Ministry of Public Works and Settlement
Government of Republic of Turkey

Specification for Buildings to be Built in Seismic Zones (2007)

REQUIREMENTS FOR BULDINGS TO BE BUILT IN SEISMIC ZONES

CHAPTER 1 – GENERAL REQUIREMENTS

1.1. SCOPE

1.1.1 – Requirements of this Specification shall be applicable to newly constructed buildings in seismic zones as well as to existing buildings previously constructed.

1.1.2 – Requirements applicable to existing buildings, which are subject to modification in occupancy and/or structural system and those to be assessed and retrofit before or after an earthquake are given in **Chapter 7**.

1.1.3 – Requirements of this Specification shall be applicable to reinforced concrete (cast-in-situ and prestressed or non-prestressed prefabricated) buildings, structural steel and masonry buildings and building-like structures.

1.1.4 – Until relevant code requirements are enforced, the minimum requirements and rules to be applied to timber buildings and building-like structures shall be determined by the Ministry of Public Works and Settlement and the designs shall be made accordingly.

1.1.5 – In addition to buildings and building-like structures, non-building structures permitted to be designed in accordance with the requirements of this Specification are limited with those specified in **2.12** of **Chapter 2**. In this context bridges, dams, harbour structures, tunnels, pipelines, power transmission lines, nuclear power plants, natural gas storage facilities, underground structures and other structures designed with analysis and safety rules that are different than those for buildings are outside the scope of this Specification.

1.1.6 – Requirements of this Specification shall not be applied to buildings equipped with special system and equipment between foundation and soil for the purpose of isolating the building structural system from the earthquake motion, and to buildings incorporating other active and passive control systems.

1.1.7 – Requirements to be applied to structures which are outside the scope shall be specifically determined by the Ministries supervising the constructions based on contemporary international standards and such structures shall be designed to those requirements until their own special specifications are prepared.

1.2. GENERAL PRINCIPLES

1.2.1 – The general principle of earthquake resistant design to this Specification is to prevent structural and non-structural elements of buildings from any damage in low-intensity earthquakes; to limit the damage in structural and non-structural elements to repairable levels in medium-intensity earthquakes, and to prevent the overall or partial collapse of buildings in high-intensity earthquakes in order to avoid the loss of life. The performance criteria to be considered in assessment and retrofit of existing buildings are defined in **Chapter 7**.

1.2.2 – The design earthquake considered in this Specification corresponds to *high-intensity* earthquake defined in **1.2.1** above. For buildings with Building Importance Factor of $I = 1$ in accordance with **Chapter 2**, **Table 2.3**, the probability of exceedance of the design earthquake within a period of 50 years is 10 %. Earthquakes with different probabilities of exceedance are defined in **Chapter 7** to be considered in assessment and retrofit of existing buildings.

1.2.3 – Seismic zones cited in this Specification are the first, second, third and fourth seismic zones depicted in *Seismic Zoning Map of Turkey* prepared by the Ministry of Public Works and Settlement and issued by the decree of the Council of Ministers.

1.2.4 – Buildings to be constructed to this Code shall follow the material and workmanship requirements of "General Technical Specification" of Ministry of Public Works and Settlement.

CHAPTER 2 – ANALYSIS REQUIREMENTS FOR EARTHQUAKE RESISTANT BUILDINGS

2.0. NOTATION

$A(T)$ = Spectral Acceleration Coefficient
A_o = Effective Ground Acceleration Coefficient
B_a = Design internal force component of a structural element in the direction of its principal axis a
B_{ax} = Internal force component of a structural element in the direction of its principal axis a due to earthquake in x direction
B_{ay} = Internal force component of a structural element in the direction of its principal axis a due to earthquake in y direction perpendicular to x direction
B_b = Design internal force quantity of a structural element in principal direction b
B_{bx} = Internal force component of a structural element in the direction of principal axis b a due to earthquake in x direction
B_{by} = Internal force component of a structural element in the direction of principal axis a due to earthquake in y direction perpendicular to x direction
B_B = Any response quantity obtained by modal combination in the Mode-Superposition Method
B_D = Amplified value of B_B
D_i = Amplification factor to be applied in Equivalent Seismic Load Method to ± %5 additional eccentricity at i'th storey of a torsionally irregular building
d_{fi} = Displacement calculated at i'th storey of building under fictitious loads F_{fi}
d_i = Displacement calculated at i'th storey of building under design seismic loads
F_{fi} = Fictitious load acting at i'th storey in the determination of fundamental natural vibration period
F_i = Design seismic load acting at i'th storey in Equivalent Seismic Load Method
f_e = Equivalent seismic load acting at the mass centre of the mechanical and electrical equipment
g = Acceleration of gravity (9.81 m/s^2)
g_i = Total dead load at i'th storey of building
H_i = Height of i'th storey of building measured from the top foundation level (In buildings with rigid peripheral basement walls, height of i'th storey of building measured from the top of ground floor level) [m]
H_N = Total height of building measured from the top foundation level (In buildings with rigid peripheral basement walls, total height of building measured from the top of the ground floor level) [m]
H_w = Total height of structural wall measured from the top foundation level or top of the ground floor level
h_i = Height of i'th storey of building [m]
I = Building Importance Factor
ℓ_w = Plan length of structural wall or a piece of coupled wall
M_n = Modal mass of the n'th natural vibration mode
M_{xn} = Effective participating mass of the n'th natural vibration mode of building in the x earthquake direction considered
M_{yn} = Effective participating mass of the n'th natural vibration mode of building in the y earthquake direction considered
m_i = i'th storey mass of building ($m_i = w_i / g$)
$m_{\theta i}$ = With floors are modelled as rigid diaphragms, mass moment of inertia around vertical axis passing through mass centre of i'th storey of a building
N = Total number of stories of building from the foundation level (In buildings with rigid peripheral basement walls, total number of stories from the ground floor level)

n = Live Load Participation Factor
q_i = Total live load at i'th storey of building
R = Structural Behaviour Factor
R_{alt},$R_{üst}$= R factors specified for stories below and the roof, respectively, in the case where single-story frames with hinged columns at the top are used as roofs of cast-in-situ reinforced concrete, precast or structural steel buildings
$R_{NÇ}$ = Structural Behaviour Factor defined in **Table 2.5** for the case where entire seismic loads are carried by frames of nominal ductility level
R_{YP} = Structural Behaviour Factor defined in **Table 2.5** for the case where entire seismic loads are carried by walls of high ductility level
R_a(T) = Seismic Load Reduction Factor
$S(T)$ = Spectrum Coefficient
$S_{ae}(T)$ = Elastic spectral acceleration [m /s^2]
$S_{aR}(T_n)$ = Reduced spectral acceleration for the n'th natural vibration mode [m /s^2]
T = Building natural vibration period [s]
T_1 = First natural vibration period of building [s]
T_A ,T_B = Spectrum Characteristic Periods [s]
T_m , T_n = m'th and n'th natural vibration periods of building [s]
V_i = Storey shear at i'th storey of building in the earthquake direction considered
V_t = In the Equivalent Seismic Load Method, total equivalent seismic load acting on the building (base shear) in the earthquake direction considered
V_{tB} = In the Mode-Superposition Method, total design seismic load acting on the building (base shear) obtained by modal combination in the earthquake direction considered
W = Total weight of building calculated by considering Live Load Participation Factor
w_e = Weight of mechanical or electrical equipment
w_i = Weight of i'th storey of building by considering Live Load Participation Factor
Y = Sufficient number of natural vibration modes taken into account in the Mode-Superposition Method
α = Coefficient used for determining the gap size of a seismic joint
α_S = Ratio of the sum of shears at the bases of structural walls of high ductility level to the base shear of the entire building
β = Coefficient used to determine lower limits of response quantities calculated by Mode-Superposition Method
Δ_i = Reduced storey drift of i'th storey of building
$(\Delta_i)_{ort}$ = Average reduced storey drift of i'th storey of building
ΔF_N = Additional equivalent seismic load acting on the N'th storey (top) of building
δ_i = Effective storey drift of i'th storey of building
$(\delta_i)_{max}$ = Maximum effective storey drift of i'th storey of building
η_{bi} = Torsional Irregularity Factor defined at i'th storey of building
η_{ci} = Strength Irregularity Factor defined at i'th storey of building
η_{ki} = Stiffness Irregularity Factor defined at i'th storey of building
Φ_{xin} = In buildings with floors modelled as rigid diaphragms, horizontal component of n'th mode shape in the x direction at i'th storey of building
Φ_{yin} = In buildings with floors modelled as rigid diaphragms, horizontal component of n'th mode shape in the y direction at i'th storey of building
$\Phi_{\theta in}$ = In buildings with floors modelled as rigid diaphragms, rotational component of n'th mode shape around the vertical axis at i'th storey of building
θ_i = Second Order Effect Indicator defined at i'th storey of building

2.1. SCOPE

2.1.1 – Seismic loads and analysis requirements to be applied to earthquake resistant design of all cast-in-situ and prefabricated reinforced concrete buildings, structural steel buildings and building-like structures to be built in seismic zones defined in **1.2.3** are specified in this chapter. Rules for masonry buildings are specified in **Chapter 5**.

2.1.2 – Rules for the analysis of building foundations and soil retaining structures are specified in **Chapter 6**.

2.1.3 – Non-building structures which are permitted to be analysed in accordance with the requirements of this chapter shall be limited to those given in **Section 2.12**.

2.1.4 – Analysis rules to be applied to seismic performance assessment and retrofit of existing buildings are given in **Chapter 7**.

2.2. GENERAL GUIDELINES AND RULES

2.2.1. General Guidelines for Building Structural Systems

2.2.1.1 – The building structural system resisting seismic loads as a whole as well as each structural element of the system shall be provided with sufficient stiffness, stability and strength to ensure an uninterrupted and safe transfer of seismic loads down to the foundation soil.

2.2.1.2 – The floor systems should possess sufficient stiffness and strength to ensure the safe transfer of lateral seismic loads between the elements of the structural system. Otherwise appropriate collector elements should be provided.

2.2.1.3 – In order to dissipate a significant part of the seismic energy fed into the structural system, *ductile design* principles specified in **Chapter 3** and in **Chapter 4** of this Specification should be followed.

2.2.1.4 – Design and construction of irregular buildings defined in **2.3.1** should be avoided. Structural system should be arranged symmetrical or nearly symmetrical in plan and torsional irregularity defined as type **A1** irregularity in **Table 2.1** should preferably be avoided. In this respect, it is essential that stiff structural elements such as structural walls should be placed so as to increase the torsional stiffness of the building. On the other hand, vertical irregularities defined as types **B1** and **B2** in **Table 2.1** leading to *weak storey* or *soft storey* at any storey should be avoided.

2.2.1.5 – Effects of rotations of column and in particular wall supporting foundations on soils classified as group (C) and (D) in **Table 6.1** of **Chapter 6** should be taken into account by appropriate methods of structural modelling.

2.2.2. General Rules for Seismic Loads

2.2.2.1 – Unless specified otherwise in this chapter, seismic loads acting on buildings shall be based on *Spectral Acceleration Coefficient* specified in **2.4** and *Seismic Load Reduction Factor* specified in **2.5**.

2.2.2.2 – Unless specified otherwise in this Specification, seismic loads shall be assumed to act non-simultaneously along the two perpendicular axes of the building in the horizontal plane. Rules are given in **2.7.5** for combined effects earthquakes considered.

2.2.2.3 – Unless specified otherwise in this Specification, load factors to be used to determine design internal forces under the combined effects of seismic loads and other loads according to *ultimate strength theory* shall be taken from the relevant structural specifications.

2.2.2.4 – It shall be assumed that the wind loads and seismic loads act non-simultaneously, and the most unfavourable response quantity due to wind or earthquake shall be considered for the design of each structural element. However, even if the quantities due to wind govern, rules given in this Specification shall be applied for dimensioning and detailing of structural elements and their joints.

2.3. IRREGULAR BUILDINGS

2.3.1. Definition of Irregular Buildings

Regarding the definition of irregular buildings whose design and construction should be avoided because of their unfavourable seismic behaviour, types of irregularities in plan and in elevation are given in **Table 2.1** and relevant conditions are given in **2.3.2** below.

2.3.2. Conditions for Irregular Buildings

Conditions related to irregularities defined in **Table 2.1** are given below:

2.3.2.1 – Irregularity types **A1** and **B2** govern the selection of the method of seismic analysis as specified in **2.6** below.

2.3.2.2 – In buildings with irregularity types **A2** and **A3**, it shall be verified by calculation in the first and second seismic zones that the floor systems are capable of safe transfer of seismic loads between vertical structural elements.

2.3.2.3 – In buildings with irregularity type **B1**, if total infill wall area at i'th storey is greater than that of the storey immediately above, then infill walls shall not be taken into account in the determination of η_{ci} . In the range $0.60 \leq (\eta_{ci})_{min} < 0.80$, Structural Behaviour Factor, given in **Table 2.5** shall be multiplied by $1.25\ (\eta_{ci})_{min}$ which shall be applicable to the entire building in both earthquake directions. In no case, however, $\eta_{ci} < 0.60$ shall be permitted. Otherwise strength and stiffness of the weak storey shall be increased and the seismic analysis shall be repeated.

2.3.2.4 – Conditions related to buildings with irregularities of type **B3** are given below:

(a) In all seismic zones, columns at any storey of the building shall in no case be permitted to rest on the cantilever beams or on top of or at the tip of gussets provided in the columns underneath.

TABLE 2.1 – IRREGULAR BUILDINGS

A – ***IRREGULARITIES IN PLAN***	***Related Items***
A1 – Torsional Irregularity : The case where *Torsional Irregularity Factor* η_{bi}, which is defined for any of the two orthogonal earthquake directions as the ratio of the maximum storey drift at any storey to the average storey drift at the same storey in the same direction, is greater than 1.2 (**Fig. 2.1**). [$\eta_{bi} = (\Delta_i)_{max} / (\Delta_i)_{ort} > 1.2$] *Storey drifts shall be calculated in accordance with* **2.7**, *by Considering the effects of* $\pm$ *%5 additional eccentricities.*	**2.3.2.1**
A2 – Floor Discontinuities : In any floor (**Fig. 2.2**); **I -** The case where the total area of the openings including those of stairs and elevator shafts exceeds 1/3 of the gross floor area, **II** – The cases where local floor openings make it difficult the safe transfer of seismic loads to vertical structural elements, **III** – The cases of abrupt reductions in the in-plane stiffness and strength of floors.	**2.3.2.2**
A3 – Projections in Plan : The cases where projections beyond the re-entrant corners in both of the two principal directions in plan exceed the total plan dimensions of the building in the respective directions by more than 20%. (**Fig. 2.3**).	**2.3.2.2**
B – ***IRREGULARITIES IN ELEVATION***	***Related Items***
B1 – Interstorey Strength Irregularity (*Weak Storey*) : In reinforced concrete buildings, the case where in each of the orthogonal earthquake directions, *Strength Irregularity Factor* η_{ci} , which is defined as the ratio of the *effective shear area* of any storey to the *effective shear area* of the storey immediately above, is less than 0.80. [$\eta_{ci} = (\sum A_e)_i / (\sum A_e)_{i+1} < 0.80$] *Definition of effective shear area in any storey* : $\sum A_e = \sum A_w + \sum A_g + 0.15 \sum A_k$ (*See* **3.0** *for notations*)(*)	**2.3.2.2**
B2 – Interstorey Stiffness Irregularity (*Soft Storey*) : The case where in each of the two orthogonal earthquake directions, *Stiffness Irregularity Factor* η_{ki} , which is defined as the ratio of the average storey drift at any storey to the average storey drift at the storey immediately above or below, is greater than 2.0. [$\eta_{ki} = (\Delta_i/h_i)_{ort} / (\Delta_{i+1}/h_{i+1})_{ort} > 2.0$ or $\eta_{ki} = (\Delta_i /h_i)_{ort} / (\Delta_{i-1}/h_{i-1})_{ort} > 2.0$] *Storey drifts shall be calculated in accordance with* **2.7**, *by considering the effects of* $\pm$ *%5 additional eccentricities.*	**2.3.2.1**
B3 – Discontinuity of Vertical Structural Elements : The cases where vertical structural elements (columns or structural walls) are removed at some stories and supported by beams or gusseted columns underneath, or the structural walls of upper stories are supported by columns or beams underneath (**Fig. 2.4**).	**2.3.2.4**

(*) See APPENDIX