National Standard
of the People’s Republic of China
中华人民共和国国家标准

Code for Seismic Design of Buildings

建筑抗震设计规范

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NOTICE

The code is written in Chinese and English. The Chinese text shall be taken as the ruling one in the event of any inconsistency between the Chinese text and the English text.
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Chapter 1  General

1.0.1 This code is prepared for the purpose of carrying out "The Law of Construction of People’s Republic of China" and "The Law of Earthquake-prevention and Disaster Mitigation of People’s Republic of China", and carrying out the policy of giving priority to the prevention of earthquake disasters. So that, when the buildings are made earthquake-fortification, the damages to buildings, loss of life and economic losses will be mitigated.

The seismic fortification objective of buildings, which designed and detailed in accordance with the requirements of this code, as follows:

When the place is subjected to frequently earthquake influence which intensity is lower than the local fortification intensity, the buildings will not be damaged or only slightly damaged, with continued service without repair.

When the place is subjected to local fortification intensity earthquake influence, the buildings will be damaged, with continued service after ordinary repair or without repair.

When the place is subjected to rarely earthquake influence which intensity is expected to higher than the local fortification intensity, the buildings will not collapse nor suffer damage that would endanger human lives.

1.0.2 Every building, which is situated on zones of fortification intensity 6 or above, must be designed to resist the effects of earthquake motions.

1.0.3 The design of seismic ordinary buildings and seismically isolated structures, which are situated on the zone of fortification intensity 6 to 9, shall be in accordance with this code.

When buildings are situated on zone where the fortification intensity is greater than 9, and/or industry buildings with specific professional requirements, the corresponding design of these buildings shall be in accordance with special provisions.

Note: The "fortification intensity" hereinafter usually referred as "intensity". For example, fortification intensity 6, 7, 8 and 9 is referred as intensity 6, 7, 8 and 9 respectively.

1.0.4 Fortification intensity of a region must be determined by documents (or maps) published by the authorized central government agency.

1.0.5 Normally, the local fortification intensity may be adopted the seismic basic intensity as provided in "the China Seismic Ground Motion Parameter Zonation Map" (or the intensity values corresponding to the design basic seismic acceleration in this code). If cities where a seismic fortification zonation has been drawn up, the approval fortification intensity or design ground motion parameters may be adopted.

1.0.6 Seismic design based on this code shall also be coordinated with provisions specified in other current compulsory design codes concerned.
Chapter 2 Definitions and notations

2.1 Definitions

2.1.1 Seismic Fortification Intensity
The seismic intensity approved by State authority, which is used as the basis for the seismic fortification of buildings in a certain region.

2.1.2 Seismic Fortification Criterion
The rule for judging the seismic fortification requirements, which depends on the seismic fortification intensity and importance of the building’s using functions.

2.1.3 Earthquake Action
The structural dynamic action due to earthquake, including horizontal seismic action and vertical seismic action.

2.1.4 Design Parameters of Ground Motion
The seismic acceleration time-history curve, the response spectrum of acceleration, and the peak value acceleration used in seismic design.

2.1.5 Design Basic Acceleration of Ground Motion
The design value of seismic acceleration, that exceeding probability is 10% during the 50-years reference period.

2.1.6 Design Characteristic Period of Ground Motion
The period value corresponding to the starting point of reduced section of seismic influence coefficient curve, which describes the earthquake magnitude, the distance of epicenter and the site-classes etc.

2.1.7 Site
An area of a building group, usually it has similar characteristic in response spectrum. Its scope approximately equivalent to a factory area, a living quarter, a village or a plain area no less than 1.0km².

2.1.8 Seismic Concept Design of Buildings
The process of making the general arrangement for the architectures and structures and of determining details, that based on the design fundamental principles and the ideas obtained from past experiences in earthquake disaster prevention and the constructional project.

2.1.9 Seismic Fortification Measures
The seismic design contents except seismic action calculation and member resistance calculation, and details of seismic design included.

2.1.10 Details of Seismic Design
All of detailed requirements, which are determined according to seismic concept design of buildings and no calculation is necessary.

2.2 Main Notations

2.2.1 Actions and effects

- $F_{Ek}, F_{Ehk}$ — characteristic value of total horizontal and vertical seismic action of structure respectively.
- $G_E, G_{eq}$ — representative value of gravity load of structure (or member) and the total equivalent gravity load of a structure in earthquake respectively.
- $w_k$ — characteristic value of wind load.
- $S_E$ — seismic effect (bending moment, axial force, shear, stress and deformation).
- $S$ — base combination of seismic effect and other load effects.
- $S_k$ — effect corresponding to characteristic value of action or load.
- $M$ — bending moment.
- $N$ — axial force.
- $V$ — shear.
- $p$ — compression on bottom of foundation.
- $u$ — lateral displacement.
- $\theta$ — rotation of story draft.

2.2.2 Resistance and Material Properties

- $K$ — stiffness of structure (or member).
- $R$ — resistant capacity of structural member.
- $f, f_k, f_e$ — design value, characteristic value and seismic design value of material strength (bearing capacity of subsoil included) respectively.

- $[\theta]$ — allowable rotation of story draft.

2.2.3 Geometric Parameters

- $A$ — cross-sectional area of structural member.
- $A_s$ — cross-sectional area of reinforcement.
- $B$ — total width of structure.
- $H$ — total height of structure, or column height.
- $L$ — total length of structure (or structural unit).
- $a$ — distance.
- $a_s, a_s'$ — distance from near extreme fiber of section to the point for resultant of force of all longitudinal reinforcement in tension and compression respectively.
- $b$ — width of cross section of member.
$d$—depth or thickness of soil, or diameter of reinforcement.

$h$—height of story, or height of cross section of member i.e. depth of member.

$l$—length or span of member.

$t$—thickness of seismic structural-wall or slab.

2.2.4 Coefficients of Calculation

$a$—horizontal seismic influence coefficient.

$a_{\text{max}}$—maximum value of horizontal seismic influence coefficient.

$a_{\text{vmax}}$—maximum value of vertical seismic influence coefficient.

$\gamma_G, \gamma_E, \gamma_w$—partial factor of gravity, earthquake and wind load respectively.

$\gamma_{RE}$—seismic adjusting factor for bearing capacity of member.

$\xi$—calculation factor.

$\eta$—amplification factor or adjusting factor of seismic effect (inner force or deformation).

$\lambda$—slenderness ratio of member, or proportional factor.

$\xi_y$—yield strength coefficient of structure (or members).

$\rho$—reinforcement ratio or ratio.

$\varphi$—stability factor of compressive member.

$\psi$—combination value coefficient, or effect factor.

2.2.5 Others

$T$—natural period of structure.

$N$—penetration resistance (in blow number).

$I_{LE}$—liquefaction index of subsoil under earthquake.

$X_{ji}$—mode coordinate of displacement (relative displacement of mass $i$-th of
mode $j$-th in the $x$ direction).

$Y_{ji}$—mode coordinate of displacement (relative displacement of mass $i$-th of
mode $j$-th in the $y$ direction).

$n$—total number, such as number of stories, masses, reinforcement bars, spans etc.

$u_{se}$—equivalent shear-wave velocity of soil.

$\Phi_{ji}$—mode coordinate of rotation (relative rotation of mass $i$-th of mode $j$-th
around the $z$ axial direction).
Chapter 3  Basic requirements of seismic design

3.1  Classifications of seismic fortification and corresponding criterion

3.1.1  Every building shall be classified, according to the importance of their using functions, as a seismic fortification category A, B, C or D defined as follows:

    Category A buildings are those, major buildings or the failure of which would result in severe secondary disaster.

    Category B buildings are those which the continual function is necessary during earthquake or could be restored quickly after earthquake.

    Category C buildings are those not assigned to either category A, B or D buildings.

    Category D buildings are those less important buildings.

3.1.2  Each building shall be assigned to a fortification category in accordance with the current national standard “Standard for seismic fortification classification of buildings” GB 50223.

3.1.3  Fortification categories are used in this code to determine fortification criterion as follows:

    1  For buildings assigned to category A, the earthquake action of which shall be higher than that of the local fortification intensity, that values shall be determined based on the site seismic safety appraisal results. When the fortification intensity is 6 ~ 8, the seismic measures shall be one grade higher than that of the local fortification intensity; However, the seismic measures shall be appropriately higher than that of fortification intensity 9, where zones belong to fortification intensity 9.

    2  For buildings assigned to category B, the earthquake action of which shall be adopted as local fortification intensity. Normally When the fortification intensity is 6 ~ 8, the seismic measures shall be one grade higher than that of the local fortification intensity; However, the seismic measures shall be appropriately higher than that of fortification intensity 9, where zones belong to fortification intensity 9. And the seismic measures for foundation shall comply with relevant provisions.

      For smaller buildings assigned to category B, only when their structural system changed into that with higher seismic capability, it is permitted to take seismic measures as that of local fortification intensity.

    3  For buildings assigned to category C, the earthquake action and seismic measures shall be take as that of local fortification intensity.

    4  For buildings assigned to category D, the earthquake action shall be take as that of local fortification intensity, and the seismic measures shall be appropriately lower than
that of local fortification intensity. However, seismic measures cannot be lowered where zones belong to fortification intensity 6.

3.1.4 If the buildings assigned to fortification category B, C and D are situated on zone where the fortification intensity is 6, except as specified in this code, earthquake action is permitted not to be calculated.

3.2 Seismic influences

3.2.1 The seismic influence for the buildings situated region shall be described by using the design basic acceleration of ground motion and design characteristic period of ground motion, or by using the design ground motion parameters as indicated in Clause 1.0.5 of this code.

3.2.2 The corresponding relationship between the fortification intensity and the design basic acceleration of ground motion as indicated in Table 3.2.2. Where the design basic acceleration of ground motion is 0.15g and 0.30g, except as specified in this code, the seismic design of buildings shall be adopted as that of fortification intensity 7 and 8 respectively.

<table>
<thead>
<tr>
<th>Fortification intensity</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design basic acceleration of ground motion</td>
<td>0.05g</td>
<td>0.10 (0.15)g</td>
<td>0.20 (0.30)g</td>
<td>0.40g</td>
</tr>
</tbody>
</table>

Note: g is the gravitational acceleration.

3.2.3 The design characteristic period of ground motion shall be determined according to the design earthquake groups and Site-classes of location of each building. For Site-class II, the design characteristic period of ground motion for 1st, 2nd, and 3rd design earthquake group shall be taken as 0.35s, 0.40s and 0.45s respectively.

Note: The "design characteristic period of ground motion", hereinafter reference as "characteristic period".

3.2.4 The values of fortification intensity, design basic acceleration of ground motion and design earthquake groups for main cities and towns in China may be indicated in Appendix A of this code.

3.3 Site and subsoil

3.3.1 When selecting a construction place, a comprehensive assessment classified as favorable plat, unfavorable plat or hazardous plat to seismic fortification shall be made, according to seismicity of the region, and the geotechnical and geological data of site dependent to necessities of project. The favorable plats to seismic fortification shall be selected, while unfavorable plats shall be avoided except appropriate seismic measures have been taken. The buildings assigned to Fortification Category A, B and C. shall not be construct-
ed on the hazardous plats.

3.3.2 Only the construction field belong to Site-class I, the seismic designed details is permitted taken as follows:

For building assigned to Fortification Category A or B, seismic detail requirements could be taken as that for local fortification intensity.

For building assigned to Fortification Category C, seismic detail requirements could be taken as that for intensity of one grade lowers than local fortification intensity, but shall not be reduced for local fortification intensity 6.

3.3.3 When design basic acceleration of ground motion is 0.15g and 0.30g, while construction field assigned to Site-class III or IV, except as specified in this code, the seismic designed details should be taken as that of fortification intensity 8 (0.20g) and 9 (0.40g) respectively.

3.3.4 Design requirement of subsoil and foundation shall be as follows:

1 Foundation of same structural unit should not be posed on subsoil with entirely different characteristics.

2 Foundation of same structural unit should not consist of partly natural subbase and partly pile foundation.

3 For base-soil with layers consisted of soft clay, liquefied soil, recently back-filled soil, or soil with extremely non-uniform distribution, differential settlement and/or other harmful impact under earthquake shall be calculated in design and corresponding measures shall be taken.

3.4 Regularity of architectural design and structural design

3.4.1 The architectural design shall be made in accordance with the requirements of seismic concept design of buildings, a seriously irregular design scheme of building shall not be adopted.

3.4.2 The plan arrangement of architecture and lateral-force-resisting members should be regular and symmetrical, and shall have good integrity. The configuration and elevation of building should be regular, the lateral stiffness of structure should be changed equably, and the cross-sectional dimensions and its material strength of vertical lateral-force-resisting members should be reduced along whole structure from lower part to upper part gradually, to avoid sudden change in stiffness and bearing capacity of lateral-force-resisting system of the structure.

Buildings having one or more of the features listed in Table 3.4.2-1 shall be designated as having plan structural irregularity, buildings having one or more of features listed in Table 3.4.2-2 shall be designated as having vertical structural irregularity. Their design shall comply with the requirements in Clause 3.4.3 of this code.
Table 3.4.2-1 Plan structural irregularities

<table>
<thead>
<tr>
<th>Type of irregularity</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torsion irregularity</td>
<td>Maximum story displacement or story drift, computed including accidental torsion, at one end of structure transverse to an axis is more than 1.2 times the average of the story displacement or story drift at two ends of the structure respectively, when diaphragms are not flexible</td>
</tr>
<tr>
<td>Re-entrant corners irregularity</td>
<td>Both projections of the structure beyond a re-entrant corner greater than 30% of the plan dimension of the structure in the given direction</td>
</tr>
<tr>
<td>Diaphragm discontinuity</td>
<td>Diaphragms with abrupt discontinuities or variations in stiffness, including those having cutout or open areas greater than 30% of the gross enclosed diaphragm area, or effective width less than 50% of total width of diaphragm, or more distinct from one floor slab to other at same story</td>
</tr>
</tbody>
</table>

Table 3.4.2-2 Vertical structural irregularities

<table>
<thead>
<tr>
<th>Type of irregularity</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiffness irregularity</td>
<td>The lateral stiffness is less than 70% of that in the story or less than 80% of the average stiffness of the three stories above; the horizontal dimension less than 75% that of next story lower, except top story of building</td>
</tr>
<tr>
<td>Discontinuity in vertical anti-lateral-force members</td>
<td>The internal forces of vertical lateral-force-resisting members (columns, structural walls and braces) transfer to lower those members by using the horizontal transmission member (girders or trusses)</td>
</tr>
<tr>
<td>Discontinuity in bearing capacity</td>
<td>The story lateral shear capacity is less than 80% that of next story above. The story lateral shear capacity is the total capacity of anti-lateral-force members sharing the story for the direction under consideration</td>
</tr>
</tbody>
</table>

3.4.3 For the irregular structure, the analysis of horizontal seismic action and internal force adjustment of structure shall comply with the following requirements, and the effective seismic designed details of weak point shall be taken.

1 For plan irregular and vertical regular structure, the three-dimensional computed model shall be adopted, and comply with the following requirements:

1) Structure having torsion irregularity shall calculate the torsion effects, and the maximum story displacement or story drift at one end of structure transverse to an axis should not be more than 1.5 times the average of the story displacement or story drift at two ends of structure respectively;

2) Structure having re-entrant corner irregularity or diaphragm discontinuity shall calculate the possible deformation in plane of diaphragm and torsion effects where torsion irregularity exist also.

2 For vertical irregular and plan regular structure, the three-dimensional computed model shall be adopted, the seismic shear forces of weak stories shall be increased by factor 1.15, the elasto-plastic deformation analysis shall be made as required by this code, and
comply with following requirements:

1) Vertical lateral-force-resisting member having discontinuity, its seismic internal force shall be increased by factors 1.25 to 1.5 to transfer on the horizontal transmission members;

2) Story capacity having abrupt discontinuity, the shear capacity of weak story shall not be less than 65% that of next story above.

3) The structure having plan and vertical irregularities shall comply with every requirements in point 1 and 2 of this Clause.

3.4.4 For masonry structures and single-story factory buildings, the plan and vertical irregularity shall comply with requirement in relevant chapters and sections of this code respectively.

3.4.5 The structures having complicate shapes or extreme irregular plan and elevations, isolation joints may be installed in appropriate point according to actual condition, to divide into some regular lateral-force-resisting structural units.

3.4.6 The width of isolation joint shall be enough large which is determined in accordance with seismic fortification intensity, the structural material, the structure system, the height and its difference of structural units; and two structural units divided by isolation joint shall be separated completely.

When the expansion joints or settlement joints have been installed, their width shall satisfy the requirements for isolation joints.

3.5 Structure system

3.5.1 The seismic structure system of a building shall be determined through comprehensive analysis for technical and economic conditions considering the following factors: fortification categories, fortification intensity, building height, site conditions, subsoil, structural material, and construction technology.

3.5.2 Seismic structure system shall comply with the following requirements:

1) The system shall have a clear computed model and reasonable transferred ways for seismic action.

2) The system shall have an ability to avoid loss of either seismic capacity or bearing gravity capacity of whole structure, that due to damage to some structural members or components.

3) It shall be provided with necessary seismic bearing capacity, adequate deformability, and better energy dissipation ability.

4) Some measures shall be taken to enhance earthquake resistance capacity of weak points.

3.5.3 Seismic structure system should also comply with the following requirements:

1) It should be installed with seismic multiple-defense lines.
2 It should be provided with reasonable distribution of stiffness and bearing capacity, to avoid existed weak point due to local weakening or abrupt changes so that the great concentrate of stress or deformation may be produced at weak points.

3 The dynamic characteristics of the structure in two principal axial directions should be similar.

3.5.4 The structural members shall comply with following requirements:

1 The masonry members shall be installed with the reinforced concrete ring-beams, tie-columns and core-columns in accordance with relevant provision, or shall be adopted with reinforced masonries.

2 The concrete members shall be selected with reasonable dimensions and be arranged with longitudinal bars and hoops, to avoid the shear failure occurring before flexural failure, the concrete crush occurring before reinforcements yielded, and the anchorage and cohesion failure of reinforcements occurring before member damaged.

3 In prestressed concrete members, sufficient non-prestress steel bars shall be arranged.

4 The steel members shall be controlled with reasonable dimensions to avoid the local instability or whole instability of members.

3.5.5 The connections of seismic structures shall comply with the following requirements:

1 The failure of connected nodes of members shall not occur before that of members it connects.

2 The anchorage failure of embedded parts shall not occur before that of members it connects.

3 The connections of prefabricated structures shall ensure the integrality of the structure.

4 Prestressing tendons of prestressed concrete members should be anchored at the exterior face of the core of joint or beyond.

3.5.6 The seismic bracing system of single-story fabricated factory shall ensure the stability of whole structure during an earthquake.

3.6 Structure analysis

3.6.1 The analysis for internal force and deformation of building structures under frequently earthquake shall be carried out, except otherwise provision in this code. In these analysis, it may be assumed that the structures and its members are working at elastic state, so the internal force and deformation may be calculated with the linear static /dynamic analyzing method.

3.6.2 For structures having irregularity and existing weak locations that may result in serious seismic damage, the elasto-plastic deformation analysis under rarely earthquake shall
be carried out according to relevant provisions of this code. In these analysis, the elasto-
plastic static analyzing method or elastic-plastic time-history analyzing method may be
adopted depending on the structural characteristics.

When there are specific provisions of this code, the simplified methods analyzing elasto-
plastic deformations of the structures may be adopted also.

3.6.3 When the gravity additional bending moment due to seismic story drift is greater
than 10% of original bending moment, the secondary effect of gravitation shall be taken into
consideration.

Note: the gravity additional bending moment is the product by the total gravity load at and above this story
and story drift; the original bending moment is the product by the seismic story shear and story
height of the building.

3.6.4 In seismic analysis, the floor and roof shall be assumed as the rigid, semi-rigid or
flexible diaphragm depending on deformation in slab plan, then the interaction behavior be-
tween lateral-force-resisting members may be determined by using above assumption, and
then, the seismic internal forces of these members may be obtained.

3.6.5 The structure having rigid diaphragms and nearly symmetric distribution of masses
and stiffness, as well as the structure with specific provisions of this code, may adopt plane
structural model to carry out the seismic analysis. All other structures shall adopt three-di-

dimensional structural models to carry out the seismic analysis.

3.6.6 The seismic analysis of structures by computers shall comply with following re-
quivalences:

1 The determination of computing model, necessary simplified calculation and tech-
nique for a structure shall comply with the actual performance of this structure.

2 The technical conditions of computer programmer shall comply with relevant provi-
sions in this code and other design standards, and its contents and special technique shall al-
so be clarified.

3 The analysis for internal force and deformation of complicate structures under fre-

quently earthquake shall be adopted at least two different mechanic models, and the compari-
son shall be made for the calculation results of these models.

4 The rationality and validity of all the calculation results from the computer pro-
gramer shall be judged and affirmed, and after then it is permitted to use in the project de-

sign.

3.7 Nonstructural components

3.7.1 Nonstructural components of building including architectural, mechanical and
electrical components permanently attached to structures, the supporting structures and
attachments (hereinafter referred to as “components”), shall be designed and constructed
to resist seismic action.
3.7.2 The seismic design of nonstructural components shall be carried out by those relevant professionals respectively.

3.7.3 The attached elements shall be reliably connected or anchored to relevant structural members, so that human injury or damage to important equipment due to their collapse can be avoided.

3.7.4 For the arrangement of exterior nonstructural walls and partition wall their unfavorable influence on seismic performance of structure shall be considered; irrational arrangement of these walls that would cause damage to main structure shall be avoided.

3.7.5 Curtain wall and veneers shall be firmly adhered to main structure, so that human injury due to their falling can be avoided.

3.7.6 The attachments and supports of mechanical and electrical components permanently attached to structures shall satisfy the functional requirements under earthquake, and damages to relevant portions of structures shall be avoided.

3.8 Seismically isolation and energy-dissipating design

3.8.1 The seismically isolated and energy-dissipating structures shall mainly be applied to that buildings, which have special performance requirements or its fortification intensity is 8 degree or 9 degree.

3.8.2 The seismically isolated and energy-dissipating structures under the frequently, fortification and rarely earthquake influence shall meet the requirements higher than that in Clause 1.0.1 of this code.

3.9 Structural materials and construction

3.9.1 Specified material and construction requirements for seismic structures shall be clearly stated in the design documents.

3.9.2 Structural material property shall comply with minimum requirements as follows:

1 Material strengths of masonry structures shall meet the following requirements:
   1) The strength grades of fired clay common bricks and perforated bricks shall not be less than MU10, and the strength grades of mortar for such bricks shall not be less than M5;
   2) The strength grades of small-sized concrete hollow blocks shall not be less than MU7.5, and the strength grades of mortar for such blocks shall not be less than M7.5.

2 Material property of concrete structures shall meet the following requirements:
   1) The strength grades of concrete for framed beams, columns and joint-core of structure assigned to seismic Grade 1, as well as frame-supported beams and columns, shall not be less than C30; the strength grades of concrete for ring-
beams, tie-columns, core-columns and other members shall not be less than C20;
2) For the non-prestressed longitudinal reinforcements of framed structures assigned to seismic Grade 1 or 2, the ratio of the actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25, and the ratio of actual tensile yield strength to characteristic strength shall not be greater than 1.3.
3) Material property of steel structures shall meet the following required:
   1) The ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.2;
   2) It shall have obvious yield steps, and the elongation rate shall be greater than 20%;
   3) It shall have good weld-ability and qualified shock tenacity.
3.9.3 Structural material property should also comply with following requirements:
1) The non-prestress reinforcements having better elongation, weld-ability and tenacity should be given priority to selective using; the longitudinal non-prestress reinforcement bars should be selected grade HRB400 and HRB335 hot-rolling bars, the hoop bars should be selected grade HRB335, HRB400 and HPB235 hot-rolling bars.
   Note: the checkout method of steel bars shall comply with the requirement of current national standard “Code for construction quality acceptance of concrete structure” GB 50204
2) The strength grades of concrete for concrete structures should not exceed C60 and C70 where fortification intensity 9 and 8 respectively.
3) The steel type of steel structures should be selected the Q235 grade B, C, D of carbon structural steel or Q345 grade B, C, D, E of low alloy and high strength structural steel; when there is reliable condition, other type and grade structural steel may also be selected.
3.9.4 In construction of concrete structures, if main longitudinal steel bars are necessary to be replaced by those with strength grade higher than that of original design, then shall be made as follow:
   The conversion shall be made according to equal tensile capacity design values of such bars, and shall also comply with the requirements for serviceability limit states and seismic details.
3.9.5 For steel structures adopting welded connections, if the thickness of steel plate is not less than 40mm and tension along direction of thick, then contraction rate along direction of thick under tension test shall not be lower than allowable values of grade Z15. Such contraction rate is determined by current national standard “Thickness direction property of steel plate” GB 50313.
3.9.6 In construction of the tie-columns and core-columns of masonry structures, and framed columns which seismic-brick-walls of a masonry building with bottom-frame, the
masonry walls shall be laid before the such concrete column is cast.

3.10 Seismic response observation system of buildings

3.10.1 The high-rise buildings with heights exceeding 160m, 120m and 80m, for the seismic fortification intensity 7, 8 and 9 respectively, shall be installed the seismic response observation system, so the object design shall leave rooms for the observation equipment and relevant circuits.
Chapter 4  Site, Subsoil and Foundation

4.1 Site

4.1.1 When selecting a constructional place, the identification as favorable plat, unfavorable plat or hazardous plat to seismic fortification shall be made according to Table 4.1.1.

<table>
<thead>
<tr>
<th>Plats</th>
<th>Geological, topographical and geomechanical description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable to seismic</td>
<td>Stable rock, stiff soil, or dense and homogeneous medium-stiff soil, which are in a wide-open area.</td>
</tr>
<tr>
<td>fortification</td>
<td></td>
</tr>
<tr>
<td>Unfavorable to seismic</td>
<td>Soft soil, liquefied soil, stripe-protruding spur, Loney tall hill, non-rocky steep slope, river bank or boundary of slope,</td>
</tr>
<tr>
<td>fortification</td>
<td>Soil stratification having obviously heterogeneous distribution in plane and cause of formation, lithology, and state (such as abandoned and filled river beds, fractured zone of fault, and hidden swamp, creek, ditch and pit, as well as subsoil formatted with excavated and filled).</td>
</tr>
<tr>
<td>Hazardous to seismic</td>
<td>Places where landslide, avalanche, subsidence, ground fissure and debris flow are liable to occur during the earthquake, and where ground dislocation may be occur at active faulted zone.</td>
</tr>
<tr>
<td>fortification</td>
<td></td>
</tr>
</tbody>
</table>

4.1.2 The site class of building structures shall be classified according to the equivalent shear-wave velocity of soil and thickness of site overlying layer as guideline.

4.1.3 The measure of shear-wave velocity of soil shall comply with following requirements:

1. At the stage of primary investigation, for large areas of same geologic units, the number of borings for the shear-wave-velocity tests shall be 1/3 to 1/5 of the controlled boring numbers. For the mountain valleys or mountain slopes, such number may be reduced apropos but should not be less than 3.

2. At the stage of detailed investigation, for every building, the number of borings for shear-wave-velocity tests should not be less than 2; when the data varies significantly, the number can be increased apropos. In the case of close-set tall building groups in one sub-zone, which are built at the same geologic unit, such number may be reduced apropos but shall not be less than one for each tall building.

3. For buildings assigned to Category D or to Category C with less than 10 stories and no more than 30m in height, when the shear-wave velocity data are not available, appropriate shear-wave velocity values are permitted to be estimated by used the known geologic conditions. In these cases, the type of soil may be classified according to Table 4.1.3 by the geotechnical description of the soil, and then the shear-wave velocity of each soil layer may be estimated within the range as per set in Table 4.1.3 based on the local experiences.
### Table 4.1.3 Classification of soil and range of shear-wave velocity

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Geotechnical description</th>
<th>Shear-wave velocity of soil layer (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiff soil or rock</td>
<td>Stable rock, dense detritus</td>
<td>( v_s &gt; 500 )</td>
</tr>
<tr>
<td>Medium-stiff soil</td>
<td>Medium dense or slightly dense detritus, dense or medium dense gravel, coarse or medium sand, cohesive soil and silt with ( f_\text{a} &gt; 200 \text{kPa} )</td>
<td>( 500 \geq v_s &gt; 250 )</td>
</tr>
<tr>
<td>Medium-stiff soil</td>
<td>Slightly dense gravel, coarse or medium sand, fine and muddy sand other than that which is loose, cohesive soil and silt with ( f_\text{a} \leq 200 \text{kPa} ), fill land with ( f_\text{a} &gt; 130 \text{kPa} )</td>
<td>( 250 \geq v_s &gt; 140 )</td>
</tr>
<tr>
<td>Soft soil</td>
<td>Muck and mucky soil, loose sand, new alluvial sediment of cohesive soil and silt, fill land with ( f_\text{a} \leq 130 \text{kPa} )</td>
<td>( v_s \leq 140 )</td>
</tr>
</tbody>
</table>

Note: \( f_\text{a} \) is the reference value of load-bearing capacity of soil; \( v_s \) is the shear-wave velocity.

#### 4.1.4 The thickness of site overlaying layer shall be determined according to the following provisions:

1. In generally, the thickness of site overlaying layer shall be determined according to the distance from the ground surface to a soil-layer level, under which the shear-wave velocity is more than 500 m/s.

2. For a soil layer, which depth lower than 5 m underground and the shear-wave velocity is more than 2.5 times of that in above this soil layer and is not less than 400 m/s, then the thickness of site overlaying layer may be adopted the distance from the ground surface to this layer.

3. The limestone and lenticular-soil with a shear-wave velocity greater than 500 m/s shall be deemed the same as surrounding soil profile.

4. The hard volcanic inter-bedded rock in the soil profile shall be deemed as rigid body and its thickness shall be deducted from the thickness of site overlaying layer.

#### 4.1.5 The equivalent shear-wave velocity of the soil profile shall be calculated according to the following equation:

\[
v_{se} = \frac{d_0}{t}
\]

\[
t = \sum_{i=1}^{n} \left( \frac{d_i}{v_{si}} \right)
\]

where: \( v_{se} \) —— equivalent shear wave velocity, in m/s.

\( d_0 \) —— calculated depth, in m; it shall be taken as the minor of both the overlaying thickness and 20 m.

\( t \) —— the transmission time of the shear-wave from the ground surface to the calculated depth.

\( d_i \) —— the thickness of the \( i \)-th soil layer within the range of calculated depth, in m.
\( v_{si} \) — the shear-wave velocity of the \( i \)-th soil layer within the calculated depth, in m/s.

\( n \) — number of soil layers within the range of calculated depth.

4.1.6 The construction sites shall be classified as four Site-classes defined in Table 4.1.6 depend on the equivalent shear-wave velocity and the overlaying thickness of soil profile. Only the values of the reliable shear-wave velocity and/or the overlaying thickness are near to the dividing line of the listed site values in Table 4.1.6, the design characteristic period value shall be permitted to determined by the interpolation method in calculating the seismic action.

<table>
<thead>
<tr>
<th>Equivalent shear-wave velocity (m/s)</th>
<th>Site-classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v_s &gt; 500 )</td>
<td>I</td>
</tr>
<tr>
<td>( 500 &gt; v_s &gt; 250 )</td>
<td>&lt;5</td>
</tr>
<tr>
<td>( 250 &gt; v_s &gt; 140 )</td>
<td>&lt;3</td>
</tr>
<tr>
<td>( v_s \leq 140 )</td>
<td>&lt;3</td>
</tr>
</tbody>
</table>

4.1.7 When seismogenic faults exist within the site, the impact assessment on the project for the fault shall be made, which shall comply with the following requirements:

1. If one of the following conditions can be satisfied, the impact on the building structures for the fault motion may be neglected:
   1) For Intensity 6 and 7;
   2) Not Holocene active faults;
   3) For Intensity 8 and 9, the depth of overlaying soil for the hidden pre-Quaternary fault is greater than 60m and 90m respectively.

2. In the event that the situation does not conform to the provisions in item 1 of this clause, the main fault zone shall be avoided in the selection of site. The distance of avoidance should not be less than the minimum distance of avoidance in accordance with Table 4.1.7.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Specification</td>
<td>300m</td>
<td>200m</td>
<td>—</td>
</tr>
<tr>
<td>9</td>
<td>Specification</td>
<td>500m</td>
<td>300m</td>
<td>—</td>
</tr>
</tbody>
</table>

4.1.8 When buildings assigned to Category C or A and B need to be constructed in unfavorable plats, which are such as stripe-protruding spur, lonely tall hill, non-rocky steep slop, river banks or boundary of slopes, that shall conform to follows:
Ensuring the stability of those buildings under earthquake. The amplification of design seismic parameters on the unfavorable plat shall also be taken into consideration, so that the maximum value of seismic influence coefficient shall be multiplied by the amplifying factor. The value of amplifying factor may be determined based on the actual condition of the unfavorable plat, but not exceed 1.6.

4.1.9 The geological investigation of the site shall be carried out as follows:

To classify the plats that are favorable, unfavorable or hazardous to seismic fortification, to provide the Site-classes of soil profile and to assess geotechnical stability under earthquake (whether landslide, avalanche, liquefaction or ground subsidence would occur) according to the actual condition.

For buildings that the time-history analysis is necessary, the relevant dynamic parameters and the overlaying depth shall also be provided as required by designer.

4.2 Natural subsoil and foundations

4.2.1 For the following buildings, the seismic bearing capacity check may not be carried out for the natural subsoil and foundation:

1 Masonry building structures;
2 Buildings without soft cohesive soil in the main load-bearing layer of the subsoil:
   1) The ordinary single-story factory buildings and single-story spacious houses;
   2) The ordinary civil framed buildings not more than 8 stories and 25m in height;
   3) Multi-story framed factory buildings with foundation load equivalent to point 2).
3 Buildings that seismic check for the upper-structure is non-necessary in accordance with this code.

Notes: soft cohesive soil layer refers to the soil layer, which the soil bearing capacity characteristic values are less than 80, 100 and 120 kPa for Intensity 7, 8 and 9 respectively.

4.2.2 When seismic check needs to be done for natural subsoil foundations, the characteristic combination of seismic effect shall be adopted, and the seismic soil bearing capacity shall be determined by the soil bearing capacity characteristic value to multiply with the seismic adjusting factor of soil bearing capacity.

4.2.3 The seismic soil bearing capacity shall be calculated according to the following equation:

\[ f_{se} = \zeta_s f_s \]  \hspace{1cm} (4.2.3)

where: \( f_{se} \) — seismic soil bearing capacity.
\( \zeta_s \) — the seismic adjusting factor of soil bearing capacity, which shall be taken in accordance with Table 4.2.3.
\( f_s \) — soil bearing capacity characteristic values after depth and width adjustment, that shall be determined according to the current national standard “Code for foundation design of buildings” GB50007.
4.2.3 | Seismic adjusting factor of soil bearing capacity

<table>
<thead>
<tr>
<th>Name and characteristic of rock and soil</th>
<th>$\zeta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock, dense detritus, dense gravel, course and medium sand, cohesive soil and silt with $f_{ak} \geq 300$ kPa</td>
<td>1.5</td>
</tr>
<tr>
<td>Medium dense and slightly dense detritus, medium dense gravel, course and medium sand, dense and medium dense fine and very fine sand, cohesive soil and silt with $150 \leq f_{ak} &lt; 300$ kPa, and hard loess</td>
<td>1.3</td>
</tr>
<tr>
<td>Slightly dense fine and very fine sand; cohesive soil and silt with $100 \leq f_{ak} &lt; 150$, plastic loess</td>
<td>1.1</td>
</tr>
<tr>
<td>Mud, silty soil, loose sand, fill land, newly piled loess and streambed loess</td>
<td>1.0</td>
</tr>
</tbody>
</table>

4.2.4 When checking the vertical seismic bearing capacity of natural subsoil, the mean pressure of foundation bottom and maximum pressure on the foundation edge according to the seismic effect characteristic combination shall conform to the requirement of the following equation:

\[ p \leq f_{ak} \]  \hspace{1cm} (4.2.4-1)
\[ p_{\text{max}} \leq 1.2 f_{ak} \]  \hspace{1cm} (4.2.4-2)

where: $p$—mean pressure on foundation bottom according to seismic effect characteristic combination

$p_{\text{max}}$—maximum pressure on the foundation bottom edge according to seismic effect characteristic combination.

For high-rise buildings with height-width ratio greater than 4, the foundation bottom shall have no tensioned stress under the earthquake; for other buildings, the area of zero stress zone between the subsoil and the foundation bottom shall not exceed 15% of the foundation bottom area.

4.3 Liquefaction and soft subsoil

4.3.1 For Intensity 6, the consequences of liquefaction of the saturated soil (loess not included) and the mitigation measures need not be considered for the ordinary buildings, but buildings assigned to Category B which is sensitive to the settlement caused by liquefaction, that may be carried out as intensity 7. For the buildings assigned to Category B, the assessment of consequences of the liquefaction and the mitigation measures may be considered by referring to the original intensity for Intensity 7 to 9.

4.3.2 For the subsoil inside which saturated sand and saturated silt (loess not included) exist, the assessment of liquefaction shall be made, except where is Intensity 6; when there is liquefaction, corresponding mitigation measures shall be taken depend on the Fortification Category, the liquefaction grade and other actual condition.

4.3.3 If one of the following condition is satisfied, the saturated sand and saturated silt (loess not included) may be primarily discriminated as non-liquefaction or consequences of liquefaction need not be considered:
1. The geochron of soil is Epistlestocene of Quaternary (Q3) or earlier, it may be discriminated as non-liquefied soils for Intensity 7 to 9.

2. The percentage of contain of clay particles (diameter less than 0.005mm) in silt is not less than 10%, 13% and 16% for Intensity 7, 8 and 9 respectively, it may be discriminated as non-liquefied soils.

Note: The clay particles contain shall be determined by use of sodium hexametaphosphate as the dispersant.

When other methods are used, it shall be correspond converted according to relative provisions.

3. For buildings with natural subsoil, the consequences of liquefaction need not be considered when the thickness of the overlaying non-liquefiable soils and the elevation of groundwater table comply with one of following conditions:

\[ d_u > d_b - 2 \] (4.3.3-1)

\[ d_w > d_b - 3 \] (4.3.3-2)

\[ d_u + d_w > 1.5d_0 + 2d_b - 4.5 \] (4.3.3-3)

where: 
- \( d_u \) — elevation of groundwater table (in m), for which the mean annual highest elevation during the reference period should be used, or the annual highest elevation in recent years may also be used.
- \( d_u \) — thickness of the overlaying non-liquefiable layer (in m), in which the thickness of mud and silt seams should be deducted.
- \( d_b \) — foundational depth (in m), when it is less than 2m, shall equal 2m.
- \( d_0 \) — reference depth of liquefaction soil (in m), it may be taken as Table 4.3.3.

<table>
<thead>
<tr>
<th>Type of saturated soil</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
<th>Intensity 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Sand</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

4.3.4 When the sequence discriminated liquefaction need be considered base on the primary discrimination, the standard penetration tests shall be performed, in which the discriminated depth shall be taken as 15m underground, but shall be taken as 20m underground for the pile foundation or for foundation buried depth greater than 5m.

When the measured value of standard penetration resistance (in blow-number, and bar-length-modification is not included) is less than the critical value of that, the saturated soil shall be discriminated as liquefied soil; and other methods, if already proved successful, may also be used.

Within the depth of 15m underground, the critical value of standard penetration resistance (in blow-number) for liquefaction discrimination may be calculated according to the following equation:

\[ N_{cr} = N_0[0.9 + 0.1(d_u - d_w)] \sqrt{3/\rho_c} \quad (d_u \leq 15) \] (4.3.4-1)

Within the depth of 15~20m underground, the critical value of standard penetration
resistance (in blow-number) for liquefaction discrimination may be calculated according to
the following equation:

\[ N_{cr} = N_0 (2.4 - 0.1d_m) \sqrt{\frac{3}{\rho c}} \quad (15 \leq d_s \leq 20) \]  

(4.3.4-2)

where: \( N_{cr} \) — critical value of standard penetration resistance (in blow-number) for liq-
uefaction discrimination;

\( N_0 \) — reference value of standard penetration resistance (in blow-number) for liq-
uefaction discrimination, it shall be taken from Table 4.3.4;

\( d_s \) — depth of standard penetration for saturated soil (in m);

\( \rho c \) — percentage of clay particle content; when it is less than 3% or when the soil
is sand, the value shall equal 3%.

<table>
<thead>
<tr>
<th>Table 4.3.4 Reference value of standard penetration resistance (in blow-number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design seismic group</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Group 1st</td>
</tr>
<tr>
<td>Group 2nd or 3rd</td>
</tr>
</tbody>
</table>

Note: Values in the brackets are used for the design basic acceleration of ground motion is 0.15g and 0.30g.

4.3.5 For the subsoil with liquefied soil layers, the level and thickness of soil layer shall
be explored and the liquefaction index shall be calculated by the following equations, and
then the liquefaction grades shall be comprehensively classified according to Table 4.3.5:

\[ I_{LE} = \sum_{i=1}^{n} \left( 1 - \frac{N_i}{N_{cri}} \right) d_i W_i \]  

(4.3.5)

where: \( I_{LE} \) — liquefaction index.

\( n \) — total number of standard penetration test points in each bore within the dis-
criminated depth under the ground surface.

\( N_i, N_{cri} \) — measured value and critical value of standard penetration resistance (in blow-
number) at the \( i \)-th point respectively, when the measured value is greater
than the critical value, shall take as equal critical value.

\( d_i \) — thickness of soil layer (in m) at the \( i \)-th point, it may be taken as half of the
difference in depth between the upper and lower neighboring standard pen-
etration test points; but the upper point level shall not be less than the ele-
vation of groundwater table, and the lower point level not greater than the liq-
uefaction depth.

\( W_i \) — weighted function value of the \( i \)-th soil layer (in m\(^{-1}\)), which is considered
the effect of the layer portion and level of the unit soil layer thickness. For discrimi-

nination depth is 15m underground, such value is equal 10 when the
depth of the midpoint of the layer is less than 5m, is zero when it equals
15m, and linear interpolation when it is between 5 m and 15m. For discrimi-
The liquefaction index is 20m underground, such value is equal 10 when the depth of the midpoint of the layer is less than 5m, is zero when it equals 20m, and linear interpolation when it is between 5m and 20m.

### Table 4.3.5 Grade of liquefaction

<table>
<thead>
<tr>
<th>Grades of liquefaction</th>
<th>Light</th>
<th>Moderate</th>
<th>Serious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquefaction index for discrimination depth is 15m</td>
<td>$0 &lt; I_{fc} &lt; 5$</td>
<td>$5 &lt; I_{fa} &lt; 15$</td>
<td>$I_{fa} &gt; 15$</td>
</tr>
<tr>
<td>Liquefaction index for discrimination depth is 20m</td>
<td>$0 &lt; I_{fc} &lt; 6$</td>
<td>$6 &lt; I_{fa} &lt; 18$</td>
<td>$I_{fa} &gt; 18$</td>
</tr>
</tbody>
</table>

### 4.3.6 For the even liquefied soil layer, the liquefaction mitigation measures shown in Table 4.3.6 may be selected; and the effect of the gravity for structural system may also be considered to adjust the above liquefaction mitigation measures.

The liquefied soil layer, which mitigation measure such as ground stabilization has not made, should not be used as bearing stratum of the footings.

### Table 4.3.6 Liquefaction mitigation measures

<table>
<thead>
<tr>
<th>Building category</th>
<th>Grades of liquefaction subsoil</th>
<th>Moderate</th>
<th>Serious</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Differential settlement due to liquefaction to be partially eliminated, or adjusted design of foundation and structural systems</td>
<td>Differential settlement due to liquefaction to be completely eliminated, or partially to be eliminated together with adjusted design of foundation and structural systems</td>
<td>Differential settlement due to liquefaction to be completely eliminated</td>
</tr>
<tr>
<td>C</td>
<td>Adjusted design of foundation and structural systems, or mitigation measures may not be taken</td>
<td>Adjusted design of foundation and structural systems, or other more strict measures may be taken</td>
<td>Differential settlement due to liquefaction to be completely eliminated, or partially to be eliminated together with adjusted design of foundation and structural system</td>
</tr>
<tr>
<td>D</td>
<td>Mitigation measures may not be taken</td>
<td>Mitigation measures may not be taken</td>
<td>Adjusted design of foundation and structural systems, or other low-cost measures may be taken</td>
</tr>
</tbody>
</table>

### 4.3.7 The measures to eliminate completely the differential settlement due to liquefaction shall comply with the following requirements:

1. When pile foundation is used, the length (pile-tip not included) of the pile driven into the stable soil layer below the liquefaction depth shall be determined by calculation. And for detritus, gravel, coarse and medium sand, stiff cohesive soil, and dense silt, such length shall not be less than 500 mm; for other non-rocky soil, that should not be less than 1.5 m also.

2. When deep foundations are used, the depth of the foundational bottom embedded in the stable soil layer below the liquefaction depth shall not be less than 500mm.

3. When a compaction method is used for strengthening (e.g. vibrating impact, vibrating compaction, sand or detritus pile compaction, and strong ramming), compaction
shall be carried out down to the lower margin of liquefaction depth. After strengthen the measured value of the standard penetration resistance (in number) of soils shall be greater than the corresponding critical value of provision in Clause 4.3.4 of this code.

4 Removal of all the liquefaction soil layers, and then fills non-liquefiable soils.

5 When the compaction method or removal of liquefiable soil methods are adopted, the strengthened width outside the foundation edge shall exceed 1/2 of its depth under the foundation bottom; moreover, the width shall not be less than 1/5 of the foundation width.

4.3.8 Measures to eliminate partially the differential settlement due to liquefaction shall comply with the following requirements:

1 The compacted or removal shall be carried out to a depth so that the liquefaction index of the subsoil shall be not greater than 4 for discriminated depth 15m and than 5 for discriminated depth 20m. For individual footings and strip footings, such depth shall also not be less than the reference depth of liquefaction soil measured from the bottom of the footing or the width of the foundation, which is greater.

2 In the range of the above depth, the liquefaction soil layers shall be strengthened by compaction, so that the measured value of the standard penetration resistance (in blow-number) of the compacted soil layer should be more than the corresponding critical value of provision in Clause 4.3.4 of this code.

3 The strengthened width outside the foundation shall conform to the requirements in Item 5 of Clause 4.3.7 of this section.

4.3.9 For design of the foundation and the structural system to reduce the influence of liquefaction, the following mitigation measures can be taken based on comprehensive considerations:

1 Select the appropriate buried depth of foundation.

2 Adjust the foundation bottom area to reduce the eccentricity of the foundation.

3 Increase the integrality and rigidity of the foundation, for example, the use of box-shape foundation or raft footing, the use of cross-strip footing, adding foundation ring beams or connecting beams.

4 Decrease the load, increase the integrality, uniformity and symmetry of the structural system, install rational settlement joints, and avoid the use of a structural configuration that is vulnerable to differential settlement.

5 At locations where pipelines pass through the building, sufficient space shall be left beforehand for the pipelines, or flexible connections shall be used.

4.3.10 For abandoned and filled river beds, modern riverside and beaches where the liquefaction grade is moderate or serious, when there is the possibility of lateral expansion or now-sliding due to liquefaction, no permanent buildings should be constructed within 100 m of the normal waterline. Otherwise, anti-sliding checks must be carried out, and anti-sliding measures for the earth and anti-cracking measures for the structure must be taken.
Note: the normal waterline may also be adopted according to the mean annual highest level during the reference period or the annual highest level in recent years.

4.3.11 If the main load-bearing soil of building inside which the soft cohesive soil or collapsible loess exists, the measures such as adoption of pile foundation, strengthening of subsoil or those measures in Clause 4.3.9 of this section, shall be taken based on the comprehensive consideration the actual conditions. And corresponding measures may also be taken based on the estimation of the settlement under earthquake.

4.4 Pile foundation

4.4.1 For the following buildings, the pile foundation, with low pile caps and mainly resisting vertical load but without liquefaction soil, mud, silt soil or backfill soils with characteristic value of load-bearing capacity not greater than 100 kPa, may not be checked for the seismic bearing capacity:

1. Buildings as specified in Item 1 and 3 of Clause 4.2.1 of this chapter.
2. The following buildings for Intensity 7 and 8:
   1) Ordinary single-story factory buildings or single-story spacious buildings;
   2) Ordinary framed civil buildings with not more than 8 stories and 25m in height;
   3) Multi-story framed factory with foundation load equivalent to that in point 2).

4.4.2 The seismic check of pile foundation with low pile caps in non-liquefaction soil shall comply with the following requirements:

1. The seismic bearing capacity characteristic values in the vertical and horizontal direction of a single pile may both increase by 25% than that is required for non-seismic designs.
2. When the dry density of tamped backfill around the pile cap satisfying the requirements for backfill provided in "Code for design of building foundations", the pile and its front backfill soil may together resist the horizontal seismic action. However, the friction between the bottom surface and the subsoil shall not be taken into account.

4.4.3 The seismic check of pile foundation with low pile cap in the liquefaction soil shall comply with the following requirements:

1. For the ordinary shallow foundations, the resistance of the pile cap surrounding soil and the horizontal seismic-resistance of the rigid ground floor should not be taken into account.
2. When there is non-liquefaction soil or non soft soil layer with the thickness of 1.5m and 1.0m in the upper and lower pile cap, the seismic check may be carried out according to the following two cases, and the design shall be carried out according to unfavorable conditions:
   1) The pile designed to resist all the seismic action, and the bearing capacity of the pile shall be determined from Clause 4.4.2 of this section, but the friction and
the horizontal resistance of the pile in liquefaction soil shall all multiplied by the reduction factor defined in Table 4.4.3.

Table 4.4.3 Reduction factor for the liquefaction effect of soil layer

<table>
<thead>
<tr>
<th>Ratio of measured value of standard penetration resistance (in blow-number) to critical value of that</th>
<th>depth (d_c) (m)</th>
<th>Reduction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 0.6)</td>
<td>(d_c \leq 10)</td>
<td>0</td>
</tr>
<tr>
<td>(10 &lt; d_c \leq 20)</td>
<td>1/3</td>
<td></td>
</tr>
<tr>
<td>(&gt; 0.6 - 0.8)</td>
<td>(d_c \leq 10)</td>
<td>1/3</td>
</tr>
<tr>
<td>(10 &lt; d_c \leq 20)</td>
<td>2/3</td>
<td></td>
</tr>
<tr>
<td>(&gt; 0.8 -1.0)</td>
<td>(d_c \leq 10)</td>
<td>2/3</td>
</tr>
<tr>
<td>(10 &lt; d_c \leq 20)</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

2) The seismic action shall be determined according to 10% of the maximum value of horizontal seismic influence coefficient, which provided in this code. And the pile bearing capacity shall be determined from Clause 4.4.2 of this section, but all of the friction, in the liquefaction soil and in the non-liquefaction soil within the depth of 2m under the pile cap, shall be deducted.

3) For hammered and other driving piles, when the pile center-to-center mean spacing is 2.5 to 4 times of pile diameters and the pile group is not less than 5 × 5, the compacting effect for driving piles and the favorable affect of the pile on restricting the soil deformation may be taken into consideration. When the standard penetration resistance (in blow-number) of soil around pile meet the requirements for non-liquefaction, the bearing capacity of single pile may not be reduced, however, when checking the capacity of the pile-tip bearing stratum, the diffusion angel outside the pile group shall be taken as zero. The standard penetration resistance (in blow-number) on the soil around the pile after pile driving should be determined by tests, and may also be determined according to the following equation:

\[
N_1 = N_p + 100 \rho (1 - e^{-0.3N_p})
\]  

(4.4.3)

where: \(N_1\) — the standard penetration resistance (in blow-number) after pile driving;
\(\rho\) — ratio of the area conversion for piles to soils,
\(N_p\) — the standard penetration resistance (in blow-number) before pile driving.

4.4.4 The area around the pile cap in liquefaction soils should be tamped with non-liquefiable soil; if sand or silty-soil are used, the standard penetration resistance (in blow-number) of the soil layer shall not be less than the critical value for liquefaction of provisions in Clause 4.3.4 of this chapter.

4.4.5 The reinforced range of the pile in liquefaction soil shall cover from the top of the pile to depth under the liquefaction soil, comply with the required depth for eliminating completely the different settlement due to liquefaction. In within, the longitudinal reinforcement shall be the same as the top of the pile, the stirrups shall be densified.
4.4.6 In plats where exist lateral movement due to liquefaction, the pile foundation with a distance less than 100m from the normal waterline, besides satisfying other provisions set forth in this section, shall also take the lateral-force due to soil-flow into consideration. Moreover, the area bearing lateral-force shall be calculated according to the distance between the both of side-piles.
Chapter 5  Seismic action and seismic checking for structures

5.1 General

5.1.1 Seismic action of every building structure shall be considered and complied with the following principles:

1 In generally, horizontal seismic actions may be considered and checked separately along the two orthogonal major axial directions of the building structure; and that horizontal seismic action shall be resisted by all of the corresponding direction lateral-force-resisting members.

2 Structures having the oblique direction lateral-force-resisting members and the oblique angel to major orthogonal axes is greater than 15°, the horizontal seismic action along the direction of each lateral-force-resisting member shall be considered respectively.

3 Structures having obviously asymmetric mass and stiffness distribution, the torsion effects caused by both two orthogonal horizontal direction seismic action shall be considered; and other structures, it is permitted that a simplified method, such as adjusting the seismic effects method, to consider their seismic torsion effects.

4 Large-span structures and long-cantilevered structures for Intensity 8 or 9, and tall buildings for Intensity 9, vertical seismic action shall be considered.

Note: For building structures adopting seismic-isolated designs for Intensity 8 and 9, the vertical seismic action shall be calculated according to relevant provisions in this code.

5.1.2 The following methods shall be taken for seismic computation of any building structure:

1 For structures, which is not higher than 40m with deformations predominantly due to shear and a rather uniform distribution of mass and stiffness in elevation, or for structures modeled as a single-mass system, a simplified method, such as the base shear method, may be used.

2 For building structures other than those as stated in the above clause, the response spectrum method for modal analysis should be used.

3 For buildings having extremely irregular configuration, buildings assigned Fortification Category A, and tall buildings within the height range given in Table 5.1.2-1, a time-history analysis method under frequently earthquake shall be used as an additional computation. And then the greater value between the average value of the time-history calculation results and the result of the response spectrum method may be adopted.

When the time-history method is adopted in the analysis, at least 2 sets of strong earthquake records and 1 set of artificial acceleration time-history curve shall be selected based on
the intensity, the Design seismic group and Site-class. Their average seismic influence coefficient curve shall be in conformity with the seismic influence coefficient curve when adopting the response spectrum method; the maximum value for its acceleration time-history may be adopted according to Table 5.1.2-2. When adopting elastic time-history analyzing method, the structure base shear force obtained from each time-history curve shall not be less than 65% of that from the response spectrum method, and the average value from several time-history curve shall not be less than 80% of that from the response spectrum method.

<table>
<thead>
<tr>
<th>Intensity and Site-class</th>
<th>Range of building height(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity 7, Intensity 8 with Site-class I , II</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Intensity 8 with Site-class III , IV</td>
<td>&gt;80</td>
</tr>
<tr>
<td>Intensity 9</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seismic action</th>
<th>Intensity 6</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
<th>Intensity 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently earthquake</td>
<td>18</td>
<td>35 (55)</td>
<td>70 (110)</td>
<td>140</td>
</tr>
<tr>
<td>Rarely earthquake</td>
<td>220 (310)</td>
<td>400 (510)</td>
<td>620</td>
<td></td>
</tr>
</tbody>
</table>

Note: Values in the brackets are used that the design basic acceleration of ground motion is 0.15g and 0.30g respectively.

4 When calculating the deformation of the structure under rarely earthquake, the simplified elasto-plastic analyzing method or elasto-plastic time-history analyzing methods shall be adopted in accordance with the provisions in Section 5.5 of this chapter.

Note: The seismic-isolation and the energy-dissipating design of the building structures shall adopt the calculation method provided in Chapter 12 of this Code.

5.1.3 In the computation of seismic action, the representative value of gravity load of the building shall be taken as the sum of characteristic values of the weight of the structure and members plus the combination values of variable loads on the structure. The combination coefficients for different variable loads shall be taken from Table 5.1.3.

<table>
<thead>
<tr>
<th>Type of variable load</th>
<th>Combination coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow load</td>
<td>0.5</td>
</tr>
<tr>
<td>Dust load on the roof</td>
<td>0.5</td>
</tr>
<tr>
<td>Active load on the roof</td>
<td>Not considered</td>
</tr>
<tr>
<td>Active load on the floor, calculated according to actual state</td>
<td>1.0</td>
</tr>
</tbody>
</table>

28
Table 5.1.3 (continued)

<table>
<thead>
<tr>
<th>Type of variable load</th>
<th>Combination coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active load on the floor, calculated</td>
<td>Library, Archives</td>
</tr>
<tr>
<td>according to equivalent uniform load</td>
<td>Other civil buildings</td>
</tr>
<tr>
<td>Gravity for hanging object of crane</td>
<td>Cranes with hard hooks</td>
</tr>
<tr>
<td></td>
<td>Cranes with flexible hooks</td>
</tr>
<tr>
<td></td>
<td>Not considered</td>
</tr>
</tbody>
</table>

Note: When the hanging weight of crane with hard hooks is bigger, the combination coefficient shall be adopted according to the actual condition.

5.1.4 Seismic influence coefficient of a building structure shall be determined according to the Intensity, Site-class, Design seismic group, and natural period and damping ratio of the structure. The maximum value of horizontal seismic influence coefficient shall be taken from Table 5.1.4-1; the characteristic period shall be taken as Table 5.1.4-2 according to Site-class and Design seismic group, that shall be increased 0.05s for rarely earthquake of Intensity 8 and 9.

Notes: 1. The seismic influence coefficient shall be studied specifically for building structures with natural period greater than 6.0s;
2. Only the cities that have established seismic fortification zonation, it shall be permitted to adopt correspondent seismic influence coefficient according to the approved design seismic parameters.

Table 5.1.4-1 Maximum value of horizontal seismic influence coefficient

<table>
<thead>
<tr>
<th>Earthquake influence</th>
<th>Intensity 6</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
<th>Intensity 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently earthquake</td>
<td>0.04</td>
<td>0.08 (0.12)</td>
<td>0.16 (0.24)</td>
<td>0.32</td>
</tr>
<tr>
<td>Rarely earthquake</td>
<td>—</td>
<td>0.50 (0.72)</td>
<td>0.90 (1.20)</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Note: the values in the brackets are separately used for where the design basic seismic acceleration is 0.15g and 0.30g.

Table 5.1.4-2 Characteristic period value(s)

<table>
<thead>
<tr>
<th>Design earthquake group</th>
<th>Site-class 1</th>
<th>Site-class 2</th>
<th>Site-class 3</th>
<th>Site-class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Group</td>
<td>0.25</td>
<td>0.35</td>
<td>0.45</td>
<td>0.65</td>
</tr>
<tr>
<td>2nd Group</td>
<td>0.30</td>
<td>0.40</td>
<td>0.55</td>
<td>0.75</td>
</tr>
<tr>
<td>3rd Group</td>
<td>0.35</td>
<td>0.45</td>
<td>0.65</td>
<td>0.90</td>
</tr>
</tbody>
</table>

5.1.5 The damping adjusting and forming parameters on the building seismic influence coefficient curve (Fig.5.1.5) shall comply with the following requirements:

1. The damping ratio of building structures shall select 0.05 except otherwise provided, the damping adjusting coefficient of the seismic influence coefficient curve shall select 1.0, and the coefficient of shape shall conform to the following provisions:
   1) Linear increase section, whose period($T$) is less than 0.1 s;
   2) Horizontal section, whose period from 0.1s thought to characteristic period, shall select the maximum value ($\alpha_{max}$);
   3) Curvilinear decrease section, whose period from characteristic period thought to 5
times of the characteristic period, the power index(γ)shall choose 0.9.
4) Linear decrease section, whose period from 5 times characteristic period thought
to 6s, the adjusting factor of slope(η₁)shall choose 0.02.

![Seismic influence coefficient curve](image)

Figure 5.1.5  Seismic influence coefficient curve

2 When the damping ratio of building structures is not equal to 0.05 according to rel-
levant provisions, the damping adjusting and forming parameters on the seismic influence co-
efficient curve shall comply with the following requirements:
1) The power index of the curvilinear decrease section shall be determined according
to the following equation:

\[ \gamma = 0.9 + \frac{0.05 - \xi}{0.5 + 5\xi} \]  \hspace{1cm} (5.1.5-1)

where: \( \gamma \)——the power index of the curvilinear decrease section;
\( \xi \)——the damping ratio.
2) The adjusting factor of slope for the linear decrease section shall be determined
from following equation:

\[ \eta_1 = 0.02 + \frac{(0.05 - \xi)}{8} \]  \hspace{1cm} (5.1.5-2)

where: \( \eta_1 \)——the adjusting factor of slope for the linear decrease section, when it is less
than 0, shall equal 0.
3) The damping adjustment factor shall be determined according to the following
equation:

\[ \eta_2 = 1 + \frac{0.05 - \xi}{0.06 + 1.7\xi} \]  \hspace{1cm} (5.1.5-3)

where: \( \eta_2 \)——the damping adjustment factor, when it is smaller than 0.55, shall equal
0.55.

5.1.6 The seismic check of the building structure shall comply with the following re-
quirements:
1 Only the buildings assigned to fortification intensity 6 (except higher buildings
built on Site-class IV), unfired earth house and wood house, the seismic checking of cross
section of structural members shall be permitted to not carry out. However the relevant
seismic detail requirements for those buildings shall be satisfied.
2. For building structures other than those as stated in point 1 of this clause, seismic checking of cross section of structural members shall be carried out under frequently earthquakes.

Note: The seismic check of building structures adopting seismic-isolation design shall comply with relevant provisions.

5.1.7 For structures conforming to the provisions in Section 5.5 of this chapter, besides carrying out cross section seismic check, corresponding deformation check shall also be carried out.

5.2 Calculation of horizontal seismic action

5.2.1 When the base shear force method is used, only one degree of freedom may be considered for each story; the characteristic value of horizontal seismic action of the structure shall be determined by the following equations (Fig. 5.2.1):

\[ F_{Ek} = \alpha_1 G_{q1} \quad (5.2.1-1) \]

\[ F_i = \frac{G_i H_i}{\sum_{j=1}^{n} G_j H_j} F_{Ek} (1 - \delta_n) \quad (i = 1, 2, \ldots n) \quad (5.2.1-2) \]

\[ \Delta F_n = \delta_n F_{Ek} \quad (5.2.1-3) \]

where: 
- \( F_{Ek} \) — characteristic value of the total horizontal seismic action of the structure.
- \( \alpha_1 \) — horizontal seismic influence coefficient corresponding to the fundamental period of the structure, which shall be determined by using Clause 5.1.4. For multi-story masonry buildings and multi-story brick buildings with bottom-frames or inner-frames, the maximum value of horizontal seismic influence coefficient should be taken.
- \( G_{q1} \) — equivalent total gravity load of a structure. When the structure is modeled as a single-mass system, the representative value of the total gravity load shall be used; and when the structure is modeled as a multi-mass system, the 85% of the representative value of the total gravity load may be used.
- \( F_i \) — characteristic value of horizontal seismic action applied on mass \( i \)-th.
- \( G_i, G_j \) — representative values of gravity load concentrated at the masses of \( i \)-th and \( j \)-th respectively, which shall be determined by Clause 5.1.3.
- \( H_i, H_j \) — calculated height of mass \( i \)-th and \( j \)-th from the base of the building respectively.
- \( \delta_n \) — additional seismic action factors at the top of the building; for multi-story reinforced concrete buildings, it may be taken using Table 5.2.1; for multi-story brick buildings with inner-frames, a value of 0.2 may be used; no need to con-
sider for other buildings.

$\Delta F_n$—additional horizontal seismic action applied at top of the building.

<table>
<thead>
<tr>
<th>Table 5.2.1 Additional seismic action factors at top of the building</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_\phi(s)$</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>$\leq 0.35$</td>
</tr>
<tr>
<td>$&gt; 0.35 - 0.55$</td>
</tr>
<tr>
<td>$&gt; 0.55$</td>
</tr>
</tbody>
</table>

Note: $T_1$ is the fundamental period of the structure.

5.2.2 When the response spectrum method is used for model analysis, if the torsion effect of a structure is not considered, the seismic action and its effect may be calculated according to the following requirements:

1. The characteristic value of horizontal seismic action on mass $i$-th of the structure, corresponding to $j$-th mode, shall be determined by the following equations:

$$F_{jk} = a_j \gamma_j X_j G_l \quad (i = 1, 2, \cdots n, \ j = 1, 2, \cdots m)$$

$$\gamma_j = \frac{\sum_{i=1}^{n} X_i G_i}{\sum_{i=1}^{n} X_j G_i} \quad (5.2.2-2)$$

where: $F_{jk}$—characteristic value of horizontal seismic action of mass $i$-th corresponding to mode $j$-th.

$a_j$—seismic influence coefficient corresponding to the natural period of mode $j$-th of the structure, determined by clause 5.1.4 of this chapter.

$\gamma_j$—mode participation factor of mode $j$-th.

2. Total effect of the horizontal seismic action (bending moment, shear, axial force, or deformation) shall be determined by the following equation:

$$S_{k} = \sqrt{\sum S_j^2} \quad (5.2.2-3)$$

where: $S_{k}$—characteristic value of horizontal seismic effect.

$S_j$—effect caused by the horizontal seismic action of mode $j$-th, and only the first two or three modes may be taken. When the fundamental natural period is greater than 1.5s, or the height-width-ratio of the building exceeds 5, number of modes used shall be increased in the computation.

5.2.3 When considering the torsion effect of horizontal earthquake actions, structural seismic action and its effect shall be calculated according to the following requirements:

1. When no coupled torsion calculation is to be carried out for regular structures, the seismic effect of the two side trusses parallel to the earthquake action direction shall be multiplied by the amplifying factor. In one word, the short side may select the factor 1.15, and the longer side may choose the factor 1.05; when the torsion rigidity is smaller, it is appro-
appropriate to select the factor no less than 1.3.

2 When calculating according to coupled torsion method, three degrees of freedom may be selected for each floor, including two orthogonal horizontal deformations and a rotation around the vertical axis, and the seismic action and its effect shall be calculated according to the following equations. When there are sufficient reasons, other simplified methods may also be used in determining the seismic effect.

1) The horizontal seismic action characteristic value in the floor $i$-th for mode $j$-th of natural vibration of structure shall be determined according to the following equation:

$$F_{xji} = a_i \gamma_i X_{ji} G_i$$
$$F_{yji} = a_i \gamma_i Y_{ji} G_i \quad (i = 1, 2, \ldots n, j = 1, 2, \ldots m)$$
$$F_{zji} = a_i \gamma_i r_j^2 \varphi_{ji} G_i \quad (5.2.3-1)$$

where: $F_{xji}, F_{yji}, F_{zji}$ — the seismic action characteristic value of floor $i$-th for mode $j$-th of natural vibration of structure in direction of $x$, $y$ and rotation respectively.

$X_{ji}, Y_{ji}$ — the horizontal relative displacement of the center of floor $i$-th for mode $j$-th of natural vibration of structure in direction of $x$, $y$ respectively.

$\varphi_{ji}$ — relative rotation angle of floor $i$-th for mode $j$-th of natural vibration of structure.

$r_j$ — the rotating radius of floor $i$-th, which is the square root of that the rotating moment of inertia around the center of floor $i$-th divided by the mass of this floor.

$\gamma_i$ — mode participation factor of mode $j$-th considering rotation effect, that may be determined in accordance with the following equation:

When only the seismic action in $x$ direction is considered

$$\gamma_{ij} = \frac{\sum_{i=1}^{n} X_{ji} G_i}{\sum_{i=1}^{n} (X_{ji}^2 + Y_{ji}^2 + \varphi_{ji}^2 r_j^2)} G_i \quad (5.2.3-2)$$

When only the seismic action in $y$ direction is considered

$$\gamma_{ij} = \frac{\sum_{i=1}^{n} Y_{ji} G_i}{\sum_{i=1}^{n} (X_{ji}^2 + Y_{ji}^2 + \varphi_{ji}^2 r_j^2)} G_i \quad (5.2.3-3)$$

When the seismic action oblique with $x$ direction is considered

$$\gamma_{ij} = \gamma_{xj} \cos \theta + \gamma_{yj} \sin \theta \quad (5.2.3-4)$$

where: $\gamma_{xj}, \gamma_{yj}$ — the participation factors defined by equations (5.2.3-2) and (5.2.3-3) respectively.
\( \theta \) — angle between the seismic action direction and \( x \) direction.

2) The torsion effect of single direction horizontal seismic action may be determined in accordance with following equation:

\[
S_{Ek} = \sqrt{\sum_{j=1}^{k} \sum_{k=1}^{k} \rho_{jk} S_j S_k} \tag{5.2.3-5}
\]

\[
\rho_{jk} = \frac{8 \xi_j \xi_k (1 + \lambda_T) \lambda_T^{1.5}}{(1 - \lambda_T^2)^2 + 4 \xi_j^2 \xi_k (1 + \lambda_T)^2 \lambda_T} \tag{5.2.3-6}
\]

where: \( S_{Ek} \) — torsion effect caused by the seismic action characteristic value.

\( S_j, S_k \) — the effect caused by seismic action of modes \( j \)-th and \( k \)-th respectively, the first 9~15 modes may be selected.

\( \xi_j, \xi_k \) — the damping ratio of modes \( j \)-th and \( k \)-th respectively; and in Eq. (5.2.3-6) shall taken as \( \xi_j = \xi_k \).

\( \rho_{jk} \) — coupling factor of modes \( j \)-th and \( k \)-th.

\( \lambda_T \) — ratio between the natural periods of modes \( k \)-th and \( j \)-th.

3) The torsion effect of double direction horizontal seismic action shall be determined according to the greater value calculated from the following two equations:

\[
S_{Ek} = \sqrt{S_j^2 + (0.85S_k)^2} \tag{5.2.3-7}
\]

or

\[
S_{Ek} = \sqrt{S_j^2 + (0.85S_k)^2} \tag{5.2.3-8}
\]

where: \( S_j, S_k \) — the torsion effect caused by horizontal seismic action along \( x \) and \( y \) directions determined accordance with Formula (5.2.3-5) respectively.

5.2.4 When the base shear method is used, the seismic effect of penthouse, parapet and chimney on the roof should be multiplied by an amplifying factor of 3; such increase part of effect shall only be assigned to the members of roof, not to the lower part of the structure.

When modal analysis method is used, the projecting part may be considered as one mass; the amplifying factor of seismic effect of the projecting skylight frame of a single-story factory building shall comply with relevant provisions in Chapter 9 of this code.

5.2.5 The horizontal seismic shear force at each floor level of the structure shall comply with the requirement of the following equation:

\[
V_{Eki} > \lambda \sum_{j=1}^{n} G_j \tag{5.2.5}
\]

where: \( V_{Eki} \) — the floor \( i \)-th shear corresponding to horizontal seismic action characteristic value.

\( \lambda \) — shear factor, it shall not less than values in Table 5.2.5; for the weak location of vertical irregular structure, these values shall be multiplied by the amplifying factor of 1.15.
$G_j$ — the representative value of gravity load in floor $j$-th of the structure.

<table>
<thead>
<tr>
<th>Structures</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
<th>Intensity 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures with obvious torsion effect or fundamental period is less than 3.5s</td>
<td>0.016 (0.024)</td>
<td>0.032 (0.048)</td>
<td>0.064</td>
</tr>
<tr>
<td>Structures with fundamental period greater than 5.0s</td>
<td>0.012 (0.018)</td>
<td>0.024 (0.032)</td>
<td>0.040</td>
</tr>
</tbody>
</table>

Notes: 1. The values may be selected through interpolation method for structures whose fundamental period is between 3.5s and 5s.
2. Values in the brackets are used at the regions with basic seismic acceleration as 0.15g and 0.30g respectively.

5.2.6 The horizontal seismic shear force at each floor level of the structure shall be distributed to the lateral-force-resisting members (such as walls, columns, and seismic braces) according to the following principles:

1. For buildings with rigid diaphragms, such as cast-in-place and monolithic-prefabricated concrete floors and roofs, the distribution should be done in proportion to the equivalent stiffness of the lateral-force-resisting members.

2. For buildings with flexible diaphragms, such as wood roof and wood floors, the distribution should be done according to the ratio of gravity load representative value on the areas which are subordinated the lateral-force-resisting members.

3. For buildings with semi-rigid diaphragms, such as ordinary prefabricated concrete roof and floors, the distributed may select the average value of the above two methods.

4. The above distribution results may be adjusted in accordance with the relevant provisions in this code, to consider the space interaction of the lateral-force-members, deformation of diaphragms, elasto-plastic deformation of the wall, and torsion response.

5.2.7 In the seismic computation of a structure, in general, the subsoil-structure interaction may be ignored; if the subsoil-structure interaction of reinforced concrete tall buildings for Intensity 8 and 9 and with Site-class III or IV is need to consider, that shall comply with following requirements:

The tall building structures shall be with box-type or a relatively rigid raft foundation or box-pile foundation; and the fundamental period of the structure is within the scope of 1.2 to 5 times of the characteristic period of Site.

If the subsoil-structure interaction is considered for those structures, the horizontal seismic shear forces assumed for rigid base may be reduced in accordance with the following provisions, and the story drift may be calculated according to the reduced story shear force.

1. For structures with height-width-ratio less than 3, the reduction factor of horizontal seismic shear of each floor may be determined by following equation:

$$\phi = \left(\frac{T_1}{T_1 + \Delta T}\right)^{0.9}$$

(5.2.7)

where: $\phi$ — seismic shear reduction factor considering the subsoil-structure interaction.
$T_1$—the fundamental period of the structure, which determined by assumption of the rigid base (in s).

$\Delta T$—the additional period after considering the subsoil-structure interaction (in s), that may be determined from Table 5.2.7.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Site-class III</th>
<th>Site-class II</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0.08</td>
<td>0.20</td>
</tr>
<tr>
<td>9</td>
<td>0.10</td>
<td>0.25</td>
</tr>
</tbody>
</table>

2 For structures whose height-width-ratio is not less than 3, the seismic shear of the structural bottom may be reduced according to point 1 of this clause, that of the top may not reduced, and that of the middle floors may be reduced according to the linear interpolation values.

3 The reduced horizontal shear of all floors shall satisfy the requirements of Clause 5.2.5 of this chapter.

5.3 Calculation of vertical seismic action

5.3.1 For tall buildings for Intensity 9, the characteristic value of vertical seismic action shall be determined by the following equations (Fig. 5.3.1). The effects of vertical seismic action at the floor level may be distributed in proportion of the representative value of gravity load acting on the members, which should multiply with the amplifying factor 1.5.

\[
F_{Evk} = \alpha_{\text{max}} G_{eq}
\]  

(5.3.1-1)

\[
F_{vi} = \frac{G_i H_i}{\Sigma G_i H_i} F_{Evk}
\]  

(5.3.1-2)

where: $F_{Evk}$—characteristic value of the total vertical seismic actions of the structure.

$F_{vi}$—characteristic value of vertical seismic action at the level of mass $i$-th.

$\alpha_{\text{max}}$—maximum value of vertical seismic influence coefficient, which may be taken as 65% of the maximum value of the horizontal seismic influence coefficient.

$G_{eq}$—equivalent total gravity load of the structure, which may be taken as 75% of the representative value of the total gravity load of the structure.

5.3.2 For a flat lattice truss roof and for trusses with a span greater than 24m, the characteristic value of vertical seismic action should be taken as the product of the representative value of the gravity load and the coefficient of vertical seismic action. Values for the coefficient of vertical seismic action may be determined using Table 5.3.2:
Table 5.3.2 Coefficients of vertical earthquake action

<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Intensity</th>
<th>Site-class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Flat lattice truss, Steel truss</td>
<td>8</td>
<td>not considered(0.10)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.15</td>
</tr>
<tr>
<td>Reinforced Concrete truss</td>
<td>8</td>
<td>0.10(0.15)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Note: the values in the brackets are used to design for regions where the basic seismic acceleration is 0.30g.

5.3.3 For long cantilever and other large-span structures for Intensity 8 and 9, the vertical seismic action characteristic value may be taken as 10% and 20% of the gravity load representative values of structure or member respectively. When the design basic seismic acceleration is 0.30g, which may be taken as 15% of the gravity load representative value of structure or member.

5.4 Seismic check for load-bearing capacity of structural members

5.4.1 The combination of seismic effect, which is considered as dominating, with other loads effects on structural members shall be determined by the following equation:

\[ S = \gamma_G S_{GE} + \gamma_{EH} S_{EH} + \gamma_{EV} S_{EV} + \psi_w \gamma_w S_{w_k} \]  

(5.4.1)

where: \( S \) — design value of combination of inner forces in a structural member, including design value of combination of bending moment, axial force and shear force.

\( \gamma_G \) — partial factor of gravity load, which shall be taken as 1.2 in ordinary conditions; when the effect of gravity load is favorable to the bearing capacity of the member, such factor shall not greater than 1.0.

\( \gamma_{EH}, \gamma_{EV} \) — partial factors for horizontal and vertical seismic action respectively, which shall be determined from Table 5.4.1.

\( \gamma_w \) — partial factor for wind load, which shall be taken as 1.4.

\( S_{GE} \) — effects for representative value of gravity load, in which shall be included the characteristic value of the all hanging weight of the crane.

\( S_{EH} \) — effects for characteristic value of seismic action in horizontal direction, that shall be multiplied with the relevant amplifying factor or adjusted factor.

\( S_{EV} \) — effects for characteristic value of seismic action in vertical direction, that shall be multiplied with the relevant amplifying factor or adjusted factor.

\( S_{w_k} \) — effects for characteristic value of wind load.

\( \psi_w \) — factor for combination value of wind load, which shall be taken as 0.0 for ordinary structures, and taken as 0.2 for tall building structures that the wind load is control load.

Note: Subscripts representing the horizontal seismic action direction are generally omitted in this code.
Table 5.4.1 Seismic action partial factors

<table>
<thead>
<tr>
<th>Seismic action</th>
<th>( \gamma_{eh} )</th>
<th>( \gamma_{ev} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only horizontal seismic action</td>
<td>1.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Only vertical seismic action</td>
<td>0.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Both horizontal and vertical seismic action</td>
<td>1.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>

5.4.2 The checking seismic resistance of cross section of structural members shall be made using the following design expression:

\[
S \leq R / \gamma_{RE} \tag{5.4.2}
\]

where: \( \gamma_{RE} \) — seismic adjusting factor for load-bearing capacity of the structural member, which shall be determined from Table 5.4.2 except having another requirements.

\( R \) — design value of load-bearing capacity of the structural member.

Table 5.4.2 Seismic adjusting factor of load-bearing capacity

<table>
<thead>
<tr>
<th>Material</th>
<th>Type of structural member</th>
<th>Stress type</th>
<th>( \gamma_{RE} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>Column, beam</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brace</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Panel, connecting bolt</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Connecting weld</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>Masonry</td>
<td>Walls with tie-columns or core-columns at both ends</td>
<td>Shear</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>Other seismic structural wall</td>
<td>Shear</td>
<td>1.0</td>
</tr>
<tr>
<td>Concrete</td>
<td>Beam</td>
<td>Bending</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Columns with axial force ratio &lt; 0.15</td>
<td>Eccentric compression</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Columns with axial force ratio ( \geq 0.15 )</td>
<td>Eccentric compression</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Wall</td>
<td>Eccentric compression</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>All types of member</td>
<td>Shear, eccentric tension</td>
<td>0.85</td>
</tr>
</tbody>
</table>

5.4.3 When vertical seismic action is only considered, the seismic adjusting factor should be taken as 1.0 for all structural members.

5.5 Seismic check for deformation

5.5.1 Seismic deformation checks shall be made for all types of structures as per listed in Table 5.5.1, and the maximum elastic story drift shall comply with the following requirement:

\[
\Delta u_e \leq [\theta_e] h \tag{5.5.1}
\]

where: \( \Delta u_e \) — elastic story drift caused by the characteristic value of the frequently earthquake action. The story drift may be computed as the largest difference of the horizontal displacements along any of the edges of the structure at the top and bottom of the story under consideration, except the structures having predominating flexural deformation. When calculating, all of partial fac-
tors of various actions shall be taken as 1.0, and elastic stiffness may be used for reinforced concrete members.

$[\theta_e]$—limit value of elastic story drift rotation which may be taken in accordance with Table 5.5.1.

$h$—height of calculated story.

<table>
<thead>
<tr>
<th>Material</th>
<th>Type of structure</th>
<th>$[\theta_e]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced concrete</td>
<td>Frame</td>
<td>1/550</td>
</tr>
<tr>
<td></td>
<td>Frame-wall, slab-column-wall, frame-core-tube</td>
<td>1/800</td>
</tr>
<tr>
<td></td>
<td>Wall, tube-in-tube</td>
<td>1/1000</td>
</tr>
<tr>
<td></td>
<td>Frame-supporting stories of structure</td>
<td>1/1000</td>
</tr>
<tr>
<td>Steel</td>
<td>Multi-story and tall structures</td>
<td>1/300</td>
</tr>
</tbody>
</table>

5.5.2 Elasto-plastic deformation check shall be made for the weak stories (or locations) of the structure under the rarely earthquake, and shall comply with the following requirements:

1 Elasto-plastic deformation check shall be done for the following structures:
   1) Bent-frames of single-story reinforced concrete column factory with higher columns and larger spans for Intensity 8 with Site-class III and IV, or for Intensity 9;
   2) Reinforced concrete frame structures for Intensity 7~9, when the yield strength coefficient of the story is less than 0.5;
   3) Steel structures with height more than 150m;
   4) Reinforced concrete structures and Steel structures, which assigned to Fortification Category B for Intensity 9 and to Fortification Category A;
   5) Structures adopting seismic-isolation and energy dissipating designs.

2 Elasto-plastic deformation check should be done for the following structures:
   1) Tall building structures within the height scope of as per listed in Table 5.1.2-1 and having also the vertical irregular types as per listed in Table 3.4.2-2;
   2) Reinforced concrete and steel structures assigned to Fortification Category B for Intensity 7 with Site-class III and IV, or Intensity 8;
   3) Slab-column-wall structures and masonry buildings with bottom-frame;
   4) Tall steel structures with height not more than 150m.

Note: The yielding strength coefficient of a story is the ratio between the shear bearing capacity and the elastic seismic shear force at such story under rarely earthquake. For the bent-frame, it refers to the ratio between the bending capacity and elastic seismic moment of such cross section of structure under rarely earthquake. The shear bearing capacity of a story can be determined according to the actual reinforcement area and material characteristic strength of members and the axial force of columns and walls.
5.5.3 Elasto-plastic deformation of a weak story (or location) of a structure under the rarely earthquake may be determined by the following methods:

1. For framed structures that do not exceed 12 stories in height and with no abrupt change of story stiffness as well as single-story factory buildings with reinforced concrete column, the simplified method in Clause 5.5.4 may be used.

2. For structures outside those in point 1 of this clause, the static elasto-plastic analysis method and the time-history analysis method may be used.

3. Regular structures may adopt bending shear model or planar line-members system model, irregular structures as per listed in Section 3.4 of this code shall adopt spacious structure models.

5.5.4 The simplified calculation method for elasto-plastic story drift in the weak story (or location) of a structure should comply with the following requirements:

1. The weak story (or location) may be identified as follows:

   1) For structures with a uniform distribution of story yield strength coefficient along the height of the structure, the first story of the building may be identified as the weak story;

   2) For structures with non-uniform distribution of story yield strength coefficient along the height of the structure, the story (location) with minimum, or smaller story yield strength coefficient may be identified as the weak story. However, in general, no more than two or three stories (locations) may be identified as weak stories;

   3) For single-story factory buildings, the weak location is at the upper portion of the columns.

2. The elasto-plastic story drift may be calculated by the following equations:

   \[ \Delta u_p = \eta_p \Delta u_e \]  
   \[ \Delta u_p = \mu \Delta u_y = \frac{\eta_p}{\xi_y} \Delta u_y \]  

where: \( \Delta u_p \) — elasto-plastic story drift.
\( \Delta u_y \) — yield story drift.
\( \mu \) — story ductility factor.
\( \Delta u_e \) — elastic story drift under the rarely earthquake.
\( \eta_p \) — amplifying factor for elasto-plastic story drift. When the yield strength coefficient of the weak story (location) is not less than 80% of the average value of coefficients of the neighboring stories (location), it may be taken from Table 5.5.4. When the yield strength coefficient is not more than 50% of the above-mentioned average value, it may be taken the corresponding values in the Table 5.5.4 multiplied by 1.5. When the yield strength coefficient is between the above two cases, it may be determined.
by interpolation.

\[ \xi_y \] — yield strength coefficient of story.

**Table 5.5.4 Amplifying factor for elasto-plastic story drift**

<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Total Stories or location</th>
<th>( \xi_y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-story frame structure with uniform elevation</td>
<td>2–4</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>5–7</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>8–12</td>
<td>1.80</td>
</tr>
<tr>
<td>Single-story factory building</td>
<td>Upper portion of column</td>
<td>1.30</td>
</tr>
</tbody>
</table>

5.5.5 The elasto-plastic story drift in the weak stories (locations) of a structure shall comply with the following requirement:

\[ \Delta u_p \leq \left[ \theta_p \right] h \]  \hspace{1cm} (5.5.5)

where: \( \left[ \theta_p \right] \) — limit value of elasto-plastic story drift rotation, which can be taken from Table 5.5.5. For reinforced concrete frame structures, the values may be increased. Such as, it may be increased 10% where axial-force-ratio is less than 0.40; it may be increased 20% where the stirrup characteristic value along the full height of the column is 30% greater than those provisions in Table 6.3.12. But its total increase shall not be greater than 25%.

\( h \) — height of the weak story (location) or the height of the upper portion of column in single-story factory building.

**Table 5.5.5 Limit values for elasto-plastic story drift**

<table>
<thead>
<tr>
<th>Material</th>
<th>Type of structure</th>
<th>( \left[ \delta_p \right] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced concrete</td>
<td>Bent-frame of Single-story factory building with reinforced concrete columns</td>
<td>1/30</td>
</tr>
<tr>
<td></td>
<td>Frame</td>
<td>1/50</td>
</tr>
<tr>
<td></td>
<td>Frame-wall of brick building with bottom-frame</td>
<td>1/100</td>
</tr>
<tr>
<td></td>
<td>Frame-wall, slab-column, wall, frame-core-tube</td>
<td>1/100</td>
</tr>
<tr>
<td></td>
<td>Wall, tube-in-tube</td>
<td>1/120</td>
</tr>
<tr>
<td>Steel</td>
<td>Multi-story and tall Structures</td>
<td>1/50</td>
</tr>
</tbody>
</table>

41
Chapter 7  Multi-story Masonry Buildings and Multi-story Brick Buildings with Bottom-frame or Inner-frame

7.1  General

7.1.1  This chapter is applicable to multi-story fired clay brick buildings, to multi-story concrete small hollow block buildings, as well as to multi-story brick buildings with frame-wall in the first story or first and second stories (hereinafter refer to multi-story brick buildings with bottom-frame) and to multi-story brick buildings with inner-multi-column frames (hereinafter refer to “multi-story brick buildings with inner-frame”).

The seismic design of reinforced wall structures using concrete small hollow block shall conform to the provision in Appendix F of this code.

Notes: 1  In this chapter, “fired common clay brick, fired clay perforated brick, concrete small hollow block” hereinafter refer to “common brick, perforated brick, and small block” respectively. For masonry buildings using other fired bricks and autoclaved bricks, the material property of unit shall have reliable testing data. When the shear strength of the masonry is not less than that of the clay brick masonry, it shall be carried out according to relevant provision for clay brick buildings of this charter.

2  For masonry buildings using autoclaved sand lime bricks or fly-ash-lime bricks for Intensity 6 and 7, when the shear strength of the masonry is not less than 70% that of the clay bricks, the seismic design shall comply with follows:

   The maximum number of stories shall reduce by one story than that of clay brick buildings, the maximum total height shall reduce by 3m, and the tie-columns shall be installed according to one story more for corresponding clay brick buildings, other requirements shall comply with the provisions for clay brick buildings.

3  The “multi-story brick buildings with frame-seismic-structural wall in the first story or first two stories” hereinafter refer to “multi-story brick buildings with bottom-frame”; and the “multi-story brick buildings with inner-multi-column frames”.

7.1.2  The total height and number of stories of multi-story buildings shall comply with the following requirements:

1  For usual masonry buildings, the total height and number of stories shall not exceed the limits in Table 7.1.2.

2  For multi-story buildings with rather less transverse walls, as well as hospitals or schools, the limits value of total height shall be decreased by 3m from the values in Table 7.1.2, and of the stories shall be decreased by one. For multi-story buildings with a few of transverse walls, the total height and the stories shall be reduced based on actual condition.
Note: building with rather less transverse walls refer to that rooms with span greater than 4.20m take up more than 40% of the areas in the same story.

3 For multi-story brick living buildings with rather less transverse walls, when the strengthened measures has be taken according to the provision and the seismic capacity of wall is sufficient, the total height and number of stories shall be permitted to adopt the limits in Table 7.1.2.

### Table 7.1.2 Limit values of total height and number of stories

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Min. wall thickness</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Height</td>
<td>Stories</td>
<td>Height</td>
<td>Stories</td>
</tr>
<tr>
<td>Common brick</td>
<td>240mm</td>
<td>24m</td>
<td>8</td>
<td>21m</td>
<td>7</td>
</tr>
<tr>
<td>Perforated brick</td>
<td>240mm</td>
<td>21m</td>
<td>7</td>
<td>21m</td>
<td>7</td>
</tr>
<tr>
<td>Perforated brick</td>
<td>190mm</td>
<td>21m</td>
<td>7</td>
<td>18m</td>
<td>6</td>
</tr>
<tr>
<td>Small block</td>
<td>190mm</td>
<td>21m</td>
<td>7</td>
<td>21m</td>
<td>7</td>
</tr>
<tr>
<td>With bottom-frame</td>
<td>240mm</td>
<td>22m</td>
<td>7</td>
<td>22m</td>
<td>7</td>
</tr>
<tr>
<td>With inner-frame</td>
<td>240mm</td>
<td>16m</td>
<td>5</td>
<td>16m</td>
<td>5</td>
</tr>
</tbody>
</table>

Notes:  
1 Total height of the building refers to the height from the ground level to top of the main roof slab. For semi-basement, the height is counted from the indoor ground of the basement; for basement and semi-basement with better fixing conditions, the height shall be counted from outdoor ground; for slope roof with garret, the height shall be counted to 1/2 height of the gable.  
2 When the indoor and outdoor height difference is greater than 0.6m, the total height of the building shall be permitted to increase appropriately but cannot be more than 1m.  
3 The small block buildings in this table do not include the reinforced small block buildings.  

7.1.3 For the common brick, perforated brick and small block buildings, the story-height shall not exceed 3.6m. For the bottom stories of the brick buildings with bottom-frame and the brick buildings with inner-frame, the story-height shall not exceed 4.5m.
7.1.4 Maximum ratio of the total height to total width for multi-story masonry buildings should conform to Table 7.1.4

Table 7.1.4 Maximum ratio of total height to total width for buildings

<table>
<thead>
<tr>
<th>Intensity</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. ratio</td>
<td>2.5</td>
<td>2.5</td>
<td>2.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Notes: 1 The total width of buildings with an external corridor does not include the width of the corridor;
2 When the plan of the building is close to square, the ratio shall be reduced accordingly.

7.1.5 Maximum spacing of adjacent transverse walls in buildings shall not exceed the requirements in Table 7.1.5.

Table 7.1.5 Maximum spacing of adjacent transverse walls (m)

<table>
<thead>
<tr>
<th>Type of building and type of floor or roof</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Multi-story masonry</td>
<td></td>
</tr>
<tr>
<td>Cast-in-situ or precast-monolithic reinforced concrete</td>
<td>18</td>
</tr>
<tr>
<td>Fabricated reinforced concrete</td>
<td>15</td>
</tr>
<tr>
<td>Timber</td>
<td>11</td>
</tr>
<tr>
<td>Multi-story masonry with</td>
<td></td>
</tr>
<tr>
<td>bottom-frame building</td>
<td></td>
</tr>
<tr>
<td>All masonry stories above the framed stories</td>
<td></td>
</tr>
<tr>
<td>Same as multi-story masonry</td>
<td></td>
</tr>
<tr>
<td>First story or first and second frame stories</td>
<td></td>
</tr>
<tr>
<td>Multi-story masonry with inner-frame building</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1 For top story of multi-story masonry buildings, the maximum spacing requirement of transverse walls shall be permitted loosened.
2 The provision for timber floor and roof in the table is not applicable to small block buildings.

7.1.6 The limitation of local dimension for masonry wall should comply with the requirements in Table 7.1.6:

Table 7.1.6 Limitation of local dimension for masonry wall (m)

<table>
<thead>
<tr>
<th>Location</th>
<th>Intensity6</th>
<th>Intensity7</th>
<th>Intensity8</th>
<th>Intensity9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. width of a bearing wall between windows</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Min. distance from a bearing exterior wall end to the edge of the door or window opening</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Min. distance from a non-bearing exterior wall end to the edge of the door or window opening</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Min. distance from the salient angle of inter wall to the edge of the door or window opening</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Max. height of parapet without anchorage (not at entrance)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Notes: 1 The strengthening measures shall be taken when the local scales are insufficient;
2 Parapet in exit and/or entrance shall be anchored;
3 The width of an exterior longitudinal wall between windows for multi-story brick buildings with inner-frames shall not be less than 1.5m.

7.1.7 The structure system of multi-story masonry buildings shall comply with the following requirements:
1. The structure system of bearing by transverse wall or of bearing by both longitudinal and transverse walls shall be adopted with priority.

2. The arrangement of transverse and longitudinal walls should be symmetrical, even, and aligned in-plane, shall be continued from footing to top, and the widths of all wall-segments between windows in an axis should be equivalent.

3. The seismic joints should be installed if the building has one of the following cases as well; The walls shall be arranged on both sides of the joint, and the joint clear width shall be determined dependent on the fortification intensity and the height of the building, that may be taken as 50～100mm.

1) The height difference in elevation of the building is greater than 6 m;
2) The building having staggered-floor with significant level differences;
3) The stiffness and mass of every parts of a structure are completely different.

4. The staircase should not be arranged at the end and corner of the building.

5. The flue, air duct, and refuse chute shall not weaken the walls; in case the wall is weakened, the strengthening measures shall be taken. For chimney without vertical reinforced, which is adhered to wall or having height exceeding roof surface, should not be adopted.

6. The precast reinforced concrete eaves plate without anchorage shall not be used.

7.1.8 The structural arrangement of brick buildings with bottom-frames shall comply with the following requirements:

1. All of the masonry walls above the bottom-frame story shall be or shall basically be level by the frame-beams or walls at the bottom.

2. A certain number of walls shall be installed along both the longitudinal and transverse directions at the bottom of the building, and the walls shall be arranged symmetrical or basically symmetric. If multi-story brick buildings with framed first story, that not more than 5 stories and for Intensity 6 and 7, the masonry walls at the first story may be adopted, but the additional axial force and shear force of frame caused by masonry wall shall be taken into consideration. The reinforced concrete walls shall be adopted for other cases.

3. In the longitudinal and transversal directions of multi-story brick building with framed first story, the lateral rigidity ratio of the second story to the first story shall not be greater than 2.5 for Intensity 6 and 7, and than 2.0 for Intensity 8; both shall not be less than 1.0.

4. In the longitudinal and transversal directions of multi-story brick building with framed first and second stories, the lateral rigidity ratio of third story to second story shall not be greater than 2.0 for Intensity 6 and 7, and than 1.5 for Intensity 8; both shall not be less than 1.0. And the lateral rigidity of the first to the second story shall be approximately equivalent.
5 The strip foundation, raft foundation or pile foundation shall be adopted for the walls of brick buildings with bottom-frames.

7.1.9 The structural arrangement for multi-story brick buildings with inner-frames shall comply with the following requirements:

1. Rectangular plane should be adopted for the building, and the elevation should be regular; the transversal wall of the stair should be installed through the full width of the building.

2. For the spacing of adjacent transversal wall is greater than 18m for Intensity 7 and greater than 15m for Intensity 8, the composite columns shall be installed at longitudinal external walls between windows.

3. The strip foundation, raft foundation or pile foundation shall be adopted for the walls of brick buildings with inner-frames.

7.1.10 The seismic design of reinforced concrete structural parts of brick buildings with bottom-frames and inner-frames shall comply with both the provisions in this Chapter and relevant requirements in Chapter 6 of this code. Meanwhile, the seismic measure grades for brick buildings with bottom-frame, the frame and the wall shall be taken as Grade 3, 2, and 1 for Intensity 6, 7, and 8 respectively. And the seismic measure grades for brick buildings with inner-frames shall be taken as Grade 4, 3, and 2 for Intensity 6, 7, and 8 respectively.

7.2 Essentials in calculation

7.2.1 The base shear method may be used in the seismic calculation for multi-story masonry buildings, and brick buildings with bottom-frame or inner-frame, and the seismic effects shall be adjusted in accordance with the provisions of such section.

7.2.2 For masonry buildings, the seismic checking of walls may only be made that with greater subordinating areas or with less vertical stress.

7.2.3 When carrying out seismic shear force distribution and seismic checks, the story equivalent lateral stiffness of the masonry wall shall be determined according to the principle as follows:

1. For the calculation of stiffness, the influence on height-width ratio of wall-segment shall be taken into consideration. When this ratio is less than 1, only shear deformation of wall needs to be taken into account. When this ratio is not greater than 4 and not less than 1, both the bending and shear deformation shall be taken into consideration. And this ratio is greater than 4, the equivalent lateral stiffness may be taken as 0.0.

Note: The height-width ratio refers to the ratio between the height of story and the lateral-length of wall.

In the case of spacing-walls between the opening of the door and the windows, it refers to the ratio between the clear height of the opening and the wall width on the sides of the opening.

2. The wall-segments should be divided according to the openings of the door and the
windows. For stiffness calculated according to gross wall surface in the small opening wall sections, the calculation may multiply the opening reduced factors which depend upon the opening rate and as per set in Table 7.2.3:

<table>
<thead>
<tr>
<th>Opening rate</th>
<th>0.10</th>
<th>0.20</th>
<th>0.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced factor</td>
<td>0.98</td>
<td>0.94</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Note: the opening rate is the ratio between the opening area and the gross area of the wall; when the height of window opening is greater than 50% of the story height, it shall be treated as door opening.

7.2.4 Seismic effects of brick buildings with bottom-framed shall be adjusted according to the following provision:

1. For brick buildings with framed first story, the first story longitudinal and transversal seismic shear force design value shall be multiplied by an amplifying factor. The value of this amplifying factor shall be permitted to be selected in the range from 1.2 to 1.5 according to the lateral stiffness ratio between the second story and the first story.

2. For brick buildings with framed first and second stories, the longitudinal and transversal seismic shear force design value of the first story and the second story shall all be multiplied by an amplifying factor. The value of this amplifying factor shall be permitted to be selected in the range from 1.2 to 1.5 according to the lateral stiffness ratio.

3. All of longitudinal and transversal seismic shear force design value of the first story and the second story shall be resisted by the wall of corresponding direction separately, and the distribution shall be made according to the lateral stiffness ratio of every wall.

7.2.5 Seismic effect of frames in brick buildings with bottom-frame shall be determined by the following method:

1. The seismic shear force and axial force of the bottom-framed columns should be adjusted according to the following provision:

1) Design value of seismic shear force resisted by framed columns may be determined in proportion to the effective lateral stiffness of every lateral-force-resisting member. The value of the effective lateral stiffness may not be reduced for the frame, and may be multiplied by 0.30 for the reinforced concrete wall, and may be multiplied by 0.20 for the clay brick wall.

2) Additional axial force caused by the seismic overturning moment shall be considered in the calculation of the axial force of the framed column. The seismic overturning moment carried by the elements in all axes may be determined in proportion of the lateral stiffness of walls and frames in the bottom approximately.

2. When calculating the seismic combinatory inner force for the reinforced concrete
spandrel girder for brick buildings with bottom-frames, proper calculation figure shall be adopted. If the composite effect of the upper walls and its spandrel girder may be taken into consideration, the unfavorable influence caused by the cracking of wall during earthquake shall also be taken into consideration, relevant bending moment factors and axial factors shall also be adjusted.

7.2.6 Design value of seismic shear force for columns in multi-story brick buildings with inner-frames should be determined in accordance with the following equation:

\[ V_c = \frac{\psi_c}{n_b \cdot n_s} (\zeta_1 + \zeta_2 \lambda) V \]  

(7.2.6)

where:  
- \( V_c \) — design value of seismic shear force of column.  
- \( V \) — design value of seismic shear force of story in spacing of transverse walls.  
- \( \psi_c \) — factor of type of columns, and may be taken as 0.012 for interior reinforced concrete columns, 0.0075 for composite brick columns in the exterior wall, and 0.005 for plain brick columns (or walls).  
- \( n_b \) — number of bays in spacing of transverse walls.  
- \( n_s \) — number of spans in inner-frame.  
- \( \lambda \) — the ratio between the spacing of transverse walls and the total width of the building, and may be taken as 0.75 when the ratio is less than 0.75.  
- \( \zeta_1, \zeta_2 \) — factors for calculation, and may be taken in accordance with Table 7.2.6.

### Table 7.2.6 Factors for calculation

<table>
<thead>
<tr>
<th>Total number of stories of building</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \zeta_1 )</td>
<td>2.0</td>
<td>3.0</td>
<td>5.0</td>
<td>7.5</td>
</tr>
<tr>
<td>( \zeta_2 )</td>
<td>7.5</td>
<td>7.0</td>
<td>6.5</td>
<td>6.0</td>
</tr>
</tbody>
</table>

7.2.7 The design value for seismic shear strength along the ladder shaped damage of various masonry structures shall be determined according to the following equation:

\[ f_{vk} = \zeta_N f_v \]  

(7.2.7)

where:  
- \( f_{vk} \) — the design value for seismic shear strength along the ladder shaped damage of masonry.  
- \( f_v \) — the design value for shear strength along the ladder shaped damage of masonry.  
- \( \zeta_N \) — normal stress influence factors for the seismic shear strength of masonry, and shall be taken as from Table 7.2.7.
### Table 7.2.7 Normal stress influence factor of masonry strength

<table>
<thead>
<tr>
<th>Type of masonry</th>
<th>(\sigma_0/f_s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Common brick, perforated brick</td>
<td>0.80</td>
</tr>
<tr>
<td>Small block</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Note:** \(\sigma_0\) refer to the mean pressure of the masonry cross section corresponding to gravity load representative value.

7.2.8 The seismic shear capacity for walls of common bricks and perforated bricks shall be checked according to the following provisions:

1. Generally, the check shall be made according to the following equation:

\[
V \leq f_{sE}A / \gamma_{RE}
\]  \(\text{(7.2.8-1)}\)

where: 
- \(V\) — shear of wall of masonry structures.
- \(f_{sE}\) — design value for seismic shear strength along the ladder shaped damage of masonry.
- \(A\) — cross-sectional area of wall, the gross area of cross section for perforated brick wall.
- \(\gamma_{RE}\) — seismic adjusting factor for shear bearing capacity, for bearing wall shall be taken as from Table 5.4.2 of this code, for self-bearing wall shall be taken as 0.75.

2. When the checking according to equation (7.2.8-1) fails to satisfy the requirements, the improving effect on the seismic shear capacity by the tie-columns may be taken according to the simplified methods as follows. However, such tie-columns are installed in the middle of the wall, cross-sectional areas not less than 240mm × 240mm and spacing not greater than 4m.

\[
V \leq \frac{1}{\gamma_{RE}} \left[ \eta_{E}f_{sE}(A - A_c) + \zeta f_t A_c + 0.08f_y A_s \right]
\]  \(\text{(7.2.8-2)}\)

where:
- \(A_c\) — the total cross-sectional areas of middle tie-columns; for transversal and inner longitudinal wall, when \(A_c > 0.15A\), taken as 0.15A; for external longitudinal wall, when \(A_c > 0.25A\), taken as 0.25A.
- \(f_t\) — specified concrete tensile strength of tie-column in middle.
- \(A_s\) — the total areas of reinforcements of tie-column in middle, that the steel bar ratio is not less than 0.6%. when it is greater than 1.4%, taken as 1.4%.
- \(f_y\) — design value of reinforcement tensile strength.
- \(\xi\) — the participation factor of tie-column in the middle; for only one tie-column,
taken as 0.5; for other cases, taken as 0.4.

ηc—the confined factor of wall; generally the factor adopts 1.0; when the spacing of the tie-columns is not greater than 2.8m, adopts 1.1.

7.2.9 For horizontal reinforced common brick and perforated brick walls, the seismic shear bearing capacity shall be checked in accordance with following equation:

\[ V \leq \frac{1}{\gamma_{RE}} (f_{tE}A + \zeta_s f_y A_s) \quad (7.2.9) \]

where: 
- \( A \)—cross-sectional area of wall, the gross area of cross section for perforated brick wall.
- \( f_{tE} \)—design value of reinforcement tensile strength.
- \( A_s \)—the total areas of horizontal reinforcements in height of a story, the reinforcement ratio shall not be less than 0.07% and not greater than 0.17%.
- \( \zeta_s \)—the participation factor of reinforcement, may be taken as from Table 7.2.9.

<table>
<thead>
<tr>
<th>Ratio of height to width for wall</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
<th>1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \zeta_s )</td>
<td>0.10</td>
<td>0.12</td>
<td>0.14</td>
<td>0.15</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Table 7.2.9 Participation factor of reinforcement

7.2.10 For small blocks wall, the seismic shear bearing capacity shall be checked in accordance with following equation:

\[ V \leq \frac{1}{\gamma_{RE}} [f_{tE}A + (0.3f_{tE}A_c + 0.05f_y A_s)] \quad (7.2.10) \]

where: 
- \( f_t \)—specified concrete tensile strength of core-column.
- \( A_c \)—total cross-sectional area of core-columns.
- \( A_s \)—total cross-sectional area of reinforcements in core-column.
- \( \zeta_c \)—the participation factor of core-column, may be taken as from Table 7.2.10.

Note: when both core-columns and tie-columns are installed together, the cross-sectional areas of the tie-column may be treated as the cross-sectional areas of the core-column, and the reinforcement of the tie-column may also be treated as that of the core-column.

<table>
<thead>
<tr>
<th>Hole filling rate ( \rho )</th>
<th>( \rho &lt; 0.15 )</th>
<th>( 0.15 \leq \rho &lt; 0.25 )</th>
<th>( 0.25 \leq \rho &lt; 0.5 )</th>
<th>( \rho \geq 0.5 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \zeta_c )</td>
<td>0.0</td>
<td>1.0</td>
<td>1.10</td>
<td>1.15</td>
</tr>
</tbody>
</table>

Note: Hole filling rate refer to the ratio of number of core-columns to total hole numbers.

7.2.11 For multi-story brick building with framed first story, when walls with common bricks filled in the frames satisfy the detail requirements in Clause 7.5.6 of this chapter, the seismic check shall comply with the following provisions:

1. The axial and shear force of the frame columns in the first story shall take into consideration of the additional axial and shear force according to the following equations:
\[ N_f = V_w H_f / l \quad (7.2.11-1) \]
\[ V_f = V_w \quad (7.2.11-2) \]

Where: \( V_w \) — the shear force design value distributed to the wall; for walls existed on both sides of the column, the value may be taken as the greater one.

\( N_f \) — additional axial pressure design value of the frame column. 

\( V_f \) — additional shear force design value of the frame column.

\( H_f, l \) — the story height and span of the frame respectively.

2 The seismic bearing capacity of the wall made with common bricks filled in the frame and the frame columns at the two ends of wall shall be checked according to the following equation:

\[ V \leq \frac{1}{\gamma_{REc}} \Sigma (M_{wR} + M_{yc}) / H_0 + \frac{1}{\gamma_{REW}} \Sigma f_{yk} A_{w0} \quad (7.2.11-3) \]

where: \( V \) — the shear force design value of the filled common brick wall and the frame columns at the two ends of wall.

\( A_{w0} \) — calculated horizontal sectional area of the brick wall. When wall has no opening, take as 1.25 times of the actual sectional area; when wall has opening, take as the net sectional area, but the sectional area of the wall, which width is less than 1/4 of the opening height, is not considered.

\( M_{wR}, M_{yc} \) — non-seismic bending bearing capacity design values at the upper and lower end of the frame columns in the first story respectively, and it may be determined by the provision in the current national standard “Code for design of concrete structure” GB 50010.

\( H_0 \) — calculated height of first story frame column; when there are brick walls on the both sides of the column, take as 2/3 of clear height of the column; in other cases, take as the clear height of the column.

\( \gamma_{REc} \) — seismic adjusting factor for first story frame column bearing capacity, and may be taken as 0.8;

\( \gamma_{REW} \) — seismic adjusting factor for filled common brick wall bearing capacity, and may be taken as 0.9.

7.2.12 The seismic check for composite brick column at external wall of multi-story buildings with inner-frames shall be done according to the provision in Clause 9.3.9 of this code.

7.3 Details of seismic design for multi-story clay brick buildings

7.3.1 The cast in-situ reinforcement concrete tie-columns (hereinafter referred to as tie-column) for multi-story clay brick and perforated brick buildings shall be installed in accordance with the following requirements:
1. The location installed of tie-column shall comply with the requirements in Table 7.3.1 in generally.

2. For multi-story gallery-type or one-sided corridor buildings, the tie-columns shall be installed in accordance with the Table 7.3.1, but the building assumed with one more story, and the longitudinal walls on the both sides of the one-sided corridor shall be regarded as exterior walls.

3. For buildings with rather less transversal walls such as schools and hospitals, the tie-columns shall be installed in accordance with the Table 7.3.1, but the building assumed with one more stories. When such buildings adopt the gallery-type or one-sided corridor, that shall also comply with provision in Point 2 of this clause; but the following building assumed with two more stories; does not exceed 4 stories for Intensity 6, or 3 stories for Intensity 7, or 2 stories for Intensity 8.

Table 7.3.1 Requirements for arrangement of tie-columns for brick buildings

<table>
<thead>
<tr>
<th>Number of stories in building</th>
<th>Location of installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int. 6 4, 5</td>
<td>Four corners of the interior wall and exterior longitudinal walls at large rooms</td>
</tr>
<tr>
<td>Int. 7 3, 4</td>
<td>Four corners of the staircase and elevator shaft for Intensity 7 and 8; intersections of each 15m or the unit transversal wall and exterior longitudinal wall</td>
</tr>
<tr>
<td>Int. 8 2, 3</td>
<td>Intersections of every other transversal wall (axis) and exterior wall; intersections of gable and interior walls; four corners of staircase and elevator shaft for Intensity 7 to 9</td>
</tr>
<tr>
<td>Int. 9</td>
<td>Intersections of interior wall and exterior wall, smaller piers of the interior wall; four corners of the staircase and elevator shaft of Intensity 7 to 9; intersections of interior longitudinal and transversal wall for Intensity 9</td>
</tr>
</tbody>
</table>

7.3.2 The tie-columns of the multi-story common brick and perforated brick buildings shall comply with the following requirements:

1. The minimum crosssection for the tie-column may adopt 240mm × 180mm, the longitudinal bars should adopt 4#12; spacing of the stirrups shall not be greater than 250mm, besides, in the upper and lower ends of the tie-column, the spacing of stirrups shall be reduced accordingly. When exceeding 6 stories for Intensity 7, exceeding 5 stories for Intensity 8, and for Intensity 9, the longitudinal bars of the tie-column shall adopt 4#14, and the spacing of stirrups shall not exceed 200mm. For the tie-columns in the corners of the building, cross section and stirrups shall be increased accordingly.

2. The connection of the tie-column and the adjacent walls shall be built into horse-toothed joints, the 2#6 tie bars shall be arranged in spacing each 500mm along the height of the wall, the length extending into the wall at each side should not be less than 1 m.
3 At the connection of the tie-column and the ring-beam, the longitudinal bars of the tie-column shall be through the ring-beam to ensure the continuation of longitudinal bars in the tie-column.

4 The tie-columns may not establish individual footing, but they shall extend to 500mm into the underground level, or shall be connected with the foundation ring-beam, whose buried depth less than 500mm underground.

5 When the building height and the number of stories are close to the limit values of Table 7.1.2, the spacing of tie-columns within the longitudinal and transversal walls shall also comply with the following requirements:

1) For the transversal wall, the spacing of tie-columns should not be greater than 2 times of the story height, and this spacing of tie-columns in lower 1/3 of stories should be reduced accordingly;

2) For the longitudinal walls, when the bays of building are greater than 3.9m, the exterior longitudinal walls shall adopt strengthening measures; the spacing of tie-columns of the interior longitudinal wall should not be greater than 4.2m.

7.3.3 The cast-in-situ reinforced concrete ring-beam of multi-story common brick and perforated brick buildings shall be installed in accordance with the following requirements:

1 For the buildings with precast reinforced concrete or timber floors and roof, ring-beams shall be installed as follows:

When the buildings assigned to bearing transversal wall system, ring-beams shall be installed according to the requirements in Table 7.3.3; when assigned to bearing longitudinal wall system, ring-beams shall be installed at each story and their spacing on the transversal wall shall be reduced accordingly.

2 Only the building with cast-in-situ or assembly-monolithic reinforcement concrete floors and roof that have reliable connection with the walls, the ring-beams shall be permitted not installed. But the strengthened reinforcements of in-situ slabs shall be arranged along the wall perimeters and shall be reliably connected with corresponding tie-columns.

Table 7.3.3 Requirements for installation of cast-in-situ reinforcement concrete ring-beam in brick buildings

<table>
<thead>
<tr>
<th>Type of wall</th>
<th>Intensity</th>
<th>6,7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior walls and interior longitudinal wall</td>
<td>At roof level, each floor level</td>
<td>At roof level, each floor level</td>
<td>At roof level, each floor level</td>
<td></td>
</tr>
<tr>
<td>Interior transversal wall</td>
<td>Ditto; the spacing at roof shall not be greater than 7m; spacing at the floor shall not be greater than 15m; corresponding location of the tie-column</td>
<td>Ditto; along all transversal walls at roof and the spacing shall not be greater than 7m; the spacing at floor shall not be greater than 7m; corresponding location of the tie-column</td>
<td>Ditto; all transversal walls at roof and each floor level</td>
<td></td>
</tr>
</tbody>
</table>
7.3.4 The details of cast-in-situ reinforced concrete ring-beam in multi-story common and perforated brick buildings shall comply with the following requirements:

1. The ring-beam shall be enclosed; at the location of opening, the ring-beam shall be spliced with two limbs along the upper and lower of opening. The ring-beams should be installed in the same level of the precast slabs or immediate next to the bottom of the slab.

2. For no transversal wall exists within of ring-beam spacing required by Table 7.3.3, the reinforcements in the floor girder or the joint between precast slabs shall be used for the replacement of ring-beam.

3. The cross-sectional height of the ring-beam shall not be less than 120mm, and the reinforcements shall comply with the requirements in Table 7.3.4. The ring-beams added according to the requirements of point 3 of Clause 3.3.4 of this code, the cross-sectional height shall not be less than 180mm, and the reinforcement bar shall not be less than 4¢12.

<table>
<thead>
<tr>
<th>Reinforcement</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6,7</td>
</tr>
<tr>
<td>Min. longitudinal bar</td>
<td>4¢10</td>
</tr>
<tr>
<td>Max. stirrup spacing (mm)</td>
<td>250</td>
</tr>
</tbody>
</table>

7.3.5 Roof and floors of multi-story common brick and perforated brick buildings shall comply with the following requirements:

1. The length for cast in-situ reinforced concrete roof or floor slabs extending to the transversal and longitudinal walls shall not be less than 120mm.

2. For precast reinforcement concrete floor or roof slab and the ring-beam is not installed at the same level of the slab, the length for the slab end extending into the exterior wall shall not be less than 120mm; into interior wall, than 100mm; and in to beam, than 80mm.

3. For the span of the precast slab is greater than 4.8m and is parallel to the exterior wall, the side of the precast slab next to the exterior wall shall be tied with the exterior wall or ring-beam.

4. The precast slabs of the large room at the end of the building, which assigned to the roof for Intensity 8 or to the floors and roof for Intensity 9, shall be tied with one another, as well as with the beam, wall or ring-beam, when the ring-beam is installed at the bottom of the slab.

7.3.6 The reinforced concrete girders or trusses of the roof or floor system shall be reliably connected with the wall, column (including tie-column) or ring-beam. The connection of the girder and the brick column shall not weaken the cross section of the brick column. For the independent brick columns, the top of each story shall have reliable connection in two
directions.

7.3.7 For the rooms with length greater than 7.2m of Intensity 7 or for Intensity 8 and 9, in the corners of exterior wall and intersection of exterior and inner wall, the tie bars of 2∮6 shall be installed in each 500mm along the height of the wall. Besides, the tie bars should be extended into the walls on each side with length not less than 1 m.

7.3.8 The staircase shall comply with the following requirements:

1 For the transversal wall and exterior wall of the staircase at top story for Intensity 8 and 9, 2∮6 reinforcement bars shall be installed overall length of wall and installed in each 500mm along the height of the wall. For Intensity 9, a 60mm thick reinforced concrete strip or a reinforced brick course shall be installed at the landing platform or middle level of the story in other stories of the staircase. For reinforced brick course, the strength grade of mortar shall not be less than M7.5, and the longitudinal reinforcement bars shall not be less than 2∮10.

2 For Intensity 8 and 9, the supporting length of the girder, which is at the staircase or the salient angle of the interior wall for the vestibule, shall not be less than 500mm, and the girder shall be connected with the ring-beam.

3 The precast waist slabs shall be reliably connected with the beam of the landing platform; the stairs with the cantilevered steps tread from wall or the steps riser interposed the walls shall not be adopted, and the plain brick railing shall not be adopted.

4 For staircase or elevator shaft exceeding the roof level, the tie-column shall extend to the wall top and shall connect with the ring-beam of the wall top. And its intersection of the interior and exterior walls, 2∮6 tie-bars shall be installed in each 500mm along the height of the wall; more over, the length for each side to extend into the wall shall not be less than 1 m.

7.3.9 The trusses of pitch roof shall be reliably connected with the ring-beam of the top story of building; the purlines and the roof slabs shall be connected with the walls or trusses. The tiles of eaves course at the entrance and exit of the building shall be anchored to the roof members. For Intensity 8 and 9, the stepwise piers at the top of longitudinal interior wall of the top story should be built up to support the gables.

7.3.10 The plain brick lintels shall not be adopted at the door or window openings. The supporting length of lintel shall not be less than 240mm from Intensity 6 through Intensity 8, and shall not be less than 360mm for Intensity 9.

7.3.11 The precast balcony slabs shall be reliably connected with the ring-beam and the cast-in-situ strip of the precast floor slab.

7.3.12 The post-built non-bearing partition wall shall comply with relevant provision of Section 13.3 in this code.

7.3.13 The foundation (included the pile capping) of the same structural unit should adopt foundation of the same type. The bottom of foundation shall be buried at the same lev-
el; otherwise, added foundation ring-beams shall be installed, and foundation shall be stepped on a slope 1:2.

7.3.14 For the total height and number of stories of multi-story common brick and perforated brick living buildings exceed the limit values listed in Table 7.1.2, the strengthening measures shall comply with following provisions:

1 The size of the largest bay in the building shall not be greater than 6.6m.

2 Within the same structural unit, the number of staggered-axis transversal wall should not exceed 1/3 of the total number of walls; more over, successive staggered-axis walls should not exceed two. The added tie-columns shall be installed at fall of intersection of the staggered-axis walls and longitudinal walls, and the floors and roof shall adopt in-situ reinforced concrete slabs.

3 The width of opening in the transversal wall and the interior longitudinal walls should not be greater than 1.5m; the width of opening in the exterior longitudinal wall should not exceed 2.1m or 50% of the bay dimension. More over, the locations of these opening on the interior and exterior walls shall not affect the integral connections between the interior and/or exterior longitudinal walls and transversal walls.

4 The in-situ strengthening reinforcement concrete ring-beam shall be installed for each transversal and longitudinal wall in the floors and roof. The cross-sectional height of the ring-beam should not be less than 150mm, the upper and lower longitudinal reinforcement bars shall not be less than 3Φ10, the stirrup diameter shall not be less than Φ6, and the spacing of stirrup shall not be greater than 300mm.

5 In the intersections of all transversal and longitudinal walls as well as the middle of the transversal walls, the added tie-columns shall be installed in accordance with following requirements:

The column spacing within the transversal wall should not be greater than the story height, the spacing of column within the longitudinal walls should not be greater than 4.2m;

The minimum cross section of tie-columns should not be less than 240mm×240mm; the reinforcements should comply with the requirements in Table 7.3.14.

| Table 7.3.14 Requirements for longitudinal bars and stirrups in the added tie-column |
|-------------------------------------------------|--------------|--------------|--------------|-----------------|-----------------|-----------------|
| Location | Longitudinal bars | Stirrup |                  |                  |                  |                  |
|          | Max. steel ratio (%) | Min. steel ratio (%) | Min. diameter (mm) | Scope of densified zone (mm) | Spacing in densified zone (mm) | Min. diameter (mm) |
| Corner column | 1.8 | 0.8 | 14 | Full height | 100 | 6 |
| Side column | 1.8 | 0.8 | 14 | Upper end 700 | 100 | 6 |
| Middle column | 1.4 | 0.6 | 12 | Lower end 500 |                  |                  |
6 The floors and roof of the same structural unit should be installed at the same level.

7 At the windowsill level of the top and first story of the building, the cast-in-situ reinforced concrete horizontal strip should be installed along overall length of the transversal walls and longitudinal walls. The cross-sectional height of this strip shall not be less than 60mm, the width shall not be less than 240mm, and the longitudinal bars shall not be less than 3\#6.

7.4 Details of seismic design for multi-story small-block buildings

7.4.1 The reinforced concrete core columns (hereinafter refer to core-column) for small-block buildings shall be installed in accordance with the requirements of Table 7.4.1. For buildings with rather less transversal walls such as hospital and school, core-columns shall be installed in accordance with the Table 7.4.1, but the building assumed with one more stories.

<table>
<thead>
<tr>
<th>Number of stories</th>
<th>Location of core-columns</th>
<th>Number of core-columns (filled holes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int. 6</td>
<td></td>
<td>Corner of exterior wall, four corners of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>staircase intersection of interior and exterior walls in large</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rooms, intersections of each 15m or the unit</td>
</tr>
<tr>
<td>4, 5</td>
<td>3, 4</td>
<td>transversal wall and exterior longitudinal wall</td>
</tr>
<tr>
<td></td>
<td>2, 3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>Corner of exterior wall, four corners of staircase intersection of interior and exterior walls in large</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>rooms, intersection of the interior wall and the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gable, intersection of other bay transversal wall (axis) and exterior longitudinal wall</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>Corner of exterior wall, four corners of staircase, intersection of all interior and exterior walls; for Intensity 8, intersection of interior longitudinal wall and transversal wall (axis), both sides of bigger openings</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Ditto; The spacing of the transversal wall core-column shall not be greater than 2m</td>
</tr>
</tbody>
</table>

Note: In locations such as the corners of the exterior wall, intersection of the interior and exterior wall, and corners of staircase, it shall be permitted adopted tie-columns to replace corresponding core-columns.
7.4.2 The core-columns of multi-story small-block buildings shall comply with following requirements:

1. The cross section of the core-column shall not be less than 120mm × 120mm.

2. The concrete strength grade of the core-column shall not be less than C20.

3. The longitudinal bars of the core-column shall be through overall wall and connect with the ring-beam; the longitudinal bar shall not be less than 1ф12, and than 1ф14 for the building exceeds 5 stories at Intensity 7 and exceeds 4 stories at Intensity 8.

4. The core-column shall extend to 500mm underground level or connect with foundation ring-beam with a buried depth less than 500mm.

5. The core-columns which improve the seismic shear capacity of wall should be distributed in the wall evenly, and the maximum clear spacing shall not be greater than 2.0m.

7.4.3 The tie-columns used to replace core-columns in small-block buildings shall comply with the following requirements:

1. The minimum cross section of the tie-column may adopt 190mm × 190mm, the longitudinal bars shall adopt 4ф12, the spacing of stirrups shall not be greater than 250mm and shall be densified at the upper and lower end of the column accordingly. When the building exceeds 5 stories for Intensity 7, exceeds 4 stories for Intensity 8, the longitudinal bars of the tie-column should adopt 4ф14, and the spacing of stirrups shall not be greater than 200mm. For the tie-columns at the corners of the exterior wall, the cross section and the reinforcement amount may be increased accordingly.

2. The connection of the tie-column and the adjacent block walls shall be built into horse-toothed joints, the adjacent block hole with the tie-column should be filled for Intensity 6, and shall be filled for Intensity 7, and shall be filled and dowel reinforcements for Intensity 8. The tie reinforcing fabric shall be installed in each 600mm along the height of the wall, and the length extending into the each side-wall should not be less than 1m.

3. At the connection of the tie-column and the ring-beam, the longitudinal bars of the tie-column shall be through the ring-beam to ensure the continuation of longitudinal bars in the tie-column.

4. The tie-columns may not establish individual footing, but, they shall extend to 500mm into the underground level, or shall connect with the foundation ring-beam, which buried depth less than 500mm underground.

7.4.4 The cast-in-situ ring-beam of small-block building shall be installed in accordance with the requirements in Table 7.4.4, the width of the ring-beam shall not be less than 190mm, the reinforcement shall not be less than 4ф12, and the spacing of stirrups shall not be greater than 200mm.

7.4.5 The reinforcement fabrics shall be installed at the intersection of the block walls or the intersection of the core-column and the walls. The fabric may be made through spot welding by using the diameter 4mm bars, and shall be installed in each 600mm along the
wall height, and the length extending to each side of the wall should not be less than 1 m.

Table 7.4.4 Requirements of installation for ring-beam of small-block building

<table>
<thead>
<tr>
<th>Type of wall</th>
<th>Intensity</th>
<th>6,7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior walls and interior longitudinal wall</td>
<td></td>
<td>At roof level, each floor level</td>
<td>At roof level, each floor level</td>
</tr>
<tr>
<td>Ditto; all transversal walls at roof; spacing at the floor shall not be greater than 7m; corresponding location of the tie-column</td>
<td>Ditto; all transversal walls at roof and each floor; corresponding location of the tie-column</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior transversal wall</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.4.6 For the small-block building having 7 stories at Intensity 6, exceed 5 stories at Intensity 7 and exceed 4 stories at Intensity 8, the in-situ reinforced concrete horizontal strip should be installed at the windowsill level of the top and first story of the building. This strip shall run through overall length of the transversal and longitudinal walls, the cross-sectional height shall not be less than 60mm, the longitudinal bar shall not be less than 2×10, and tie bars shall also be arranged. More concrete strength grade shall not be less than C20.

7.4.7 Other seismic design details for multi-story small-block buildings shall comply with relevant requirements in Clauses 7.3.5 through 7.3.13 of this chapter.

7.5 Details of seismic design for multi-story buildings with bottom-frame

7.5.1 For the multi-story brick structures above the bottom-frame story, the reinforced concrete tie-columns shall be installed and comply with following requirements:

1 The location of the tie-column shall be installed according to the provision in Clause 7.3.1 of this code, base on the total stories of the building. For the transitional story, tie-columns shall also be installed at the corresponding point of the frame column at the bottom.

2 The cross section of the tie-column shall not be less than 240mm × 240mm.

3 The longitudinal bars of the tie-column shall not be less than 4×14, and the spacing of stirrups shall not be greater than 200mm.

4 For the transitional story, the longitudinal bars of tie-column shall not be less than 4×16 at Intensity 7, and than 6×16 at Intensity 8. Generally, the longitudinal bars shall be developed to the frame column, when the longitudinal bars are developed to the frame beam, the corresponding location of the frame beam shall be strengthened.

5 The tie-column shall be connected with ring-beams in each story, or shall be reliably tied with the cast-in-situ slabs.

7.5.2 The centerline of the upper wall of the multi-story masonry building with bottom-frame should be coincided with the axis of the frame beam or the wall of bottom-story, and the tie-column should be continuous to the frame column.

7.5.3 The floors of the multi-story masonry building with bottom-frame shall comply
with following requirements:

1. The transference floor shall adopt cast-in-situ reinforced concrete slab. This slab thickness shall not be less than 120mm; the openings in slab shall be cut down or small; when the dimension of the opening exceeds 800mm, boundary beams shall be installed along the perimeters of the opening.

2. For other stories, when precast reinforced concrete slabs are adopted, cast-in-situ ring-beams shall be installed; only in-situ reinforced concrete slabs are adopted, ring-beams shall be permitted not installed, but the strengthened reinforcements of in-situ slabs shall be arranged along the wall perimeters and shall be reliably connected with corresponding tie-columns.

7.5.4 The reinforced concrete spandrel girder of buildings with bottom-frame shall comply with the following requirements:

1. The cross sectional width of the girder shall not be less than 300mm, and the cross sectional height shall not be less than 1/10 of the span.

2. The diameter of the hoops shall not be less than 8mm, and the spacing of hoops shall not be greater than 200mm. At the girder end within 1.5 times of girder height and not less than 1/5 of the clear span, and the both sides for the opening of the upper wall within 500mm and not less than the girder height, the spacing of hoops shall not be greater than 100mm.

3. The space bars shall be arranged along the girder height, the amount shall not be less than 2*14, and the spacing shall not be less than 200mm.

4. The main reinforcements and spacer bars of the girder shall be developed to the column according to the requirements for tensile bars; besides, the developed length of the upper longitudinal bars of girder in the support shall comply with relevant requirements for reinforced concrete frame-supporting girders.

7.5.5 The reinforced concrete wall at the bottom of buildings shall comply with the following requirements:

1. In the perimeter of the wall panel, a boundary frame formed by side beams (or hidden beams) and end columns shall be installed. The cross-sectional width of the side beams should not be less than 1.5 times of the wall panel thickness, the cross-sectional height should not be less than 2.5 times of the wall panel thickness. The cross-sectional height of the end column should not be less than 2 times of the wall panel thickness.

2. The thickness of the wall panel shall not be less than 160mm, nor less than 1/20 of the clear height of the wall panel. The wall should be installed openings to form several short wall-segments, and the height-width ratio of each wall-segment shall not be less than 2.

3. The reinforcement ratio for both vertical and horizontal distributed reinforcements of the wall shall not be less than 0.25%, which shall be arranged in two layers. The spac-
ing of tie bars for two layers shall not be greater than 600 mm, and the diameter of the tie bar shall not be less than 6 mm.

4 The boundary elements of the wall may be installed according to the requirements for general portions in Section 6.4 of this code.

7.5.6 The common brick walls, which used for the first story of the buildings with framed first story, shall conform to the following requirements:

1 The thickness of brick wall shall not be less than 240mm, the strength grade of the mortar used shall not be lower than M10, and the wall shall be built first and then cast the frame.

2 The tie bars of 2ф6 shall be arranged in each 500mm along the frame columns, and shall be installed along overall length of the brick wall; reinforcement concrete horizontal strip connecting with the both frame columns shall be installed at half height level of the wall height.

3 When the length of wall is greater than 5m, added tie-column shall be installed within the wall.

7.5.7 The strength grade of the materials used for multi-story masonry buildings with bottom-frame shall conform to the following requirements:

1 The concrete strength grade of the frame column, wall and spandrel girder shall not be lower than C30.

2 The mortar strength grade for masonry wall of transitional story shall not be lower than M7.5.

7.5.8 Other design details for multi-story masonry buildings with bottom-frame shall comply with relevant requirements from Clauses 7.3.5 through 7.3.14 of this chapter.

7.6 Details of seismic design for multi-story buildings with inner-frames

7.6.1 For the multi-story buildings with inner-frames, the reinforced concrete tie-columns shall be installed and conform to following requirements:

1 The tie-columns shall be installed in the following locations:

1) Four-corners of the exterior wall, staircase and elevator shaft; supporting location of the beam for landing slab of stair;

2) The both ends of the wall, locations corresponding to the axis of the inner-frame column at the exterior longitudinal and transversal wall that without composite columns.

2 The cross-sectional dimension of the tie-column shall not be less than 240mm × 240mm.

3 The longitudinal bars of the tie-column shall not be less than 4ф14, and the spacing of the stirrups shall not be greater than 200mm.

4 The tie-column shall be connected with ring-beams in every story, or be tied reli-
ably to the cast-in-situ floor slabs.

7.6.2 For the multi-story buildings with inner-frames, the floors and roof shall adopt cast-in-situ cast or precast-monolithic reinforced concrete slabs. When cast-in-situ reinforced concrete slabs are adopted, ring-beams shall be permitted not installed, but the strengthened reinforcements of in-situ slabs shall be arranged along the wall perimeters and shall be reliably connected with corresponding tie-columns.

7.6.3 The supporting length for the inner-frame beam on the exterior longitudinal and transversal walls shall not be less than 300mm, besides, the ends of the inner-frame beam shall be connected with the ring-beam or composite column or tie-columns reliably.

7.6.4 Other design details for multi-story brick buildings with inner-frames shall conform to relevant requirements from Clause 7.3.5 through 7.3.13 of this chapter.
Chapter 10  Single-story spacious buildings

10.1 General

10.1.1 This chapter is applicable to public buildings consisted of considerable spacious single-story hall and annex buildings.

10.1.2 The seismic joint shall not be installed between a hall and its ante-hall or stage, and also may not be installed between a hall and its attached rooms on both sides, but their connection shall be strengthened.

10.1.3 The load-bearing structures for the hall of single-story spacious buildings shall not adopt plain brick columns in one of the following situations:

1. The building assigned to for Intensity 8 with Site-class II and N or for Intensity 9.
2. There is a cantilever platform in the hall.
3. For Intensity 8 with Site-class I and II or for Intensity 7 with Site-class II and N, the span of the hall is greater than 15m or the column height is greater than 6m.
4. For Intensity 7 with Site-class I and II or for Intensity 6 with Site-class II and N, the span of the hall is greater than 18m or the column height is greater than 8m.

10.1.4 The load-bearing structure of the roof at longitudinal wall for the hall of single-story spacious buildings, besides the provisions in Clause 10.1.3, may also add composite buttress with reinforced concrete and brick at the supports of roof, but plain brick buttress shall not be adopted.

10.1.5 The lateral stiffness in the transverse direction of the ante-hall shall be increased by the structural member layout, the gatepost and independent columns in the ante-hall shall adopt reinforced concrete columns.

10.1.6 The lateral stiffness of transverse walls, which in the connection of the ante-hall and the hall, as well as the hall and the stage, shall be increased, and a certain number of reinforced concrete walls shall be established.

10.1.7 For other requirements regarding the hall can refer to Chapter 9 of this code, and attached rooms of the hall shall comply with relevant provisions in this code.

10.2 Essentials in calculation

10.2.1 In seismic calculation of the single-story spacious buildings, which may be divided into several separate units, such as the ante hall, the stage, the hall, and attached rooms, each unit is calculated according to relevant structural system provisions in this code, but one another influence for those units shall be considered.
10.2.2 The seismic calculation for single-story spacious building may adopt the base shear method, the seismic influence coefficient may be taken as the maximum value.

10.2.3 The horizontal longitudinal seismic action characteristic value of halls may be calculated according to the following equation:

\[ F_{Ek} = a_{max} G_{eq} \]  

(10.2.3)

where: \( F_{Ek} \) — the characteristic value of horizontal longitudinal seismic action on the longitudinal wall or column row in one side of the hall.

\( G_{eq} \) — equivalent gravity load representative value; it includes the half of weight for the roof of hall, the half of weight for roof of adjacent attached rooms, 50% of the snow load characteristic value, and the converted weight of the longitudinal wall or column row in one side of the hall.

10.2.4 The transversal seismic calculation for hall should comply with the following principles:

1. In case of hall without attached rooms on the two sides, the parts with and without cantilever platform may choose a typical bay for the calculation respectively; when the provisions in Chapter 9 of this code are satisfied, the space structural model may also be taken into consideration.

2. In case of hall with attached rooms on the two sides, proper calculation methods shall be selected based on the structural types of the attached rooms.

10.2.5 The seismic checking of out-of-plane for the buttress of the tall gable wall shall be carried out for Intensity 8 and 9.

10.3 Details of seismic design

10.3.1 The roof details of the hall shall comply with the provisions of Chapter 9 in this code.

10.3.2 The reinforced concrete column and composite brick-column of the hall shall comply with the following requirements:

1. The reinforcement bars of composite brick-columns shall be developed to the reinforced concrete ring-beam at the bottom of the truss. The longitudinal reinforcements of each side for the composite brick-column, besides to be determined by calculation, shall not be less than 4 Φ 14 for Intensity 6 with Site-class III or IV and Intensity 7 with Site-class I or II, or 4 Φ 16 for Intensity 7 with Site-class III or IV and Intensity 8 with Site-class I or II.

2. The reinforced concrete column shall be designed according to Grade 2 frame columns, and the reinforcement ratio shall be determined by calculation.

10.3.3 The transversal wall connecting the antehall with hall or the hall with stage shall comply with the following requirements:

1. The tie-columns or reinforced concrete columns shall be installed on the two ends.
of the transverse wall, the supports of longitudinal girders and both edges of large openings of the walls.

2 Some transversal walls that built-in plane of the reinforced concrete frame columns shall be designed according to Grade 2 reinforced concrete seismic wall.

3 The reinforced concrete structure shall be adopted for girder and columns of the front of stage. For the bearing masonry wall above the girder in front of the stage, the pillars spacing not exceeding 4m and ring-beams spacing not exceeding 3m shall be installed. And their cross-sectional dimension, reinforcement ratio, and connection with the masonry wall shall conform to the requirements for multi-story masonry buildings.

4 Brick wall on the girder in front of the stage shall not be used for bearing loads for Intensity 9.

10.3.4 A cast-in-place ring-beam shall be installed at the top of the column (wall) of the hall, and an additional ring-beam shall be installed in each about 3m along the height of the wall. When the height of the end of the trapezoid-shaped truss greater than 900mm, the additional ring-beam shall also be installed at the level of the top chord. The depth of ring-beam should be not less than 180mm, and the width of ring-beam should be the same as thickness of the wall, the reinforcements should not be less than 4ϕ 12, and stirrup spacing should not exceed 200mm.

10.3.5 When no seismic joint is installed between the hall and the attached rooms, a closed ring-beam shall be installed at the same level and tied throughout the intersection place of the hall and the attached rooms. And at the intersection of walls, 2ϕ6 tie bars shall be installed in each 500mm along the height of the wall, and the ties should be extended into the wall on both sides with length not less than 1m.

10.3.6 The cantilever platform shall be reliably anchored, and details shall be taken to prevent its overturning.

10.3.7 The reinforced concrete coping-beams along the roof levels shall be installed at the gable wall and shall be tied with the roof members. The tie-columns or composite brick-columns shall be installed in the gable wall, however, their cross-sectional area and reinforcements shall not be less than those of the bent column or composite brick-column in the longitudinal wall respectively. These columns shall extend to the corresponding tops of the gable wall and be connected with the coping-beam on the gable wall.

10.3.8 The operation platform or floor diaphragm shall be used as the horizontal support of the tall gables, which are the back wall of the stage and the junction of the hall and the antehall.
Chapter 11  Earth, wood and stone houses

11.1 Unfired earth houses in villages and towns

11.1.1 This section is applicable to the unfired earth-houses with bearing adobe, lime-earth and rammed earth walls, as well as earth-caves and earth-arch houses for Intensity 6 through Intensity 8.

Note: 1. Lime-earth walls refer to walls made of earth added with lime (or other cementing materials) or walls made of adobe added with lime.
2. Earth caves include both caves cut from undisturbed earth cliff and caves with an arch roof laid by adobe.

11.1.2 The unfired earth-houses should be of one story only; the two story houses with lime-earth-walls may be built which total height should be not exceeding 6 m for Intensity 6 and 7. For the single-story unfired earth-houses, the height of eave level should not exceed 2.5m, and the span of a room should not exceed 3.2m. The clear span of the earth-cave should not exceed 2.5m.

11.1.3 Transverse wall shall be installed in each bay of an unfired earth-house. The beams should not be laid on earth walls without bearing plate. The bearing walls made of different kinds of materials should not be used in the same house.

11.1.4 The lightweight roofing materials shall be used. For houses with purlins supported at gable wall, double-pitch roof or arch-shaped roof should be adopted, and bearing wood plate shall be installed to support purlins. On the top of wall, the wood ring-beam or bearing wood plate shall be installed; the purlins on gable wall shall extend out of the wall; the purlins on the interior wall shall be overlapped entirely or shall be connected by wood splice pieces or dovetail- dowel-connection. Members of the wood roof shall be connected each other by nails, cramp iron and galvanized wire.

11.1.5 The interior and exterior earth walls of unfired earth-house shall be laid by zigzag joint or rammed simultaneously in each layer. In the four corners of the exterior wall and the intersection of the exterior wall and the interior wall, a layer of tying materials should be laid at an interval of 300 mm along the height of the wall. And the tying materials may use bamboo bundles, timber battens or twigs of the chaste tree etc.

11.1.6 For all types of unfired earth-houses, the subsoil shall be rammed firmly, the brick or stone footing shall be adopted, and the damp-proof course should be put beneath the wall.

11.1.7 The adobe shall be molded by wet-process, using cohesive soil as raw material and straw and reed shall be added in the soil as tying materials. Adobe shall be built in flat
course and mud paste or mud-lime mortar should be used in laying walls.

11.1.8 For the houses with lime-earth walls, the ring-beam shall be installed in each story and shall pass through all transversal walls; and step-wise buttress should be added at each side of the gable wall up to the top of the interior longitudinal walls.

11.1.9 For the earth-arch houses, the multi-span arch structure shall be adopted and arranged continuously, the each arch footing shall be supported on the stable natural ground or artificial earth-walls. Thickness of the earth-arch should be 300—400 mm; the arch shall be laid by use formwork and not be laid by inclined bonds without formwork. For the exterior artificial earth-walls and the earth-arch, the doors or windows shall not be arranged.

11.1.10 For the construction of earth-caves, sites where land-slides or slumping are liable to occur shall be avoided; the soil of the earth cliff, from which the cave is cut, shall be dense and stable, and the cliff shall be smooth in slope, with no obvious vertical joints. For front of the cliff-cave, no adobe wall or walls of other materials shall be laid as the front wall; caves at different elevations should not be made, otherwise sufficient spacing between each other shall be kept for such caves, and they shall not be in line vertically

11.2 Wood houses

11.2.1 This section is applicable to houses with mortised timber frames, houses with timber trusses and wood columns, and houses with wood columns and wood beams.

11.2.2 Irregular configuration shall be avoided in the plan of wood houses. In a house, wood columns and brick columns or brick walls shall not be used simultaneously for bearing purpose.

11.2.3 The houses with timber trusses and wood columns, as well as houses with mortised timber frames, should not exceed two stories and total height of the house should not exceed 6m. The houses with wood columns and beams should be of single-story only and the height of the house should not exceed 3m.

11.2.4 For spacious houses of considerable large span, such as auditoriums, theaters and cereal warehouses, three-bay timber frame with four columns should be used.

11.2.5 The arrangement of roof brace of the timber truss shall comply with the related requirements in Section 9.3 of this code, but the roof braces on both ends of the house shall be installed in the end bay.

11.2.6 The top of the column shall be mortised to the bottom chord of the truss and connected by means of U-shaped cramp iron. For Intensity 8 and 9, foot of the column shall be anchored in the foundation by use of iron joining means.

11.2.7 The diagonal brace shall be installed between the wood column and the truss (or beam) in spacious houses; the diagonal brace shall be installed also in non-seismic partition walls in dwelling houses with considerable transverse walls; but braces need not be used in houses with mortised timber frames. Diagonal braces should be made of both timber plates
and extend to the top chord of the truss.

11.2.8 For the houses with mortised timber frames, along both longitudinal and transversal directions of houses, a piece of wood shall be installed at both upper and lower ends of the timber column, passing through and connected with the other column. And one or two diagonal column braces shall be installed in each row of columns in the longitudinal direction of house.

11.2.9 The diagonal braces and roof bracing members shall be connected with main structural members by bolts. Except for the mortised timber members, the connection of other wood members should be adopted bolts.

11.2.10 The connected part of the rafters and the purlins shall be nailed completely to ensure the integrity of the roof. In the case of wood structures, vertical diagonal bracing should be installed above the eaves along the longitudinal direction of the houses, and the aim is to improve the longitudinal stability of the houses.

11.2.11 The wood members shall comply with the following requirements:

1. The tip diameter of the wood column should not be less than 150mm. The slotting on the same level of the column in both longitudinal and horizontal directions shall be avoided; besides, the slotting area on the same section shall not exceed 1/2 of the total section area.

2. The whole piece wood shall be adopted for the columns.

3. The penetrating purlins shall be set throughout all columns of the wood structure.

11.2.12 The enclosure walls shall be reliably tied to the wood structure; masonry enclosure walls with adobes and bricks shall not enclose the wood column completely and should be set outside of the wood column.

11.3 Stone buildings

11.3.1 This section is applicable to masonry buildings with coursed square stone bearing walls (with or without chips of stone) laid by mortar for Intensity 6 to Intensity 8.

11.3.2 The total height and the number of stories of multi-story stone building shall not exceed the values as set forth in Tab 11.3.2:

<table>
<thead>
<tr>
<th>Type of masonry</th>
<th>Intensity 6</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine and semi-fine stone masonry (without chips)</td>
<td>16 m</td>
<td>13 m</td>
<td>10 m</td>
</tr>
<tr>
<td>Course and gross stone masonry (with chips)</td>
<td>13 m</td>
<td>10 m</td>
<td>7 m</td>
</tr>
</tbody>
</table>

Note: Determination for total height of building is specified in Note of Table 7.1.2 in this code.

11.3.3 The story height of multi-story stone masonry buildings shall not exceed 3m.

11.3.4 The spacing of the wall of multi-story stone masonry buildings shall not exceed the values as set forth in Table 11.3.4.
### Table 11.3.4  Spacing for transverse walls in multi-story stone buildings (m)

<table>
<thead>
<tr>
<th>Type of roofing</th>
<th>Intensity 6</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast-In-situ or precast monolithic reinforced</td>
<td>10</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>concrete slab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precast reinforced concrete slab</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

11.3.5 Multi-story stone buildings should adopt cast in-situ or precast monolithic reinforced concrete roof and floors.

11.3.6 The seismic check of stone wall may refer to Section 7.2 of this code; and its shear strength shall be determined according to data obtained from tests.

11.3.7 Reinforced concrete tie-columns shall be installed in the following positions in multi-story stone buildings:

1. Four corners of the exterior wall and of the staircase.
2. The intersections of interior walls and exterior walls in every other bay for Intensity 6.
3. The intersections of interior walls and exterior walls of each bay for Intensity 7 and 8.

11.3.8 Horizontal sectional area of the opening in a seismic transverse wall shall be not greater than one-third of the gross sectional area.

11.3.9 Ring-beams shall be installed on the longitudinal and transverse walls in each story, the depth of which shall not be less than 120mm, and the width should be the same as the wall thickness. Longitudinal reinforcements in the ring-beam shall be not less than 4Φ 10, and the spacing of stirrups shall not exceed 200mm.

11.3.10 At the intersection of the longitudinal wall and transverse wall, where no tie-columns are installed, the dressed rags shall be laid without chip of stone, and steel mesh shall be laid at intervals of about 500mm along the height of the walls. The mesh of intersection should be extended into the walls on each sides with length not less than 1m.

11.3.11 Other relevant detail requirements refer to provisions in Chapter 7 of this code.
Chapter 12  Seismic-isolation and seismic energy-dissipating design

12.1  General

12.1.1  This chapter is applicable to designs for seismic-isolated buildings that set up a seismic-isolation story between the upper structure and its foundation to isolate seismic energy, as well as to designs for seismic-energy-dissipated buildings that set up energy-dissipating devices in the lateral-force-resisting structures to dissipate the seismic energy.

The seismic-isolated and energy-dissipated building structures shall comply with the provisions in Clause 3.8.1 of this code, and the fortification subject shall comply with the provisions in Clause 3.8.2 of this code.

Notes: 1. The design of seismic isolated building in this chapter refers to the seismic-isolation story, which consists of the rubber isolator units and the damper etc, established at the bottom of the building. The purpose for establishing the layer is to increase the vibration period and the damping, reduce the seismic energy introduced to the upper structures, and satisfy the expected seismic requirements.

2. The design of energy-dissipated building refers to install energy-dissipating components, which can provide additional damping by partial deformation, dissipate the seismic energy, which introduced to the upper structure, and satisfy the expected seismic requirements.

12.1.2  The designs for seismic-isolated and energy-dissipated building structures shall be determined after the technical and economical feasibility comparison analysis, which shall be given consideration to the fortification category, the fortification intensity, the conditions of the sites, the building structural plans and the use requirements.

12.1.3  The multi-story masonry and reinforced concrete frame building structures, which need to reduce the seismic action, shall comply with the following requirements when seismic-isolation designs are to be adopted:

1  For the structures with relevant regularity, the base-shear method provided in Clause 5.1.2 of this code can be used along two axial directions of structure and the calculated fundamental period of the structure shall be less than 1.0s when it is non-isolated. For irregular building structures need to adopt seismic-isolation designs, it shall be determined after the model tests.

2  The buildings shall be assigned to Site-class I, II, or III; and the stable foundation types shall also be selected.

3  The total horizontal force produced by wind load and other non-seismic action shall not exceed 10% of the total structural gravity.

4  The seismic-isolated story shall provide necessary load bearing capacity, lateral stiffness and damping; the pipelines and circuits of equipment crossing the seismic-isolation
story shall adopt flexible connection and other effective measures to withstand the horizontal displacement during rarely earthquakes.

12.1.4 The steel and reinforced concrete building structures, which need to reduce seismic horizontal displacement, should adopt energy-dissipating designs.

The energy-dissipating components shall be able to provide sufficient additional damping, and shall respectively comply with the requirements of corresponding structural types for the provisions in this code.

12.1.5 For the design of seismic-isolated and energy-dissipated buildings, the seismic-isolator units and energy-dissipating devices shall comply with the following requirements:

1. The durability and the design parameters of the seismic-isolator units and energy-dissipated devices shall be determined by testing.

2. The location installing seismic-isolator units and energy-dissipating devices, besides to be determined by calculation, measures for the convenience of check and renewal shall also be taken.

3. The property requirements for seismic-isolator units and energy-dissipating devices shall be stated clearly in the design document. The sampling check shall be carried out on prototype parts of each predominant type and size before installation, the number of each type and size shall not be less than 3, and the quality rate of the sampling check shall be 100%.

12.1.6 The designs of seismic-isolated and energy-dissipated buildings shall also comply with the provisions of corresponding specification.

12.2 Essentials in design of seismic-isolation buildings

12.2.1 The design of seismic-isolation buildings shall select appropriate isolation story consisted of the isolator units (including the dampers) and components with the primary stiffness to resist the pulsation of the ground and the wind load, based on the expected horizontal seismic-reduced factor and the requirements for seismic displacement control.

The load bearing capacity check and horizontal displacement check under rare earthquake shall be carried out for the seismic-isolator units.

The horizontal seismic action of lateral-force-resisting system above the isolation story shall be determined according to the horizontal seismic-reducing factor. The characteristic values of vertical seismic action for that shall not be less than 20% and 40% of the total gravity load representative values of the structure above the seismic-isolation story for Intensity 8 and 9.

12.2.2 The calculation analysis of the design of seismic-isolation building structures shall comply with the following requirements:

1. The calculation model of the seismic-isolation building structures may adopt the shear type model (Figure 12.2.2). When the gravity center of the structure above the iso-
lation story and the rigidity center of the isolation story are not in a line, the influence of torsion deformation shall be taken into consideration. For the reinforced concrete seismic-isolated structures, the beam-slab structures above the isolation interface shall be deemed as a part of the structure above the isolation story for calculation and design.

2 In generally, the calculation should adopt the time-history analyzing method; the response spectrum characteristics and amount of the input seismic wave shall comply with the provisions in Clause 5.1.2 of this code; the calculation result should choose the average value. When building assigned to Category A and B is located within 10km of the causative fault and the input seismic-wave is not the near-field accelerogram, the calculation results shall be multiplied by the following near-field affected factors: within 5km, multiplied by 1.5; beyond 5km, multiplied by 1.25.

3 Masonry structures and structures similar to its fundamental period may carry out simplified calculation provided according to Appendix L of this code.

12.2.3 The rubber isolation units consisting of overlapped rubber layers and thin steel plates in the isolation story shall comply with the following requirements:

1 The ultimate horizontal displacement of the rubber isolator unit under the compressive stress provided in Table 12.2.3 shall exceed 0.55 times of its effective diameter or 3 times of the total thickness of all rubber layers, whichever is greater.

<table>
<thead>
<tr>
<th>Building category</th>
<th>Limit values of the average compressive stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Limit values of the average compressive stress (MPa)</td>
<td>10</td>
</tr>
</tbody>
</table>

Notes: 1. The average compressive stress design value shall be calculated according to the combination of the permanent load and variable load. For structures that need to check overturning, the horizontal seismic effect combination shall also be taken into consideration; for structures that need to calculate the vertical seismic action, the vertical seismic effect combination shall also be taken into consideration.

2. When the secondary form-factor of the rubber isolator unit is less than 5.0, the limit value of average compressive stress shall be reduced as follows: for less than 5 but not less than 4, reduce by 20%; for less than 4 but not less than 3, reduce by 40%.

3. In case of rubber isolator unit with outer diameter less than 300mm, the limit value for its average compressive stress shall be 12 MPa for buildings assigned to Category C.

2 After passing the durability tests of corresponding Design-reference-period, the changes of stiffness and damping characteristics of the isolator unit shall not exceed ±20% of the primary stage values, the creep shall not exceed 5% of the total thickness of all rubber layers.

3 The average compressive stress design values of all rubber isolator units shall not
exceed the provisions in Table 12.2.3.

12.2.4 The arrangement, vertical bearing capacity, lateral stiffness and damping of the seismic-isolation story shall comply with the following requirements:

1 The seismic-isolation story should be installed at locations under the first story of the structure. The rubber isolator units shall be placed at locations where the interior forces are greater, the spacing should not be too large; the size, amount and distribution shall be determined according to the requirements of the vertical bearing capacity, the lateral stiffness and the damping. The seismic-isolation story shall be stabilized under rare earthquake, and should not have non-restorable deformations. The rubber isolator units should not have tensile stress under the rare earthquakes.

2 The horizontal dynamic stiffness and equivalent viscous damping ratio can be calculated according to the following equations:

\[ K_h = \sum K_j \quad (12.2.4-1) \]
\[ \zeta_{eq} = \frac{\sum K_j \zeta_j}{K_h} \quad (12.2.4-2) \]

where; \( \zeta_{eq} \) — equivalent viscous damping ratio of the seismic-isolation story.

\( K_h \) — horizontal dynamic stiffness of the seismic-isolation story.

\( \zeta_j \) — equivalent viscous damping ratio of the \( j \)-th isolator unit determined by testing; when damper is set up independently, corresponding damping ratio of the damper shall also be taken into account.

\( K_j \) — horizontal dynamic stiffness of the \( j \)-th isolator unit determined by testing; if the dynamic stiffness of isolator units dependent on the rate of loading, the dynamic stiffness value corresponding to the vibration period of the seismic-isolated structure shall be selected.

3 When the design parameters of the isolator units are determined by testing, the vertical load shall keep the limit values of average compressive stress of provision in Table 12.2.3. For checking of frequent earthquakes, the horizontal stiffness and equivalent viscous damping ratio shall be determined by test where horizontal loading frequency is 0.3Hz and the shear deformation of the unit is 50%. For checking of rare earthquake and the isolator units with a diameter smaller than 600mm, the horizontal stiffness and equivalent viscous damping ratio should be determined by test where horizontal loading frequency is 0.1Hz and the shear deformation of the unit is 250%. For checking of rare earthquake and the isolator units with a diameter not smaller than 600mm, the horizontal stiffness and equivalent viscous damping ratio may be determined by test where horizontal loading frequency is 0.2Hz and the shear deformation of the unit is 100%.

12.2.5 The calculation of seismic action for structures above the seismic-isolation story shall comply with the following requirements:
1. The distribution of the horizontal seismic action over the height of the structure may adopt rectangular; the maximum value of horizontal seismic influence coefficient can adopt the multiplication of the maximum value of horizontal seismic influence coefficient provided in Clause 5.1.4 of this code and the horizontal seismic-reduced factor. The horizontal seismic-reduced factor shall be determined according to Table 12.2.5 dependent upon the maximum ratio, of isolated story shear force to non-isolated that, in of all stories of structure.

<table>
<thead>
<tr>
<th>Max. ratio of story shear force</th>
<th>0.53</th>
<th>0.35</th>
<th>0.26</th>
<th>0.18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal seismic-reduced factor</td>
<td>0.75</td>
<td>0.50</td>
<td>0.38</td>
<td>0.25</td>
</tr>
</tbody>
</table>

2. The horizontal seismic-reduced factor shall not be smaller than 0.25, and the total horizontal seismic action of the seismic-isolated structure shall not be lower than that of non-isolated structures for Intensity 6. The story shear force of each story shall also comply with the requirements regarding minimum shear force factors in Clause 5.2.5 of this code.

3. The calculation of the vertical seismic action for structures above the seismic-isolation story shall be carried out for Intensity 9 or for Intensity 8 with the horizontal seismic-reduced factor 0.25. And the calculation for vertical seismic action should be carried out for Intensity 8 with the seismic-reduced factor not greater than 0.5.

When calculating the vertical seismic action characteristic values of the structure above seismic-isolation story, each story may be deemed as a mass, and the vertical seismic action characteristic values may be distributed over the height of structure in accordance with the Equation (5.3.1-2) of this code.

12.2.6 The shear force of the isolator unit shall be determined according to the horizontal stiffness of all isolator units from which is the horizontal shear force of the seismic-isolation story under the rare earthquake. When calculation considered torsion, the torsion stiffness of the isolator unit shall be taken into consideration.

The horizontal displacement of the isolator unit of seismic-isolation story under the rare earthquakes shall comply with the following requirements:

\[ u_i \leq \left[ u_i \right] \quad (12.2.6-1) \]

\[ u_i = \beta_i u_e \quad (12.2.6-2) \]

where: \( u_i \) —— horizontal displacement of \( i \)-th isolator unit when taking into account of the torsion under the rare earthquakes.

\( \left[ u_i \right] \) —— limit value of horizontal displacement of \( i \)-th isolator unit; in the case of rubber isolator unit, its displacement shall not exceed 0.55 times of the effective
diameter of the unit or 3 times of the total thickness of all rubber layers, whichever is smaller.

\( u_c \) — horizontal displacement in the center of the seismic-isolation story under rare earthquakes, or when torsion is not taken into consideration.

\( \beta_i \) — torsion factor of \( i \)-th seismic-isolator unit, that shall be taken as the ratio of both calculated displacements which torsion is taken into account and not taken into account. When the mass center of the structure above the seismic-isolation story and the rigidity center of the seismic-isolation story are not eccentric in both major axial directions, the torsion factor of the side unit shall not be less than 1.15.

12.2.7 The seismic-isolation details of the structure above the seismic-isolation story shall comply with the following provisions:

1. For structural systems above the seismic-isolation story, the following details, which will not disturb significant displacement of the seismic-isolation story under rare earthquake, shall be taken:

   1) The seismic joints shall be installed along the perimeter of the structure above the seismic-isolation story, the width of the joint should not be less than 1.2 times of the maximum horizontal displacement of each seismic-isolator unit under the rare earthquake;

   2) Between the structure (including connected members) above the seismic-isolation story and the ground surface (including foundation and structures below the isolation interface), the clear horizontal separations shall be installed; when it is difficult to install horizontal separations, a reliable horizontal slipped cushion shall be installed;

   3) In location such as the corridors, the staircase, and the elevators etc., shall be no any obstruction for movement.

2. For the buildings assigned to Category C, the seismic-measures of structures above the seismic-isolation story shall not reduce the requirements in non-isolated provision of this code when the horizontal seismic-reduced factor is 0.75. And the requirements in non-isolated provisions may be properly loosened when this factor is not greater than 0.5, but corresponding vertical seismic detail requirements shall not be loosened.

For masonry structures, seismic-measures may be taken according to Appendix L of this code.

For reinforced concrete structures, the axial force ratio control of the columns and the walls shall comply with relevant provisions for non-isolated. And other requirements of calculation and seismic details of structures shall comply with provisions for corresponding seismic-measure Grade, which may be determined according to Table 12.2.7, in Chapter 6 of this code.
Table 12.2.7 Grade of cast in-situ reinforced concrete seismic-isolated structures

<table>
<thead>
<tr>
<th>Structural type</th>
<th>Intensity 7</th>
<th>Intensity 8</th>
<th>Intensity 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common frame</td>
<td>Height (m)</td>
<td>&lt; 20</td>
<td>&gt; 20</td>
</tr>
<tr>
<td></td>
<td>Grade 4</td>
<td>Grade 3</td>
<td>Grade 3</td>
</tr>
<tr>
<td>Wall structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common wall</td>
<td>Height (m)</td>
<td>&lt; 25</td>
<td>&gt; 25</td>
</tr>
<tr>
<td></td>
<td>Grade 4</td>
<td>Grade 3</td>
<td>Grade 3</td>
</tr>
</tbody>
</table>

12.2.8 The connection between the seismic-isolation story and the structure above the seismic-isolation story shall comply with the following requirements:

1. Beam-slab type floor shall be installed on the top of the seismic-isolation story, and shall comply with the following requirements:

   1) Cast-in-place or fabricated monolithic concrete floor slab shall be adopted; the thickness of the in-situ slab shall not be less than 140mm, and the thickness of in-situ topping of fabricated slabs shall not be less than 50mm. The longitudinal and transversal beams above the isolator units shall adopt the cast-in-place reinforced concrete beams;

   2) The stiffness and the bearing capacity of the beams and slabs on the top of the seismic-isolation story shall be greater than the stiffness and bearing capacity of ordinary beams and slabs;

   3) Beams and columns near the isolator units shall check the punching-shear and local-compression capacity, the hoops shall be densified and mesh reinforcements shall be installed if necessary.

2. The connected details of the isolator units and the damper shall comply with the following requirements:

   1) The isolator units and the damper shall be installed in locations where the maintenance personnel can access easily;

   2) The connected elements of the isolator unit with the floor of the top of the seismic-isolation story and with the foundation shall be able to transfer the maximum horizontal shear force of the isolator unit under rare earthquake;

   3) The spacing of the isolator units under the wall shall not be greater than 2.0m;

   4) Exposed embedded parts shall have reliable anti-rust treatment. The anchoring reinforcements of the embedded parts shall be connected to the steel plate firmly, the developed length of the anchoring reinforcement should be greater than 20 times of diameter of the anchoring bar or 250mm, whichever is greater.

12.2.9 The seismic action and check for structures under the seismic-isolation story shall adopt the vertical force, horizontal force and moment of force at the bottom of the isolator units under rare earthquake.

The seismic check for the foundation and the foundation treatment of the seismic-isola-
lated buildings shall be carried out according to the local intensity. The anti-liquefaction measures for buildings assigned to Category A and B shall be determined according to one grade higher than the liquefaction grade, until all liquefaction settlements are eliminated.

12.3 Essentials in design of seismic energy-dissipated buildings

12.3.1 For the seismic energy-dissipated buildings, the proper energy-dissipating components shall be installed according to the expected displacement of the structure under rare earthquakes. The energy-dissipating components may consist of the energy-dissipating device and the diagonal bracings, the walls, the beams or joints. The energy-dissipating device may adopt the speed-related type, the displacement-related type or other types.

Notes: 1. The speed-related type energy-dissipating device refers to the viscous energy dissipating device and viscoelastic energy-dissipating device etc.;
2. The displacement-related type energy-dissipating device refers to metal yield energy dissipating device and friction energy dissipating device etc.

12.3.2 The energy-dissipating components may be installed along the two main axis of the structure respectively if necessary. The energy-dissipating components shall be installed at locations where the story drift is significant, its number and distribution shall be determined according to comprehensive analysis, and shall be favorable for increasing the energy-dissipating capacity and for composing a even and reasonable lateral-force-resistant system of the whole structure.

12.3.3 The calculating analysis of the energy-dissipated building structures shall comply with the following provisions:

1 In generally, static non-linear analysis method or non-linear time-history analysis method should be adopted.

2 When the main structure is basically in elastic working stage, the linear analysis method may be adopted for simplified estimation. The linear analysis method depending on the deformation characteristics and height of the structure, may adopt the base-shear method, mode analysis response spectrum method and time-history analysis method according to the provisions in Section 5.1 of this code. The seismic influence coefficient can be adopted according to the provisions in Clause 5.1.5 of this code, which depends on the total damping ratio of the energy-dissipated building structures.

3 The total stiffness of the energy-dissipated structure shall be the total sum of the structural stiffness and the effective stiffness of the energy-dissipating components.

4 The total damping ratio of the energy-dissipated structure shall be the total sum of the structural damping ratio and the effective damping ratio added to the structure by the energy dissipating components.

5 For the frame structure, the limit value of the elasto-plastic story-drift-angel of the energy-dissipated structure should adopt 1/80.
12.3.4 The effective damping ratio added to the structure by energy-dissipating components may be determined according to the following methods:

1. The effective damping ratio added by the energy dissipating components, may be estimated with the following equation:

$$\xi_a = \frac{W_e}{4\pi W_s}$$  \hspace{1cm} (12.3.4-1)

where: $\xi_a$—effective damping ratio added by the energy dissipating components.

$W_e$—energy dissipated by all energy-dissipating components in one cycle of expected displacement of the structure.

$W_s$—total strain energy of energy-dissipated structures under expected displacement.

2. When the torsion effect is not taken into consideration, the total strain energy of the energy-dissipated structure under horizontal seismic action can be estimated with the following equation:

$$W_s = (1/2) \Sigma F_i u_i$$  \hspace{1cm} (12.3.4-2)

where: $F_i$—horizontal seismic action characteristic value of $i$-th mass.

$u_i$—displacement of $i$-th mass corresponding to horizontal seismic action characteristic value.

3. The energy dissipated by the speed-linear-relevant type energy-dissipating device under horizontal seismic action can be estimated with the following equation:

$$W_e = (2\pi^2/T_1) \Sigma C_j \cos^2 \theta_j \Delta u_j$$  \hspace{1cm} (12.3.4-3)

where: $T_1$—fundamental vibration period of the energy-dissipated structure.

$C_j$—linear damping factor determined by testing for $j$-th energy-dissipating device.

$\theta$—angle between the energy-dissipating direction and the horizon for $j$-th energy-dissipating device.

$\Delta u_j$—relative horizontal displacement at the two ends of $j$-th energy-dissipating device.

When the damping factor and effective stiffness of the energy-dissipating device relate to the structure vibration period, the value corresponding to the fundamental vibration period of the energy-dissipated structure may be selected.

4. The energy dissipated by displacement-related type, speed non-linear-related type and other types of energy-dissipating devices under horizontal seismic action can be estimated with the following equation:

$$W_e = \Sigma A_j$$  \hspace{1cm} (12.3.4-4)

where: $A_j$—the area of restoring-force characteristics of the $j$-th energy-dissipating device at the relative horizontal displacement $\Delta u_j$.

The effective stiffness of energy-dissipating devices can be the secant stiffness of restor-
ing-force characteristics of the $j$-th energy-dissipating device at the relative horizontal displacement $\Delta u_j$.

5 When the effective damping ratio added to the structure by the energy-dissipating components exceeds 20%, it should be counted according to 20%.

12.3.5 For non-linear time-history analysis method, it should adopt the restoring force characteristic model of the energy-dissipating components for the calculation. For static non-linear analysis method, the effective damping ratio and stiffness added to the structure by the energy-dissipating device may be determined according to the method provided in Clause 12.3.4 of this chapter.

12.3.6 The design parameters of the effective stiffness, damping ratio and restoring-force characteristic model of the energy-dissipating components shall be determined by testing, and shall comply with the following provisions:

1 For the speed-related type energy-dissipating device, the design allowable displacement, ultimate displacement and the restoring force characteristic model, which is corresponding to design allowable displacement, different temperature conditions and the loading frequency $0.1 \sim 4$Hz, that shall be determined by testing. For energy-dissipating components consisted of the speed-related energy-dissipating device with supporting members such as the diagonal, wall or beam, the stiffness of the energy-dissipating components in the direction of energy-dissipating device may be calculated with the following equation:

$$K_b = \left(\frac{6\pi}{T_1}\right)C_v$$

(12.3.6-1)

where: $K_b$—stiffness of the supporting component in the direction of the energy dissipating device.

$C_v$—linear damping factor of the energy-dissipating device, which corresponds to the fundamental vibration period of the structure and is determined by testing.

$T_1$—fundamental vibration period of the energy-dissipated structure.

2 For the displacement-related energy-dissipating device, the design allowance displacement, ultimate displacement and restoring force characteristic model parameters shall be determined by repeated static loading. For energy-dissipating components consisted of the displacement-related energy-dissipating device with the supporting members such as the diagonal, wall or beam, the restoring force characteristic model parameters of this component shall comply with the following requirements:

$$\frac{\Delta u_{py}}{\Delta u_{py}} \leq 2/3$$

(12.3.6-2)

$$(K_p/K_s)(\Delta u_{py}/\Delta u_{py}) \geq 0.8$$

(12.3.6-3)

where: $K_p$—primary stiffness of the energy-dissipating component in horizontal direction.

$\Delta u_{py}$—yield displacement of energy-dissipating component.

$K_s$—lateral stiffness of the story of energy-dissipated structure.
\[ \Delta u_{xy} \] — yield story drift of energy-dissipated structure.

3 Under the maximum allowable displacement value and repeated 60 cycles, the major performance decrease of the energy-dissipating device shall not exceed 10\%, and shall not have obvious low-cycle fatigue.

12.3.7 The connection of the energy-dissipating device with the diagonal, wall, beam and joints shall comply with the requirements for the connection of steel members or steel and reinforced concrete members, and shall be resistant to the maximum action brought to the connected point by the energy-dissipating device.

12.3.8 For the structural members connected with the energy-dissipating components, the additional internal force due to the energy-dissipating components shall be taken into consideration, and shall be transferred it to the foundation.

12.3.9 The energy-dissipating device and its connected parts shall have good durability and shall be convenient for maintenance.
Chapter 13  Nonstructural components

13.1  General

13.1.1  This chapter is mainly applicable to the connection of nonstructural components with the building structure. The nonstructural components include architectural members as well as mechanical and electrical equipment, which are permanently attached to structures.

Notes: 1. Architectural members refer to the fixing members and parts except the load-bearing skeleton system, mainly including non-bearing wall, members subordinating to the floor and roof, decorative members and parts, and large-sized storage racks fixed on the floor etc.

2. The attached mechanical and electrical equipment refer to the mechanical and electrical members, parts and systems serving the functions of modern buildings, mainly including elevators, lighting, emergency power, communication facility, pipeline, heating and air-conditioning system, smoke and fire monitoring and protection system, and community antenna.

13.1.2  The different seismic-measures for nonstructural components shall be taken according to the Category of the building, the consequence and the range of the influence to the whole building structure due to nonstructural components earthquake damage. When there are detailed requirements in specifications, seismic analysis shall be carried out by adopting different functional factors and type factors etc.

13.1.3  When two nonstructural components, which the calculation and seismic-measures requirements are different, are connected with each other, the seismic design shall be carried out according to the higher requirements.

When the connections of nonstructural components are damaged, this damage shall not cause the failure of another adjacent nonstructural components with higher requirements.

13.2  Basic requirements for calculation

13.2.1  When seismic calculation is made for building structures, the influence due to nonstructural components shall be taken into consideration according to the following provisions:

1  When calculating the seismic action, the gravity of architectural members and the mechanical and electrical equipment attached to the structural members shall be taken into consideration.

2  In the calculation, for architectural members using flexible connection, the stiffness shall not be taken into consideration; for rigid nonstructural components filled in the lateral-force-resisting member plane, the stiffness influence can be taken into consideration by adopting simplified methods such as the period adjustment. In generally, the seismic bearing capacity shall not be taken into consideration; when specific measures have been taken,
the seismic bearing capacity may be taken into consideration according to relevant specifications.

3 For subordinating mechanical and electrical equipment of the building that needs to adopt the floor spectrum for calculation, the interaction of the equipment and the structure should be taken into consideration by adopting appropriate simplified computation model.

4 The structural members supporting nonstructural components shall take the seismic action of nonstructural components as additional action, and shall satisfy the anchoring requirements of connected parts.

13.2.2 The calculating method of seismic action for the nonstructural components shall comply with the following requirements:

1 The seismic force of all members and components shall be applied at the center of gravity, and the horizontal seismic force shall be applied non-concurrently in any horizontal direction.

2 In generally, the seismic action produced by nonstructural components themselves can adopt the equivalent lateral-force method for the calculation. For nonstructural components supported in the different floors or the two sides of the seismic joints, besides considering the seismic action produced by the self gravity, the effect of the relative displacement between all supporting points shall be taken into consideration at the same time.

3 When the vibration period of the equipment is greater than 0.1s and its gravity exceeds 1% of the gravity of the floor it locates, or when the gravity of the equipment exceed 10% of the floor gravity, the floor-response-spectrum method should be adopted. Of them, for the equipment non-elastically connected with the floor of the building, the equipment and the floor can be deemed as a mass in calculation for whole structure, and such seismic action of equipment may be obtained.

13.2.3 When equivalent lateral-force method is adopted, the characteristic value of the horizontal seismic action should be calculated according to the following equation:

\[ F = \gamma \eta \zeta_1 \zeta_2 \alpha_{\text{max}} G \]  

(13.2.3)

where: \( F \) — the horizontal seismic action characteristic value applied at the center of gravity of the nonstructural components in the most unfavorable direction;

\( \gamma \) — functional factor of the nonstructural components, which is determined depending on the fortification Category and the use requirements according to relevant specification;

\( \eta \) — type factor of nonstructural components, which is determined depending on factors such as the material performance according to relevant specification;

\( \zeta_1 \) — factor of state, in cases such as precast members, cantilever members, any equipment braced to structural member lower than its center of mass, and flexible systems, the factor should be taken as 2.0; and in other cases may be taken as 1.0;
\( \xi_2 \) — factor of location, for the top of structures, the factor should be taken as 2.0; for the bottom, the factor should be taken as 1.0, and is in linear distribution along the height of structures; for the structures that need adopt the time-history analyzing method to carry out calculations according to the provisions in Section 5.1 of this code, such factor shall be adjusted depending on this results of calculation;

\( a_{\text{max}} \) — maximum value of seismic influence coefficient, which may be adopted in accordance with the provision for frequent earthquakes in Clause 5.1.4 of this code;

\( G \) — gravity of nonstructural components, it shall include the gravity of relevant personnel, medium in the container and tube during operations, as well as the gravity of the storage cabinet.

13.2.4 The internal force, which produced by the relative horizontal displacement between the supporting points of the nonstructural component, shall be calculated. That may be determined by using the product of the stiffness of the component in the displacement direction and the nominal relative horizontal displacement between the supporting points.

The stiffness of the nonstructural component in the displacement direction shall be determined based on the practical connected state, which may adopt simplified mechanic models such as rigid connection, hinge connection, elastic connection or sliding connection.

The relative horizontal displacement between the adjacent floors may adopt limit values of story-drift of structure as provided in Section 5.5 of this code, and the relative horizontal displacement between two sides of seismic joint should be determined according to use requirements.

13.2.5 When the floor-response-spectrum method is to be adopted, the horizontal seismic action characteristic value of nonstructural components may be calculated with the following equation:

\[
F = \gamma \eta \beta_s G
\]  

(13.2.5)

where \( \beta_s \) — the floor response spectrum value of nonstructural components, which is determined by the fortification Intensity and the site-condition of the structure, the period ratio, gravity ratio and damping between nonstructural and structural system, as well as the supporting location, number and connection state of nonstructural components in the structure. In generally, the nonstructural components are simplified as single-mass systems supported to the structure, but the nonstructural components, which have relative displacement between supporting points, shall adopt multi-mass system, and shall be calculated according to special methods.

13.2.6 The basic combination of the seismic effect and other loading effect of nonstruc-
ural components shall be determined according to the provision in Section 5.4 of this code. For the curtain walls, the wind loading effect shall also be combined; for the containers, the temperature effect of equipment operation and the working pressure shall also be taken into consideration.

For seismic checking of nonstructural components, the frictional resistance shall not be taken into consideration; for the seismic adjustment factor of the bearing capacity, the connected part shall be taken as 1.0, and others can be taken according to the provisions of relevant specifications.

13.3 Basic seismic-measures for architectural nonstructural members

13.3.1 In building structures, locations installing the embedded and anchoring parts which are connected with the architectural members such as curtain, enclosure, separation wall, parapet, awning, signs, billboards, ceilings and large-sized storage cabinets, the strengthened measures shall be taken to resist the seismic action transferred by nonstructural components.

13.3.2 The material, type and arrangement of non-bearing walls shall be determined after comprehensive analysis dependent on the Intensify, the height of the building, the configuration of the building, the story drift of the structure, and the lateral-force-resisting performance of the wall itself.

1 The selection of wall materials shall comply with the following requirements:

1) For reinforced concrete and steel structure, the non-bearing wall shall first adopt lightweight wall materials;

2) For single-story reinforced concrete column factory buildings, the enclosures should adopt lightweight wall panels or large-sized reinforced concrete wall panels; when the spacing of the side-columns is 12m, lightweight wall panels or large-sized reinforced concrete wall panels shall be adopted. The high span enclosing wall of factory buildings with different heights and the suspending wall at the intersection of longitudinal and transversal factory units should adopt lightweight wall panels, but lightweight wall panels shall be adopted for Intensity 8 and 9;

3) For steel structure factory buildings, the enclosure walls should adopt lightweight wall panels or reinforced concrete wall panels and shall not adopt masonry walls for Intensity 7 and 8, but the lightweight wall panels should be adopted for Intensity 9.

2 The arrangement of rigid non-bearing walls shall try to avoid abrupt changes in the stiffness and strength of the structure. For single-story reinforced concrete column factory building, the rigid enclosure wall should be arranged evenly along the longitudinal direction.

3 The walls shall be tied reliably to the seismic-force-resisting system and shall be able
to suit the story drift of any direction of seismic-force-resisting system. For Intensity 8 and 9, the walls shall have the capability of deformation to satisfy the requirements of story drift; and the walls shall also have the capability to satisfy the requirements of vertical deflection due to joint-zone rotation of adjacent cantilever structural members.

4 The connected part of the exterior wall panels shall have sufficient ductility and proper rotating capability so that the requirements for story drift of the seismic-force-resisting system under the fortification earthquake can be satisfied.

13.3.3 For masonry walls, measures shall be taken to reduce unfavorable influence on the seismic-force-resisting system, and the steel tie-bars, the horizontal tie-bands, the ring-beams, and the tie-columns shall be installed to ensure reliable tying with the seismic-force-resisting system.

1 In multi-story masonry structures, the post-laying non-bearing partition walls shall have 2×6 tie-bars in each 500mm along the height of the wall for tying with the load-bearing wall or the column, and shall be extended into each wall with length not less than 500mm. For Intensity 8 and 9, when the length of the post-laying partition walls is greater than 5m, the top of these walls shall be tied together with the slabs or beams.

2 The masonry filling wall in the reinforced concrete structures should be separated with the column or be adopted flexible connection with columns, and shall comply with the following requirements:

1) The arrangement of filling wall in plane and vertical directions should be symmetrical and even, weak story or short columns should be avoided.

2) The strength grade of the mortar used for the masonry shall not be lower than M5, and the top of the wall shall combine with the frame beam closely.

3) The 2×6 tie-bars, which are set in each 500mm along the height of the filling wall, shall be installed. And that length extended into the wall, shall be not less than 1/5 of the filling wall length or 700mm for Intensity 6 and 7, and shall be overall length of the filling wall for Intensity 8 and 9.

4) When the length of the filling wall is greater than 5m, the top of the wall shall be tied with the beam; when the length of the wall exceeds two times of the story height, tie-columns shall be installed. When the height of the filling wall is more than 4m, the horizontal tie-band shall be installed at the half height of the wall and be connected to column on both ends of the wall.

3 Masonry partition wall and enclosure wall of single-story reinforced concrete column factory buildings shall comply with the following requirements:

1) The masonry partition wall shall be separated with the column or flexibly connected with the column, and measures shall be taken to ensure the stability of the wall, cast-in-situ reinforced concrete coping shall be installed on the top of the partition wall.
2) The masonry enclosure wall of the factory building shall adopt laid to close outside and tied reliably with the column. When masonry fascia walls above lower roof level of factory buildings with different heights and the masonry suspending walls at the intersection of longitudinal and transversal units have been adopted, the masonry shall not built on the lower roof directly.

3) Cast-in-situ reinforced concrete ring-beam of masonry enclosure walls shall be installed in the following locations:

— The ring-beam shall be installed at the levels of top chord of the trapezoid truss end and the top of the column respectively; however, when the height of the truss end post is not greater than 900mm, the ring-beam may be installed synthetically;

— For Intensity 8 and 9, the added ring-beam shall be installed at the top level of the window in each 4 m approximately, according to the principle that the vertical spacing of ring-beam in upper portion shall be denser than in lower portion. Meanwhile, for the fascia walls above lower roof level of factory buildings with different heights and the suspending walls at the intersection of longitudinal and transversal units, the vertical spacing of the ring-beam shall not be greater than 3m;

— A ring-beam shall be installed on the gable wall along the roof level, and shall be connected with the ring-beam at top chord level of roof truss end.

4) The details of the ring-beam shall comply with the following requirements:

— Ring-beam shall be enclosed. The beam width should be the same as the thickness of the wall, the beam depth shall not be less than 180mm, and the longitudinal reinforcement shall not be less than 4Φ12 for Intensity 6 to 8 or 4Φ14 for Intensity 9;

— For the column top ring-beam at the corner of the factory unit, the longitudinal reinforcements within the scope of the end bay shall be not less than 4Φ14 for Intensity 6 to 8 or 4Φ16 for Intensity 9. And the diameter of stirrups of such ring beam within 1m on the two sides of the corner shall not be less than Φ8, the spacing shall not be greater than 100mm. Three horizontal diagonal bars shall be added to the corner of the ring beam, and the diameter of the bars should be the same as that of the longitudinal bars;

— Ring-beam shall be firmly connected with the column or the roof truss, the ring-beam of the gable shall be tied with the roof slabs. The anchoring bar connecting the top ring-beam with the column or roof truss shall not be less than 4Φ12, and the developed length shall not be less than 35 times of the bar diameter. At the seismic joints, the tie between the ring-beam with the column or the roof truss should be intensified.
5) For Site class III and IV of Intensity 8 or for Intensity 9, the precast foundation beam of the brick enclosure wall shall adopt cast-in-situ joints. When stripped footing of enclosure wall is established, continuous cast-in-situ reinforced concrete ring-beams shall be installed at the level of the top of column footing, and the reinforcement of ring-beam shall not be less than 4ф12.

6) The wall-beam should adopt cast-in-situ beam; if precast beams are adopted, then the bottom of the beam shall be firmly tied with the top of the brick wall, and shall also be tied with the columns. The two adjacent wall-beams at the corner of the factory building shall be firmly connected with one another.

4) The masonry enclosure wall of single-story steel structure factory building shall not adopt engaged built; for Intensity 8, the measures shall also be taken so that the wall does not hinder the horizontal displacement of the column rows along the longitudinal direction of the factory building.

5) The masonry parapet shall be anchored with the seismic-force-resisting structural system at the entrances and exits; the clear width of the seismic joints shall be sufficient, and the free ends of parapet at the two sides of the joints shall be intensified.

13.3.4 The connected parts of various ceilings with the floor shall be able to undertake the self-weight of the ceiling, the suspending heavy objects, and the relevant mechanic and electrical equipment, as well as the additional seismic action. The bearing capacity of the anchoring shall be greater than the bearing capacity of the connected parts.

13.3.5 Cantilever awnings or awnings with one end supported by the column shall be reliably connected with the seismic-force-resisting system.

13.3.6 The seismic-details of the glass curtain, precast wall panels, the cantilever members subordinated to the floor, and large-sized storage rack shall comply with the provisions of relevant specifications.

13.4 Basic seismic-measures for the supports of mechanical and electrical devices

13.4.1 The attached devices are those such as the elevator, lighting, emergency-power system, smoke-fire monitoring and protection system, heating and air-conditioning system, communication system, and community antenna. The seismic-details of connections between the attached devices and the building structure shall be determined according to the provisions of relevant specifications. In which the comprehensive analysis shall be made to consider the Fortification Intensity, the use function and the height of the building, the type and the deformation characteristics of structures, the supporting locations and the operational requirements for the equipment.

The seismic restraints are not required for the mechanical and electrical components for any of the following conditions:

—The equipment that has gravity not more than 1.8kN;
The gas pipe that has less than 25mm inside diameter, and electrical conduit that has less than 60mm inside diameter;

The rectangular air-pipes that has a cross-sectional area less than 0.38 m² and air-pipes that has less than 0.7 m diameter;

The conduits suspended by hangers less than 600mm in length form the top of the conduit to the supporting structure.

13.4.2 The mechanical and electrical equipment shall not be installed in locations that may cause its operation failure or other secondary harms. For equipment with isolation devices, it shall be paid attention to the strong vibration to influence on connected parts, and resonance of the equipment with the building structure shall also be avoided.

The braced frame of mechanical and electrical equipment shall have sufficient stiffness and strength; that must have reliable connection and anchoring with the building structure, so the equipment can be able to restore failure-free operation after the fortification earthquake occurrence.

13.4.3 The openings for pipelines, cables, air-pipes, and equipment shall try to reduce the weakening caused to the load-bearing structural members; strengthened measures shall be taken for perimeter of the openings.

The connections of pipelines and the equipment with the building structures shall be able to allow a certain relative deflection between each other.

13.4.4 The supports or the connected parts of the mechanical and electrical equipment shall be able to transfer all the seismic action of the equipment to the building structures. In building structures, locations installing the embedded and anchoring parts where are connected the mechanical and electrical equipment, the strengthened measures shall be taken to resist the seismic action transferred by mechanical and electrical components.

13.4.5 The water tank, which located at upper-position of the building, shall be connected with the structural members reliably. For high-rise buildings which need to adopt time-history analysis according to the provision in Clause 5.1.2 of this code, the additional seismic effect caused by interaction of the water and the structures should also be taken into consideration for Intensity 8 and 9.

13.4.6 The mechanical and electrical equipment, which need operating continuously within the fortification earthquake, should be installed at locations of the building structure where the seismic response is smaller, corresponding strengthened measures shall be taken for the structural members in relevant portion.
Appendix E
Seismic design requirements for the transition-stories

E.1 Frame-supporting floor design requirement for rectangular plane wall structure

E.1.1 The frame-supporting floor shall comply with the following provisions:

The floor shall adopt cast-in-situ, the thickness shall not be less than 180mm, the concrete strength grade shall not be less than C30, two-way and double layer reinforcement shall be arranged, besides, the reinforcement ratio of each layer in each direction shall not be less than 0.25%.

E.1.2 The shear force design value of frame-supporting floor slab for frame-support-wall structure shall satisfy the following requirements:

\[ V_f \leq \frac{1}{\gamma_{RE}} (0.1 f_{ct} b t) \]  \hspace{1cm} (E.1.2)

where: \( V_f \) — the combining shear force design value in the frame-supporting floor slab transmitted from discontinuous wall to continuous wall. That is calculated by rigid floor assumption and shall be multiplied by the amplification factor 2 for Intensity 8, and 1.5 for Intensity 7; for checking on the continuous wall, the amplification factor need not be considered.

\( b, t \) — the width and thickness of the frame-supporting floor slab respectively.

\( \gamma_{RE} \) — seismic adjusting factor for bearing capacity, may be taken as 0.85.

E.1.3 The seismic shear capacity at the intersection of the frame-supporting slab and the continuous to ground wall in frame-support wall structures shall be checked in accordance with the following equation:

\[ V_t \leq \frac{1}{\gamma_{RE}} (f_{ct} A_s) \]  \hspace{1cm} (E.1.3)

where: \( A_s \) — the total reinforcement section areas of the frame-supporting floor that traverses the continuous wall.

E.1.4 Boundary beams shall be installed along the perimeters of the edge and larger openings in the frame-supporting floor, its width shall not be less than 2 times of the slab thickness. The reinforcement ratio of longitudinal reinforcement shall not be less than 1%, and the adapters of reinforcement in the beam should adopt mechanical connection or welded. The reinforcement in the slab shall be developed to the boundary beams.

E.1.5 For frame-supporting story with longer-size plane or irregular in configuration or the
internal force of the seismic structural wall have big differences, the in-plane flexural and shear bearing capacity of the slab may also be checked, that may adopt simplification methods.

E. 2 Seismic design requirements for transition-stories of tube structures

E.2.1 The structural gravity centers above and below the transition-story shall be coincidence (the appartment works is not included), and the lateral-stiffness-ratio of first upper-story to lower-story shall not be greater than 2.

E.2.2 The discontinuous vertical lateral-force-resisting members (walls and/or columns) above the transition-story should directly be connected to the major structural members of the transition-floor.

E.2.3 The thick-slab-transition-story structure should not be used in tall buildings for Intensity 7 or above.

E.2.4 The transition floor shall not have larger openings, and should be close to infinite-rigidity diaphragm.

E.2.5 Reliable connections shall be made between the transition-floor and the tube or wall, the seismic check and the design details of the transition-floor should conform to relevant provisions in Section E.1 of this appendix.

E.2.6 Vertical seismic action for the transition-story structures shall be considered for Intensity 8.

E.2.7 The transition-story structure shall not be adopted for Intensity 9.
Appendix F
Seismic design for reinforced concrete small-sized hollow block wall buildings

F.1 General

F.1.1 The maximum height of the reinforced concrete small-sized hollow block wall buildings (hereinafter refer to reinforced small-block buildings) applicable to this Appendix shall conform to the provisions in Table F.1.1-1. And the maximum ratio of the total height to total width of the building shall not exceed the provisions in Table F.1.1-2. For buildings with rather less transversal walls or sited on Site-class IV, the applicable maximum height shall be reduced accordingly.

| Table F.1.1-1 Applicable maximum height of reinforced small-block buildings (m) |
|---|---|---|---|
| Min. Wall thickness (mm) | Intensity 6 | Intensity 7 | Intensity 8 |
| 190 | 54 | 45 | 30 |

Note: when the building height exceeds the height as provisions in the Table, the effective strengthened measures shall be taken based on special studies.

| Table F.1.1-2 Maximum height-width ratio of reinforced small-block buildings |
|---|---|---|
| Intensity | 6 | 7 | 8 |
| Maximum height-width ratio | 5 | 4 | 3 |

F.1.2 For reinforced small-block buildings, different measure grades shall be adopted based on Fortification Category, Intensity and the height of buildings, and shall also comply with the requirements of corresponding calculations and design details. The measure grades of buildings assigned to Category C shall be determined in accordance with the provisions in Table F.1.2.

| Table F.1.2 Seismic measure grade of reinforced small-block buildings |
|---|---|---|---|
| Intensity | 6 | 7 | 8 |
| Height (m) | ≤24 | >24 | ≤24 | >24 | ≤24 | >24 |
| Seismic-measure-grade | Grade 4 | Grade 3 | Grade 3 | Grade 2 | Grade 2 | Grade 1 |

Note: When the building height is close or equal to the height boundary, the seismic measure grade may be adjusted in consideration of the irregular degree of the building, the site and the foundation condition.

F.1.3 The building structural design shall avoid the irregular structures as provision in Section 3.4 of this code, and shall also comply with the following requirements:
1 The plane configuration should be simple, regular, and re-entrant corners should not be too significant; the vertical configuration shall be regular, even, and the setback or overhang should not be too significant.

2 Each of longitudinal or transversal seismic structural walls should be aligned in-plane. The length of each wall should not be too long, the height-width ratio of each wall portion shall not be less than 2; and the door openings should be in a line and should be arranged in rows.

3 The maximum spacing of the transversal walls in the building shall satisfy the requirements in Table F.1.3.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max spacing (m)</td>
<td>15</td>
<td>15</td>
<td>11</td>
</tr>
</tbody>
</table>

F.1.4 The building should select regular and reasonable structure systems, so that not to install seismic joint. In case seismic joint is needed, the minimum clear width of the joint shall conform to the following requirements:

When the building height does not exceed 20m, the width of the joint may be taken as 70mm. And when the building height is more than 20 m, then for the Intensity 6, 7 and 8, the width should be added by 20 mm for each 6m, 5m and 4m increases in height respectively.

F.2 Essentials in calculation

F.2.1 When seismic analysis is made for reinforced small-block buildings, the seismic effect shall be adjusted according to the provisions of this section. The seismic checking may not be carried out for Intensity 6.

F.2.2 For checking the seismic bearing capacity of reinforced small-block wall, the combining shear force design value of the cross section at the bottom-strengthened location shall be determined in accordance with the following equation:

\[ V = \eta_{vw} V_w \]  

\[(F.2.2)\]

where:  
- \( V \) — the combining shear force design value of the cross section at the bottom-strengthened location.
- \( V_w \) — the combining shear force calculating value of the cross section at bottom-strengthened location.
- \( \eta_{vw} \) — the shear force amplification factor, taken as 1.6 for Grade 1, as 1.4 for Grade 2, as 1.2 for Grade 3, and as 1.0 for Grade 4.

F.2.3 The combining shear force design value of cross section for the reinforced small-
block wall shall comply with the following requirements:

When the shear span-to-depth ratio is greater than 2

\[ V \leq \frac{1}{\gamma_{RE}} \left( 0.2 f_{gc} b_w h_w \right) \]  (F.2.3-1)

When the shear span-to-depth ratio is not greater than 2

\[ V \leq \frac{1}{\gamma_{RE}} \left( 0.15 f_{gc} b_w h_w \right) \]  (F.2.3-2)

where: \( f_{gc} \) — the specified compressive strength of core-grouting small-block masonry,
when fully grouted, the value may be taken as 2 times of the specified compressive strength of small-block masonry.

\( b_w \) — width of seismic-wall cross-section.

\( h_w \) — depth of seismic-wall cross-section.

\( \gamma_{RE} \) — seismic adjusting factor for bearing capacity, may be taken as 0.85.

Note: the shear span-to-depth ratio shall be calculated according to equation (6.2.9-3) of this code.

F.2.4 The shear bearing capacity of cross section for eccentric compressive reinforced small-block wall shall be checked in accordance with the following equations:

\[ V \leq \frac{1}{\gamma_{RE}} \left[ \frac{1}{\lambda - 0.5} (0.48 f_{gc} b_w h_w + 0.1 N) + 0.72 f_{yh} \frac{A_{sh}}{s} h_{w0} \right] \]  (F.2.4-1)

\[ 0.5 V \leq \frac{1}{\gamma_{RE}} \left( 0.72 f_{yh} \frac{A_{sh}}{s} h_{w0} \right) \]  (F.2.4-2)

where: \( N \) — axial force design value of the wall, shall not be greater than \( 0.2 f_{gc} b_w h_w \).

\( \lambda \) — shear span-to-depth ratio of the checking cross section, take as \( \lambda = M/V h_w \), as 1.5 for the ratio less than 1.5, and as 2.2 for the ratio greater than 2.2.

\( f_{gc} \) — the shear strength design value of core-grouting small-block masonry, take \( f_{gc} = 0.2 f_{gc}^{0.55} \).

\( A_{sh} \) — cross-sectional area of horizontal reinforcement with the same cross section.

\( s \) — spacing of horizontally distributed reinforcement.

\( f_{yh} \) — specified tensile strength design value of horizontally distributed reinforcement.

\( h_{w0} \) — effective depth of cross section of the seismic structural wall.

\( \gamma_{RE} \) — seismic adjusting factor for bearing capacity, may be taken as 0.85.

F.2.5 For the reinforced small-block wall, the coupling beams with span-depth ratio greater than 2.5 should adopt reinforced concrete coupling beam, which combining shear
force design value and the seismic shear bearing capacity shall conform to relevant provisions for coupling beam in the current national standard “Code for design of concrete structures” GB 50010.

F.3 Details of seismic design

F.3.1 The core-grouted concrete of reinforced small-block buildings shall adopt concrete with good slump, flowing and workable properties, as well as good bonding characters with blocks. The strength grade of core-grouted concrete shall not be lower than C20.

F.3.2 For the wall bottom of reinforced small-block buildings, that height is not less than 1/6 of the total height of wall and not less than 2 stories, the longitudinal and horizontal reinforcements shall be arranged subject to the requirements for bottom-strengthening location.

F.3.3 The arrangement of the longitudinal and horizontal reinforcement in reinforced small-block wall shall conform to the following requirements:

1. The vertical reinforcement may adopt single-row arrangement, the minimum diameter shall be 12mm; the maximum spacing shall be 600mm, and the spacing at the top and bottom stories shall be reduced accordingly.

2. The horizontal reinforcement should adopt double-row arrangement, the minimum diameter shall be 8mm, the maximum spacing shall be 600mm, and the spacing at the top and the bottom stories shall not be greater than 400mm.

3. The minimum reinforcement ratio of the vertical and horizontal reinforcement shall not be less than 0.13% for Grade 1, than 0.10% for general portion of Grade 2, than 0.10% for Grade 3 or Grade 4; and should not be less than 0.13% for bottom-strengthened portion of Grade 2.

F.3.4 The splicing length of the vertical and horizontal reinforcements in the reinforced small-block wall shall not be less than 48 times of the reinforcement diameter, the developed length shall not be less than 42 time of the reinforcement diameter.

F.3.5 The axial-force-ratio of the reinforced small-block wall under gravity load representative value shall not be greater than 0.5 for Grade 1, and than 0.6 for Grade 2 or 3.

F.3.6 When the compressive stress of the reinforced small-block walls is greater than 0.5 times of the specified core-grouted small-block compressive strength($f_{cr}$), boundary elements shall be installed at the end of the wall. The length of boundary elements, which is measured from extreme compression fiber toward to neutral axis of web, is not less than 3 times of the wall thickness and the reinforcement of the element shall conform to the requirements of Table F.3.6:

F.3.7 The seismic details of the coupling beams for reinforced small-block wall shall comply with the following requirements:

1. The length extended in wall for the longitudinal bars of the coupling-beam shall not
be less than 1.15 times of the developed length for Grade 1 or 2, than 1.05 times of the developed length for Grade 3, and than the developed length and 600mm for Grade 4.

Table F.3.6 Requirements for reinforcement in the boundary elements of reinforced small-block wall

<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum longitudinal bar amount in strengthened portion</th>
<th>Minimum longitudinal bar amount in general portion</th>
<th>Min. diameter of stirrup</th>
<th>Max. spacing of stirrup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>3#20</td>
<td>3#18</td>
<td>#8</td>
<td>200mm</td>
</tr>
<tr>
<td>Grade 2</td>
<td>3#18</td>
<td>3#16</td>
<td>#8</td>
<td>200mm</td>
</tr>
<tr>
<td>Grade 3</td>
<td>3#16</td>
<td>3#14</td>
<td>#8</td>
<td>200mm</td>
</tr>
<tr>
<td>Grade 4</td>
<td>3#14</td>
<td>3#12</td>
<td>#8</td>
<td>20mm</td>
</tr>
</tbody>
</table>

2 The hoop arrangement along the overall length of the coupling beam shall satisfy the requirements for hoop densified range of the frame beam end.

3 Within the developed length range of longitudinal bars of the top story coupling beam, hoops with spacing not greater than 200mm shall be installed, and the diameter of the hoops shall be the same as the hoops of the coupling beam.

4 For coupling beam with span-depth ratio not greater than 2.5, horizontally distributed reinforcement shall be increased from 200mm below the top-face to 200mm above the bottom-face of the beam. The spacing of this reinforcement shall not be greater than 200mm; the reinforcements of each layer shall not be less than 2#12 for Grade 1 (2#10 for Grade 2 to 4); and the length extended into the wall shall not be less than 30 times of the bar diameter and 300mm.

5 Openings should not be made on the coupling beam of the reinforced small-block wall, when openings necessary, that shall conform to the following requirements:

1) The steel sleeves with outer diameter not greater than 200mm shall be embedded in 1/3 location of the beam depth in the span middle;
2) The effective depth above and below the opening shall not be less than 1/3 of the beam depth and 200mm;
3) The strengthened bars shall be arranged near the openings, the shear bearing capacity check shall be made for cross sections weakened by the opening.

F.3.8 The details of the floor shall comply with the following requirements:

1 The floors and roof of reinforced small-block buildings should adopt the cast-in-situ concrete slabs; for Grade 4, may also be adopted monolithic-precast reinforced concrete floor.

2 Cast-in-situ concrete ring-beams shall be installed for each story. The concrete strength grade of ring-beams shall reach 2 times of that of the small-block. The depth of
Ring-beams should not be less than 200mm for the cast-in-situ slab, and than 120mm for monolithic-precast reinforced concrete floor. The diameter of the longitudinal bars shall not be less than that of the horizontally distributed bars of masonry wall, the diameter of the stirrups shall not be less than 8mm, and the spacing of the stirrups shall not be greater than 200mm.
Appendix K
Modifying stiffness method of longitudinal seismic analysis for single-story factory with brick columns

K.0.1 This appendix is applicable to the longitudinal seismic check for single-story brick column factory with the reinforced concrete roof (with or without purlin) and equal height and multi-spans.

K.0.2 Longitudinal fundamental natural period of structures of single-story brick column factory may be determined according to the following equation:

\[ T_1 = 2\psi_T \sqrt{\frac{\sum G_s}{\sum K_s}} \]  

(K.0.2)

where: \( \psi_T \) — period modifying factor, and it may be adopted according to Table K.0.2.

\( G_s \) — concentrated gravity load of the \( s \)-th column-row. It shall include the gravity load of half of span roofing and gable in the left and right of the column-row, and the conversed gravity load concentrated at the top level of the column or the wall. In which, the gravity of wall and column is conversed according to the principle of dynamic energy equivalence.

\( K_s \) — lateral stiffness of the \( s \)-th column-row.

<table>
<thead>
<tr>
<th>Type of roof</th>
<th>R.C. roof without purlin</th>
<th>R.C. roof with purlin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side span without skylight</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Side span with skylight</td>
<td>1.35</td>
<td>1.45</td>
</tr>
</tbody>
</table>

K.0.3 The total horizontal seismic action characteristic value in the longitudinal direction of single-story brick-column factory shall be determined according to the following equation:

\[ F_{Ek} = \alpha_1 \Sigma G_s \]  

(K.0.3)

where: \( \alpha_1 \) — seismic influence coefficient corresponding to the longitudinal fundamental natural period \( T_1 \) of single-story brick column factory building.

\( G_s \) — the conversed gravity load representative value concentrated at the top level of the wall of the \( s \)-th column-row; that conversed according to the principle of base shear force equality.

K.0.4 Horizontal seismic action of the top of the \( s \)-th longitudinal column-row of the factory building may be determined according to the following equation:

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\[ F_s = \frac{\phi_s K_s}{\sum \psi_s K_s} F_{Ek} \quad \text{(K.0.4)} \]

where: \( \phi_s \) — stiffness adjusting factor of column-row considering the horizontal deformation of the roof, and it shall be adopted according to the values in Table K.0.4 depend on the type of the roof and the arrangement of longitudinal wall in all of column-rows.

<table>
<thead>
<tr>
<th>Type of longitudinal walls</th>
<th>Type of roof</th>
<th>R.C. roof without purlin</th>
<th>R.C. roof with purlin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Side-column-row</td>
<td>Mid-column-row</td>
</tr>
<tr>
<td>All of row without wall</td>
<td></td>
<td>0.95</td>
<td>1.1</td>
</tr>
<tr>
<td>All of row with wall</td>
<td></td>
<td>0.95</td>
<td>1.1</td>
</tr>
<tr>
<td>Side-row with wall</td>
<td>Wall of mid-row is not less 4 bays</td>
<td>0.7</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Wall of mid-row is less 4 bays</td>
<td>0.6</td>
<td>1.8</td>
</tr>
</tbody>
</table>

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Appendix L

Simplified calculation for seismic-isolation design and seismic-isolation measures of masonry structures

L.1 Simplified calculation for seismic-isolation design

L.1.1 When the multi-story masonry structures and structures with similar fundamental natural period adopt seismic-isolation designs, the total horizontal seismic action of the structures above the seismic-isolation story may be determined simply according to Equation (5.2.1-1) of this code, but the following provisions shall be observed:

1 For the multi-story masonry structure, the horizontal seismic-reduced factor should be determined according to the following equation, that dependent upon the fundamental natural period of the seismic-isolation structural system:

\[ \psi = \sqrt{2} \eta_2 \left( \frac{T_{gm}}{T_1} \right)^{\gamma} \]  \hspace{1cm} (L.1.1-1)

where: \( \psi \) — horizontal seismic-reduced factor.

\( \eta_2 \) — damping adjustment factor of seismic influence coefficient, it shall be determined according to Clause 5.1.5 of this code dependent on the equivalent damping of the seismic-isolation story.

\( \gamma \) — the damped exponential index of the curvilinear decrease portion of the seismic influence coefficient, it shall be determined according to Clause 5.1.5 of this code dependent on the equivalent damping of the seismic-isolation story.

\( T_{gm} \) — the design characteristic period of seismic-isolation design for the masonry structure, it shall be determined according to Clause 5.1.4 of this code dependent on the design earthquake group, but shall be taken as 0.4s when that is less than 0.4s.

\( T_1 \) — the fundamental natural period of the seismic-isolation system, it shall not be more than that is larger between the 2.0s and five times of the design characteristic period.

2 For structures that have similar fundamental period with masonry structure, the horizontal seismic-reduced factor should be determined according to the following equation, that dependent upon the fundamental natural period of the seismic-isolation structural system:

\[ \psi = \sqrt{2} \eta_2 \left( \frac{T_g}{T_1} \right)^{\gamma} \left( \frac{T_0}{T_g} \right)^{0.9} \]  \hspace{1cm} (L.1.1-2)

where: \( T_0 \) — computed period of non-isolation structure, when it is less than the period characteristic value, shall be taken as the characteristic period value.
The fundamental natural period of the seismic-isolation system, it shall not be more than five times of the characteristic period value.

3 The fundamental natural period of the seismic-isolation masonry structures and structures with similar period may be determined according to the following equation:

\[ T_1 = 2\pi \sqrt{G/K_h g} \]  

(L.1.1-3)

where:  
- \( T_1 \) — the fundamental natural period of seismic-isolation structural system.  
- \( G \) — gravity load representative value of structures above the seismic-isolation story.  
- \( K_h \) — horizontal dynamic stiffness of the seismic-isolation story, it may be determined according to the provisions in Clause 12.2.4 of this code.  
- \( g \) — acceleration of gravity.

L.1.2 For the masonry structures and structures with similar period under rarely earthquakes, the horizontal shear force of the seismic-isolation story may be determined according to the following equation:

\[ V_c = \lambda_s a_1(\xi_m) G \]  

(L.1.2)

where: \( V_c \) — horizontal shear force of the isolation story under rarely earthquake.

L.1.3 For the masonry structures and structures with similar period under rarely earthquakes, the horizontal displacement of centroid of the isolation story may be determined according to the following equation:

\[ u_e = \lambda_s a_1(\xi_m) G/K_h \]  

(L.1.3)

where: \( \lambda_s \) — near-field effect factors; For building assigned to Category A and B is located within 5km of the causative fault, it shall be taken as 1.5; within 5～10km, taken as 1.25; and more than 10km, taken as 1.0; for building assigned to Category C, it may be taken as 1.0.  
- \( a_1(\xi_m) \) — the seismic influence coefficient value under rarely earthquake, it may be determined according to Clause 5.1.5 of this code dependent on the seismic-isolation story design parameters.  
- \( K_h \) — the horizontal dynamic stiffness of the seismic-isolation story under rarely earthquake, it shall be determined according to provisions in Clause 12.2.4 of this code.

L.1.4 For the plan arrangement of the isolator-unit is rectangular or nearly rectangular, which the mass center of the structure above the seismic-isolation story and the rigidity center of the seismic-isolation story are eccentric, the torsion-effect factor of the isolator-unit may be determined as follows:  

1 When the torsion of only one-way seismic action is considered, the torsion-effect factor of the isolator-unit may be estimated according to the following equation:
\[ \beta_i = 1 + 12e_i / (a^2 + b^2) \]  

(L.1.4-1)

where:  
- \( e \) — eccentricity of the mass center of the structure above the isolation story and the rigidity center of the isolation story, that orthogonal to the direction of seismic action.
- \( s_i \) — the distance from the \( i \)-th isolator-unit to the rigidity center of the isolation story orthogonal to the direction of seismic action.
- \( a, b \) — the length of two sides in the plane of the seismic-isolation story.

For side isolator-unit, its torsion-effect factor shall not be less than 1.15; when effective anti-torsion measures are taken for the seismic-isolation story and the structures above it, or when the torsion period is less than 70% of the fundamental period, the torsion-effect factor may be taken as 1.15.

2 When the torsion of both way seismic actions are considered, the torsion-effect factor of the isolator-unit may be determined according to Equation (L.1.4-1), but the eccentricity value \( (e) \) in this equation shall be replaced by the greater value estimated according to the following equations:

\[ e = \sqrt{e_x^2 + (0.85e_y)^2} \]  

(L.1.4-2)

\[ e = \sqrt{e_y^2 + (0.85e_x)^2} \]  

(L.1.4-3)

where:  
- \( e_x \) — eccentricity of seismic action along the \( y \)-axial direction.
- \( e_y \) — eccentricity of seismic action along the \( x \)-axial direction.

For side isolator-unit, its torsion-effect factor shall not be less than 1.2.

L.1.5 When vertical seismic check for masonry structures is made according to the provisions in Clause 12.2.5 of this code, the normal-stress effect factors for the seismic shear strength of masonry should be determined according to the mean compressive stress deducted of the vertical seismic effect.

L.1.6 For the longitudinal or transversal beams at the top of the seismic-isolation story of the masonry structure, the design calculation may adopt the single-span simple support or the multi-span continuous beam under the uniformly distributed load. The uniformly distributed load values may be determined according to the provisions for reinforced concrete spandrel girder in Clause 7.2.5 of this code. When the mid-span bending moment computed by continuous beam is less than 0.8 times of that computed by the single-span simple support beam, the reinforcement shall be arranged according to 0.8 times of that computed by the single-span simple support beam.

L.2 The details requirement for seismic-isolation masonry structure

L.2.1 When the horizontal seismic-reduced factor of masonry structure assigned to Cate-
gory C is not more than 0.50, the limit value of number of stories, the total height and the height-width ratio may be adopted according to the provisions, which is corresponding to one grade lower, Section 7.1 of this code.

L.2.2 Details of seismic-isolation story of masonry structure shall conform to the following provisions:

1 When the seismic-isolation story of multi-story masonry building locates at the top of the basement, the isolator-unit should not be placed on the masonry wall directly, and the local compressive capacity of the masonry wall shall be checked too.

2 The detailing of the longitudinal and transversal beams at the top of the seismic-isolation story shall comply with the requirements for reinforced concrete spandrel girder of brick buildings with bottom-frame, which as per set in Clause 7.5.4 of this code.

L.2.3 For building assigned to Category C, the seismic design details for the masonry structure above the seismic-isolation story shall comply with the following requirements:

1 The minimum distance from a bearing exterior wall end to the side of the door or window opening, as well as the cross section and reinforcement detailing of the ring-beam, shall comply with relevant provisions in Sections 7.1 and 7.3 of this code.

2 The reinforced concrete tie-columns for multi-story clay brick and perforated brick buildings shall be installed as follows:

When the horizontal seismic-reduced factor is 0.75, it shall comply with the provisions in Table 7.3.1 of this code. For Intensity 7 to 9, when the horizontal seismic-reduced factor are 0.5 and 0.38, it shall comply with the provisions in Table L.2.3-1; and when such factor is 0.25, it should comply with provisions, which corresponding to one grade lower, in Table 7.3.1 of this code.

Table L.2.3-1 Requirements for tie-column installation of seismic-isolation brick building

<table>
<thead>
<tr>
<th>Number of stories in building</th>
<th>Location of installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity 7</td>
<td>3, 4 2, 3</td>
</tr>
<tr>
<td>Intensity 8</td>
<td>5 4 2</td>
</tr>
<tr>
<td>Intensity 9</td>
<td>6,7 5 3, 4</td>
</tr>
<tr>
<td></td>
<td>Four corners of the</td>
</tr>
<tr>
<td></td>
<td>exterior wall,</td>
</tr>
<tr>
<td></td>
<td>staircase and elevator</td>
</tr>
<tr>
<td></td>
<td>shaft; intersections</td>
</tr>
<tr>
<td></td>
<td>of the transversal wall</td>
</tr>
<tr>
<td></td>
<td>in the 15th level part</td>
</tr>
<tr>
<td></td>
<td>and the exterior</td>
</tr>
<tr>
<td></td>
<td>longitudinal wall; both</td>
</tr>
<tr>
<td></td>
<td>sides of larger</td>
</tr>
<tr>
<td></td>
<td>openings; intersections</td>
</tr>
<tr>
<td></td>
<td>of interior wall and</td>
</tr>
<tr>
<td></td>
<td>exterior longitudinal</td>
</tr>
<tr>
<td></td>
<td>walls of large rooms</td>
</tr>
<tr>
<td></td>
<td>Intersections of each</td>
</tr>
<tr>
<td></td>
<td>15m or the unit</td>
</tr>
<tr>
<td></td>
<td>transversal wall and</td>
</tr>
<tr>
<td></td>
<td>exterior longitudinal</td>
</tr>
<tr>
<td></td>
<td>wall</td>
</tr>
<tr>
<td>8</td>
<td>6,7 5</td>
</tr>
<tr>
<td></td>
<td>Intersections of each</td>
</tr>
<tr>
<td></td>
<td>3 bay transversal wall</td>
</tr>
<tr>
<td></td>
<td>and exterior longitudinal</td>
</tr>
<tr>
<td></td>
<td>wall</td>
</tr>
<tr>
<td></td>
<td>Intersections of every</td>
</tr>
<tr>
<td></td>
<td>other transversal wall</td>
</tr>
<tr>
<td></td>
<td>(axis) and exterior</td>
</tr>
<tr>
<td></td>
<td>wall; intersections of</td>
</tr>
<tr>
<td></td>
<td>gable and interior walls;</td>
</tr>
<tr>
<td></td>
<td>intersections of</td>
</tr>
<tr>
<td></td>
<td>exterior and interior</td>
</tr>
<tr>
<td></td>
<td>walls for four stories</td>
</tr>
<tr>
<td></td>
<td>and Intensity 9</td>
</tr>
<tr>
<td></td>
<td>Intersections of</td>
</tr>
<tr>
<td></td>
<td>interior wall and</td>
</tr>
<tr>
<td></td>
<td>exterior wall, smaller</td>
</tr>
<tr>
<td></td>
<td>piers of the interior</td>
</tr>
<tr>
<td></td>
<td>wall. Intersections of</td>
</tr>
<tr>
<td></td>
<td>every other transversal</td>
</tr>
<tr>
<td></td>
<td>wall (axis) and interior</td>
</tr>
<tr>
<td></td>
<td>longitudinal wall for</td>
</tr>
<tr>
<td></td>
<td>seven stories and</td>
</tr>
<tr>
<td></td>
<td>Intensity 8;</td>
</tr>
<tr>
<td></td>
<td>Intersections of</td>
</tr>
<tr>
<td></td>
<td>interior longitudinal</td>
</tr>
<tr>
<td></td>
<td>and transversal wall</td>
</tr>
<tr>
<td></td>
<td>(axis) for Intensity 9</td>
</tr>
</tbody>
</table>

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3 The reinforced concrete core-columns for multi-story small-block buildings shall be installed as follows:

When the horizontal seismic-reduced factor is 0.75, it shall comply with the provisions in Table 7.4.1 of this code. For Intensity 7 to 9, when the horizontal seismic-reduced factor are 0.5 and 0.38, it shall comply with the provisions in Table L.2.3-2; and when such factor is 0.25, it should comply with provisions, which is corresponding to one grade lower, in Table 7.4.1 of this code.

<table>
<thead>
<tr>
<th>Number of stories</th>
<th>Location of core-columns</th>
<th>Number of core-columns (filled holes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity 7</td>
<td>Corner of exterior wall, four corners of staircase, intersection of interior and exterior walls in large rooms, intersections of each 15m or the unit transversal wall and exterior longitudinal wall</td>
<td>Corners of the exterior wall, 3 holes shall be filled; intersection of interior and exterior walls, 4 holes</td>
</tr>
<tr>
<td>3, 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity 8</td>
<td>Corner of exterior wall, four corners of staircase, intersection of interior and exterior walls in large rooms, intersection of the interior wall and the gable, intersection of each 3 bay transversal wall (axis) and exterior longitudinal wall</td>
<td></td>
</tr>
<tr>
<td>2, 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity 9</td>
<td>Corner of exterior wall, four corners of staircase, intersection of interior and exterior walls in large rooms, intersection of the interior wall and the gable, intersection of other bay transversal wall (axis) and exterior longitudinal wall; For Intensity 8 or 9, intersection of exterior longitudinal wall and transversal wall (axis), both sides of bigger openings</td>
<td>Corners of the exterior wall, 5 holes shall be filled; intersection of interior and exterior walls, 4 holes; intersection of interior walls, 4 or 5 holes; both sides of opening, 1 hole</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity 8</td>
<td>Corner of exterior wall, four corners of staircase, intersection of all interior and exterior walls; For Intensity 8 or 9, intersection of interior longitudinal wall and transversal wall (axis), both sides of bigger openings</td>
<td>Corners of the exterior wall, 7 holes shall be filled; intersection of interior and exterior walls, 5 holes; intersection of interior walls, 4 or 5 holes; both sides of opening, 1 hole</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 Other seismic detailing requirements for structures above the seismic-isolation story shall conform to follows:

When the horizontal seismic-reduced factor is 0.75, it shall comply with the provisions in Chapter 7 of this code;

When the horizontal seismic-reduced factor is 0.5 or 0.38, it can comply with the provisions, which is corresponding to one grade lower for Intensity 7 to 9, in Chapter 7 of this code; and

When the horizontal seismic-reduced factor is 0.25, it may be two grades lower but not less than Intensity 6.
Explanation of words in this code

1 In order to treat different situations according to their individual conditions during the implementation of this code, words denoting the different degrees of strictness of demands are explained as follows:

1) Words denoting a very strict or mandatory requirement:
   "must" is used for affirmation;
   "must not" is used for negation.

2) Words denoting a strict requirement under normal conditions:
   "shall" is used for affirmation;
   "shall not" is used for negation.

3) Words denoting a permission of slight choice or an indication of the most suitable choice when conditions allow:
   "should" is used for affirmation;
   "should not" is used for negation.

   And "may" denoting a permission of choice or an indication of the suitable choice when conditions allow.

2 "Be in accordance with" or "be compliance with" are used to indicate that it is necessary to implement items in this code according to other relative standards and stipulations.