Turkish Government
Ministry of Reconstruction
and Resettlement

Earthquake Research Institute

Specifications for structures to be built in disaster areas

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SPECIFICATIONS FOR STRUCTURES TO BE BUILT IN DISASTER AREAS

PART: I

GENERAL

Section 1 - Scope of Specifications

1.1. All government or private buildings to be altered, expanded, newly constructed or to undergo major repair work and located in disaster areas as determined by Section 2 of Act 7269 as revised by Act 1051, shall conform to the technical provisions stated in this specification in accordance with Section 3 of Act 7269 as revised by Act 1051.

1.2. The material and labour standards in buildings to be constructed in disaster areas shall conform to the provisions of the Turkish Standards and the "General Technical Specifications" of the Ministry of Public Works.

Section 2 - Land with Restricted Building Construction

2.1. No buildings or dwellings shall be constructed upon, nor shall existing buildings and dwellings located on land restricted for construction as per Section 14 of Act 7269 as revised by Act 1051. Furthermore, no buildings or dwellings shall be constructed upon artificial fills less than 30 years old, unless special subsoil compaction is provided.

2.2. In regions affected by at least one of the hazards of avalanche, rock-fall or land slide, and declared as hazard area in accordance with Section 2 of Act No.7269 as revised by Act No.1051, no buildings or dwellings shall be constructed, nor shall existing buildings or dwellings be repaired.

PART: II

PROTECTION AGAINST FLOOD AND FIRE

Section 3 - Protection Against Flood

3.1. In regions declared as hazard areas as result of a flood, according to Section 14 of Act 7269 as revised by Act 1051, buildings may be constructed, existing buildings and dwellings may be repaired, provided the area is not resticted for construction and the provisions set forth in subsections 3.1.1 through 3.1.5 are complied with.

3.1.1. In portions of buildings which may come into direct contact with water, natural or artificial building materials unable to withstand the effects of water shall not be used (e.g. Adobe, timber, tuft, plaster stone, walls with mud mortar).

3.1.2. Portions of buildings that may come into direct contact with water shall be built of natural masonry stone laid with a cement mortar having a cement content of 250 kg/m^3, concrete with coarse aggregate content of 33%, or other materials exhibiting higher durability. Such portions shall extend at least 0.30 m above the highest possible water level.

3.1.3. Where the possibility exists that the subbase may be completely flooded, necessary precautions shall be taken.

3.1.4. Each portion of buildings to be altered, expanded or to undergo major repair shall be altered, newly built or renovated in a way so as to increase the durability of the building against flood water.

3.1.5. Storage, laundry or shelter areas shall not be built in the case they are completely immersed under the highest possible flood level.

Section 4 - Protection Against Fire

4.1. In regions declared as fire disaster areas in accordance with Section 2 of Act 7269, in buildings to be built or repaired, the following minimum precautions shall be taken until the relevant Turkish Standard against fire-protection is prepared.

4.1.1. In adjacent buildings with no separation in between, timber or other inflammable materials shall not be used on the exterior walls.

4.1.2. In chimneys to be built on roof-slabs, the thickness of the exterior walls of the chimney shall be at least one brick (19 cm). In office buildings and centrally heated buildings this thickness shall not be less than 1,5 bricks (29 cm). Chimneys shall in no case come into contact with timber elements and a clear space of at least 5 cms shall be provided between the chimney and timber portions. Exterior faces of chimneys shall be plastered and gaps between bricks or briquets in the interior shall be filled using planed timber or metal sheet forms. The material used in chimneys shall be non-flammable material such as normal brick, concrete briquets or similar masonry blocks.

4.1.3. Chimneys shall extend at least 0.75 m above their level of intersection with the roof.

4.1.4. In multistorey steel frame structures, beams and columns susceptible to fire damage shall be covered by a suitable non-flammable material and protective and preventive measures shall be taken in locations where possibility of piling of inflammable materials exists.

4.1.5. Timber frame structures shall not be built in an adjoining manner. Such buildings shall have a clear space of at least 5.0 m between the exterior face of the buildings and the edge of the plot of land.

4.1.6. In adjoining buildings, along the common boundary, a fire curtain masonry wall of at least 1 brick thickness and plastered on both faces shall be provided. Such walls shall bear on the roof slab, shall extend at least 0.60 m beyond roof level and shall be built with a slope parallel to the maximum slope of the roof.

4.1.7. Each portion of buildings to be altered, expanded or to undergo major repair shall be altered, newly built or renovated in a way so as to increase the resistance of the building against fire hazard.

PART: III

PROTECTION AGAINST EARTHQUAKES

Section 5 - Range of Application.

5.1. All buildings, dams, bridges etc. whose construction and calculation principles are not covered by this part shall be subject to the requirements of the ministries supervising the construction and the pertinent projects shall be designed accordingly until such later date when special specifications become available.

5.2. Earthquake risk zones mentioned in Part III are determined in accordance with the Earthquake Zoning Map of Turkey as prepared by the Ministry of Construction and Settlement and formalised by ruling No. 7/5551 of the Council of Ministers on December 12, 1972.

Section 6 - Reinforced Concrete Buildings

6.1. Notation

a = Maximum unsupported length of rectangular hoop measured between perpendicular legs of the hoop or supplementary cross ties

s = Shear reinforcement spacing in the direction of longitudinal reinforcement

z = Moment-arm for bending moment in beams

b = Width of beam or column section

h = Effective depth for beam or column section

Ø = Cross-sectional diametre of reinforcing bars

fe = Area of transverse hoop bar (one leg)

Fe = Area of tension reinforcement in beams

Fb = Cross area of concrete section

FB = Area of shear reinforcement within a given distance

V = Shear force incident on a column

No = Axial compression force incident on column within beam-column joint region

M_{left} = Support-moment of left beam framing into beam-column joint (positive moments producing tension at bottom of beam)

M_{right} = Support-moment of right beam framing into beam-column joint (positive moments producing tension at bottom of beam)

μ = Ratio of longitudinal tensile reinforcement

μ_s = Volumetric ratio of transverse reinforcement (ratio of hoop or spiral reinforcement volume to volume of enclosed concrete core within one step of transverse reinforcement)

σ_{eu} = Yield strength of reinforcing steel

σ_{bu} = 28-days compressive strength of concrete sylinders (kg/cm^2)

σ_e = Stress in reinforcing steel

$\sigma_{e,em}$ = Allowable stress for reinforcing steel

τ_b = Shear stress in concrete (shear stress on section)

τ_e = Shear stress covered by transverse reinforcement

6.2. Scope

Reinforced concrete buildings to be built in earthquake risk zones shall conform to the provisions set forth in this specifications along with the requirements of other pertinent specifications. Structural elements utilising structural grade steel profiles as reinforcement are not covered by this section.

The principles stated in this section are applicable to monolithical(*) structures consisting of in-situ cast frame, shear-wall, or frame-shearwall systems.

(*) Monolithical Structure: Structures where the superstructure and sub-structure act jointly and continuously to resist incident loads.

"Ductile systems" are structures consisting of reinforced concrete frame, shearwall or frame-shearwall systems and conforming to the provisions stated hereforth, and prestressed concrete structures in which provisions for ductility are satisfied.

Ductile systems also encompass prefabricated construction where ductility is achieved through special measures.

6.3. General Principles

6.3.1. All bearing or nonbearing elements affecting the behaviour of the structure under seismic loads shall be taken into consideration at the design stage.

6.3.2. Structural systems consisting of frames or shearwalls and conforming to the provisions stated herein shall be designed in accordance with the lateral load provisions set forth in Section 13. Floor systems shall be sufficiently rigid to transfer seismic loads to the frames or shear-walls.

6.3.3. In all structures where the importance coefficient is larger than 1;

No concrete with a compressive cube strength less than 225 kg/cm^2 (B 225) shall be utilised in first and second degree earthquake zones. In all earthquake zones concrete shall be mixed with mechanical mixers and compacted by vibrators.

6.3.4. Lateral displacements of reinforced concrete columns or shear walls within one storey height under the action of lateral seismic loads shall be less than 0.0025 times the storey height. Separations or panels not conforming to this limitation and presenting danger of damage shall be prevented from doing so by leaving sufficient spacing between such elements and the load bearing system or through appropriate effective measures.

6.4. Joints

6.4.1. Where lateral displacements under seismic loads are not determined by calculations and where special measures are not taken, construction joints provided for differential temperature effects, shrinkage, differential heights and various soil conditions shall have a width of not less than 3 cm up to 6.00 m height, and shall be increased by 1 cm for each additional 3.00 m height after 6.00 m.

6.4.2. With the exception of joints provided for differential heights and soil conditions, building foundations can be built without joints.

6.5. Foundations

6.5.1. Foundation base and Foundations:

Foundations* shall be designed and constructed in accordance with the principles of soil mechanics pertinent to their subsoil and in a such a way so as to prevent damage to the superstructure due to total or differential settlements. Inasmuch as possible partial basement storeys shall not be constructed.

6.5.2. Foundation Ties:

6.5.2.1. In structures supported on piles, such foundations shall be suitably tied in both directions wherever possible. In the case of continuous footings foundation ties shall be provided, in a direction perpendicular to the footing axis. Where the subbase consists of bedrock, tie-beams can be reduced in number or altogether eliminated.

6.5.2.2. Tie-beams for foundations shall satisfy the minimum requirements given in Table 6.1 as per earthquake zone and subsoil classification.

TABLE: 6.1

MINIMUM REQUIREMENTS FOR TIE-BEAMS

Earthquake Zone	Dimension	Soil Class (See Section 13) I	II	III	IV
1st degree zone	Design tensile force (percentage of maximum normal force incident on columns into which the tie-beams frames)	8%	8%	10%	10%
	Minimum Cross-sectional area	700 cm^2	700 cm^2	900 cm^2	900 cm^2
	Minimum Longitudinal Reinforcement	4Ø14	4Ø14	4Ø14	4Ø14
	Minimum Dimension	25 cm	25 cm	30 cm	30 cm
2nd, 3rd and 4th degree zones	Design Tensile Force	5%	5%	8%	10%
	Minimum Cross-sectional area	700 cm^2	700 cm^2	900 cm^2	900 cm^2
	Minimum Longitudinal Reinforcement	4Ø14	4Ø14	4Ø14	4Ø14
	Minimum Dimension	25 cm	25 cm	30 cm	30 cm

6.5.2.3. Stirrup spacing in tie beams shall not exceed one-half the largest dimension of the tie beam nor shall be more than 20 cms.

6.5.2.4. Reinforced concrete slabs can be used in lieu of tie beams. In the case where such slabs are used, the thickness of the slab shall not be less than 15 cm, nor less than 1/50 of the smaller of the two spans. Calculations showing the vertical and lateral load transfer capacity of such slabs shall be required.

6.6. Columns

6.6.1. Columns shall be placed so as to coincide vertically along the height of the structure. In the case where this is not possible calculations shall be based on the fact that the structural system has an "irregular layout". Care shall be exercised so as to provide common planes for columns along their plan axes.

6.6.2. The minimum dimension of columns shall be not less than 25 cm, nor less than 1/20th of the clear storey height, nor shall the ratio of the larger dimension to the smaller one be greater than 3.00. Circular columns shall have a minimum cross-sectional diametre not less than 30 cm.

6.6.3. The vertical reinforcement ratio in columns shall be limited to a minimum of 1.0 percent and to a maximum of;

3.0 percent for B 160
3.5 percent for B 225
4.0 percent for B 300

No steel of higher grade than St III shall be used for vertical reinforcement in columns. Where lap splices are used, the ratio of total reinforcement (sum total of continuous bars and lapped bars) shall not exceed the following values:*

4.0 percent for B 160
5.0 percent for B 225
6.0 percent for B 300

6.6.4. Insofar as possible laps shall be staggered in columns subject to tensile stresses. In the case where this is not possible the lap length shall be increased by 100% for $\sigma_e = \sigma_{e,em}$ and by 50% for $\sigma_e < \sigma_{e,em}$.

Only in the case where sufficient transverse reinforcement is provided can half the bars be spliced. Where the steel stresses σ_e are smaller than $\sigma_{e,em}$, the percentage of spliced bars may be increased.

**St III: Reinforcing steel with a yield stress of 4200 kg/cm^2.*

6.6.5. Three separate regions are defined in columns with respect to the spacing of transverse reinforcement

a) Region of column confinement
b) Column middle region
c) Beam-column joint region (Fig. 6.1).

6.6.5.1. Region of Column Confinement:

Column confinement regions shall be provided at the uppermost and lowermost sections of all columns to provide for tight confinement of the concrete core and to prevent fragile failure of the section under the effect of normal, shear and flexural stresses. Such regions shall extend from the uppermost level of the floor slab at the bottom of the column and from the lowermost level of the deepest beam framing into the column at the top for a distance not less than the largest dimension of the column section (cross sectional diametre in circular columns), not less than 1/6 of the clear height of the column, nor less than 45 cms.

Within the region of confinement, the volumetric ratio μ_s of rectangular hoops, rectangular or circular spirals shall not be less than that given by Eq. (6.1) nor less than 0.01.

$$\mu_s = 0.12 \frac{\sigma_{bu}}{\sigma_{eu}} \qquad (6.1)$$

The pitch of continuous circular spirals shall be not less than one-fifth the core diametre nor less than 8 cms. In the case where closed or continuous rectangular hoops are used within the region of confinement, the cross sectional are of a single leg of such hoops shall be not less than that given by Eq. (6.2)

$$Fe = \frac{a \mu_s s}{3} \qquad (6.2)$$

where a = maximum unsupported length of hoop leg,
s = centre-to-centre spacing of hoops.

Within the region of confinement, the minimum size of bars to be used for transverse reinforcement shall be not less than Ø8 and the centre-to-centre spacing of such reinforcement shall be not less than 5 cms nor more than 10 cms. Hoops provided within the confinement region shall have hooks bent to 135° and extending a length of 10 bar diametres beyond the bend. (Fig.6.2a)

Preference should be given to continuous spiral or continuous rectangular hoop transverse reinforcement in confinement regions. This will prevent congestion of transverse reinforcement as well as providing more effective confinement at post-crushing stages for the concrete-core. Tie-bars can

can also be employed in conjuction with normal on continuous rectangular hoops, giving rise to a smaller value of "a" and thus to economy in transverse reinforcement. Such tie-bars must have standard semi-circular hooks at each end extending a length of 10 bar diametres and must be securely fastened to both the transverse and the longitudinal reinforcement to avoid being displaced during concreting. (Fig. 6.2b)

Where columns carry discontinuous shear-walls or similarly rigid superstructures, the transverse reinforcement required in the region of confinement shall be continued throughout the entire height of the column.

Special Case: In buildings located within third or fourth degree earthquake risk zones, where the maximum design shear stress within the column confinement region is less than 0.07 σ_{bu}, the requirement for minimum volumetric transverse reinforcement ratio given by Eq. (6.1) can be waived and the hoop spacing within the confinement region can be adequately accepted to be one-half that of the spacing within the column middle region.

6.6.5.2. Column Middle Region:

The minimum cross sectional area of the transverse reinforcement provided within this region shall be not less than that required to resist the maximum design shear force under vertical loads and earthquake effects.

Within this region the centre-to-centre spacing of transverse reinforcement shall be not less than one-half the larger dimension of the column, nor less than 20 cm, nor less than 12 times the diametre of the smallest longitudinal reinforcing bar. Longitudinal reinforcement shall preferably be spliced within the column middle region and in accordance with the accepted principles of reinforced concrete construction.

6.6.5.3. Beam-Column Joint Region:

In beam-column joints Fig. (6.1) transverse reinforcement shall be provided to resist the maximum possible shear force. A typical beam-column joint diagramme is given in Fig. (6.2c) showing the forces acting and their positive senses.

At any section A-A within this region, the shear force V_A can be conservatively calculated by the following equation:

$$V_A = -\frac{M_{right}}{z_{right}} + \frac{M_{left}}{z_{left}} - V_o \qquad (6.3)$$

where z_{right} and z_{left} are the cross-sectional moment arms for the right and left beams, respectively. Note that M_{left} or M_{right} vanish in peripheral columns.

The shear stress τ_b caused by the shear force V_A, can be calculated by Eq. (6.4)

$$\tau_b = \frac{V_A}{bz} \tag{6.4}$$

and should be less than the value given by Eq. (6.5)

$$\tau_b \leq 2.5\sqrt{\sigma_{bu}} \quad (kg/cm^2) \tag{6.5}$$

where σ_{bu} = concrete cylinder compressive strength. In Eq. (6.4) b and z denote the width and moment arm of the section respectively. The shear stress used in calculating the amount of transverse reinforcement, τ_e, is given by

$$\tau_e = \beta \ \tau_b \tag{6.6}$$

where

$$\beta = 1 - \frac{0.62}{\tau_b} \sqrt{(1 + 0.06 \frac{N_o}{F_b}) \ \sigma_{bu}} \tag{6.7}$$

In Eq. (6.7) No is the minimum vertical axial force on the section during an earthquake and F_b is the cross-sectional area of the beam-column joint. The units of kg and cms shall be used for τ_b, σ_{bu}, No and F_b. The increase of 33% shall not be applicable for the stress obtained from Eqs. (6.5) and (6.6).

In beam-column joints when four beams frame into the same column, and where the narrowest beam in wides than one-half the width of the column it frames into, and where the ratio of the depth of the shallowest beam to that of the deepest beam is at least 0.75, the amount of transverse reinforcement can be reduced to not less than one-half the amount calculated above.

Under no circumstances shall the amount of transverse reinforcement per unit length within the beam-column joint region be less than the amount requride within the column middle region.

6.6.5.4. Window openings between columns located above filler walls shall not be permitted. Where the presence of such windows becomes unavoidable, it should either be recognised that short-column action is prevalent and the short column reinforced along its clear height with continuous hoops (the amount of such reinforcement should not be less than that required within the column confinement region) whence it shall be required that the effect of short-column action leading to increased stiffness be included in the distribution of shear forces within that particular storey along with the effect on calculation of the natural period and torsional analysis, or, the filler walls should be constructed separately from the main bearing system so as not to affect the column stiffnesses.

6.6.5.5. Filler walls should be designed and constructed in such a way that their effects on the natural period and torsional behaviour of the building under earthquake loading are minimised.

6.7. Shear Walls:

6.7.1. Shear walls shall be designed in such a way so as to safely resist moments, axial forces and shear forces arising from lateral loading.

6.7.2. Shear walls shall denote vertical bearing elements whose larger plan dimension is at least five times the smaller plan dimension. The minimum thickness of reinforced concrete shear walls shall be not less than 1/20 of the wall-width of the storey-height, nor less than 15 cms.

Where the chosen thickness cannot be substantiated by calculations, the minimum thickness stipulation shall be used for the first 10 m of wall height, and the minimum thickness shall be increased in the lower storeys by 2 cm for each additional 6 m height.

The minimum reinforcement provided for shear walls shall be not less than 0.0025 A_H *for the horizontal reinforcement, and not less than 0.0020* A_V *for the vertical reinforcement, where* A_H *and* A_V *denote gross cross-sectional areas of the shear-wall in the horizontal and vertical directions respectively. The spacing between two consecutive reinforcing bars shall be not more than 1.5 times the wall thickness, nor more than 30 cms. Where vertical load bearing elements fall between the definitons of columns and shear-walls, such elements shall have their minimum dimensions not less than 25 cms, and furthermore, shall satisfy the minimum requriments for both columns and shear-walls as regards their reinforcement. The lateral load coefficients used for such elements shall be those for shear walls.*

6.7.3. At either end of shear-walls, within a distance of 0.10 times the larger plan dimension, the vertical reinforcement spacing shall be halved.

Where tensile stresses are present on the wall cross-section, based on the assumption of a homogeneous cross-section, the reinforcements provided at the ends shall not less than

0.005 for St I
0.004 for St II
0.005 for St III

times the statically required cross-sectional area.

6.7.4. The splice lengths for reinforcement in shear-walls shall conform to those required for column reinforcement splices.

6.7.5. On all sides of openings in shear-walls, a minimum of 2Ø16 reinforcing bars shall be provided on either face of the wall. In the case where large openings are present, the design calculations shall account for such openings and the amount of reinforcement provided at the sides shall be not less than the reinforcement interrupted by the opening in either direction. Furthermore, a minimum 2Ø16 bars shall be provided at each corner of the opening on either face of the wall at 45^{o} with the horizontal (Fig. 6.3).

6.7.6. Where walls frame into other walls or structural elements, sufficient reinforcement shall be provided to ensure continuity. Care shall also be exercised to ensure adequate detailing of the joint.

6.8. Floor Slabs:

6.8.1. Reinforced concrete floor slabs shall have a minimum thickness of 10 cm except for slabs carrying only roofs which shall have a minimum thickness of 8 cm.

6.8.2. Special reinforcement of at least 2Ø12 bars shall be provided around openings in normal floor slabs and such reinforcement shall not be less than the amount of reinforcement cut-off for the opening. Where slabs are subject to lateral loads, at least 2Ø12 bars shall be provided at each corner of the opening, making an angle of 45^{o} with the adjacent sides and having a length not less than twice the length required for bond development, in order to effectively transfer the tensile and compressive stresses of the slab to other structural elements. In both cases the special reinforcement shall be distributed equally between the top and bottom of the slab.

6.8.3. For rib-slabs with or without concrete masonry filler blocks the maximum percentage of reinforcement shall not exceed that specified for beams. Such slabs, when built in earthquake risk zones shall satisfy the following conditions:

a) The slab thickness shall not be less than 7 cm.
b) Where the height of the building above base exceeds

12.00 m in 1st degree earthquake zones
15.00 m in 2nd degree earthquake zones
18.00 m in 3rd degree earthquake zones
21.00 m in 4th degree earthquake zones

shear walls extending to foundation level and having their plan centre of rigidity coincide as much as possible with the centre of mass of the building shall be provided in order to transfer safely the lateral loads to the foundations.

6.8.4. Flat-plate or flat-slab floor systems shall be provided with the minimum dimensions and reinforcement required to safely resist and transfer the lateral loads due to earthquakes, in addition to vertical loads, to the vertical bearing elements.

6.9. Beams:

6.9.1. The minimum dimensions of reinforced concrete beams forming part of a frame shall not be less 20 cms by 30 cms and such beams shall have a width not more than 1.5 times the beam depth plus the width of the supporting column face.

Where the width of the beam exceeds the value given above the excess shall not be used in calculations for rigidity and reinforcement unless a detailed analysis is carried out.

6.9.2. The minimum longitudinal reinforcement ratio in beams shall not be less than the values in Table 6.2. Where the reinforcement provided at every section, positive or negative, is at least one-third greater than that required by analysis, the minimum reinforcement ratio requirement may be waived.

TABLE 6.2

Longitudinal Reinforcement Ratio	St I	St II	St III
μ_{min}	0.005	0.004	0.003

6.9.3. Whenever possible, beams shall be designed as singly reinforced beams within the middle region. Compressive reinforcement shall be used whenever required, however the ratio of such reinforcement shall not exceed 0.01 nor one-half times the amount of the tensile reinforcement. Where beams are singly reinforced, at least 2Ø12 bars shall be provided at the compression side of the beam.

6.9.4. The bottom reinforcement at beam supports (compressive reinforcement for vertical loads) shall be not less than one-third of the reinforcement at the top (tensile reinforcement for vertical loads) nor less than one-half of the larger amount of reinforcement in the middle region of the next span. A minimum of one-fourth of the larger amount of the tension (top) reinforcement required at either end shall continue throughout the top of the beam. A minimum of one-third of the tension reinforcement at the support shall extend not less than the anchorage length beyond the inflection-point, nor less than one-fourth of the clear span, whichever is larger.

6.9.5. Tensile steel shall not be spliced by lapping in a region of tension or reversing stress unless the region is confined by stirrup-ties, the amount of which is given by Eq. (6.1). Lap splices shall be avoided in regions of high shear-stress.

6.9.6. Beams framing into only one side of a column, in any vertical plane, shall have top and bottom reinforcement extending to the far face of the column, terminating in a standard 90° hook with a leg whose length shall be not less than that required for anchorage. Where beams frame into a column on both sides, top and bottom reinforcement shall be continuous through the column. In the case where the two beams have different depths, the conditions applying to non-continuous beams shall be satisfied.

6.9.7. Beams shall have sufficient transverse reinforcement to resist the shear stresses induced by vertical loads and end moments due to earthquakes. The minimum diametre for transverse reinforcement bars, in 1st and 2nd degree earthquake risk zones, shall be not less than 8 mm.

The spacing of transverse reinforcement shall be not more than the width of the beam, nor more than one-half of the beam depth.

6.9.8. At each end of the beam, within a distance of at least twice the beam depth the transverse reinforcement provided shall be not less than

$$F_B = 0.15 \frac{s}{h} Fc \qquad (6.8)$$

The spacing of stirrup-ties within this distance shall not exceed one-fourth the beam depth, and the distance between the first stirrup-tie and the cohesive face shall be not more than 5 cm.

6.10. Filler Walls:

6.10.1. Filler walls shall be constructed as thin as possible and preferably of light material. Where the wall height exceeds 3.00 m, an intermediate bond beam shall be provided.

6.10.2. Isolated walls or portition walls not connected to other walls shall have a minimum thickness of 1/2 brick or shall be constructed with 10 cm thick light concrete blocks or other patented material approved by the Ministries of Public Works and of Construction and Settlement.

6.10.3. Line loads due to walls bearing on slab spans shall not exceed 700 kgms per meter run of wall. Such walls shall not have a clear span more than 4.00 m.

Section 7 - Steel Structures

7.1. The methods of calculation of lateral loads stipulated in Section 13 shall apply in the calculation, design and detailing of structural steel members.

7.2. In structures with steel skeletons, rigid beam-column connections shall be detailed in a manner so as to effectively transfer the member forces.

7.3. Floors of steel skeleton buildings may be of reinforced concrete prefabricated elements or special metal floor plate elements. Where the building has reinforced concrete cores or reinforced concrete rigid frames provided only at certain axes, either a monolithical floor-slab capable of transferring lateral loads or sufficient lateral rigid elements in a composite floor-slab should be provided to transfer the lateral loads cuting on the floor to the rigid cores or frames.

7.4. Walls and partitions may be constructed of lightweight prefabricated wall elements or masonry wall elements. The connections of such walls to columns and beams shall be sufficiently strong to prevent overturning or spalling even under earthquake effects. In the case where the interaction of non-structural walls with the steel skeleton is not desired, the connections shall be detailed accordingly.

7.5. In truss systems, the slenderness ratio of tensile members shall not exceed 250. (This does not include elements for wind and stability bracing).

7.6. Bracing elements for stability and wind loads shall be designed in such a way so as to safely transfer earthquake loads down to foundations.

7.7. The roof system shall be designed so as to be as light as possible and unless necessary, shall not be burclened by additional installations.

7.8. Bolts to be used in first and second degree earthquake zones shall be designed for 30% smaller allowable stresses and shall have double nuts.

Section 8. Timber Frame Structures

8.1. Scope and General Principles

Buildings having masnory foundations and/or basement walls, timber bearing storey walls and timber skeleton floors shall hereafter be referred to as timber frame structures. The aseismic design of engineered timber structures not falling within the scope of this definition, shall comply with provisions acceptable to the project control authorities.

Timber frame structures shall not be built higher than two storeys, excluding the basement. The clear height of any storey shall not exceed 3.00 m.

8.2. Foundations

Construction of foundations shall comply with the requirements set in section 9.2. "Foundations of masonry structures".

8.3. Walls

8.3.1. In buildings with basements, basement walls shall be 0.50 m thick and not higher than 2.40 m. Basement partition walls may be built of brick or lightweight concrete blocks.

8.3.2. Ground storey walls shall be built of masonry or timber frame, whereas 1st storey walls shall be built of timber frame.

Construction of masonry walls shall comply with the requirements of section 9.3, Masonry Structures.

8.3.3. Skeletons for bearing walls shall consist of posts spaced not more than 1.50 m, top chord and bottom heel beams placed above and below the posts, secondary beams between the posts and finally, diagonal members forming triangular openings.

Intermediate openings in such timber frames shall be filled with material such as bricks, adobe clay, smaller pieces of timber, and the faces of the walls shall be covered by plaster applied on wire-mesh, timber lathes, or on bamboo canes. Wood panels or corrugated metal sheeting may also be used.

8.3.4. Vertical posts and diagonal members shall not be lapped and shall be scarf connected to top chord and bottom heel beams. Where a scarf-connection cannot be provided, a triangular wedge shall be provided at either face of the member and securely fastened by nails. (Fig. 8.1)

8.3.5. Top chord and bottom heel beams may be lapped. Where such laps are required, the two parts shall be skew-end lapped and shall be fastened together either by nuts or by nails not shorter than the thickness of the lapped member (Fig. 8.2).

8.3.6. Connections for all timber frame members of bearing walls shall be of the flat or skew-end tongue and groove type.

8.3.7. For one-storey buildings with or without basements and for second storeys of buildings with masonry construction ground storey walls, the minimum sectional dimensions shall be; 10x10 cms for vertical posts, diagonals, top chord and bottom heel beams and 5x10 cms for other intermediate members. For two-storey buildings where both storeys have timber frame walls, the minimum dimensions shall be; 12x12 cms for vertical posts, diagonal members, and both beams in the ground storey, 6x12 cms for other members.

8.3.8. Lateral and longitudinal walls in timber frame structures shall intersect each other at not more than every 4.50 m. Where the interior partitioning does not satisfy this condition, bearing posts of the longitudinal wall shall be connected to the roof trusses at every 4.50 m (Fig. 8.3).

8.3.9. Walls shall have solid panels with timber frame skeletons not narrower than 1.50 m at each corner of the building in either direction, and not less than 0.75 m between two consecutive openings.

8.4. Floors

Floor beams shall be made to bear upon timber heel beams at ground storey level and upon top chord beams of timber frames at first storey level, and shall be nailed to the supporting members (Fig. 8.4).

Diagonal bracing shall be provided at each corner of the building, consisting of members not less than 5x10 cms in cross-section.

8.5. Bond Beams and Lintels

8.5.1. For buildings with masonry ground floors, bond beams and lintels shall conform to the requirements of masonry structures, section 9.5.

8.5.2. In timber frame buildings upper lintels for doors and upper and lower lintels for windows shall have the cross-sectional dimensions of the posts and shall be scorf connected to the posts.

Section 9 - Masonry Structures

9.1. Scope and General

Structures without frames but that have bearing walls made of natural or artificial building materials approved by the Turkish Institute of Standards and other associated institutions, and whose floors consist of reinforced-concrete slabs or any other floor slab systems having the lateral rigidity provided by reinforced concrete slabs shall hereafter be referred to as "Masonry Structures".

It is recommended that the walls of masonry structures be designed by appropriate analytical methods, insofar as the application of such methods is possible, and reinforcement steel be used both horizontally and vertically.

Allowable heights for masonry structures shall not exceed two storeys in first degree earthquake zones, three storeys in second and third degree earthquake zones, four storeys in fourth degree earthquake zones, excluding basements, provided a sufficiently rigorous statical analysis is carried out and the structure is constructed in complete accordance with the principles of calculation and methods of construction stipulated in "Specifications for Masonry Structures", unless required otherwise by this specifications. Maximum storey heights shall not exceed 3.00 m.

Above roof parapet level, metal or wooden terrace balustrades, shield walls, penthouse flats with walls made of non-masonry lightweight material and water tanks not exceedings 5.00 cu.m. in capacity may be built. In the case where the penthouse flat plan area exceeds one-quarter of the plan area of the building, the construction (penthouse flat) shall be considered as a complete storey of the building. Additional basements shall be considered as full-storeys.

The plan layout of masonry buildings shall be simple and uniformly shaped. Bearing walls in either direction shall be arranged so that masses and stiffnesses are distributed as symmetrically as possible with respect to the principal axes of the building.

It is recommended that no partial basements be built. All bearing walls shall be made to coincide axially in the vertical direction and shall transfer loads to the soil through foundations whose construction principles are given below in section 9.2.

Where ground storeys of masonry buildings are designed for use as commercial establishments, requiring large volumes with fairly long spans, reinforced concrete frames shall be provided in order to transfer the vertical and lateral loads transmitted by the masonry walls of upper storeys down to foundation level. The design of such frames and their foundations shall conform to the requirements for reinforced concrete structures.

9.2. Foundations

Unless designated by calculations, the following minimum requirements shall hold for foundations.

9.2.1. Building foundations shall be designed and constructed in accordance with the requirements of section 6.5.1.

9.2.2. Foundations for bearing walls shall be made of concrete with minimum B.160 quality.

9.2.3. Foundations for Soil Classes I and II (x)

9.2.3.1. In all earthquake zones foundations of bearing walls shall have a minimum width not less than the thickness of the wall plus 15 cms on each side of the wall.

9.2.3.2. The minimum thickness of wall foundations shall not be less than 30 cms, and such foundations shall have a minimum reinforcement of 6Ø12 bars. The centre-to-centre spacing between two adjacent longitudinal bars in either top or bottom layer of reinforcement shall not exceed 30 cms. Such reinforcement shall be properly lapped at corners and joints of two foundations and rectangular hoops of 6 mm diametre of 30 cm spacing shall be provided.

9.2.3.3. The level of foundation shall be determined on the basis of soil characteristics, ground water level and local frost depth. In sloping ground foundations may be constructed in steps. The maximum height of each step shall not exceed 30 cms, nor shall overlaps be less than 30 cms. The spacing between steps shall not be less than 1.00 m.

9.2.3.4. In all earthquake zones, bearing wall foundations need not be provided where the base is bed-rock.

9.2.4. Foundations for Soil Class III

9.2.4.1. In all earthquake zones foundations of bearing walls shall have a minimum width not less than the thickness of the wall plus 20 cms on each side of the wall, nor less than 60 cms.

9.2.4.2. The minimum thickness of wall foundations shall not be less than 40 cms, and such foundations shall have a minimum reinforcement of 6Ø14 bars. The centre-to-centre spacing between two adjacent longitudinal bars in either top or bottom layers of reinforcement shall not exceed 30 cms. Such reinforcement shall be properly lapped at corners and joints of two foundations and rectangular hoops of 8 mm diametre at 30 cm spacing shall be provided.

(x) See Section 13 for Classification of Soils.

9.2.4.3. The level of foundation shall be determined in accordance with the requirements of 9.2.3.3. In sloping ground foundations may be constructed in steps. The maximum height of each step shall not exceed 30 cms, nor shall overlaps be less than 40 cms. The spacing between steps shall not be less than 1.50 m.

9.2.5. Foundations for Soil Class IV

9.2.5.1. In all earthquake zones foundations of bearing walls shall have a minimum width not less than the thickness of the wall plus 30 cms on each side of the wall, nor less than 80 cms.

9.2.5.2. The minimum thickness of wall foundations shall not be less than 40 cms, and such foundations shall have a minimum reinforcement of 8Ø14 bars. The centre-to-centre spacing between two adjacent bars in either top or bottom layers of reinforcement shall not exceed 30 cms. Such reinforcement shall be properly lapped at corners and joints of two foundations and rectangular hoops of 8 mm diametre at 30 cm spacing shall be provided.

9.2.5.3. The level of foundation shall be determined in accordance with the requirements of 9.2.3.3. Stepped foundations shall not be constructed.

9.2.6. Sufficient precautions shall be taken in wall foundations and in walls directly beneath windows in the storey directly above wall foundations, against cracks in walls below windows.

9.3. Bearing Walls:

9.3.1. Materials

The properties of masonry blocks and mortars to be used in walls shall conform to the related specifications.

Bricks, hollow concrete blocks, rubble briquets, bricks with horizontal openings manufactured for purposes other than bearing masonry blocks shall not be used in walls. The compressive strength of masonry blocks shall be not less than 50 kg/cm^2 for artificial blocks and not less than 350 kg/cm^2 for natural masonry stone. In exterior walls of basements no artificial masonry blocks with a compressive strength less than 100 kg/cm^2 shall be used. The average compressive strength of artificial masonry blocks to be used in the basement and ground floor walls of buildings having two or more storeys in addition to the basement shall be greater than 75 kg/cm^2. The mortar to be used in such walls shall be either lime-cement mortar (cement: lime: sand, volumetric ratio, 1:2:9) or cement mortar (cement:sand, volumetric ratio, 1:6 or 1:4).

Where concrete walls are substituted for masonry basement walls, the concrete quality shall be at least B160.

The choice of masonry blocks and type of mortar shall be made on the basis of the loads acting on the wall.

9.3.2. Wall Thicknesses

In the absence of a statical analysis, the minimum unplastered wall thickness shall conform to the values given below.

9.3.2.1. In all earthquake zones, natural masonry stone and concrete walls shall be used only in the basement and ground floor walls of buildings. The minimum thickness of natural masonry stone walls shall be not less than 50 cms, and of concrete walls not less than 25 cms. Natural masonry stone walls in buildings having two or more storeys above the ground floor shall not contain rubble masonry blocks.

9.3.2.2. In buildings with or without basements, having two or more storeys in addition to the ground floor, the thickness of the walls in the basement or ground floor, shall be at least 1.5 bricks in the case of brick walls, and at least 40 cms. in the case of walls built of regular masonry blocks having dimensions of 10 cms or multiples thereof.

9.3.2.3. In buildings with three or more storeys (including basement if any) the minimum wall thickensses shall be as given below:

In the top floor; 1 brick width (19 cm), in the 2nd from top floor; 1 brick width (19 cm) or 30 cms for walls built of regular masonry blocks having dimensions of 10 cms or multiples thereof, in the 3rd from top floor; 1,5 brick width (29 cm) or 40 cms for walls built of regular masonry blocks having dimensions of 10 cms or multiples thereof.

9.3.2.4. The minimum wall thickness shall be at least 1 brick (19 cm) in single storey buildings. Table 9.3.2. shows the permitted number of storeys for masonry buildings in earthquake zones and the minimum wall thicknesses in connection with the number of storeys to be built.

TABLE: 9.3.2.

NUMBER OF STOREYS AND MINIMUM WALL THICKNESS FOR MASONRY STRUCTURES (cms)

1st DEGREE EARTHQUAKE ZONES

BUILDINGS WITH BASEMENTS

No. of storeys including basement		Natural Stone	Concrete	Brick	Artificial Blocks or solid concrete briquets
3	Basement	50	25	1,5 brick	40
	Ground	50	-	1 "	30
	First	-	-	1 "	30
2	Basement	50	25	1,5 "	40
	Ground	50	-	1 "	30

BUILDINGS WITHOUT BASEMENTS

No. of storeys		Natural Stone	Concrete	Brick	Artificial Blocks or solid concrete briquets
2	Ground	50	-	1,5 brick	40
	First	-	-	1 "	30
1	Ground	50	-	1 "	30

2nd and 3rd DEGREE EARTHQUAKE ZONES

BUILDINGS WITH BASEMENTS

No. of storeys including basement		Natural Stone	Concrete	Brick	Artificial Blocks or solid concrete briquets
4	Basement	50	25	1,5 brick	40
	Ground	50	-	1,5 "	40
	First	-	-	1 "	30
	Second	-	-	1 "	30
3	Basement	50	25	1,5 "	40
	Ground	50	-	1 "	30
	First	-	-	1 "	30
2	Basement	50	25	1,5 "	40
	Ground	50	-	1 "	30

BUILDINGS WITHOUT BASEMENTS

No. of Storeys		Natural Stone	Concrete	Brick	Artificial Blocks or solid concrete briquets
3	Ground	50	-	1,5 brick	40
	First	-	-	1 "	30
	Second	-	-	1 "	30
2	Ground	50	-	1,5 "	40
	First	-	-	1 "	30
1	Ground	50	-	1 "	30

4th DEGREE EARTHQUAKE ZONES

BUILDINGS WITH BASEMENTS

No. of storeys including basement		Natural Stone	Concrete	Brick	Artificial Blocks or solid concrete briquets
5	Basement	50	25	1,5 brick	40
	Ground	50	-	1,5 "	40
	First	-	-	1,5 "	40
	Second	-	-	1 "	30
	Third	-	-	1 "	30
4	Basement	50	25	1,5 "	40
	Ground	50	-	1,5 "	40
	First	-	-	1 "	30
	Second	-	-	1 "	30
3	Basement	50	25	1,5 "	40
	Ground	50	-	1 "	30
	First	-	-	1 "	30
2	Basement	50	25	1,5 "	40
	Ground	50	-	1 "	30

BUILDINGS WITHOUT BASEMENTS

No. of storeys		Natural Stone	Concrete	Brick	Artificial Blocks or solid concrete briquets
4	Ground	50	-	1,5 brick	40
	First	-	-	1,5 "	40
	Second	-	-	1 "	30
	Third	-	-	1 "	30
3	Ground	50	-	1,5 "	40
	First	-	-	1 "	30
	Second	-	-	1 "	30
2	Ground	50	-	1,5 "	40
	First	-	-	1 "	30
1	Ground	50	-	1 "	30

9.3.3. Stability of Walls and Openings in Walls

9.3.3.1. Stability:

All bearing walls shall be rendered stable against lateral loads by means of perpendicularly connecting walls extending at least the full length of the room and having a thickness not less than 19 cms. The clear span of bearing walls measured between the centres of two consecutive perpendicularly connecting walls providing stability shall not exceed 5.50 m in 1st degree earthquake zones, and 7.00 m in other earthquake zones. Where this limitation cannot be satisfied, vertical reinforced concrete bond elements shall be provided in the bearing wall, spaced not more than 4.00 m apart, and the wall length shall be limited to 15.00 m.

9.3.3.2. Openings in Walls

The following requirements shall be satisfied for openings in walls.

a) In 1st and 2nd degree earthquake zones the minimum width of solid exterior wall between the corner of the building and the nearest door or window opening shall be not less than 1.50 m. In the case where the building height is less than 7.50 m this width may be reduced to 1.00 m.

b) In 3rd and 4th degree earthquake zones the width of the wall mentioned in (a) shall be not less than 1.00 m. In the case where the building height does not exceed 7.50 m, this width may be reduced to 0.80 m.

c) The clear distance of the first wall opening to the intersection of a bearing wall with a perpendicular stability wall, in either wall, shall be not less than 0.50 m.

d) The minimum width of solid wall section between two consecutive window or door openings shall be not less than 1/4 of the width of the larger opening on either side, nor less than 0.80 m in 1st and 2nd degree earthquake zones, and 0.60 m in 3rd and 4th degree earthquake zones.

e) The clear width of window and door openings shall not exceed 3.00 m.

f) Along any wall, the ratio of the total length of openings to the length of the wall shall not exceed 0.40.

9.4. Floor Slabs

Only reinforced concrete floor slabs or other types of slabs providing the horizontal continuity of reinforced concrete slabs shall be permitted. The design of such slabs shall conform to the requirements of this specification set forth in the section for reinforced concrete construction.

Balconies, corniches, roof-slab extensions that are continuations of the floor slab shall not cantilever more than 1.50 m. Cantilever stairs shall not extend more than 1.10 m beyond the floor slab.

No cantilever portions except at floor slab level shall be permitted.

9.5. Bond Beams and Lintels

9.5.1. Door and window lintels shall be made to bear upon the wall for a length not less than 0.20 m, nor less than 15% of the clear span of the lintel.

9.5.2. Where slabs, including roof and stairway slabs are to be supported on bearing walls, reinforced concrete periphery beams poured monolithically with the slab, not less than 20 cms in depth and not narrower than the width of the supporting wall or vertical bond column, if any, shall be provided. The quality of concrete for such beams shall be at least B160 and the reinforcement provided shall be not less than 4Ø10 bars longitudinally with a transverse reinforcement of Ø6 stirrup ties spaced not more than 25 cms on centres. Such reinforcement shall be properly lapped at corners and intersections.

9.5.3. In rubber masonry walls bond beams conforming to the provisions stated in 9.5.2. shall be provided for every 1.50 m of height.

9.6. Roof

Roof trusses shall be designed in such a way so as to resist earthquake effects as a unit, and shall not transfer lateral loads other than wind or earthquake effects.

Splices and connections of members shall be designed and constructed in such a way so as to transfer both tensile and compressive forces. The maximum slenderness ratio shall not exceed 250 even in tensile members. Wind bracing and stability elements shall be arranged so as to transfer the incident forces safely to the supports.

The connections of the roof trusees to the slab or walls of the building shall be in conformity with the provisions set in the specifications for "Masonry structures".

9.7. Non-structural Elements

9.7.1. Nonbearing partition walls, when built 10 cms thick (0,5 brick), shall be connected suitably to the bearing walls so as to provide stability, but shall be constructed at a later stage in order not to be subjected to the loads of the floor-slab directly above.

9.7.2. Masonry garden walls shall be built no higher than 1.00 m. above pedestrian pavement level.

9.7.3. The height of the wall in terrace parapets shall not exceed 0.60 m. Where shield walls are higher than 2.00 m, reinforced concrete bond beams shall be provided to increase stability. Wherever necessary, buttress elements shall be provided for parapet and shield walls to increase their lateral stability.

Section 10 - Semi-masonry Structures

10.1. Scope and General Principles

Structures that have no bearing frames, but consist of bearing walls constructed of material in conformity with the provisions of specifications approved by the Turkish Institute of Standards and other authorised institutions and whose floor systems do not fall within the scope of definition of floor slabs for masonry buildings shall be referred to as "Semi-masonry buildings".

Floor-slabs in semi-masonry buildings shall be made to bear upon periphery beams specified in the section "Masonry Structures".

In all earthquake zones, semi-masonry buildings shall have no more than two storeys excluding the basement.

10.2. The principles that govern the construction of masonry buildings (Section 9) shall apply equally to semi-masonry buildings.

Section 11 - Adobe Buildings

11.1. Scope and General Principles

Buildings that have their foundations and basement walls, if any, constructed of natural masonry stone and their bearing walls of cut or cast-in-place adobe clay shall be hereafter referred to as "Adobe buildings".

Unless specified to the contrary, adobe buildings shall be constructed as single storey buildings provided that the provisions set for masonry buildings are adhered to. The storey height shall not exceed 2.70 m, nor shall the basement height, if any, exceed 2.40 m.

The plan layout of adobe buildings shall preferably be rectangular, and bearing walls in either direction shall be placed symmetrically about the two principal axes of the building. Deviations from this symmetry shall be kept down to a minimum. It is recommended that partial basements not be constructed.

11.2. Foundations

11.2.1. In all earthquake zones foundation walls shall be made of rubble stone laid with cement mortar or lime mortar reinforced with cement (cement:lime:sand, 1:2:9, volumetric ratio) and shall have a minimum thickness of 0.50 m. Such walls shall extend at least 0.50 m above ground level.

11.2.2. The minimum depth for foundations shall be not less than 0.80 m. Foundations shall be constructed below the frost depth.

11.2.3. In buildings with basements, basement walls shall have a thickness of 50 cms and foundation walls shall have a thickness of 60 cms. Such walls shall be made of rubble stone laid with cement reinforced lime mortar of 1:2:9 ratio in 1st degree earthquake zones, and with lime mortar of 1:3 ratio in 2nd, 3rd and 4th degree earthquake zones.

11.3. Bearing Walls

11.3.1. Materials

The production or manufacture of adobe clay blocks shall be in conformity with provisions set in "Specification for Masonry Structures".

Adobe brick walls shall be laid with adobe putty used in the manufacture of adobe bricks. The joint between the rubble stone foundation walls and adobe brick walls shall be insulated against moisture.

11.3.2. Wall Thicknesses

11.3.2.1. Basement rubble stone walls, if any, shall have a minimum thickness not less than 50 cms.

11.3.2.2. Exterior and interior bearing adobe brick walls shall have thicknesses not less than 1,5 and 1 adobe brick dimension. Standard adobe brick dimensions shall be 30x25x15 cms or 30x15x15 cms.

11.3.3. Stability of Walls and Openings in Walls

11.3.3.1. Stability

a) The stability of all bearing walls against lateral loads shall be provided by means of walls connecting perpendicularly. The minimum thickness of perpendicular stability walls shall be no less than 1 adobe brick.

b) The free span of the bearing walls, measured centre-to-centre of two consecutive stability walls, shall not exceed 4.50 m.

c) Due care shall be exercised in the construction of chimneys. In the case where the material of the chimney is different from adobe, a construction joint shall be provided. Chimneys made of material other than adobe brick, shall be arranged in such a way so as not to disrupt the continuity of bearing walls.

11.3.3.2. Openings in Walls

a) The minimum width of solid exterior wall between the corner of the building and the nearest window or door opening shall be not less than 1.00 m.

b) The clear distance of the first wall opening to the intersection of a bearing wall with a perpendicular stability wall, in either wall, shall be not less than 0.50 m.

c) Door openings in walls shall be no larger than 1.0x2.10 m. Only one door opening shall be permitted in any bearing or stability wall between two consecutive intersections.

d) Window openings in wall shall be no larger than 0.90x1.40 m.

e) The minimum width of solid wall section between a window and a door opening shall not be less than 60 cms. In the case where this is not possible, two vertical timber elements of 10x10 cm cross section shall be provided on each side of the opening and such elements shall be connected to the window top lintel and to the bond beam below the window.

11.4. Floors

Floors shall be made to bear upon and connected securely to bond beams between foundation or basement walls and adobe brick walls.

11.5. Bond Beams and Lintels

11.5.1. On foundation or basement walls, concrete or timber bond beams of 0.15 m depth and having a width not less than the wall thickness shall be provided. Where the bond beam is made of concrete, the cement content shall be no less than 250 kg/m^2 and the beam shall have longitudinal reinforcement of 4Ø10 bars. Transverse reinforcement of Ø6 stirrups spaced 25 cms on centres shall be provided.

In the case where the bond beam is made of timber, the beams shall consist of two 10x10 cm asphalt treated sections, connected at every 50 cm by a transverse 5x10 cm section nailed to the 10x10 cm sections, and the interior space shall be filled with crushed stone.

11.5.2. In adobe brick walls, timber bond beams, similar to those in section 11.5.1, shall be provided below and above windows, and on walls where roof beams or trusses are to bear.

11.5.3. Bond beams other than base beams, roof bond beams, door and window lintels may be made of bamboo canes in regions where bamboo grows, spaced 5 cms apart and tied together at every 50 cms with a thin wire.

11.6. Roofs

11.6.1. Roofs of adobe buildings shall be made to extend at least 0.50 m beyond exterior walls. Due care shall be exercised in the construction of bearing walls so that the bearing characteristics are not impaired due to external effects.

11.6.2. In 1st and 2nd degree earthquake zones flat earth roofs shall not be constructed on adobe buildings. In 3rd and 4th degree earthquake zones the thickness of the earth layer in the roof shall not exceed 15 cms.

Section 12 - Repairs and Alterations

12.1. Structures damaged by previous earthquakes shall be repaired according to design drawings prepared to provide sufficient strength against future earthquakes, in conformity with the provisions of this specification and approved by the related building authorities.

12.2. Each portion to be newly constructed, altered or repaired in buildings located in earthquake zones and to undergo alteration, expansions or major repair shall be designed and constructed in conformity with the provisions of this specification and in accordance with design drawings approved by the related building authorities.

Section 13 - Method of Analysis for a Seismic Design of Buildings

13.1. Notation

C = Seismic coefficient

C_o = Seismic zone coefficient

D = Dimension of building in metres in a direction parallel to the applied earthquake forces

F = The total lateral force or shear at the base

F_i = Lateral force applied to level "i"

F_t = Concentrated lateral force considered acting at the top of the structure

G_i = Total dead load on "i"th floor

H = Height of the building in metres from foundation base

H_z = Thickness of underlying soil stratum

h_i = Height of "i"th floor above foundation base (metres)

I = Building importance coefficient

K = Coefficient related to structural type

N = Number of storeys in the building

N_{sp} = Number of blows, standard penetrations test

n = Live load factor

P_i = Total live load on "i"th floor

S = Dynamic coefficient for the structure (Spectral Coeff.)

T = Natural period of the building,sec.

T_o = Predominant period of underlying soil stratum, sec.

V_s = Shear-wave velocity, m/sec.

W = Total weight of building

W_i = Weight of "i"th floor.

13.2. General:

13.2.1. This section covers the principles of calculating the lateral forces to be used in the aseismic design of buildings in earthquake zones. Earthquake effects acting on buildings covered by this section shall be considered as lateral static forces applied at each floor level.

Lateral forces shall be assumed to act along the principal axes of the building in each direction, but not simultaneously in both directions. Such forces shall be distributed to the vertical hearing elements in proportion to their stiffnesses.

Where the principal axes of the vertical bearing elements do not lie along the principal axes of the building, the possibility of unfavourable conditions due to skew loading shall be investigated.

13.2.2. Lateral forces, whose principles of calculation are set forth in this section shall be taken as minimum loads acting on the whole of the structure.

13.2.3. In designing the elements, it shall be assumed that the structure is not subject to earthquake and wind loading simultaneously and the more unfavourable of the two loadings shall be considered in the design.

13.3. Definitions and Scope:

13.3.1. In this specification structures shall be considered in two classes as regards their principles of aseismic design are concerned

a) Structures with regular load bearing systems:

Structures where the bearing systems consist of slabs and/or beams with vertical columns, and where columns and shear-walls extend continuously down to the foundation level.

b) Structures with irregular load bearing systems:

Structures not falling within the scope of the definitions given for class (a) structures and structures having discontinuously or irregularly (to distributed) rigidity and mass.

13.3.2. All reinforced concrete or steel frame structures with regular load bearing systems not higher than 75 m above foundation base, all masonry buildings, chimneys, towers and elevated tanks may be designed using the lateral loads stipulated in this section in the absence of a rigorous dynamic analysis.

13.3.3. Where the structure has an irregular load bearing system or the clear height of the structure above the base level exceeds 75 m, such structures shall be designed against earthquakes using an appropriate and rigorous dynamic analysis.

Such analysis shall comprise the complete dynamic properties of both the structure and the underlying soil. Modal superposition method based on real or idealised spectra, integration of the equation of motions with respect to time etc, or experimental model analysis are acceptable methods of solution. However, the total lateral load values calculated as a result of such dynamic analyses shall not be less than 70% of the lateral load values determined using the method of calculation of this section.

13.3.4. The aseismic design calculations of bridges, three dimensional spare structures, gravity type dams, tunnels, underground structures, and of surface load carrying structures such as domes, shell roop and arch dams, are not covered by this specification.

13.3.5. In the calculation of lateral loads acting on structures in accordance with the principles of this specification, four separate soil groups are defined and the characteristics of each group listed in Table 13.1.

13.3.6. Owners of buildings in earthquake risk areas shall permit the installation of the required number of strong motion accelerographs in such buildings as may be designated by the Ministry of Construction and Settlement.

13.4. Calculation of Total Lateral Load:

The total lateral equivalent statical load to be used in the aseismic design of buildings is given by:

$$F = C\ W \qquad (13.1)$$

where C = seismic coefficient, and is to be calculated by

$$C = C_o\ K\ S\ I \qquad (13.2)$$

in which C_o = *seismic zone coefficient*
K = *coefficient related to structural type*
S = *dynamic coefficient for the structure (spectral coefficient)*
I = *building improtance coefficient.*

TABLE 13.1

SOIL CLASSIFICATION TO BE USED IN DETERMINATION OF PREDOMINANT PERIOD OF VIBRATION

Soil Class	Identification	N_{sp} Number of blows standard penetration test	D_r Relative Compaction %	q_u Unconfined compressive strength kg/cm^2	V Shear Wave Velocity m/sec
I	a) Massive volcanic rocks and deep bedrock, undecomposed sound metamorphic rocks, very stiff cemented sedimentary rocks	-	-	-	
	b) Very dense sand	>50	85-100	-	>700
	c) Very stiff clay	>32	-	>4.0	
II	a) Loose magmatic rocks such as tuff or agglomerate, decomposed sedimentary rocks with planes of discontinuity	-	-	-	
	b) Dense sand	30-50	65-85	-	400-700
	c) Stiff clay	16-32	-	2.0-4.0	
III	a) Decomposed metamorphic rocks and soft, cemented sedimentary rocks with planes of discontinuity	-	-	-	
	b) Medium dense sand	10-30	35-64	-	200-400
	c) Medium stiff clay, silty clay	8-16	-	1.0-2.0	
IV	a) Soft and deep alluvial layers with a high water-table, marshland or ground recovered from sea by mud-fill, all fill layers	-	-	-	
	b) Loose sand	0-10	≤ 35	-	< 200
	c) Soft clay, silty clay	0-8	-	≤ 1.0	

13.4.2. The seismic zone coefficient, C_o, is given below, in Table 13.2:

TABLE 13.2

VALUES OF SEISMIC ZONE COEFFICIENT

Seismic Zone	C_o
1	0.10
2	0.08
3	0.06
4	0.03

13.4.3. The values of K, structural type coefficient, are given in Table 13.3.

TABLE 13.3.

STRUCTURAL COEFFICIENT

Structure Type		K
All building framing systems except as hereinafter classified		1.00
Buildings with box systems with shear-walls		1.33
Buildings with frame systems where the frame resists the total lateral force (see note (2) for filler-wall types a, b and c).		
1. Ductile moment resisting frames (1) (steel or reinforced concrete)	a)	0.60
	b)	0.80
	c)	1.00
2. Non-ductile moment resisting frames	a)	1.20
	b)	1.50
	c)	1.50
3. Steel space frames with diagonal bracing	a)	1.33
	b)	1.50
	c)	1.60
Shear-wall systems with ductile frames capable of resisting at least 25% of the total lateral forces	a)	0.80
	b)	1.00
	c)	1.20
Masonry buildings		1.50
Elevated tanks not supported by a building		3.00

cont'd.

Structure Type	K
Structures other than buildings, towers and chimney stacks	2.00

Notes: 1) See section 6.2 for the definition of "ductile frames"

2) Filler-wall types:

a) Reinforced concrete or partition walls of masonry blocks with horizontal and vertical reinforcement.

b) Unreinforced masonry block partition walls

c) Light and sparse partition walls or prefabricated concrete partition walls.

13.4.4. The spectral coefficient shall be calculated by:

$$S = \frac{1}{|0.8 + T - T_o|} \qquad (13.3)$$

where T = Natural period of the structure in the first mode (sec)
T_o = Predominant period of underlying soil (sec).

The value of S calculated by Eq. (13.3) shall not be taken larger than 1.0 (*)

Note: In all one or two storey buildings the value of S shall be taken as 1.0 and the structural coefficient K shall be not less than 1.0. In masonry buildings S shall be taken as 1.0.

13.4.5. Unless calculated by experimental or theoretical methods, based on valid assumptions, the value of T, the natural period of the structure, shall be calculated by both of the following approximate relations;

$$T = \frac{0.09\ H}{\sqrt{D}} \qquad (13.4)$$

$$T = (0.07 - 0.10)N^{**} \qquad (13.5)$$

and the less favourable value of T shall be used in Eq. (13.3). In Eqs. (13.4) and (13.5)

(*) Curves obtained from Eq. (13.3) are plotted in Fig. (13.1).

(**) The value of the coefficient for Eq. (13.5) shall be determined by interpolation between the values 0.07 and 0.10 according to the degree of general structural flexibility.

H = height of structure above base level (metres)
D = dimension of building in a direction parallel to the applied lateral forces (metres)
N = number of storeys above foundation level.

Note: Eqs. (13.4) and (13.5) shall not apply to; industrial structures with large spans, cinemas, sport halls and stadiums, etc., buildings with regular bearing systems but with a height more than 35.0 m above foundation level, chimney stacks, towers, elevated tanks. The natural periods of such structures shall be calculated through a rigorous dynamic analysis where the properties of the soil and the structure (soil-structure interaction) are taken into consideration.

13.4.6. Unless determined by experimental, empirical or theoretical principles based on valid assumptions and geological observations, the value of T_o may be selected from Table 13.4. These values are valid only for the case where the top layer of soil directly above bed-rock or other formations with similar characteristics has a thickness of the order of 50.0 m. Where the thickness of the top layer of soil is greatly different than 50 m, the values of the shear-wave velocity, V_s (m/sec) and the thickness of the top layer, H_z, (metres) shall be determined more accurately by experimental, empirical or theoretical methods. In this case, the value of T_o shall be calculated by the equation $T_o = 4H_z/V_s$. Where the value of V_s cannot be determined accurately for use in the formula given above, the values of V_s given in Table 13.1 may be used.

Where the underlying soil consists of a number of layers with different values of V_s, a separate value of T_o shall be calculated for each and every layer.

Soils that have a V_s value larger than 700 m/sec shall be assumed to be very sound and layers below the depth where this value is exceeded shall not be taken into consideration.

TABLE 13.4

Soil	Class	T_o Predominant Period of soil (sec)	T_o Average (sec)
I	a b c	0.20 0.25 0.30	0.25
II	a b c	0.35 0.40 0.50	0.42
III	a b c	0.55 0.60 0.65	0.60
IV	a b c	0.70 0.80 0.90	0.80

Note: For structures defined below; appropriate and sufficient seismic and subsoil exploration along with laboratory experiments shall be carried out for the accurate solution of soil related problems such as foundation type, bearing capacity and settlements, and also to be able to determine as realistically as possible the predominant period of vibration of the soil layer.

i) Buildings having a height more than 75 meters above foundation level

ii) Industrial structures with large spans, buildings such as theatres, cinemas

iii) Towers, chimney stacks, elevated tanks etc.

13.4.7. The structure importance coefficient I is given in Table 13.5.

TABLE 13.5

STRUCTURE IMPORTANCE COEFFICIENT

Structure Type	I
a) Structures and buildings to be used during or immediately after an earthquake (Post office, fire stations, broadcasting buildings, power stations, hospitals, stations and terminals, refineries, etc.)	1.50
b) Buildings housing valuable and important items (museums, etc.)	1.50
c) Buildings and structures of high occupancy (schools, stadiums, theatres, cinemas, concent halls, religious temples, etc.)	1.50
d) Buildings and structures of low occupancy (private dwellings, hotels, office buildings, restaurants, industrial structures, etc.)	1.00

13.4.8. The value of the seismic coefficient shall in no case be taken less than $C_o/2$.

13.4.9. The total structure weight to be used in the calculation of the total lateral load shall be calculated by

$$W = \sum_{i=1}^{N} W_i \qquad (13.6)$$

where, W_i, weight of "i"th floor, is given by:

$$W_i = G_i + nP_i \qquad (13.7)$$

in which, G_i = total dead load on "i"th floor
P_i = total live load on "i"th floor.

The values of n, the live load factor, are given below in Table 13.6:

TABLE 13.6

LIVE LOAD FACTOR

Type of Structure	n
Warehouses, etc.	0.80
Schools, student housing buildings, stadiums, cinemas, theatres, concert halls, garages, restaurants, commercial establishments, etc.	0.60
Private dwellings, hotels, hospitals, office buildings, etc.	0.30

13.5. Vertical Distribution of Lateral Loads:

13.5.1. Lateral loads F_i to be applied at floor levels of the structure shall be calculated by the relation:

$$F_i = (F - F_t) \frac{W_i h_i}{\Sigma W_i h_i} \qquad (13.8)$$

in which F = total lateral load (base shear)
W_i = weight of "i"th floor
h_i = elevation of "i"th floor above foundation level
F_t = concentrated lateral load acting at the top of the structure.

The value of F_t shall be calculated as follows:

$$F_t = 0.004\ F(H/D)^2 \tag{13.9}$$

Note: 1) The value F_t shall in no case exceed $0.15F$

2) Whenever the ratio H/D is equal to or smaller than 3, then F_t may be assumed as zero

i.e. for $H/D \leq 3$, $F_t = 0$

13.5.2. For tall structures such as towers, chimney stacks, the total height of the structure may be subdivided into a sufficient number of portions whereby Eqs. (13.8) and (13.9) become applicable.

13.5.3. For elevated tanks, the value of C as calculated by Eq. (13.2) shall be not less than 0.12 nor greater than 0.25, and the total lateral load shall be assumed to act as a single load at the centre of gravity of the tank.

13.6. Horizontal Torsional Moment:

Buildings shall be designed to resist torsional moments due to an eccentricity in each direction calculated as the difference between the centres of mass and stiffness of any floor, plus 5% of the largest plan dimension of the building perpendicular to the direction of the lateral loads.

13.7. Parts and/or Portions of Buldings:

Earthquake loads acting on parts and/or portions of buildings such as parapet walls, chimneys, cantilever parts, and balconies shall be calculated separately. In these calculations the coefficient C as determined for the structure by Eq. (13.2) shall be increased threefold and the lateral load F, determined by Eq. (13.1) shall be assumed to act at the centre of gravity of the part or portion in the more unfavourable direction.

13.8. Allowable Stresses:

13.8.1. In the aseismic design of sections the allowable stresses for concrete and steel may be increased by not more than 33%.

13.8.2. In reinforced concrete structures an increase in bond stresses shall not be permitted. In steel structures allowable stresses for all connections and joints shall not exceed the values for increased allowable stresses. The same shall apply to the design of diagonal wind bracing and stability members.

13.8.3. Whenever the effects of earthquake are considered, the allowable bearing pressures for subsoils may be increased by not more than 33% in soils of class I, II and III. No such increase shall be permitted for class IV soils.

13.8.4. Where the top layer of soil is of class II, III or IV soil, possible settlements and/or differential settlements due to seismic vibrations should be determined in addition to those settlements due to static loads, so as to be incorporated into the calculations.

13.8.5. In foundations bearing directly on class IV soils no increase in allowable stresses for concrete and reinforcing steel shall be permitted.

13.9. Retaining Walls and Sheet-pile Walls:

13.9.1. For the design of retaining walls and sheet-pile walls in earthquake zones with heights in excess of 6.00 m, the characteristics of the soil shall be determined by appropriate laboratory and field testing.

13.9.2. In the calculation of earth pressure, the angle of shear strength shall be decreased by;

6^{o} in 1st and 2nd degree earthquake zones,
4^{o} in 3rd and 4th degree earthquake zones.

Section 14 - Miscellaneous Provisions

14.1. All sections of this specification shall be considered to be interrelated. Furthermore, Part III, "Protection Against Earthquakes" shall be applied in conjunction with Section 4, "Protection Against Fire".

14.2. "Specifications for Buildings to be Built in Disaster Areas" as published in the official gazette No. 12801 on 16/1/1968, is no longer in effect.

14.3. This specification shall be effective as of 9/8/1975.

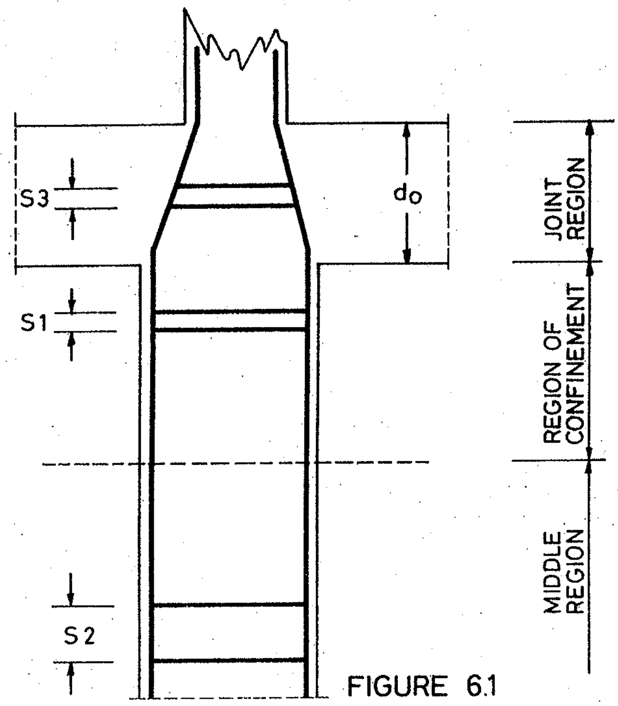


FIGURE 6.1

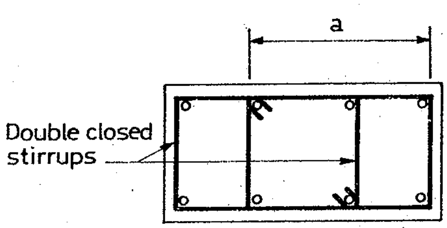


FIGURE 6.2 a

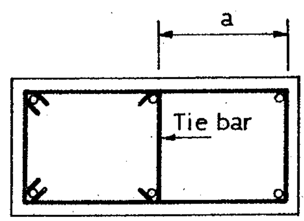


FIGURE 6.2 b

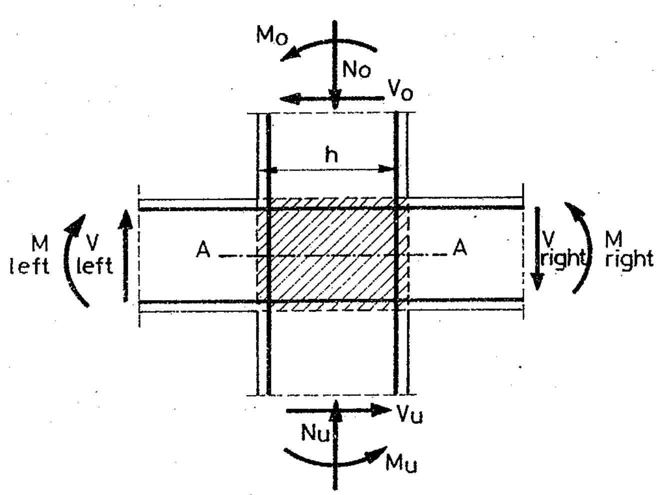


FIGURE 6.2 c

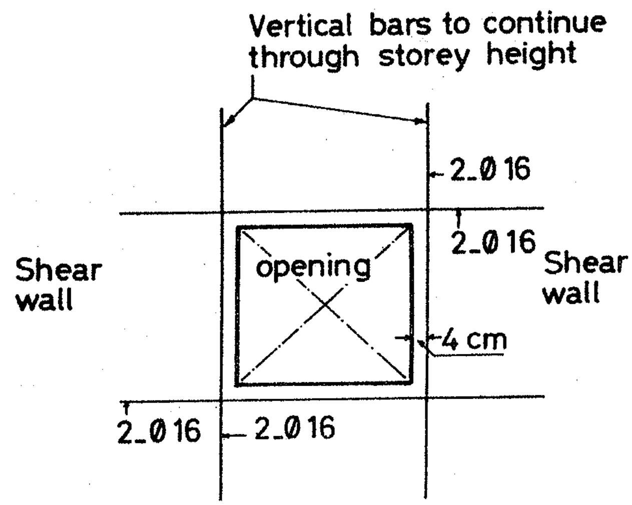


FIGURE 6.3

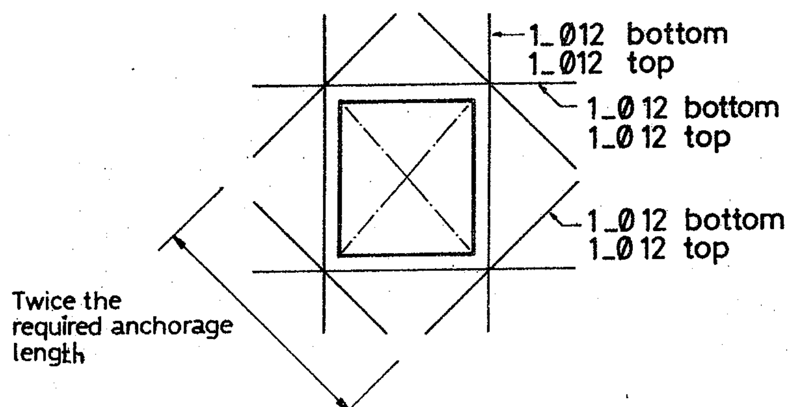


FIGURE 6.4

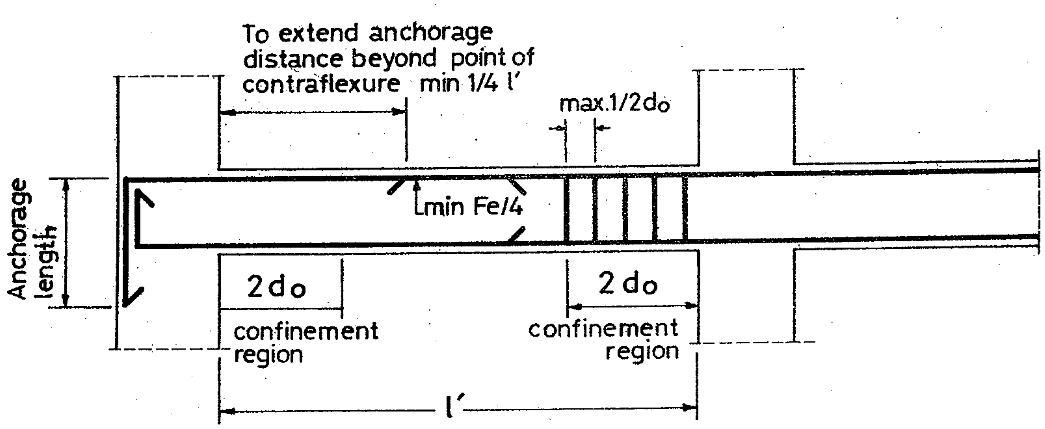


FIGURE 6.5

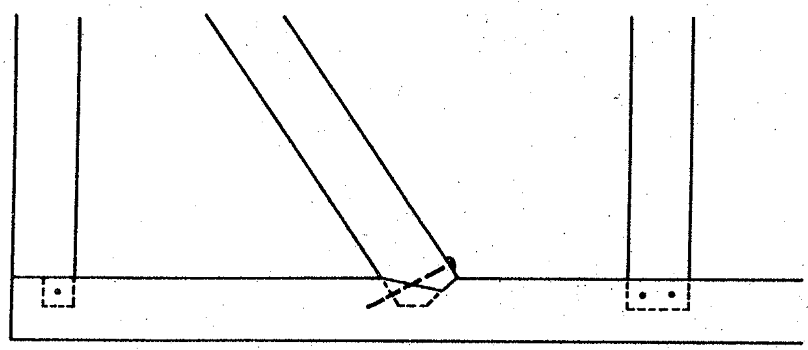
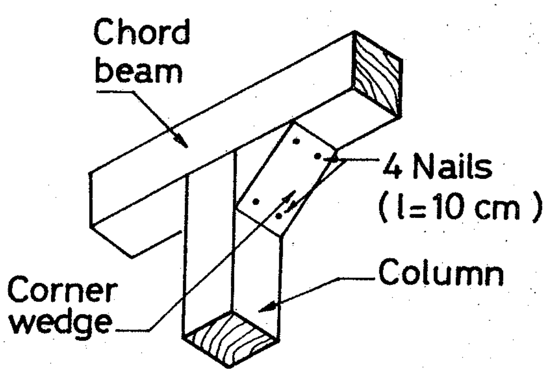


FIGURE 8.1



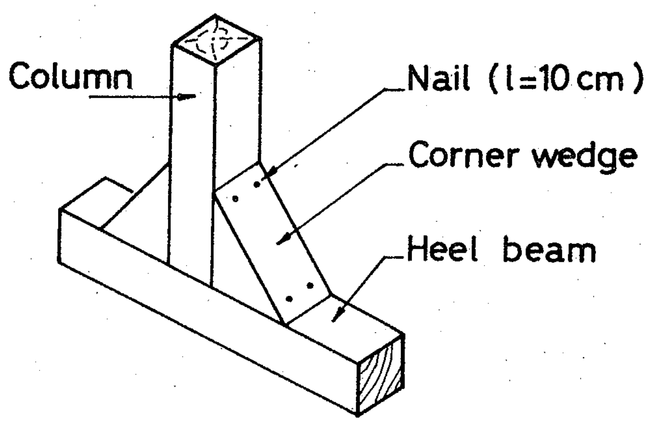


FIGURE 8.2

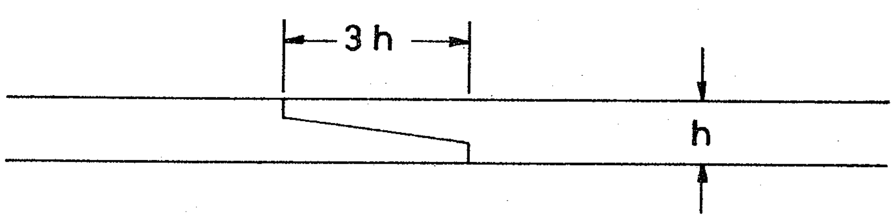
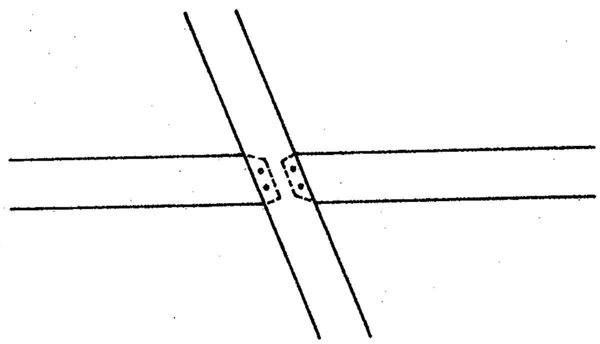


FIGURE 8.3



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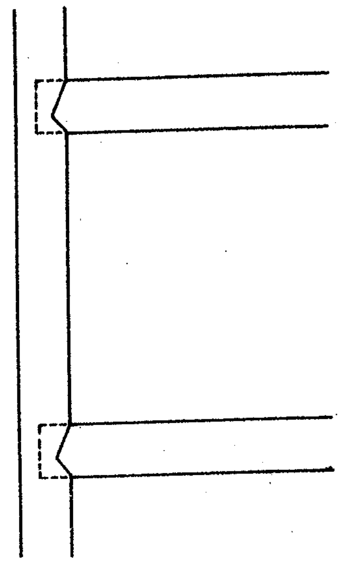

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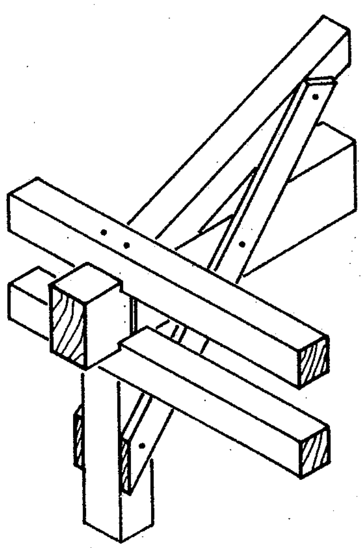


FIGURE 8.6

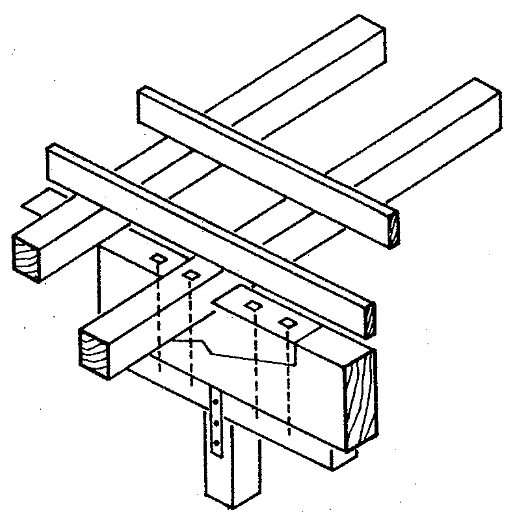
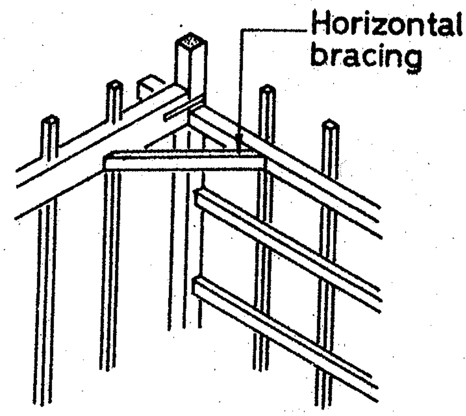


FIGURE 8.7



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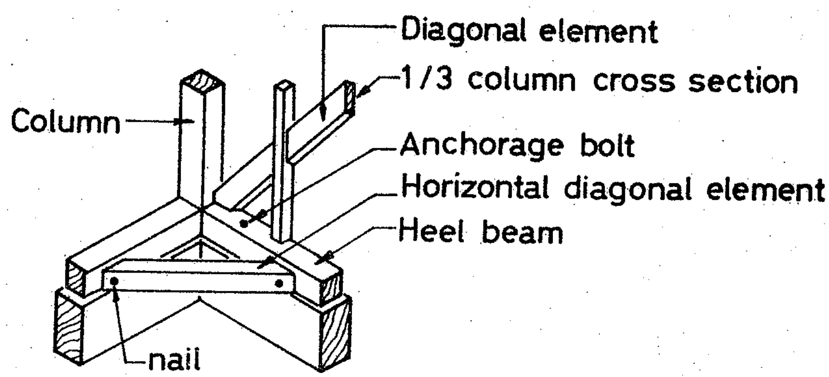

FIGURE 8.9

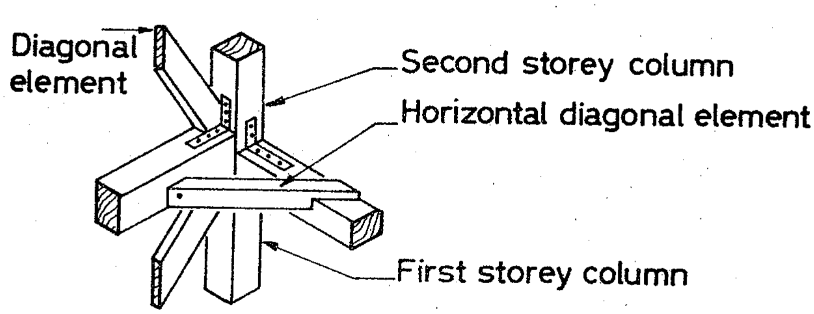

FIGURE 8.10

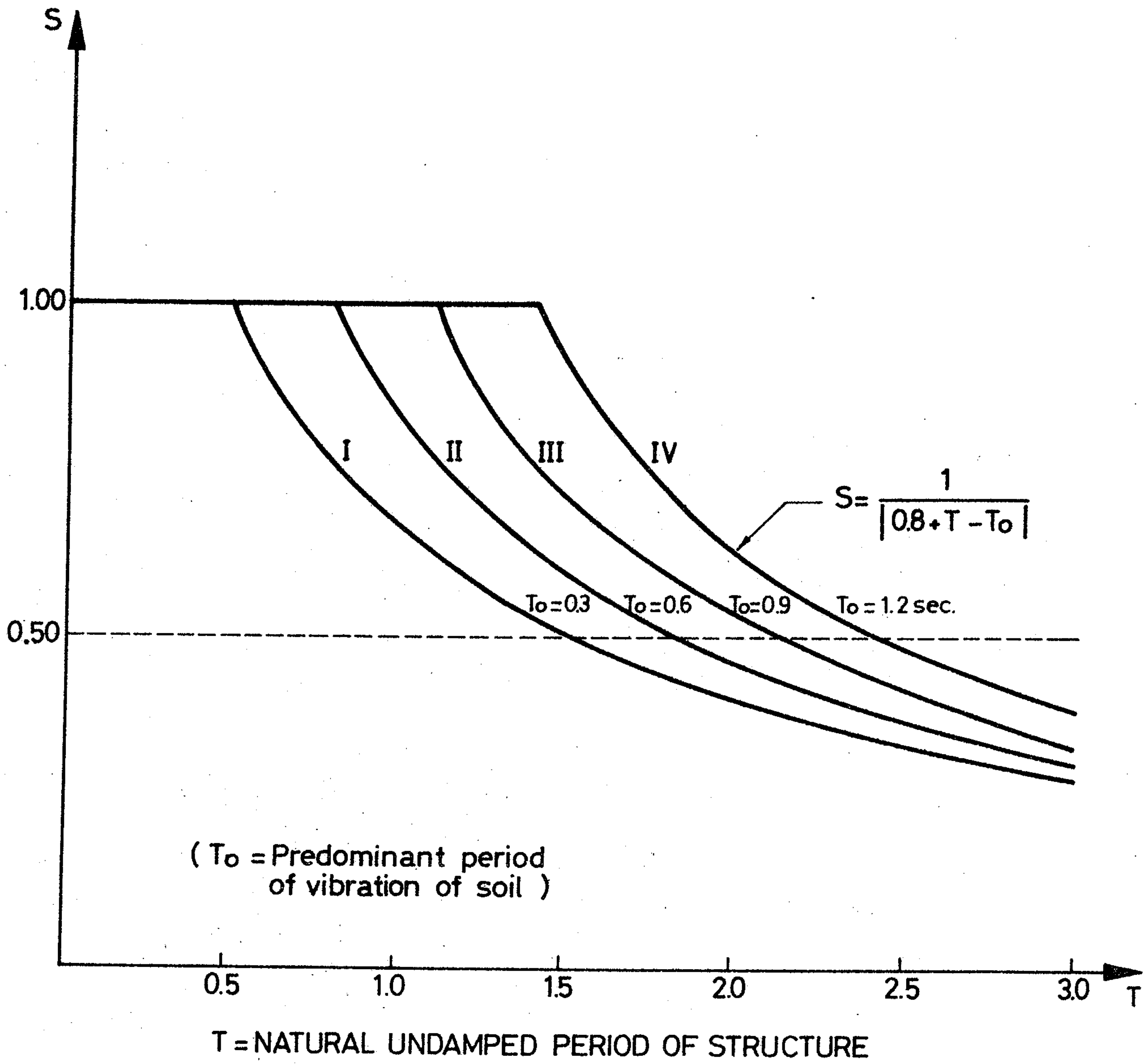
S
1.00
0.50
I
II
III
IV
S= 1 / |0.8+T -To|
To=0.3
To=0.6
To=0.9
To=1.2 sec.
(To = Predominant period of vibration of soil)
0.5
1.0
1.5
2.0
2.5
3.0
T
T = NATURAL UNDAMPED PERIOD OF STRUCTURE

FIGURE 13.1