions:

a- The fundamental period of these structures shall be determined by a rational method.

b- When the fundamental period of non-building structures exceed 0.5 seconds calculating of lateral force shall be done by one of the dynamic analysis methods.

c- The behavior factor for non-building structures shall be as Table-8. However the ratio of $\frac{B}{R}$ shall not be taken less than 0.5.

d- Non-building structures with a fundamental period less than 0.06 second are assumed to be rigid and their $\frac{B}{R}$ value shall be taken as 0.5.

e- The lateral force distribution in height for nonbuilding structures shall be in accordance with the provisions of Sections 2-3-9 or 2-4.

f- The drift limitation of Section 2-5 need not to be met in these structures unless structural or non-structural damages may lead to life casualty or special serviceability limitations need to be imposed.

Table 8: Non-building Structure Behavior Factor, R

Item	Type	R
1	Structures with behaviors similar to inverted pendulum systems, water tanks mounted on braced or unbraced supports	3
2	Silos, chimneys and in general all structures having distributed mass, behaving as a cantilever	5
3	Cooling towers mounted on braced supports	3
4	Funnel and truss panel structures mounted on braced or unbraced supports	4
5	Stacks and trussed towers, braced or unbraced	4
6	Signs, billboards, special recreational facilities and monuments	5
7	Other nonbuilding structures	3.5

2-14-2 The effective lateral earthquake load acting on reservoirs, underground or above- ground, shall be determined in accordance with the provisions of Publication No.123 of "Iran Management and planning Organization".

2-15 Combinations of Earthquake Loads with Other Loads, Design Stresses

When design is based on Allowable Stress Method, the provisions of Iranian Standard No.519 or National Building Code shall be observed. When design is based on Ultimate Strength or Limit State Methods, the provisions of Iranian Concrete Code (ABA), for reinforced concrete, and an appropriate design code, for steel structures, shall be observed. Allowable limits, yield strength and material failure criteria shall be in accordance with the same design codes.

Chapter Three

PROVISIONS FOR SEISMIC DESIGN OF UNREINFORCED MASONRY BUILDINGS

3-1 Definition

Masonry buildings are all buildings in which walls are made of bricks, concrete blocks or stone, and all or part of the vertical loads are carried by walls. Buildings in which vertical loads are partially carried by masonry walls and partially by steel or reinforced concrete elements are also considered as masonry buildings and shall be subjected to the provisions of this chapter, as indicated in section 1.3.2. Provisions of this chapter shall be applicable in all seismic zones.

3-2 Limitation in Height and Number of Stories

3-2-1 The maximum number of stories for masonry buildings, excluding the basement, is limited to two. Additionally the elevation of roof with respect to the average ground level shall not exceed 8.0 meters. Basement is defined as a floor where its top level does not exceed 1.5 meters above the average ground level. Otherwise the basement shall be considered as a story. The maximum number of basements is limited to one.

3-2-2 The maximum story clear height is limited to 4.0 meters. In case this limit is exceeded, an additional tie beam to the one required in section 3.9.1 shall be provided at a maximum height of 4.0 meters from the floor level. In no cases the story height shall exceed 6.0 meter.

3-2-3 The minimum thickness to height ratio for masonry walls shall be taken according to applicable national code, however, this ratio shall not be taken less than 1/10 for unsupported, 1/15 for supported structural walls, section 3.6, and 1/12 for unsupported non-structural walls.

3-3 Building Plan

3-3-1 Building plans shall generally have the following characteristics:

a) Building length shall not exceed three times its width.
b) Building plan shall be symmetrical or nearly symmetrical with respect to the two principal axes.
c) Building plan shall not have excessive projections and setbacks.

3-3-2 In cases the length-to-width ratio of the building exceeds 3.0, or the building is not symmetrical, or when projections and setbacks exceed the values of section 3.3.3, appropriate separation joints shall be provided in accordance with section 1.4.d, so that each separated block conforms to the criteria of section 3.3.1. Separation joints need not be provided in the foundation. Some appropriate divisions are illustrated in Figure2.

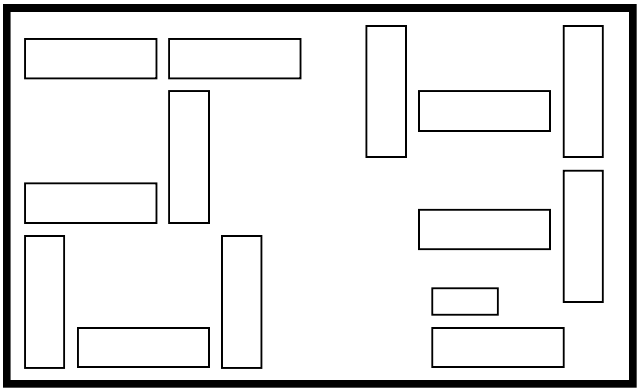

Figure 2: Division of the building into appropriate blocks using separation joints

3-3-3 The dimension of projections in building plan, where no separation joint is considered, is limited to the values shown in Figure3.

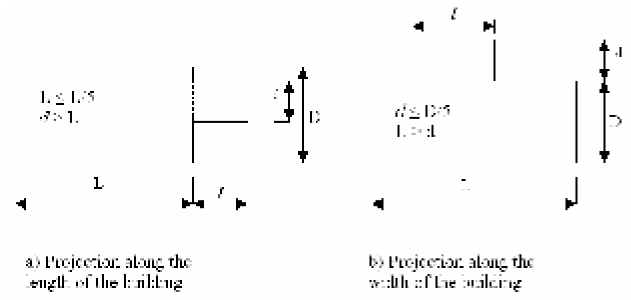

Figure 3: Limitation of Projection dimensions in plan

In cases where d > D/2 in Figure (3.a), or **l** > L/2 in Figure (3.b), these parts are not considered as projections, of the building and the limitations do not apply, Provided the plan of the building does not become excessively asymmetrical.

3-3-4 Bearing walls shall be placed in a regular and symmetrical configuration as much as possible to provide uniformity in resisting seismic forces and minimizing the induced torsion.

3-4 Vertical Section of Building

3-4-1 It is generally preferable that the building have not any projection. However, if projections do exist, the following provisions shall be observed:

a) The length of the cantilever projections shall not exceed 1.20 meters for balconies open on three sides, and 1.50 meters for balconies open on two sides. The cantilevers shall be securely anchored in the floor.
In case the above criteria are not met, then the cantilever shall be calculated for the vertical component of earthquake in accordance with section 2.3.12.

b) Projection along vertical direction where the upper floor protrudes as a cantilever ahead of the lower floor is permitted only when the following conditions are met.
i) The cantilever length is less than 1.0 meter.

ii) The projecting part is designed in such a way that none of its walls carry the load of the upper floor or its walls.
iii) The walls of the projecting part are securely anchored with vertical steel or reinforced concrete tie beams. The tie beams themselves shall be properly anchored inside the structural floor elements. Tie beams shall be provided so that each tie beam supports a maximum of 2.0 meters of wall. Moreover, tie beams shall be provided at both sides of any window longer than 2.0 meters. The minimum cross section and reinforcement of these vertical tie beams shall be in accordance with the provisions of section 3.9.2.1 and 3.9.2.2.

3-4-2 Construction of floors with different levels in one story shall be avoided as far as possible. If these levels differ more than 60 cm, the walls between them shall be reinforced with additional tie beams or the two parts may be separated by joint.

3-4-3 Foundations shall be constructed on the same horizontal level as far as possible. In cases this cannot be achieved, due to the slope of the ground or other reasons, then each part of the foundation shall be constructed on horizontal level. In any case, construction of foundation with a slope greater than 15% is to be avoided.

3-5 Openings (Doors, Windows, Cupboards)

3-5-1 Wide openings shall be generally avoided in masonry buildings. The openings shall be placed in the central part of the walls as far as possible.

3-5-2 The following limitations shall be observed for any structural wall, as defined in section 3.6:

a) The total area of the openings in each bearing wall shall not exceed 1/3 of the total area of the wall;
b) The total length of the openings in each bearing wall shall not exceed 1/2 of the length of the wall;
c) The distance of the first opening from the external edge of the building, or the beginning of the wall, shall be less than 2/3 of the height of the opening or 75 cm, whichever is less, unless vertical tie beams are

provided in both sides of the opening;

d) The horizontal distance between two adjacent openings shall be less than 2/3 of the height of the shorter of the two openings and also less than 1/6 of the sum of the lengths of the two openings. Otherwise, the part of the wall between the openings is considered as part of the opening and shall not be considered as part of the bearing wall. The lintel over the openings shall also be considered as a continuous element with a span equal to the sum of the lengths of the opening and the wall section between them;

e) Neither of the dimensions of the opening shall exceed 2.5 meters, otherwise both sides of the opening shall be reinforced with vertical tie beams that are connected to the horizontal top and bottom tie beams of the story. Moreover, the lintel above the opening shall be anchored in the vertical tie beams around the opening.

3-6 Structural Walls

Structural walls are those walls that carry the vertical and/or lateral loads in the building.

3-6-1 The "wall ratio" in the any direction of the story shall not be less than the values given in Table-9. The wall ratio is defined as the ratio of the horizontal section area of all structural walls in that direction to the floor area of the story. In determining this ratio, only the structural walls thicker than 20 cm with horizontal tie beams at the their floor levels, are to be considered. The walls above and below the openings are not to be considered in calculating the wall ratio.

Table 9: Minimum wall ratio in any direction of the building

Type of Building	Number of stories	Basement	First floor	Second floor
Brick wall	1-Story	6%	4%	---
	2-Story	8%	6%	4%
Concrete block wall	1-Story	10%	6%	---
	2-Story	12%	10%	6%
Stone Block Wall	1-Story	6%	5%	---
	2-Story	8%	8%	5%

3-6-2 The maximum permissible length of a structural wall between two supports shall not be more than 30 times its thickness or 8.0 meters. A support is defined as a wall that intersects with the structural wall and is located in another direction. A support wall shall have a minimum thickness of 20 cm and a minimum length of 1/6 of the longest span of the wall at both sides of the support, including the thickness of the structural wall. A vertical tie beam may be considered as a support.

3-6-3 The height of structural walls shall conform to the provisions of section 3.2.

3-7 Non-structural walls and Partitions

3-7-1 The maximum permissible length of non-structural walls and partitions between two supports shall not be more then 40 times the thickness of the wall or 6.0 meters. The supports shall have a minimum thickness equal to that of the wall and a minimum length of 1/6 of the longest span of the walls at both sides. Vertical steel, reinforced concrete or wooden elements may be used instead of supports provided that their ends are adequately anchored in the floor and roof of the story.

3-7-2 The maximum permissible height of non-structural walls and partitions is 3.5 meters. Otherwise, the wall shall be strengthened by horizontal tie beams.

3-7-3 Partitions that are continuous through out the story height shall be properly attached to the upper ceiling. For this purpose, the last row of partition brick shall be pressured into the gap between the partition and upper ceiling with sufficient mortar.
When the partitions are not continuous, their upper edge shall be properly anchored to the structure or tie beams located at both sides of the partition by using steel, reinforced concrete or wooden tie beams.

3-7-4 The vertical edge of partitions shall not be free. Instead, the edge shall be connected to another partition, a wall perpendicular to the partition, an element of the structure or a vertical steel, reinforced concrete or wooden element particularly provided for this purpose. This vertical element may be a No.6 steel channel section or its equivalent section. If the length of the supporting partition is less than 1.5 meters, its edge may be free.

3-7-5 When the wall and the partition leaning against it are constructed monolithically, or through “Lariz” (racking), or “Hashtgir” methods, then their connections shall be considered adequate. On the other hand, if the partition is constructed after the wall, then it shall be properly connected and anchored to the wall. Otherwise the vertical edge of the partition shall be considered free and vertical elements shall be provided for it in accordance with section 3.7.4. Two orthogonal partitions shall be securely interconnected to each other.

3-8 Parapets and Chimneys

3-8-1 The height of parapets on the perimeters of roofs and balconies, from the finished floor surface, shall not exceed 50 and 90 cm for parapet thickness of 10 and 20 cm respectively. Otherwise, the parapet shall be supported by vertical steel or reinforced concrete elements and be properly fixed to the roof or balcony floor.

3-8-2 Chimneys, traditional aeration towers and similar elements shall not rise more than 1.5 meters above the roof level. Otherwise, they shall be adequately strengthened with vertical steel or reinforced concrete elements and be properly fixed to the roof floor.

3-9 Tie Beams

3-9-1 Horizontal Tie Beams

3-9-1-1 Horizontal tie beams shall be provided in all bearing walls masonry buildings of one or two story at following levels:

a) Base level:
Tie beam shall be reinforced concrete with a width not less than the thickness of wall or 25 cm, and a height not less than 2/3 of the wall thickness or 25 cm.

b) Under floor level:
Tie beams shall be reinforced concrete with a width equal to the wall thickness,

except in exterior walls it may be reduced to 12 cm less than the wall thickness. However, the width of the tie beam shall not be less than 20 cm. Height of the tie beams shall not be less than 20 cm.
Steel sections equivalent to I10 profile may be used instead of reinforced concrete tie beams provided I10 profile is appropriately seated on the floor and be anchored to the vertical tie beams, or walls by means of a thick mortar layer. If the floor is a cast in place concrete slab, additional horizontal tie beams are not required under floor level.

3-9-1-2 The minimum diameter of longitudinal steel bar in horizontal tie beams is 10 mm, for deformed bars, and 12 mm, for plain bars. Plain bars, shall have 180 degree bent at their ends and their splices. A minimum number of 4 longitudinal bars shall be used at the corners. When the width of the tie beam exceeds 35 cm, the number of longitudinal bars shall be increased to 6 or more, with a distance not more than 25 cm between adjacent bars.
Longitudinal bars shall be supported by transverse ties with a minimum diameter of 6 mm. The maximum space between transverse ties shall be the lesser of tie beam height or 25 cm. At the vicinity of the vertical ties for a distance equal to 75 cm from their faces the spacing of the transverse ties shall be reduced to 15 cm.
The minimum concrete cover for longitudinal bars shall be 5 and 2.5 cm at the base and floor tie beams, respectively.

3-9-1-3 Floor tie beams shall be properly connected to each other at every level to provide an integrated and uniform resisting system. Reinforcement at the inter-section of tie beams shall be detailed in such a way that adequate connection be provided, especially at floor levels.
Floor level tie beams shall not be discontinuous anywhere. When a chimney, HVAC and other duct passing through floor intersects with tie beams, the bars shall be continued on sides of these ducts. However, the diameter or width of these ducts shall not exceed half of tie beams width.

3-9-1-4 When a masonry building has steel or reinforced concrete columns, they shall suitably be connected to the floor elements or the beam on the top, and to the tie beam under the wall.

3-9-2 Vertical Tie Beams

3-9-2-1 Vertical tie beams shall be provided in all masonry buildings except one-story buildings designated as “low importance”. Vertical ties shall conform to the following specifications:

Vertical tie beams shall be provided within length of walls, at the main corners of the building, and preferably at the intersections of the walls, in such a way, that the distance between their axes does not exceed 5.0 m.

The cross section of reinforced concrete vertical tie beams shall not be less than 20 cm. An I10 steel section or its equivalent may replace reinforced concrete tie beams, provided it is properly connected to the walls by means of horizontal steel bars. Wooden tie beams with a minimum cross sectional area of 50 cm^2 may be used as vertical tie beams in one-story buildings with “medium or low importance” or in admissible wooden floor systems, Section 3.11.1.

Profile sections of doors and windows may be used as vertical tie beams, provided they are properly anchored in the floor tie beam and satisfy the minimum cross sectional area requirement.

It is strongly recommended that reinforced concrete vertical tie beams are constructed simultaneously with the bearing wall, or an adequate connection between tie beam and wall is provided by means of horizontal bars.

3-9-2-2 The minimum diameter of longitudinal steel bars in vertical tie beams is 10 mm, for deformed bars, and 12 mm, for plain bars. A minimum of 4 longitudinal bars shall be used and placed in the corners of the section and properly anchored at the ends.

Longitudinal bars shall be supported by ties with minimum diameter of 6 mm and with a maximum spacing of 20 cm. The minimum concrete cover for longitudinal bars shall be 2.5 cm.

3-9-2-3 Vertical tie beams shall be properly connected to the horizontal ties at every intersection with the longitudinal bars of all ties extending along the intersection, so that ties and walls provide a three dimensional resisting system. Where vertical ties are not continuous, their longitudinal bars shall extend at least 30 cm inside the horizontal tie and be anchored properly.

3-9-2-4 Alternatively, steel bars may be distributed along the wall to replace any vertical tie beams required in section 3.9.2.1, as shown in Figure-4, provided that:

a) The wall shall have sand and cement mortar.
b) The distance between two adjacent vertical bars shall not be less than 60 cm and not more than 120 cm.
c) Vertical bars shall be tied together at a maximum distance of 25 cm using a minimum 6 mm diameter horizontal bars.
d) Bars shall be placed so that there shall be no void between mortars. Around each bar, a space with a minimum dimension of 6 cm for each side shall be provided and filled with mortar while the wall is being constructed.
e) Vertical bars shall be anchored in horizontal tie beams, below and above the wall.

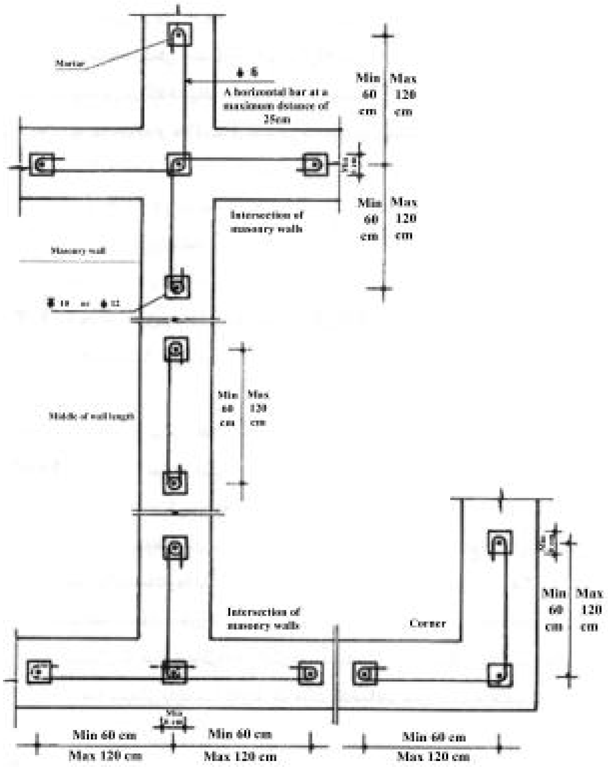

Figure 4: Horizontal and vertical wall reinforcement arrangement details

Notes: -Longitudinal bars of vertical tie beams shall have 90^0 bent at both ends.

3-9-3 Tie Beams for Gable Walls

In buildings with a slope light roofs, it is preferred that the bearing trusses be also placed on the end walls. Otherwise, these walls shall be strengthened in their triangular part according to the following provisions:

a) At the base of the triangular part of the end walls, horizontal tie beams are provided on the same level of the supporting tie beams of the truss. These tie beams shall be tied together.
b) The upper surface of the triangular wall is covered with a tie beam in such away that upper surface of the tie is parallel to roof cover and the lower surface form a step shape on the wall.
c) Vertical tie beams are provided and anchored to the upper and lower ties at distances, not more than 5.0m.
d) The dimension and reinforcements of the above tie beams are the same as those in sections 3.9.1 and 3.9.2.

3-9-4 Minimum splice length for longitudinal bars of tie beams and minimum development length for hooks shall be 40 cm.

3-10 Construction of Bearing walls

3-10-1 Mud and lime mortar are not permitted in masonry buildings. Stone or concrete block walls shall be constructed with sand and cement mortar with a minimum of 200 kg cement per cubic meter of mortar. In brick walls, sand and lime mortar may also be used, provided that it contains a minimum of 100 kg cement and 125 kg lime per cubic meter of mortar.
Roof parapets, balconies and cantilever parts of chimneys shall only be constructed with sand and cement mortar, with a minimum of 200 kg cement per cubic meter of mortar. The mortar shall be used within maximum one hour after being prepared.

3-10-2 Walls made of rectangular blocks of stone or of brick or concrete blocks shall be constructed in such a way that vertical joints do not fall in one line and they are thoroughly filled with mortar. Walls made of rubble stone shall be laid in such a way that rubbles become interconnected and the interfaces are thoroughly filled with mortar.

3-10-3 All bearing walls that are interconnected, particularly in the corners of the building, shall be constructed simultaneously at any level, as far as possible. When this is not possible, the “Lariz” construction method shall be used. In bearing walls connections “Hashtgir” construction method, which is usually used for construction of dented long walls or intersecting walls connections, is not allowed. The latter method may be solely used for partition walls connections provided that the upper and lower joints of brickwork in these locations are thoroughly filled with mortar.

3-10-4 Structural walls shall be reinforced horizontally at three levels, in middle and in 1/6 of wall’s height, with one plain Φ12 or one deformed Φ10 bar.

3-10-5 Brick, concrete block and stone used in construction of walls shall be made of fine quality material, have adequate load bearing capacity and proper durability. Bricks and concrete blocks shall be completely saturated and soaked in water prior to their use.

3-11 Floors

3-11-1 Material

Floors shall be constructed with proper material in such a way that under the action of seismic loads do not detach from their supports, and also maintain their integrity and strength.
Use of wood as floor’s bearing element is only permitted when the sheathing is made of light material such as: boards, iron sheets, metal or cement asbestos corrugated sheets. In these cases wooden tie beams can also be used. Construction of wooden floors with mat, reed and mud sheathing or mud and lime mixture mortar or sun dried brick is not allowed.

3-11-2 Floors connection of to their Supports

Floor elements including steel, concrete and wooden beams and joists, and concrete slabs shall be properly connected to their supports; bearing beams, horizontal tie beams or columns, so that the seismic roads are transferred to the vertical load bearing elements without displacement of the floor. The following provisions shall be satisfied for this purpose:

a) For floors supported on bearing beams, the main floor elements shall be anchored to the bearing beams, which, in turn, are anchored to the wall tie beams.

b) For floors supported on walls, if the floor is constructed by brick jack arching system, the floor beams shall be either anchored to the reinforced concrete tie beams, or welded to the steel plates installed on the ties and anchored there, or be properly connected to the steel tie beams. In this case the length of floor beams, support shall not be less than the height of the beams or 20 cm. For precast concrete slabs, it is preferred that the slab is anchored in the horizontal tie beam. Supporting a precast slab on tie beams shall be avoided unless they are properly connected to each other. Floors made of joists and blocks system shall be properly anchored to the horizontal tie beams and the concrete is poured monolithically for joists and tie beams. Cast in place reinforced concrete floors shall have a minimum support length equal to the thickness of the wall minus 12 cm, but always greater than 15 cm.

c) The structural elements of stairways shall be anchored to the floor horizontal tie beams in landings which are at the same level of the building floors.

3-11-3 Floor Integrity

3-11-3-1 Brick Jack Arching Floors
a) Steel beams shall be connected diagonally by means of steel bars or plates so that the length of the criss-crossed rectangle does not exceed 1.5 times its width and its area does not exceed 25 m^2.

b) An appropriate support is provided for the last span of arches' impost. This support may be a properly detailed concrete tie beam or a steel section connected or anchored to the tie beam. In the latter case, the section shall be connected to the last floor main beam by means of fully stretched steel bars or plates at both ends and also at spaces less than 2.0 m.

c) The minimum cross sectional area of the steel bars or plates for diagonal bracing of floor beams shall be equal to 1.5 cm^2.

3-11-3-2 Joist and Block Floors

a) Joists shall be connected to horizontal tie beams according to the provisions of 3.11.2.b.

b) The minimum concrete slab thickness on the blocks shall be 5 cm. The minimum diameter of reinforcement perpendicular to the joist shall be 6 mm and they shall be placed at a maximum spacing of 25 cm.

c) When the joist's span exceeds 4.0 m, they shall be connected together by transverse ties. These ties shall have a minimum width of 10 cm and a minimum of two continuous 10 mm deformed bars, each placed at the top and the bottom.

d) In case of cantilevers, additional bars shall be provided at the support over the joists. These bars shall at least be equal to the joist bottom reinforcements, with a minimum development length of 1.5 m.

3-11-3-3 Trusses

a) The integrity of the floor shall be ensured by providing suitable vertical and horizontal braces.

b) Elements of wooden trusses shall be firmly connected together at nodes, using bolts and nuts or steel clamps. Connections by means of nails alone, are not sufficient.

c) In slope roofs without trusses, appropriate elements shall be provided to withstand the thrust of the roof.

3-11-4 Suspended False Ceilings

The following provisions shall be observed for suspended false ceilings:

a) Suspended false ceilings shall be made of light material, to the extent possible, and their framing shall be connected to the structure or tie beams so that their earthquake impacts do not damage the adjacent walls.

b) Suspended ceilings shall be properly connected to the main structural frames, floors, tie beams and walls, so that, in addition to their weight, the lateral forces induced in these elements are transferred to the main structure.

3-11-5 Arch Roofs

Arch roofs may be used upon observing the following provisions:

a) Necessary provisions are sought to minimize thrusts and the means to withstand it. The walls shall also be properly anchored.

b) Continuous tie beams are provided at the base of the roof and the arch roof be suitably supported on it. In cylindrical arches, the two sides of the springing tie beams shall be connected together by means of steel tie rods which are anchored in the tie beams. The spacing of these tie rods shall not exceed 1.5 m and their minimum cross-sectional area be of 3.0 cm^2.

3-12 Façades

3-12-1 It is preferred that the facing brick is placed simultaneously with the masonry wall bricks. The thickness of these two bricks shall be equal or almost equal so that both courses may be laid on a single mortar bed.

When the facing bricks are laid after the construction of the wall, they shall be anchored to the wall bricks by installing steel bars inside the wall mortar and attaching their other free end to the facing brick mortar. The minimum spacing of these bars in both vertical and horizontal direction shall not exceed 50 cm.

3-12-2 Construction of façades with stone plates other than cornerstone, that are laid horizontally on top of each other, shall conform to the provisions of section 3.12.1. For cornerstones plates installed vertically, clamps or other proper anchors shall be provided to prevent the detachment and falling of the façade during earthquake.

3-13 Lofts

If loft area is greater than 25% of the area of the beneath floor, the loft shall be taken as another story and the provisions of 3.2 shall be applied.

The maximum height of the loft shall be 3 m, and it shall be subjected to all the provisions of this chapter regarding the horizontal and vertical tie beams and other construction details.

Appendix 1

Design Base Acceleration Ratio for Various seismic zones in Iran

A

Item	City	Province	Seismic relative hazard			
			VH [1]	H [2]	I [3]	L [4]
1	Abadan	Khouzestan				×
2	Abadeh	Fars		×		
3	Abarkooh	Yazd			×	
4	Ab-bar	Zanjan	×			
5	Abbasabad	Semnan		×		
6	Abdanan	Ilam			×	
7	Abgarm-e-avaj	Ghazvin		×		
8	Abhar	Zanjan		×		
9	Abyaneh	Esfahan		×		
10	Abyek	Ghazvin	×			
11	Aghajari	Khouzestan		×		
12	Aghda	Yazd		×		
13	Agh-ghala	Golestan		×		
14	Ahar	E. Azarbayjan		×		
15	Ahram	Bushehr			×	
16	Ahvaz	Khouzestan			×	
17	Ajabshir	E. Azarbayjan			×	
18	Alamdeh	Mazandaran		×		
19	Alasht	Mazandaran		×		
20	Alavijeh	Esfahan			×	
21	Alashtar	Lorestan		×		
22	Aliabad-e-gorgan	Golestan		×		
23	Aligoodarz	Lorestan		×		
24	Amirabad	Semnan		×		
25	Amol	Mazandaran		×		
26	Anar	Kerman		×		
27	Anarak	Esfahan			×	
28	Andimeshk	Khouzestan		×		
29	Arak	Markazi			×	
30	Aran	Esfahan		×		
31	Ardakan	Yazd			×	
32	Ardal	Chaharmahal		×		
33	Ardebil	Ardebil		×		
34	Ardestan	Esfahan		×		
35	Arjmand	Tehran	×			
36	Arsanjan	Fars			×	

1. Very high 2. High 3. Intermediate 4. Low

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
37	Arvand kenar	Khouzestan				×
38	Asad abad	Hamedan		×		
39	Ash khaneh	N. Khorasan		×		
40	Ashtiyan	Markazi		×		
41	Aslandooz	Ardebil		×		
42	Astaneh	Gilan		×		
43	Astaneh	Markazi			×	
44	Astaneh	Semnan		×		
45	Astara	Gilan		×		
46	Avaj	Ghazvin		×		
47	Azarshahr	E. Azarbayjan		×		
48	Azna	Lorestan	×			

B

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Babol	Mazandaran		×		
2	Babolsar	Mazandaran		×		
3	Badrood	Esfahan			×	
4	Bafgh	Yazd		×		
5	Baft	Kerman		×		
6	Baghmalek	Khuzestan		×		
7	Bahrestan	Fars		×		
8	Bajestan	Khorasan-e-razavi		×		
9	Bajgiran	Khorasan-e-razavi		×		
10	Baladeh	Mazandaran		×		
11	Bam	Keraman		×		
12	Bampoor	Sisitan va baluchestan			×	
13	Bandar abbas	Hormozgan		×		
14	Bandar gaz	Golestan		×		
15	Bandar lengeh	Hormozgan		×		
16	Bandar-e- emam Khomeini	Khouzestan				×
17	Bandar-e- taheri	Bushehr		×		
18	Bandar-e- torkaman	Golestan		×		
19	Bandar-e-anzali	Gilan		×		
20	Bandar-e-asaluyeh	Bushehr		×		
21	Bandar-e-dayyer	Bushehr		×		
22	Bandar-e-deylam	Bushehr			×	
23	Bandar-e-genaveh	Bushehr			×	

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
24	Bandar-e-khamir	Hormozgan		×		
25	Bandar-e-mogham	Hormozgan		×		
26	Baneh	Kordestan		×		
27	Bardaskan	Khorasan-e- razavi		×		
28	Bardsir	Kerman		×		
29	Bastak	Hormozgan		×		
30	Bastam	Semnan		×		
31	Bazman	Sisitan va baluchestan			×	
32	Behabad	Yazd		×		
33	Behbahan	Khouzestan		×		
34	Behshahr	Mazandaran		×		
35	Biarjomand	Semnan			×	
36	Bijar	Kordestan			×	
37	Bil-e-savar	Ardebil		×		
38	Birjand	S. Khorasan		×		
39	Bisotoon	Kermanshah		×		
40	Bojnoord	N. Khorasan		×		
41	Boldaji	Chaharmahal		×		
42	Bonab	E . Azarbayjan			×	
43	Bookan	W . Azarbayjan			×	
44	Borazjan	Bushehr		×		
45	Boroojen	Chaharmahal		×		
46	Boroojerd	Lorestan	×			
47	Boshruiyeh	Khorasan-e-razavi		×		
48	Bostan	Khouzestan			×	
49	Bostan abad	E. Azarbayjan	×			
50	Bumhen	Tehran	×			
51	Bushehr	Bushehr			×	
52	Buyin zahra	Ghazvin	×			

C

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Chabahar	Sisitan va baluchestan		×		
2	Chaboksar	Gilan		×		
3	Chadgan	Esfahan		×		
4	Chaloos	Mazandaran		×		
5	Chaman bid	N. Khorasan		×		
6	Charka	Hormozgan		×		
7	Charmahin	Esfahan		×		

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
8	Chenaran	Khorasan-e-razavi		×		

D

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Dalaki	Bushehr		×		
2	Damavand	Tehran	×			
3	Damghan	Semnan		×		
4	Darab	Fars		×		
5	Daran	Esfahan		×		
6	Dargaz	Khorasan-e-razavi		×		
7	Darreh shahr	Ilam			×	
8	Dasht-e-abbas	Ilam			×	
9	Dasht-e-bayaz	S. Khorasan	×			
10	Dehaghan	Esfahan		×		
11	Dehak	Sisitan va baluchestan		×		
12	Dehbid	Fars		×		
13	Dehdez	Khouzestan		×		
14	Dehloran	Ilam			×	
15	Dehshir	Yazd		×		
16	Deilaman	Gilan		×		
17	Delijan	Markazi		×		
18	Delvar	Bushehr			×	
19	Deyhook	Yazd	×			
20	Dezfool	khouzestan		×		
21	Divandareh	Kordestan			×	
22	Dizin	Tehran	×			
23	Dogonbadan	Kohkilouyeh		×		
24	Dorood	Lorestan	×			
25	Dorooneh	Khorasan-e-razavi		×		

E

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Eghlid	Fars		×		
2	Eivan	Ilam			×	
3	Eivanekey	Semnan		×		
4	Esfahan	Esfahan			×	
5	Esfarayen	N. Khorasan		×		
6	Eshtehard	Tehran	×			

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
7	Eslamabad-e-gharb	Kermanshah		×		
8	Estahban	Fars		×		

F

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Famenin	Hamedan			×	
2	Fanooj	Sisitan va baluchestan		×		
3	Farashband	Fars		×		
4	Fariman	Khorasan-e-razavi		×		
5	Farmahin	Markazi			×	
6	Farooj	N. Khorasan	×			
7	Farsan	Chaharmahal	×			
8	Fasa	Fars		×		
9	Fasham	Tehran	×			
10	Ferdows	S. Khorasan	×			
11	Fereydoon kenar	Mazandaran		×		
12	Fereydoon shahr	Esfahan		×		
13	Fin	Esfahan		×		
14	Firoozabad	Ardebil	×			
15	Firoozabad	Fars		×		
16	Foroomad	Semnan		×		
17	Firoozkuh	Tehran	×			
18	Fuman	Gilan		×		

G

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Gachsar	Tehran	×			
2	Gachsaran	Kohkilouyeh		×		
3	Gandoman	Chaharmahal		×		
4	Garmkhan	N. Khorasan		×		
5	Garmsar	Semnan		×		
6	Gavbandi (parsian)	Hormozgan		×		
7	Gazoran	Ghom		×		
8	Gerash	Fars		×		
9	Ghader abad	Fars			×	
10	Ghaemshahr	Mazandaran		×		
11	Ghaen	S. Khorasan	×			
12	Ghamsar	Esfahan		×		

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
13	Ghara aghaj	E. Azarbayjan		×		
14	Ghara ziaeodin	W. Azarbaygan		×		
15	Ghasr-e-ghand	Sisitan va baluchstan		×		
16	Ghasr-e-shirin	Kermanshah		×		
17	Ghazvin	Ghazvin	×			
18	Gheidar	Zanjan		×		
19	Gheshm	Hormozgan		×		
20	Ghir	Fars		×		
21	Ghom	Ghom		×		
22	Ghorveh	Kordestan		×		
23	Ghotoor	W. Azarbayjan	×			
24	Ghuchan	Khorasan-e-razavi	×			
25	Gilan-e-gharb	Kermanshah		×		
26	Gilavan	Zanjan	×			
27	Golbaf	Kerman	×			
28	Gavater	Sisitan va baluchestan		×		
29	Germi	Ardebil		×		
30	Gifan	N. Khorasan	×			
31	Givi	Ardebil		×		
32	Golpayegan	Esfahan			×	
33	Gonabad	Khorasan-e-razavi		×		
34	Gonbad-e-kavoos	Golestan		×		
35	Gorgan	Golestan		×		

H

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Haftgel	Khouzestan		×		
2	Haji abad	Hormozgan		×		
3	Hamedan	Hamedan		×		
4	Hamidiyeh	Khouzestan			×	
5	Harat	Yazd		×		
6	Haris	E. Azarbayjan		×		
7	Harsin	Kermanshah		×		
8	Hashtgerd	Tehran	×			
9	Hashtjin	Ardebil	×			
10	Hashtpar	Gilan		×		
11	Hashtrood	E. Azarbayjan		×		
12	Hassan abad	Tehran		×		
13	Hassan kif	Mazandaran		×		

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
14	Hendijan	Khouzestan			×	
15	Hoveyzeh	Khouzestan			×	

I

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Ilam	Ilam			×	
2	Iranshahr	Sisitan va baluchestan		×		
3	Izeh	Khouzestan		×		

J

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Jam	Semnan		×		
2	Jahrom	Fars		×		
3	Jajarm	N. Khorasan		×		
4	Jalegh	Sisitan va baluchestan		×		
5	Jam	Bushehr		×		
6	Jandagh	Esfahan		×		
7	Jask	Hormozgan		×		
8	Javanrood	Kermanshah		×		
9	Jirandeh	Gilan	×			
10	Jiroft	Kerman		×		
11	Joghatai	Khorasan-e-razavi		×		
12	Jolfa	E. Azarbayjan		×		

K

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Kabudar ahang	Hamedan			×	
2	Kahak	Ghom		×		
3	Kahnooj	Kerman		×		
4	Kakhk	Khorasan-e-razavi	×			
5	Kalachay	Gilan		×		
6	Kalaleh	Golestan		×		
7	Kalat-e-naderi	Khorasan-e-razavi		×		
8	Kaleybar	E. Azarbayjan		×		
9	Kamyaran	Kordestan	×			
10	Kangan	Bushehr		×		
11	Kangavar	Kermanshah	×			

Item	City	Province	Seismic relative hazard			
			VH	**H**	**I**	**L**
12	Karaj	Tehran	×			
13	Kashan	Esfahan		×		
14	Kashmar	Khorasan-e-razavi		×		
15	Kavar	Fars		×		
16	Kazeroon	Fars		×		
17	Kelisa kandi	W. Azarbayjan		×		
18	Kerned	Kermanshah		×		
19	Kerman	Kerman		×		
20	Kermanshah	Kermanshah		×		
21	Khaf	Khorasan-e-razavi		×		
22	Khalkhal	Ardebil		×		
23	Khansar	Esfahan			×	
24	Kharameh	Fars		×		
25	Khark	Bushehr			×	
26	Khash	Sisitan va baluchestan		×		
27	Khavaran	Fars		×		
28	Khezri	S. Khorasan	×			
29	Khomeyn	Markazi			×	
30	Khondab	Markazi			×	
31	Khonj	Fars		×		
32	Khoor	Yazd			×	
33	Khoor	Esfahan			×	
34	Khormooj	Bushehr			×	
35	Khorram abad	Lorestan		×		
36	Khorram darreh	Zanjan		×		
37	Khorram shahr	Khouzestan				×
38	Khosf	S. Khorasan			×	
39	Khoy	W. Azarbayjan		×		
40	Kianshahr	Kerman		×		
41	Kiasar	Mazandaran		×		
42	Kilan	Tehran	×			
43	Kish	Hormozgan		×		
44	Koli	S. Khorasan	×			
45	Koloor	Ardebil	×			
46	Komijan	Markazi			×	
47	Konarak	Sisitan va baluchestan		×		
48	Kuhak	Sisitan va baluchestan		×		
49	Kuhani	Hamedan	×			
50	Kuhbanan	Kerman		×		
51	Kuhdasht	Lorestan		×		
52	Kuhpayeh	Esfahan			×	

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
53	Kuhrang	Chaharmahal	×			
54	Kushk-e-nosrat	Ghom		×		

L

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Lahijan	Gilan		×		
2	Lahrood	Ardebil		×		
3	Lali	Khozestan		×		
4	Lamerd	Fars		×		
5	Lar	Fars		×		
6	Lavan	Hormozgan		×		
7	Lavas an	Tehran	×			
8	Lordegan	Chaharmahal		×		

M

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Mahabad	W. Azarbayjan			×	
2	Mahalat	Markazi			×	
3	Mahan	Kerman		×		
4	Mahmood abad	Mazandaran		×		
5	Mahneshan	Zanjan		×		
6	Mahshahr	Khouzestan				×
7	Maku	W. Azarbayjan		×		
8	Malaye r	Hamedan		×		
9	Mamoon	Lorestan		×		
10	Manjil	Gilan	×			
11	Maragheh	E. Azarbayjan			×	
12	Marand	E. Azarbayjan		×		
13	Maraveh tappeh	Golestan		×		
14	Mard abad	Tehran	×			
15	Marivan	Kordestan	×			
16	Marvast	Yazd		×		
17	Marvdasht	Fars		×		
18	Marzan abad	Mazandaran		×		
19	Marzdaran	Khorasan-e-razavi		×		
20	Mashhad	Khorasan-e-razavi		×		
21	Masjed soleyman	Khouzestan		×		
22	Masuleh	Gilan	×			

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
23	Mehdi shahr	Semnan	×			
24	Mehr	Fars		×		
25	Mehran	Ilam			×	
26	Mehriz	Yazd			×	
27	Meshkin shahr	Ardebil		×		
28	Meybod	Yazd			×	
29	Meymeh	Esfahan			×	
30	Miandoab	W. Azarbayjan			×	
31	Mianeh	E. Azarbayjan	×			
32	Miyami	Semnan		×		
33	Mojen	Semnan		×		
34	Mosha	Tehran	×			
35	Minab	Hormozgan		×		
36	Minoodasht	Golestan		×		
37	Mir javeh	Sisitan va baluchestan		×		
38	Moalem kelayeh	Ghazvin	×			
39	Moaleman	Semnan		×		
40	Mobarakeh	Esfahan		×		
41	Mollasani	Khouzestan			×	
42	Mussian	Ilam			×	

N

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Naein	Esfahan		×		
2	Naghadeh	W. Azarbayjan		×		
3	Naghan	Charmahal		×		
4	Nahavand	Hamedan	×			
5	Najaf abad	Esfahan			×	
6	Naming	Ardebil		×		
7	Natanz	Esfahan		×		
8	Nayband	Yazd	×			
9	Nehbandan	S. Khorasan		×		
10	Neka	Mazandaran		×		
11	Neyriz	Fars		×		
12	Neyshabur	Khorasan-e-razavi		×		
13	Nikshahr	Sisitan va baluchestan		×		
14	Nir	Ardebil		×		
15	Nobaran	Markazi		×		
16	Nosood	Kermanshah		×		

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
17	Nosrat abad	Sisitan va balouchestan		×		
18	Nowshahr	Mazandaran		×		
19	Nur	Mazandaran		×		
20	Nurabad-e-mamasani	Fars		×		

O

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Omidiyeh	Khouzestan			×	
2	Orumiyeh	W. Azarbayjan			×	
3	Oshnaviyeh	W. Azarbayjan		×		

P

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Pars abad	Ardebil		×		
2	Paveh	Kermanshah		×		
3	Piranshahr	W. Azarbayjan		×		
4	Pishva	Tehran		×		
5	Poldashat	W. Azarbayjan		×		
6	Poldokhtar	Lorestan			×	
7	Pol-e-sefid	Mazandaran		×		
8	Poloor	Mazandaran	×			

R

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Rafsanjan	Kerman		×		
2	Ramhormoz	Khozestan		×		
3	Ramiyan	Golestan		×		
4	Ramsar	Mazandaran		×		
5	Ramshir	Khouzestan			×	
6	Rasht	Gilan		×		
7	Ravansar	Kermanshah		×		
8	Ravar	Kerman		×		
9	Rayen	Kerman		×		
10	Razan	Hamedan		×		
11	Rey	Tehran	×			
12	Rezvanshahr	Gilan		×		
13	Riz	Bushehr		×		

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
14	Robat	N. Khorasan	×			
15	robat karim	Tehran	×			
16	Robat-e-poshtbadam	Yazd		×		
17	Rosht khar	Khorasan-e-razavi		×		
18	Rudan	Hormozgan		×		
19	Rudbar	Gilan	×			
20	Rud-e-hen	Tehran	×			
21	Rudsar	Gilan		×		

S

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Saadat shahr	Fars			×	
2	Sabzabad	Kerman		×		
3	Sabzevar	Khorasan-e-razavi		×		
4	saein ghaleh	Zanjan		×		
5	Saghand	Yazd		×		
6	Saghez	Kordestan		×		
7	Sahneh	Kermanshah	×			
8	Salafchegan	Ghom		×		
9	Saleh abad	Khorasan-e-razavi		×		
10	Salmas	W. Azarbayjan	×			
11	Saman	Chaharmahal		×		
12	Sanandaj	Kordestan		×		
13	Sangan	Khorasan-e-razavi		×		
14	Sarab	E. Azarbayjan		×		
15	Sarab-e-niloofar	Kermanshah		×		
16	Sarakhs	Khorasan-e-razavi		×		
17	Saravan	Sisitan va balouchestan		×		
18	Sarayan	S. Khorasan	×			
19	Sarbandan	Tehran	×			
20	Sarbandar	Khouzestan				×
21	Sarbaz	Sisitan va balouchestan		×		
22	Sarbisheh	S. Khorasan		×		
23	Sarcheshmeh	Kerman		×		
24	Sardasht	W. Azarbayjan		×		
25	Sar-e-pol zahab	Kermanshah		×		
26	Sareyn	Ardebil		×		
27	Sari	Mazandaran		×		
28	Sarkhoon	Chaharmahal		×		

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
29	Saveh	Markazi		×		
30	Sedeh	S. Khorasan		×		
31	Sedeh	Fars			×	
32	Semirom	Esfahan		×		
33	Semnan	Semnan		×		
34	Sepidan (Ardakan)	Fars		×		
35	Sero	W. Azarbayjan			×	
36	Shabankareh	Bushehr			×	
37	Shabestar	E.Azarbayjan	×			
38	Shadegan	Khouzestan				×
39	Shahdad	Kerman	×			
40	Shahin shahr	Esfahan			×	
41	Shahindezh	W. Azarbayjan			×	
42	Shahmirzad	Semnan	×			
43	Shahrakht	S. Khorasan	×			
44	Shahr-e-jadid parand	Tehran		×		
45	Shahr-e-kord	Chaharmahal		×		
46	Shahreza	Esfahan		×		
47	Shahriyar	Tehran	×			
48	Shahrood	Semnan		×		
49	Shalamzar	Chaharmahal		×		
50	Shandiz	Khorasan-e-razavi		×		
51	Sharafkhaneh	E. Azarbayjan	×			
52	Shar-e-babak	Kerman		×		
53	Shazand	Markazi		×		
54	Shiraz	Fars		×		
55	Shirvan	N. Khorasan	×			
56	Shush	Khouzestan			×	
57	Shushtar	Khouzestan		×		
58	Siah cheshmeh	W. Azarbayjan		×		
59	Siahkal	Gilan		×		
60	Sib sooran	Sisitan va balouchestan		×		
61	Sirch	Kerman	×			
62	Sirjan	Kerman			×	
63	Sisakht	Kohkilouyeh		×		
64	Sultan abad	Khorasan-e-razavi		×		
65	Sultan abad	Zanjan		×		
66	Soltaniyeh	Zanjan		×		
67	Songhor	Kermanshah		×		
68	Sorkheh	Semnan		×		
69	Sufian	E. Azarbayjan	×			

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
70	Suleghan	Tehran	×			
71	Sumar	Kermanshah			×	
72	Surian	Fars		×		
73	Susangerd	Khouzestan			×	

T

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Tabas	Yazd	×			
2	Tabriz	E. Azarbayjan	×			
3	Tafresh	Markazi		×		
4	Taft	Yazd			×	
5	Takab	W. Azarbayjan			×	
6	Takestan	Ghazvin		×		
7	Taleghan	Tehran	×			
8	Talesh	Gilan		×		
9	Tasooj	E. Azarbayjan	×			
10	Taybad	Khorasan-e-razavi		×		
11	Tazareh	Semnan		×		
12	Tehran	Tehran	×			
13	Tiran	Esfahan			×	
14	Tonekabon	Mazandaran		×		
15	Torbat-e-heydariyeh	Khorasan-e-razavi		×		
16	Torbat-e-jam	Khorasan-e-razavi		×		
17	Torood	Semnan		×		
18	Tuyserkan	Hamedan		×		

V

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Varamin	Tehran		×		
2	Varzaghan	E. Azarbayjan		×		
3	Varzaneh	Esfahan			×	

Y

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Yasooj	Kohkilouyeh		×		
2	Yazd	Yazd			×	

Z

Item	City	Province	Seismic relative hazard			
			VH	H	I	L
1	Zabol	Sisitan va balouchestan		×		
2	Zaboli	Sisitan va balouchestan		×		
3	Zahedan	Sisitan va balouchestan		×		
4	Zanjan	Zanjan		×		
5	Zarand	kerman		×		
6	Zarghan	Fars		×		
7	Zavareh	Esfahan			×	
8	Zefreh	Esfahan		×		
9	Zehak	Sisitan va balouchestan		×		
10	Zonooz	E. Azarbayjan		×		