SIA 261 (2003) Actions on Structures
SIA 261 (2003) Einwirkungen auf Tragwerke (in German)
SIA 261 (2003): Actions sur les structures porteuses (in French)

2003

Swiss Society of Engineers and Architects SIA,
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Editorial note: According to the information provided by the national delegate,
Seismic Code has been changed in 2003. It is available in German, French and English.

Comments on Building Codes

1. General
   a. Name of Country: Switzerland
   b. Name of Codes:
   SIA 261 (2003) Actions on Structures
   in German: SIA 261 (2003) Einwirkungen auf Tragwerke
   in French: SIA 261 (2003): Actions sur les structures porteuses
   Issued by: Swiss Society of Engineers and Architects SIA, Zurich

   c. Enforcement Year: 2003

2. Structural Design Method
   a. Format: (please check)
   - ☐ Working Stress Design : Allowable Stress ≧ Actual Stress
   - ☐ Ultimate Strength Design: Ultimate Member Strength ≧ Required Member Strength
     Limit State Design : Ultimate Lateral Strength ≧ Required Lateral Strength
   - ☐ Other Design Method :

   In 2003, a new generation of Structural Standards (Swisscodes) SIA 260 to SIA 267 based on the Eurocodes EN 1990 to EN 1998 were published. The seismic regulations are based on Eurocode 8. They are integrated into the Standard SIA 261 Actions on Structures, as well as into the different material related Standards SIA 262 to SIA 266.

   b. Material Strength (Concrete and Steel):

   The resistance is determined by minimal material strength (2% fractile).

   c. Strength Reduction Factors:

   The strength reduction factors (called: resistance factors) are specified in the material related Standards: SIA 262 (concrete), SIA 263 (steel), SIA 264 (composite), SIA 265 (timber), SIA 266 (masonry):
   - reinforced concrete structures: γ_S = 1,15 and γ_C = 1,5
   - steel structures: γ_{M1} = 1,05
   - masonry structures: γ_M = 2,0

   d. Load Factors for Gravity Loadings and Load Combination:

   Different design situations, each characterized by a leading action and one or more accompanying actions, have to be verified. For buildings, the following design situations are usually determinant:
   1,5 (imposed loads) + 1,35 (self-weight)
   1,5 (wind) + 1,35 (self-weight) + 0,7 (imposed loads)
   1,0 (earthquake) + 1,0 (self-weight) + 0,3 (imposed loads)

   e. Typical Live Load Values:

   - Office Buildings: 3 kN/m^2
   - Residential Buildings: 2 kN/m^2 (3 kN/m^2 for balconies and 4 kN/m^2 stairways)

   f. Special Aspects of Structural Design Method

   In addition to the verification of the ultimate limit state and serviceability limit state, conceptual and constructional measures have to be respected.

Schweizer Norm
Norme suisse
Norma svizzera

SIA 261:2003 Civil Engineering

505 261

REGISTERED CODE OF THE SWISS STANDARDS ASSOCIATION

Replaces, together with the code SIA 261/1, Section 4 of the code SIA 160, Edition 1989

Einwirkungen auf Tragwerke
Actions sur les structures porteuses
Azioni sulle strutture portanti

Actions on Structures

261

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CONTENTS

FOREWORD

The present code SIA 261 is directed towards design engineers. Also addressed are owners and those involved in site supervision and the execution of construction works.

SIA 261 is part of the Swiss structural codes. It follows in general the different parts of the European Standard EN 1991 *Actions on Structures* and, together with SIA 261/1, includes the actions listed in the code SIA 160 (1989).

The Swiss structural codes comprise the following:
- SIA 260 Basis of structural design
- SIA 261 Actions on structures
- SIA 262 Concrete structures
- SIA 263 Steel structures
- SIA 264 Composite steel and concrete structures
- SIA 265 Timber structures
- SIA 266 Masonry
- SIA 267 Geotechnical design.

It is planned to add to the Swiss structural codes a code on the conservation of structures.

The present code differs from Section 4 of SIA 160 mainly in the following points:
- Instead of representative values, short- and long-term values, characteristic values of actions are provided. Reduction factors for occasional, frequent and quasi-permanent values of variable actions are given in SIA 260.
- Actions imposed by the ground are treated in more detail.
- The magnitude and presentation of roof shape coeffecients for snow loads have been changed.
- The reference value of the dynamic pressure due to wind corresponds to a return period of 50 instead of 30 years. Force and pressure coefficients are given in Appendix C.
- For live loads in buildings, concentrated loads are given in addition to distributed loads.
- Normal road traffic is treated using a single load model. The axle group is slightly changed in geometry and is applied to two lanes of traffic instead of one. The distributed loads have been significantly increased, in particular for relatively narrow structures. Load models for exceptional transports are dealt with in SIA 261/1.
- For normal gauge rail traffic a third load model has been introduced together with a factor to classify standard load models. Vehicle loads and correlated acceleration, braking and centrifugal forces are considered as groups of actions. The dimensioning values of derailment loads have been significantly increased.
- Forces on barriers for pedestrians as well as the impact of road and rail vehicles are treated in a more detailed manner.
- Ground classes have been introduced to account for the influence of ground conditions on earthquake actions. Response factors to take into account the ductility of structures are given in SIA 262 to 267.
- Crane track loads as well as friction and recovery forces at support bearings are treated in SIA 261/1.

Project Management Swisscodes and Drafting Panel for SIA 261

0 SCOPE

0.1 Limitations

0.1.1 The present code deals with usual actions on structures. Actions not covered in this code or insufficiently covered for a specific use shall be specified analogously to the present requirements.

0.1.2 Actions due to landslides and mudslides, floods, avalanches and snow pressures, hail as well as falling rocks, blocks and ice masses shall be specified according to SIA 261/1.

0.1.3 Loads and forces on crane tracks as well as on silos and tanks shall be specified according to the information and references given in SIA 261/1.

0.1.4 Friction and recovery forces at support bearings shall be specified according to the information and references given in SIA 261/1.

0.1.5 Actions on formwork shall be determined by taking into account the construction stages and the concreting programme. Loads for horizontal formwork and pressures for vertical formwork are given in SIA 261/1.

0.2 References

The present code is valid in combination with the following codes and recommendations:

– Code SIA 260	Basis of structural design
– Code SIA 261	Actions on structures
– Code SIA 261/1	Actions on structures – supplementary specifications
– Code SIA 262	Concrete structures
– Code SIA 262/1	Concrete structures – supplementary specifications
– Code SIA 263	Steel structures
– Code SIA 263/1	Steel structures – supplementary specifications
– Code SIA 264	Composite steel and concrete structures
– Code SIA 264/1	Composite steel and concrete structures – supplementary specifications
– Code SIA 265	Timber structures
– Code SIA 265/1	Timber structures – supplementary specifications
– Code SIA 266	Masonry
– Code SIA 266/1	Masonry – supplementary specifications
– Code SIA 267	Geotechnical design
– Code SIA 267/1	Geotechnical design – supplementary specifications
– Recommendation SIA 183	Fire protection in building construction
– SIA Documentation 81	Fire risk assessment, methods of analysis
– Swiss Fire Protection Register VKF	

0.3 Exceptions

0.3.1 Exceptions to the present code are permissible, provided they are justified by new knowledge in the field relevant to the actions in question or if they are well founded theoretically or through measurements.

0.3.2 Deviations from the code shall be recorded in detail in the construction works documents and the reasons given.

16 EARTHQUAKE

16.1 General

16.1.1 The following provisions describe the seismic actions and the basis for a suitable seismic design of structures.

16.1.2 The objectives of a suitable seismic design include the protection of persons, the limitation of damage and the ensurance of the functionality of important construction works for a given design earthquake action.

16.1.3 The degree of protection is determined by the assignment of the construction works to a construction works class (*BWK*) according to Section 16.3. The criteria for this classification are the average number of persons affected, the damage potential and the environmental hazard due to a failure and the importance of the construction works in overcoming the catastrophe immediately after the earthquake.

16.1.4 Seismic actions shall be treated as accidental actions.

16.1.5 The verification of structural safety is required for all construction works classes. The verification of serviceability is only necessary for Construction Works Class III.

16.1.6 In addition to numerical verifications, conceptual and constructional measures that improve the seismic behaviour are important. The basic principles for a suitable seismic design shall be considered already in the early phases of the conception.

16.1.7 The ability of a structure to resist seismic action in the non-linear range with overstrength may be considered according to Section 16.2.4 by a reduction of the elastic response spectra with the response factor q. The response factor depends on the plastic deformation and energy dissipation capacity of the structure and shall be taken into account according to the information given in SIA 262 to 267.

16.1.8 Depending on the magnitude of the response factor q, a distinction is made between non-ductile and ductile structural behaviour. If the dimensioning is carried out for ductile structural behaviour, the corresponding provisions given in SIA 262 to 267 for the conception and detailing shall be complied with.

16.2 Seismic actions

16.2.1 Seismic zones

16.2.1.1 As shown in Appendix F, Switzerland is divided into four seismic zones: *Z*1, *Z*2, *Z*3a and *Z*3b. The hazard within each zone is assumed to be constant.

16.2.1.2 A dimensioning value of horizontal ground acceleration a_{gd} is assigned to each seismic zone:
- *Z*1 a_{gd} = 0.6 m/s^2
- *Z*2 a_{gd} = 1.0 m/s^2
- *Z*3a a_{gd} = 1.3 m/s^2
- *Z*3b a_{gd} = 1.6 m/s^2.

16.2.1.3 The dimensioning value of the ground acceleration a_{gd} corresponds to the maximum horizontal ground acceleration in Ground Class A for a reference return period of 475 years.

16.2.2 **Ground**

16.2.2.1 The influence of ground conditions is generally considered by assigning the site of the structure to a ground class according to Table 25. This assignment shall be carried out primarily on the basis of the description given in Table 25.

16.2.2.2 For Ground Class F as well as for sites whose ground conditions cannot be classified according to Table 25, it is necessary to perform special investigations to determine the seismic actions.

16.2.2.3 If a seismic microzonation is available, it is recommended to use this to determine the seismic action.

16.2.2.4 In the case of deep foundations in layered soils the assignment of a ground class depends on the location where the seismic forces act.

Table 25: Ground classes and parameters for the elastic response spectrum and the dimensioning spectrum

Ground Class	Description	v_s [m/s]	N_{SPT}	s_u [kN/m^2]	S	T_B [s]	T_C [s]	T_D [s]
A	firm rock (e.g. granite, gneiss, quartzite, siliceous limestone, limestone) or soft rock (e.g. sandstone, conglomerate, Jura marl, Opalinus claystone) beneath a maximum soil cover of 5 m	> 800	–	–	1.00	0.15	0.4	2.0
B	deposits of extensive cemented gravel and sand and/or overconsolidated soils with a thickness exceeding 30 m	400…800	> 50	> 250	1.20	0.15	0.5	2.0
C	deposits of normally consolidated and uncemented gravel and sand and/or moraine with a thickness exceeding 30 m	300…500	15…50	70…250	1.15	0.20	0.6	2.0
D	deposits of unconsolidated fine sand, silt and clay with a thickness exceeding 30 m	150…300	< 15	< 70	1.35	0.20	0.8	2.0
E	alluvial surface layer of Ground Classes C or D, with a thickness of 5 to 30 m lying above a stiffer layer of the Ground Classes A or B	–	–	–	1.40	0.15	0.5	2.0
F	deposits of structurally-sensitive and organic deposits (e.g. peat, lake marl, slide material) with a thickness exceeding 10 m	–	–	–	–	–	–	–

16.2.3 **Elastic response spectrum**

16.2.3.1 The response spectra of the horizontal ground acceleration given in Figure 14 are determined as follows:

$$S_e = a_{gd}\, S \left[1 + \frac{(2.5\,\eta - 1)\,T}{T_B}\right] \qquad (0 \le T \le T_B) \qquad (25)$$

$$S_e = 2.5\, a_{gd}\, S\, \eta \qquad (T_B \le T \le T_C) \qquad (26)$$

$$S_e = 2.5\, a_{gd}\, S\, \eta\, \frac{T_C}{T} \qquad (T_C \le T \le T_D) \qquad (27)$$

$$S_e = 2.5\, a_{gd}\, S\, \eta\, \frac{T_C\, T_D}{T^2} \qquad (T_D \le T) \qquad (28)$$

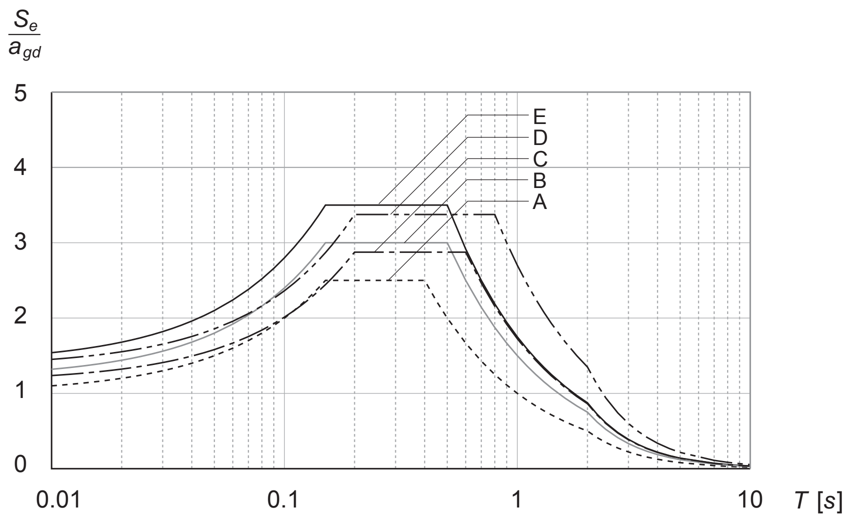
The ordinate values S_e are mean values. T denotes the period of vibration and η is a correction factor that depends on the viscous damping factor ξ, which for $\xi = 0.05$ equals 1:

$$\eta = \sqrt{\frac{1}{0.5 + 10\,\xi}} \geq 0.55 \qquad (29)$$

The parameters S, T_B, T_C and T_D shall be taken from Table 25.

16.2.3.2 For the determination of the elastic response spectrum of the vertical component of the seismic action, the ordinate values S_e are multiplied by a factor 0.7.

Figure 14: Elastic response spectra for $\xi = 0.05$



16.2.4 **Dimensioning spectrum**

16.2.4.1 The dimensioning spectrum of horizontal ground acceleration is determined from the elastic response spectrum for a viscous damping factor of 5%, taking into account the response factor q and the importance factor γ_f according to Table 26 (g denotes the acceleration of gravity):

$$S_d = \gamma_f \frac{a_{gd}}{g} S \left[0.67 + \left(\frac{2.5}{q} - 0.67\right)\frac{T}{T_B}\right] \qquad (0 \leq T \leq T_B) \qquad (30)$$

$$S_d = 2.5\, \gamma_f \frac{a_{gd}}{g} \frac{S}{q} \qquad (T_B \leq T \leq T_C) \qquad (31)$$

$$S_d = 2.5\, \gamma_f \frac{a_{gd}}{g} S \frac{T_C}{T\, q} \qquad (T_C \leq T \leq T_D) \qquad (32)$$

$$S_d = 2.5\, \gamma_f \frac{a_{gd}}{g} S \frac{T_C\, T_D}{T^2 q} \geq 0.1\, \gamma_f \frac{a_{gd}}{g} \qquad (T_D \leq T) \qquad (33)$$

16.2.4.2 To determine the dimensioning value of the vertical component of the seismic action, the ordinate values of the dimensioning spectrum S_d are multiplied by a factor 0.7. The response factor q is set to 1.5.

16.2.4.3 The dimensioning value of the ground displacement amounts to:

$$u_{gd} = 0.05\, \gamma_f\, a_{gd}\, S\, T_C\, T_D \qquad (34)$$

16.3 Construction works classes

16.3.1 Construction works shall be classified according to the criteria given in Section 16.1.3 in one of the three construction works classes (*BWK*) with the associated importance factor γ_f given in Table 26.

16.3.2 For construction works coming under the interference ordinance, the construction works class and the importance factor γ_f shall be determined on the basis of a seismic risk analysis corresponding to the state of the art in safety technology.

Table 26: Construction works classes and importance factors

BWK	Characteristics	Examples	γ_f
I	– no large public gatherings – no goods or installations of particular value – no environmental risk	– residential, office and commercial buildings – industrial buildings and warehouses – car parks – bridges of secondary importance after an earthquake (e.g. pedestrian bridges, bridges for agricultural and forestry purposes, provided they do not span over traffic routes of considerable importance)	1.0
II	– large public gatherings possible – goods or installations of particular value – important infrastructure function – limited environmental risk	– hospitals including equipment and installations, provided they are not assigned to Construction Works Class III – shopping centres, sports stadiums, cinemas, theatres, schools and churches – buildings for public administration – bridges of considerable importance after an earthquake as well as bridges which span over traffic routes of considerable importance after an earthquake – retaining walls and slopes in the neighbourhood of traffic routes of considerable importance after an earthquake – construction works, equipment and installations for supply and waste disposal services and communications provided they are not assigned to Construction Works Class III – tall chimneys	1.2
III	– vital infrastructure function – considerable environmental risk	– crucial hospitals including equipment and installations – construction works, equipment and installations for protection in the case of catastrophe (e.g. fire station buildings and ambulance garages) – bridges of great importance for the access to an area after an earthquake – retaining walls and slopes in the neighbourhood of traffic routes of great importance for the access to particular construction works or an area after an earthquake – construction works vital for supply and waste disposal services as well as communications	1.4

16.4 Conceptual and constructional measures

16.4.1 Measures relating to buildings are given in Table 27. Their binding character depends on the combination of the seismic zone (*Z*) and the construction works class (*BWK*). Further measures are specified in accordance with the regulations given in SIA 262 to 267.

Table 27: Measures in buildings

Binding character of measures: * recommended; ** exceptions must be justified; *** mandatory	*Z*1/*BWK* I *Z*1/*BWK* II *Z*2/*BWK* I	*Z*1/*BWK* III *Z*2/*BWK* II *Z*3/*BWK* I	*Z*2/*BWK* III *Z*3/*BWK* II *Z*3/*BWK* III
Plan view, detailing			
1. Structural members transferring horizontal forces (frames, shear walls and cores, trusses, etc.) shall be distributed as symmetrically as possible in plan view and provided with similar deformational properties. Their interaction shall be ensured by adequate floor slabs and bracing, etc.	*	**	**
2. For structural members transferring horizontal forces, sudden changes in stiffness (in the vertical direction) and resistance to bending, shear and torsion shall be avoided (exception: transition to basement).	*	**	**
3. Basement designed as rigid box structure.	*	**	**
Construction			
1. For buildings of more than 12 m in height to the eaves or buildings very unsymmetrical in plan view: masonry walls, which are subjected to horizontal forces or vertical loads shall be reinforced.	**	***	***
2. Prefabricated elements are to be connected to other structural members.	*	***	***
3. For prefabricated elements supported on sliding bearings: length of bearing zone shall be $^1/_{70}$ of the span or a minimum of 150 mm.	***	***	***
Foundation			
1. Structure shall not be founded on ground exhibiting significantly different stiffnesses.	*	**	***
2. To ensure uniform displacements: avoid isolated footings on loose soil or tie them together with ground beams.	*	**	***
Secondary elements			
Non-loadbearing walls, suspended ceilings, façade elements, parapet walls, etc.: connect to the structure or support in such a way that vibrations are resisted.	**	***	***

16.4.2 Measures relating to bridges are given in Table 28. Their binding character depends on the construction works class. Further measures shall be specified in accordance with the provisions of SIA 262 to 267.

16.4.3 One may deviate from the measures stipulated in Tables 27 and 28, if justified by numerical investigations.

16.4.4 The minimum dimensions of the bearing zones to prevent the fall of bridge girders according to Figure 15 are:

– for fixed support at one abutment

$$b_1 \geq 0.2\text{ m} + a_2 + \frac{\alpha\, l}{1600\text{ m}}\, u_{gd} \leq 0.2\text{ m} + a_2 + 2\, u_{gd} \qquad (35)$$

$$b_2 \geq 0.2\text{ m} + a_1 + \frac{\alpha\, l}{1600\text{ m}}\, u_{gd} \leq 0.2\text{ m} + a_1 + 2\, u_{gd} \qquad (36)$$

– for floating support

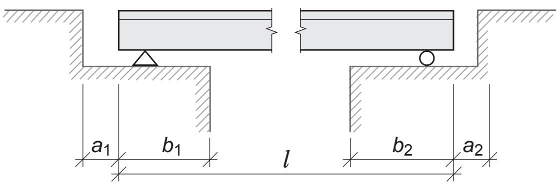
$$b_2 \geq 0.2\text{ m} + \left(1.3 + \frac{\alpha\, l}{1600\text{ m}}\right) u_{gd} \leq 0.2\text{ m} + 3.3\, u_{gd} \qquad (37)$$

where l denotes the length of bridge section between two expansion joints. The correction factor α is 1.0 for Ground Class A, while for Ground classes B and C it is 1.5 and for Ground classes D and E it is 2.0. In the case of joints between bridge sections, b_2 shall be increased by 30%.

Table 28: Measures for bridges

Binding characters of measures: * recommended; ** exceptions must be justified; *** mandatory	*BWK* I	*BWK* II *BWK* III
Bearing zones		
1. Despite a failure of the bearing the vertical load-bearing function is ensured.	***	***
2. Minimum dimensions of the bearing zone to ensure safety of bridge girders against falling.	***	***
Foundation		
Inaccessible parts of the foundation below ground shall be provided with 30% more ultimate resistance than the parts lying above them.	*	**

Figure 15: Minimum dimensions of bearing zones to ensure safety of bridge girders against falling



16.5 Structural analysis

16.5.1 General

16.5.1.1 The effects of seismic actions shall be determined on the basis of a linear elastic analysis. The plastic deformation capacity and the overstrength are taken into account by means of the response factor q.

16.5.1.2 Alternatively, non-linear analyses may be carried out if required. In this case, the basic principles of the present code are to be considered.

16.5.1.3 A structural system can be assumed to be symmetrical in plan if the following criteria are fulfilled:
- with respect to two orthogonal directions the construction works is approximately symmetrical in plan regarding horizontal stiffness and mass distribution
- the shape of the construction works in plan is compact. The overall dimensions of recesses or openings shall not be greater than 25% of the total external dimension of the construction works in plan in the corresponding direction
- the stiffness of the floor slabs in their plane is large in comparison with the horizontal stiffness of the structural members carrying vertical load.

16.5.1.4 A structural system can be assumed to be symmetrical in elevation if the following criteria are fulfilled:
- all structural members resisting horizontal forces, such as shear walls and cores, or frames, run without interruption from the foundation to the top of the construction works or part of the construction works
- the horizontal stiffness, the structural resistance to horizontal forces and the masses of the individual floors remain constant over the height of the construction works or decrease gradually without any abrupt changes from bottom to top (exception: transition to basement).

16.5.1.5 If the structural analysis is carried out with two two-dimensional structural models, the response factor q can be assigned a different value for each principal direction.

16.5.1.6 In the case of mixed structures, the response factor q shall be assumed to be the smallest factor for the different parts of the structure.

16.5.2 Equivalent force method

16.5.2.1 The equivalent force method may be applied to structural systems that can be represented by two two-dimensional structural models whose behaviour is not substantially influenced by higher modes of vibration. These conditions are fulfilled, in general, if the condition of the regularity of the structure in plan and elevation are complied with according to Sections 16.5.1.3 and 16.5.1.4 and if the fundamental period of vibration T_1 in both principal directions is not greater than 2 s.

16.5.2.2 The fundamental period of vibration T_1 shall generally be determined on the basis of a structural model with stiffness assumptions corresponding to Section 16.5.5.2. In the case of buildings Section 16.5.2.3 may be applied.

16.5.2.3 The fundamental period of vibration T_1 (in s) of buildings can be estimated as a function of the height of the building h (in m) and the type of structural system:

$$T_1 = C_t\, h^{0.75} \tag{38}$$

For the factor C_t the following values hold:
- steel space frame subjected to flexure 0.085
- reinforced concrete space frame subjected to flexure 0.075
- all other structures 0.050.

Alternatively, the fundamental period of vibration T_1 (in s) for each principal direction may be calculated as follows:

$$T_1 = 2\sqrt{u} \tag{39}$$

where u (in m) represents the fictitious horizontal displacement at the top of the building under the horizontal action of permanent and quasi permanent loads G_k and $\psi_2 Q_k$.

16.5.2.4 The equivalent horizontal force due to seismic action is determined for each principal direction as follows:

$$F_d = S_d(T_1) \sum_j (G_k + \sum \psi_2 Q_k)_j \tag{40}$$

where $S_d(T_1)$ represents the ordinate value of the dimensioning spectrum according to Section 16.2.4.1.

16.5.2.5 For buildings, the equivalent horizontal force acting at the floor level i is determined in both directions as follows:

$$F_{di} = \frac{z_i(G_k + \sum \psi_2 Q_k)_i}{\sum_j z_j(G_k + \sum \psi_2 Q_k)_j}\, F_d \tag{41}$$

where z_i and z_j denote, respectively, the heights of the *i*-th and *j*-th floors above the level at which the seismic action is applied.

16.5.2.6 For bridges, as an approximation, the equivalent horizontal force may be distributed proportional to the mass.

16.5.2.7 To take into account torsional effects in buildings (due to planned and accidental eccentricity of the centre of mass of the individual floors), the eccentricity of the resultant equivalent force of the overlying floors shall be located as follows:

$$e_{d,sup} = 1.5\,e + 0.05\,b \quad (42)$$

$$e_{d,inf} = 0.5\,e - 0.05\,b \quad (43)$$

where *e* denotes the eccentricity of the resultant equivalent force of the overlying floors with respect to the centre of stiffness of the floor under consideration, and *b* the width of the building perpendicular to the direction of seismic action.

16.5.3 Response spectrum method

16.5.3.1 The response spectrum method shall be used for construction works that do not fulfil the conditions given in Section 16.5.2.1 for the application of the equivalent force method.

16.5.3.2 In general, a three-dimensional structural model shall be used. For structural systems that fulfil the criteria of Section 16.5.1.3 it is sufficient to use a two-dimensional model for each principal direction.

16.5.3.3 For the seismic action the value S_d shall be considered in all determinant directions.

16.5.3.4 To take into account torsional effects in buildings due to accidental eccentricity, the position of the centre of mass of the individual floors in both determinant directions shall be located as follows:

$$e_{d,sup} = e + 0.05\,b \quad (44)$$

$$e_{d,inf} = e - 0.05\,b \quad (45)$$

where *e* denotes the effective eccentricity of the centre of mass with respect to the centre of stiffness of the floor, and *b* the width of the building perpendicular to the direction of seismic action.

If two two-dimensional structural models are used, Section 16.5.2.7 applies analogously.

16.5.3.5 The internal forces and moments and the displacements of all modes of vibration, which make a substantial contribution to the global vibrational behaviour, shall be taken into account. In general, the sum of the effective modal masses of the modes considered should amount to at least 90% of the total mass of the structure.

16.5.3.6 The maximum value of an internal force or moment and of a displacement shall be determined from the corresponding individual values E_i for the modes of vibration considered as follows:

$$E = \sqrt{\sum_i E_i^2} \quad (46)$$

16.5.4 Vertical component of seismic action

In special cases the vertical component of the seismic action is also to be taken into account, e.g. for horizontal cantilevers or for beams that support columns.

16.5.5 Displacements

16.5.5.1 The dimensioning value of a displacement relative to the foundation due to seismic action is:

$$u_d = q\,u_{el} \quad (47)$$

where u_{el} represents the elastic part of the displacement obtained from the dimensioning spectrum.

16.5.5.2 In determining u_{el}, a mean stiffness up to the point of yield shall be assumed and the torsional effects of the seismic action must be considered.

16.5.5.3 For the verification of the serviceability of construction works of Construction Works Class III the serviceability limits given in SIA 260 shall be considered.

16.6 Earthquake-proof joints

16.6.1 To prevent an impact, the width of the joints between buildings or parts of buildings must be greater than the sum of the horizontal displacements determined according to Section 16.5.5. A minimum value of 40 mm shall be observed.

16.6.2 If Section 16.6.1 cannot be adhered to, buildings shall be detailed such that any impact that occurs does not impair the structural safety.

16.7 Non-loadbearing components

16.7.1 For non-loadbearing components that, in the case of failure, can endanger persons, damage the structure or impair the operation of important equipment, the earthquake dimensioning situation shall be considered both for the non-loadbearing component and for related connections and fastenings, or anchorages.

16.7.2 The following horizontal force shall be applied in the most unfavourable direction at the centre of mass of the non-loadbearing component:

$$F_a = \frac{2\,\gamma_f\,a_{gd}\,S\,G_a(1 + z_a/h)}{g\,q_a(1 + (1 - T_a/T_1)^2)} \qquad (48)$$

where G_a, T_a and z_a denote the dead load, the fundamental period of vibration and the height of the non-loadbearing component above the foundation of the construction works, respectively. The response factor q_a is taken into account according to Table 29. T_1 and h denote the fundamental period of vibration of the construction works in the principal direction and the total height of the construction works, respectively.

Table 29: Response factor q_a for non-loadbearing components

Examples of non-loadbearing components	q_a
– exterior and interior walls – chimneys, masts and tanks on leg supports that act as non-stayed cantilever structures over less than one half of their total height or that are stayed or anchored to the structure at the height of their centre of mass or above it – anchorages for cupboards and bookshelves permanently supported by the floor slabs – anchorages for suspended ceilings and light fittings	2.0
– overhanging parapets or ornaments – signs and advertising boards – chimneys, masts and tanks on legs that act as non-stayed cantilever structures over more than one half of their total height	1.0

Legend for the seismic zone map (Appendix F)

Zone 1:

Zurich, Berne (excluding regions in Zones 2 and 3a), Lucerne (excluding regions in Zone 2), Zug, Fribourg (excluding regions in Zone 2), Solothurn (excluding regions in Zone 2), Schaffhausen, Appenzell Ausserrhoden, Appenzell Innerrhoden, St-Gall (excluding regions in Zone 2), Grisons (excluding regions in Zone 2), Aargau (excluding regions in Zone 2), Thurgau, Ticino, Vaud (excluding regions in Zones 2 and 3a), Neuchâtel, Geneva, Jura

Zone 2:

Berne (only districts of Interlaken, Niedersimmental, Obersimmental, Oberhasli, Thun and excluding the region of Zone 3a), Lucerne (only the municipalities of Greppen, Vitznau, Weggis), Uri, Schwyz, Obwalden, Nidwalden, Glarus, Fribourg (only the districts of Gruyère and Veveyse), Solothurn (only the districts of Dorneck and Thierstein), Basel-Land (excluding regions in Zone 3a), St-Gall (only the districts of Gaster, Obertoggenburg, Oberrheintal, Sargans, Werdenberg, and the municipitalities of Au, Balgach, Berneck, Diepoldsau, Widnau), Grisons (only the districts of Albula, Bernina, Hinterrhein (excluding the district of Rheinwald), Imboden, Inn, Landquart, Maloja, Prättigau/Davos, Plessur), Argau (only the district of Rheinfelden), Vaud (only the district of Vevey)

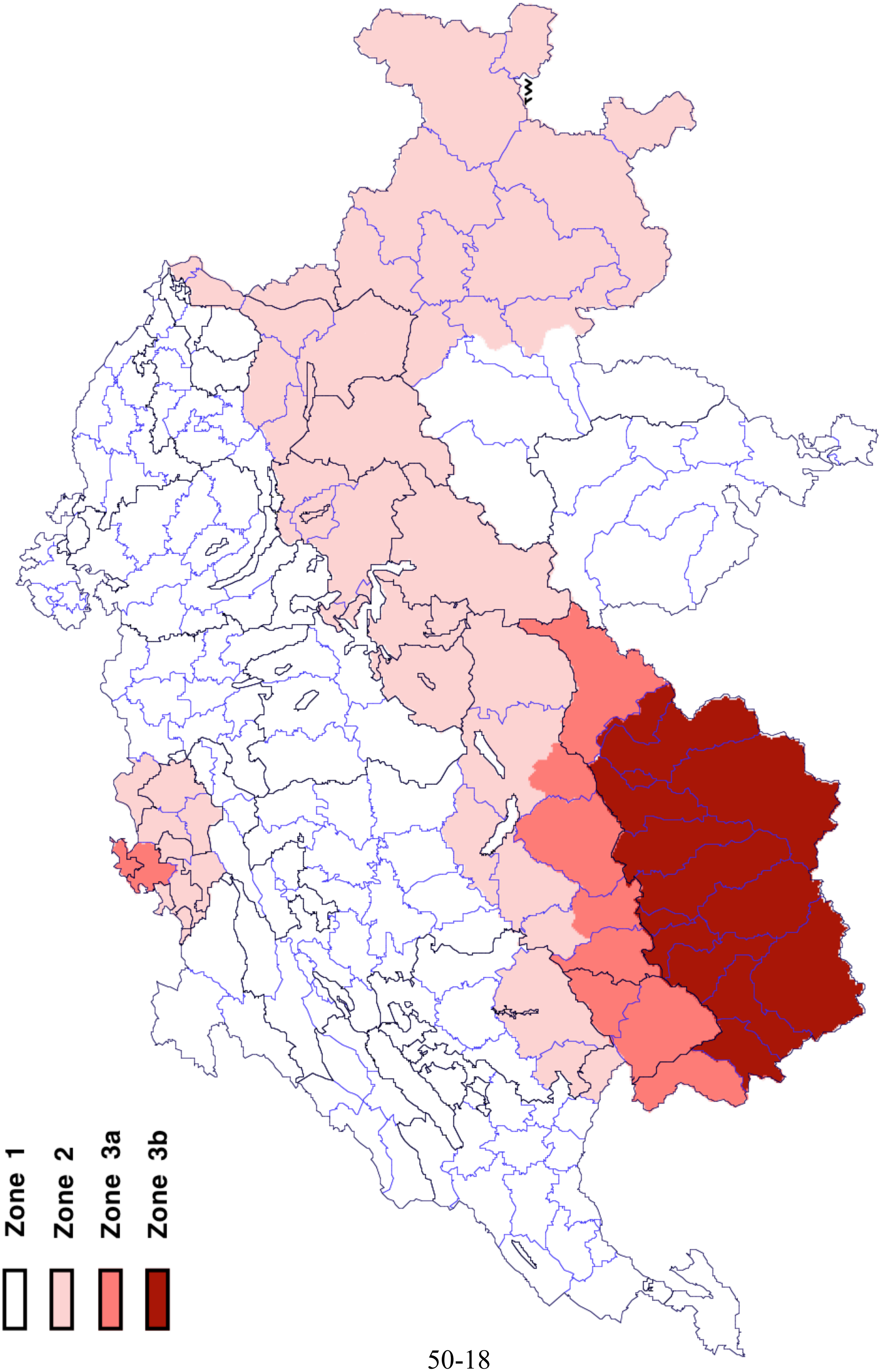
Principality of Liechtenstein

Zone 3a:

Berne (only the districts of Fruttigen and Sarine and the municipalities of Lauterbrunnen, Lenk i.S., St-Stefan), Basel-Stadt, Basel-Land (only the district of Arlesheim), Vaud (only the districts of Aigle and Pays-d'Enhaut), Valais (only the districts of Goms and Monthey)

Zone 3b:

Valais (excluding regions in Zone 3a)


Zone 1
Zone 2
Zone 3a
Zone 3b