

Chapter 1 Commentary

GENERAL PROVISIONS

Chapter 1 sets forth general requirements for applying the analysis and design provisions contained in Chapters 2 through 14 of the *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*. It is similar to what might be incorporated in a code as administrative regulations.

Chapter 1 is designed to be as compatible as possible with normal code administrative provisions, but it is written as the guide to use of the rest of the document, not as a regulatory mechanism. The word “shall” is used in the *Provisions* not as a legal imperative, but simply as the language necessary to ensure fulfillment of all the steps necessary to technically meet a minimum standard of performance.

It is important to note that the *Provisions* is intended to serve as a resource document for use by any interested member of the building community. Thus, some users may alter certain information within the *Provisions* (e.g., the determination of which use groups are included within the higher Seismic Use Groups might depend on whether the user concluded that the generally more-demanding design requirements were necessary). It is strongly emphasized, however, that such “tailoring” should be carefully considered by highly qualified individuals who are fully aware of all the implications of any changes on all affected procedures in the analysis and design sequences of the document.

Further, although the *Provisions* is national in scope, it presents minimum criteria. It is neither intended to nor does it justify any reduction in higher standards that have been locally established, particularly in areas of highest seismicity.

Reference is made throughout the document to decisions and actions that are delegated to an unspecified “authority having jurisdiction.” The document is intended to be applicable to many different types of jurisdictions and chains of authority, and an attempt has been made to recognize situations where more than technical decision-making can be presumed. In fact, the document anticipates the need to establish standards and approval systems to accommodate the use of the document for development of a regulatory system. A good example of this is in Sec. 1.1.2.5 where the need for well-established criteria and systems of testing and approval are recognized even though few such systems are in place. In some instances, the decision-making mechanism referred to is clearly most logically the province of a building official or department; in others, it may be a law-making body such as a state legislature, a city council, or some other state or local policy-making body. The term “authority having jurisdiction” has been used to apply to all of these entities. A good example of the need for keeping such generality in mind is provided by the California law concerning the design and construction of schools. That law establishes requirements for independent special inspection approved and supervised by the Office of the State Architect, a state-level office that does not exist in many other states.

Note that Appendix A to this *Commentary* volume presents a detailed explanation of the development of *Provisions* Maps 1 through 24 and Appendix B describes development of the U.S. Geological Survey seismic hazard maps on which the *Provisions* maps are based. An overview of the Building Seismic Safety Council (BSSC) and its activities appears at the end of the volume.

1.1 GENERAL

1.1.1 Purpose. The goal of the *Provisions* is to present criteria for the design and construction of new structures subject to earthquake ground motions in order to minimize the hazard to life for all structures, to increase the expected performance of structures having a substantial public hazard due to occupancy or use as compared to ordinary structures, and to improve the capability of essential facilities to function

after an earthquake. To this end, the *Provisions* provides the minimum criteria considered prudent for the protection of life safety in structures subject to earthquakes. The *Provisions* document has been reviewed extensively and balloted by the architectural, engineering, and construction communities and, therefore, it is a proper source for the development of building codes in areas of seismic exposure.

Some design standards go further than the *Provisions* and attempt to minimize damage as well as protect building occupants. For example, the *California Building Code* has added property protection in relation to the design and construction of hospitals and public schools. The *Provisions* document generally considers property damage as it relates to occupant safety for ordinary structures. For high occupancy and essential facilities, damage limitation criteria are more strict in order to better provide for the safety of occupants and the continued functioning of the facility.

Some structural and nonstructural damage can be expected as a result of the “design ground motions” because the *Provisions* allow inelastic energy dissipation in the structural system. For ground motions in excess of the design levels, the intent of the *Provisions* is for the structure to have a low likelihood of collapse.

It must be emphasized that absolute safety and no damage even in an earthquake event with a reasonable probability of occurrence cannot be achieved for most structures. However, a high degree of life safety, albeit with some structural and nonstructural damage, can be achieved economically in structures by allowing inelastic energy dissipation in the structure. The objective of the *Provisions* therefore is to set forth the minimum requirements to provide reasonable and prudent life safety. For most structures designed and constructed according to the *Provisions*, it is expected that structural damage from even a major earthquake would likely be repairable, but the damage may not be economically repairable.

Where damage control is desired, the design must provide not only sufficient strength to resist the specified seismic loads but also the proper stiffness to limit the lateral deflection. Damage to nonstructural elements may be minimized by proper limitation of deformations; by careful attention to detail; and by providing proper clearances for exterior cladding, glazing, partitions, and wall panels. The nonstructural elements can be separated or floated free and allowed to move independently of the structure. If these elements are tied rigidly to the structure, they should be protected from deformations that can cause cracking; otherwise, one must expect such damage. It should be recognized, however, that major earthquake ground motions can cause deformations much larger than the specified drift limits in the *Provisions*.

Where prescribed wind loading governs the stress or drift design, the resisting system still must conform to the special requirements for seismic-force-resisting systems. This is required in order to resist, in a ductile manner, potential seismic loadings in excess of the prescribed loads.

A proper, continuous load path is an obvious design requirement for equilibrium, but experience has shown that it often is overlooked and that significant damage and collapse can result. The basis for this design requirement is twofold:

1. To ensure that the design has fully identified the seismic-force-resisting system and its appropriate design level and
2. To ensure that the design basis is fully identified for the purpose of future modifications or changes in the structure.

Detailed requirements for selecting or identifying and designing this load path are given in the appropriate design and materials chapters.

1.1.2.1 Scope. The scope statement establishes in general terms the applicability of the *Provisions* as a base of reference. Certain structures are exempt and need not comply:

1. Detached one- and two-family dwellings in Seismic Design Categories A, B, and C are exempt because they represent low seismic risks.
2. Structures constructed using the conventional light-frame construction requirements in Sec. 12.5 are deemed capable of resisting the seismic forces imposed by the *Provisions*. While specific elements of conventional light-frame construction may be calculated to be overstressed, there is typically a great deal of redundancy and uncounted resistance in such structures. Detached one- and two-story wood-frame dwellings have generally performed well even in regions of higher seismicity. The requirements of Sec. 12.5 are adequate to provide the safety required for such dwellings without imposing any additional requirements of the *Provisions*.
3. Agricultural storage structures are generally exempt from most code requirements because of the exceptionally low risk to life involved and that is the case of the *Provisions*.
4. Structures in areas with extremely low seismic risk need only comply with the design and detailing requirements for structures assigned to Seismic Design Category A.

The *Provisions* are not retroactive and apply only to existing structures when there is an addition, change of use, or alteration. As a minimum, existing structures should comply with legally adopted regulations for repair and rehabilitation as related to earthquake resistance. (Note: Publications such as the *Handbook for the Seismic Evaluation of Buildings—A Prestandard* [FEMA 310] and the *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* [FEMA 356] are available.)

The *Provisions* are not written to prevent damage due to earth slides (such as those that occurred in Anchorage, Alaska), to liquefaction (such as occurred in Niigata, Japan), or to tsunami (such as occurred in Hilo, Hawaii). It provides for only minimum required resistance to earthquake ground shaking, without settlement, slides, subsidence, or faulting in the immediate vicinity of the structure.

1.1.2.2 Additions. Additions that are structurally independent of an existing structure are considered to be new structures required to comply with the *Provisions*. For additions that are not structurally independent, the intent is that the addition as well as the existing structure be made to comply with the *Provisions* except that an increase of up to 5 percent of the mass contributing to seismic forces is permitted in any elements of the existing structure without bringing the entire structure into compliance with the *Provisions*. Additions also shall not reduce the lateral force resistance of any existing element to less than that required for a new structure.

1.1.2.3 Change of use. When a change in the use of a structure will result in the structure being reclassified to a higher Seismic Use Group, the existing structure must be brought into compliance with the requirements of the *Provisions* as if it were a new structure. Structures in higher Seismic Use Groups are intended to provide a higher level of safety to occupants and in the case of Seismic Use Group III to be capable of performing their safety-related function after a seismic event. An exception is allowed when the change is from Seismic Use Group I to Seismic Use Group II where S_{DS} is less than 0.3. The expense that may be necessary to upgrade such a structure because of a change in the Seismic Use Group cannot be justified for structures located in regions with low seismic risk.

1.1.2.4 Alterations. Alterations include all significant modifications to existing structures that are not classified as an addition. No reduction in strength of the seismic-force-resisting system or stiffness of the structure shall result from an alteration unless the altered structure is determined to be in compliance with the *Provisions*.

Like additions, an increase of not greater than 5 percent of the mass contributing to seismic forces is permitted in any structural element of the existing structure without bringing the entire structure into compliance with the *Provisions*.

The cumulative effects of alterations and additions should not increase the seismic forces in any structural element of the existing structure by more than 5 percent unless the capacity of the element subject to the increased seismic forces is still in compliance with the *Provisions*.

1.1.2.5 Alternate materials and alternate means and methods of construction. It is not possible for a design standard to provide criteria for the use of all possible materials and their combinations and methods of construction either existing or anticipated. While not citing specific materials or methods of construction currently available that require approval, this section serves to emphasize the fact that the evaluation and approval of alternate materials and methods require a recognized and accepted approval system. The requirements for materials and methods of construction contained within the document represent the judgment of the best use of the materials and methods based on well-established expertise and historical seismic performance. It is important that any replacement or substitute be evaluated with an understanding of all the ramifications of performance, strength, and durability implied by the *Provisions*.

It also is recognized that until needed approval standards and agencies are created, authorities having jurisdiction will have to operate on the basis of the best evidence available to substantiate any application for alternates. If accepted standards are lacking, it is strongly recommended that applications be supported by extensive reliable data obtained from tests simulating, as closely as is practically feasible, the actual load and/or deformation conditions to which the material is expected to be subjected during the service life of the structure. These conditions, where applicable, should include several cycles of full reversals of loads and deformations in the inelastic range.

1.2 SEISMIC USE GROUPS

The expected performance of structures shall be controlled by assignment of each structure to one of three Seismic Use Groups. Seismic Use Groups are categorized based on the occupancy of the structures within the group and the relative consequences of earthquake-induced damage to the structures. The *Provisions* specify progressively more conservative strength, drift control, system selection, and detailing requirements for structures contained in the three groups, in order to attain minimum levels of earthquake performance suitable to the individual occupancies.

In previous editions of the *Provisions*, this categorization of structures, by occupancy, or use, was termed a Seismic Hazard Exposure Group. The name Seismic Use Group was adopted in the 1997 *Provisions* as being more representative of the definition of this classification. Seismic hazard relates to the severity and frequency of ground motion expected to affect a structure. Since structures contained in these groups are spread across the various zones of seismicity, from high to low hazard, the groups do not really relate to hazard. Rather the groups, categorized by occupancy or use, are used to establish design criteria intended to produce specific types of performance in design earthquake events, based on the importance of reducing structural damage and improving life safety.

In terms of post-earthquake recovery and redevelopment, certain types of occupancies are vital to public needs. These special occupancies were identified and given specific recognition. In terms of disaster preparedness, regional communication centers identified as critical emergency services should be in a higher classification than retail stores, office buildings, and factories.

Specific consideration is given to Group III, essential facilities required for post-earthquake recovery. Also included are structures that contain substances, that if released into the environment, are deemed to be hazardous to the public. The 1991 Edition included a flag to urge consideration of the need for utility services after an earthquake. It is at the discretion of the authority having jurisdiction which structures are required for post-earthquake response and recovery. This is emphasized with the term “designated” before many of the structures listed in Sec. 1.2.1. Using Item 3, “designated medical facilities having emergency treatment facilities,” as an example, the authority having jurisdiction should inventory medical facilities having emergency treatment facilities within the jurisdiction and designate those to be

required for post-earthquake response and recovery. In a rural location where there may not be a major hospital, the authority having jurisdiction may choose to require outpatient surgery clinics to be designated Group III structures. On the other hand, these same clinics in a major jurisdiction with hospitals nearby may not need to be designated Group III structures.

Group II structures are those having a large number of occupants and those where the occupants' ability to exit is restrained. The potential density of public assembly uses in terms of number of people warrant an extra level of care. The level of protection warranted for schools, day care centers, and medical facilities is greater than the level of protection warranted for occupancies where individuals are relatively self-sufficient in responding to an emergency.

Group I contains all uses other than those excepted generally from the requirements in Sec. 1.1.2.1. Those in Group I have lesser life hazard only insofar as there is the probability of fewer occupants in the structures and the structures are lower and/or smaller.

In structures with multiple uses, the 1988 Edition of the *Provisions* required that the structure be assigned the classification of the highest group occupying 15 percent or more of the total area of the structure. This was changed in the 1991 Edition to require the structure to be assigned to the highest group present. These requirements were further modified to allow different portions of a structure to be assigned different Seismic Use Groups provided the higher group is not negatively impacted by the lower group. When a lower group impacts a higher group, the higher group must either be seismically independent of the other, or the two must be in one structure designed seismically to the standards of the higher group. Care must be taken, however, for the case in which the two uses are seismically independent but are functionally dependent. The fire and life-safety requirements relating to exiting, occupancy, fire-resistive construction and the like of the higher group must not be reduced by interconnection to the lower group. Conversely, one must also be aware that there are instances, although uncommon, where certain fire and life-safety requirements for a lower group may be more restrictive than those for the higher group. Such assignments also must be considered when changes are made in the use of a structure even though existing structures are not generally within the scope of the *Provisions*.

Consideration has been given to reducing the number of groupings by combining Groups I and II and leaving Group III the same as is stated above; however, the consensus of those involved in the *Provisions* development and update efforts to date is that such a merging would not be responsive to the relative performance desired of structures in these individual groups.

Although the *Provisions* explicitly require design for only a single level of ground motion, it is expected that structures designed and constructed in accordance with these requirements will generally be able to meet a number of performance criteria, when subjected to earthquake ground motions of differing severity. The performance criteria discussed here were jointly developed during the BSSC Guidelines and Commentary for Seismic Rehabilitation of Buildings Project (ATC, 1995) and the Structural Engineers Association of California Vision 2000 Project (SEAOC, 1995). In the system established by these projects, earthquake performance of structures is defined in terms of several standardized performance levels and reference ground motion levels. Each performance level is defined by a limiting state in which specified levels of degradation and damage have occurred to the structural and nonstructural building components. The ground motion levels are defined in terms of their probability of exceedance.

Although other terminology has been used in some documents, four performance levels are commonly described as meaningful for the design of structures. These may respectively be termed the operational, immediate occupancy, life safety, and collapse prevention levels. Of these, the operational level represents the least level of damage to the structure. Structures meeting this level when responding to an earthquake are expected to experience only negligible damage to their structural systems and minor damage to nonstructural systems. The structure will retain nearly all of its pre-earthquake strength and

stiffness and all mechanical, electrical, plumbing, and other systems necessary for the normal operation of the structure are expected to be functional. If repairs are required, these can be conducted at the convenience of the occupants.

The risk to life safety during an earthquake in a structure meeting this performance level is negligible. Note, that in order for a structure to meet this level, all utilities required for normal operation must be available, either through standard public service or emergency sources maintained for that purpose. Except for very low levels of ground motion, it is generally not practical to design structures to meet this performance level.

The immediate occupancy level is similar to the operational level although somewhat more damage to nonstructural systems is anticipated. Damage to the structural systems is very slight and the structure retains all of its pre-earthquake strength and nearly all of its stiffness. Nonstructural elements, including ceilings, cladding, and mechanical and electrical components, remain secured and do not represent hazards. Exterior nonstructural wall elements and roof elements continue to provide a weather barrier, and to be otherwise serviceable. The structure remains safe to occupy; however, some repair and clean-up is probably required before the structure can be restored to normal service. In particular, it is expected that utilities necessary for normal function of all systems will not be available, although those necessary for life safety systems would be provided. Some equipment and systems used in normal function of the structure may experience internal damage due to shaking of the structure, but most would be expected to operate if the necessary utility service was available. Similar to the operational level, the risk to life safety during an earthquake in a structure meeting this performance level is negligible. Structural repair may be completed at the occupants' convenience, however, significant nonstructural repair and cleanup is probably required before normal function of the structure can be restored.

At the life safety level, significant structural and nonstructural damage has occurred. The structure may have lost a substantial amount of its original lateral stiffness and strength but still retains a significant margin against collapse. The structure may have permanent lateral offset and some elements of the seismic-force-resisting system may exhibit substantial cracking, spalling, yielding, and buckling. Nonstructural elements of the structure, while secured and not presenting falling hazards, are severely damaged and cannot function. The structure is not safe for continued occupancy until repairs are instituted as strong ground motion from aftershocks could result in life threatening damage. Repair of the structure is expected to be feasible, however, it may not be economically attractive to do so. The risk to life during an earthquake, in a structure meeting this performance level is very low.

At the collapse prevention level a structure has sustained nearly complete damage. The seismic-force-resisting system has lost most of its original stiffness and strength and little margin remains against collapse. Substantial degradation of the structural elements has occurred including extensive cracking and spalling of masonry and concrete elements and buckling and fracture of steel elements. The structure may have significant permanent lateral offset. Nonstructural elements of the structure have experienced substantial damage and may have become dislodged creating falling hazards. The structure is unsafe for occupancy as even relatively moderate ground motion from aftershocks could induce collapse. Repair of the structure and restoration to service is probably not practically achievable.

The design ground motion contained in the *Provisions* is taken as two-thirds of the maximum considered earthquake ground motion. Such ground motion may have a return period varying from a few hundred years to a few thousand years, depending on the regional seismicity. It is expected that structures designed in accordance with the requirements for Group I would achieve the life safety or better performance level for these ground motions. Structures designed in accordance with the requirements for Group III should be able to achieve the Immediate Occupancy or better performance level for this ground motion. Structures designed to the requirements for Group II would be expected to achieve performance better than the life safety level but perhaps less than the immediate occupancy level for this ground motion.

While the design ground motion represents a rare earthquake event, it may not be the most severe event that could ever affect a site. In zones of moderate seismicity, it has been common practice in the past to consider ground motion with a 98 percent chance of non-exceedance in 50 years, or an average return period of 2,500 years, as being reasonably representative of the most severe ground motion ever likely to affect a site. This earthquake has been variously termed a maximum credible earthquake, maximum capable event and, most recently, a maximum considered earthquake. The recent terminology is adopted here in recognition that ground motion of this probability level is not the most severe motion that could ever effect the site, but is considered sufficiently improbable that more severe ground motions need not practically be considered. In regions near major active faults, such as coastal California, estimates of ground motion at this probability of exceedance can produce structural demands much larger than has typically been recorded in past earthquakes. Consequently, in these zones, the maximum considered earthquake is now commonly taken based on conservative estimates of the ground motion from a deterministic event, representing the largest magnitude event that the nearby faults are believed capable of producing.

It is expected that structures designed to the requirements for Group I would be capable of responding to the maximum considered earthquake at a near collapse or better performance level. Structures designed to the requirements for Group III should be capable of responding to such ground motions at the life safety level. Structures designed and constructed to the requirements for Group II structures should be capable of responding to maximum considered earthquake ground motions with a performance intermediate to the near collapse and life safety levels.

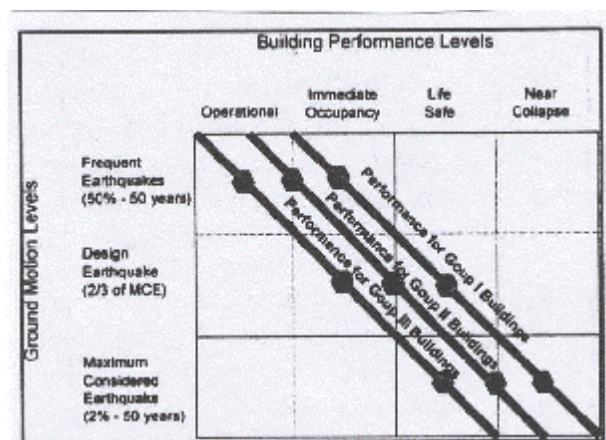


Figure 1.2-1 Expected building performance.

In zones of high seismicity, structures may experience strong motion earthquakes several times during their lives. It is also important to consider the performance expected of structures for these somewhat less severe, but much more frequent, events. For this purpose, earthquake ground shaking with a 50 percent probability of non-exceedance in 50 years may be considered. Sometimes termed a maximum probable event (MPE), such ground motion would be expected to recur at a site, one time, every 72 years. Structures designed to the requirements for Group I would be expected to respond to such ground motion at the Immediate Occupancy level. Structures designed and constructed to either the Group II or Group III requirements would be expected to perform to the Operational level for these events. This performance is summarized in Figure C1.2-1.

It is important to note that while the performance indicated in Figure C1.2-1 is generally indicative of that expected for structures designed in accordance with the *Provisions*, there can be significant variation in the performance of individual structures from these expectations. This variation results

from individual site conditions, quality of construction, structural systems, detailing, overall configuration of the structure, inaccuracies in our analytical techniques, and a number of other complex factors. As a result of these many factors, and intentional conservatism contained in the *Provisions*, most structures will perform better than indicated in the figure and others will not perform as well.

1.2.5 Seismic Use Group III structure access protection. This section establishes the requirement for access protection for Seismic Use Group III structures. There is a need for ingress/egress to those structures that are essential post-earthquake facilities and this shall be considered in the siting and design of the structure.

1.3 OCCUPANCY IMPORTANCE FACTOR

Although the concept of an occupancy importance factor for structural systems has been included in the *Uniform Building Code* for many years, it was first adopted into the 1997 Edition of the *Provisions*. The inclusion of the occupancy importance factor is one of several requirements included in this edition of the *Provisions* where there are attempts to control the seismic performance capability of structures in the different Seismic Use Groups. Specifically, the occupancy importance factor modifies the R coefficients used to determine minimum design base shears. Structures assigned occupancy importance factors greater than 1.0 must be designed for larger seismic forces. As a result, these structures are expected to experience lower ductility demands than structures designed with lower occupancy importance factors and, thus sustain less damage. The *Provisions* also include requirements that attempt to limit vulnerability to structural damage by specifying more stringent drift limits for structures in Seismic Use Groups of higher risk. Further discussion of these concepts is found in *Commentary* Sec. 4.2.1 and 4.5.

1.4 SEISMIC DESIGN CATEGORY

This section establishes the design categories that are the keys for establishing design requirements for any structure based on its use (Seismic Use Group) and on the level of expected seismic ground motion. Once the Seismic Design Category (A, B, C, D, E, or F) for the structure is established, many other requirements such as detailing, quality assurance, system limits, height limitations, specialized requirements, and change of use are related to it.

Prior to the 1997 edition of the *Provisions*, these categories were termed Seismic Performance Categories. While the desired performance of the structure, under the design earthquake, was one consideration used to determine which category a structure should be assigned to, it was not the only factor. The seismic hazard at the site was actually the principle parameter that affected a structure's category. The name was changed to Seismic Design Category to represent the uses of these categories, which is to determine the specific design requirements.

The earlier editions of the *Provisions* utilized the peak velocity-related acceleration, A_v , to determine a building's Seismic Performance Category. However, this coefficient does not adequately represent the damage potential of earthquakes on sites with soil conditions other than rock. Consequently, the 1997 *Provisions* adopted the use of response spectral acceleration parameters S_{DS} and S_{DI} , which include site soil effects for this purpose. Instead of a single table, as was present in previous editions of the *Provisions*, two tables are now provided, relating respectively to short-period and long-period ground motions.

Seismic Design Category A represents structures in regions where anticipated ground motions are minor, even for very long return periods. For such structures, the *Provisions* require only that a complete seismic-force-resisting system be provided and that all elements of the structure be tied together. A nominal design force equal to 1 percent of the weight of the structure is used to proportion the lateral system.

It is not considered necessary to specify seismic-resistant design on the basis of a maximum considered earthquake ground motion for Seismic Design Category A structures because the ground motion

computed for the areas where these structures are located is determined more by the rarity of the event with respect to the chosen level of probability than by the level of motion that would occur if a small but close earthquake actually did occur. However, it is desirable to provide some protection against earthquakes and many other types of unanticipated loadings. Thus, the requirements for Seismic Design Category A provide a nominal amount of structural integrity that will improve the performance of buildings in the event of a possible but rare earthquake even though it is possible that the ground motions could be large enough to cause serious damage or even collapse. The result of design to Seismic Design Category A requirements is that fewer buildings would collapse in the vicinity of such an earthquake.

The integrity is provided by a combination of requirements. First, a complete load path for lateral forces must be identified. Then it must be designed for a lateral force based on a 1 percent acceleration of the mass. The minimum connection forces specified for Seismic Design Category A also must be satisfied.

The 1 percent value has been used in other countries as a minimum value for structural integrity. For many structures, design for the wind loadings specified in the local buildings codes normally will control the lateral force design when compared to the minimum integrity force on the structure. However, many low-rise, heavy structures or structures with significant dead loads resulting from heavy equipment may be controlled by the nominal 1 percent acceleration. Also, minimum connection forces may exceed structural forces due to wind in some structures.

Seismic Design Category B includes Seismic Use Group I and II structures in regions of seismicity where only moderately destructive ground shaking is anticipated. In addition to the requirements for Seismic Design Category A, structures in Seismic Design Category B must be designed for forces determined using Maps 1 through 24.

Seismic Design Category C includes Seismic Use Group III structures in regions where moderately destructive ground shaking may occur as well as Seismic Use Group I and II structures in regions with somewhat more severe ground shaking potential. In Seismic Design Category C, the use of some structural systems is limited and some nonstructural components must be specifically designed for seismic resistance.

Seismic Design Category D includes structures of Seismic Use Group I, II, and III located in regions expected to experience destructive ground shaking but not located very near major active faults. In Seismic Design Category D, severe limits are placed on the use of some structural systems and irregular structures must be subjected to dynamic analysis techniques as part of the design process.

Seismic Design Category E includes Seismic Use Group I and II structures in regions located very close to major active faults and Seismic Design Category F includes Seismic Use Group III structures in these locations. Very severe limitations on systems, irregularities, and design methods are specified for Seismic Design Categories E and F. For the purpose of determining if a structure is located in a region that is very close to a major active fault, the *Provisions* use a trigger of a mapped maximum considered earthquake spectral response acceleration parameter at 1-second period, S_1 , of 0.75 or more regardless of the structure's fundamental period. The mapped short period acceleration, S_5 , was not used for this purpose because short period response accelerations do not tend to be affected by near-source conditions as strongly as do response accelerations at longer periods.

Local or regional jurisdictions enforcing building regulations need to consider the effect of the maps, typical soil conditions, and Seismic Design Categories on the practices in their jurisdictional areas. For reasons of uniformity of practice or reduction of potential errors, adopting ordinances could stipulate particular values of ground motion, particular Site Classes, or particular Seismic Design Categories for all or part of the area of their jurisdiction. For example:

1. An area with an historical practice of high seismic zone detailing might mandate a minimum Seismic Design Category of D regardless of ground motion or Site Class.
2. A jurisdiction with low variation in ground motion across the area might stipulate particular values of the ground motion rather than requiring use of the maps.
3. An area with unusual soils might require use of a particular Site Class unless a geotechnical investigation proves a better Site Class.

There are two limits on period for permission to ignore S_{DI} when establishing the Seismic Design Category. The first rule, requiring T_a be less than 80% of T_s , allows some conservatism for the uncertainty in estimating periods. The second rule only applies where a different period is used for computing drift than for computing forces. In that case, the period used for establishing drift must be less than the corner period, T_s . It should be noted that the period used for establishing drift could simply be T_a and, as such, does not require that the actual building period be calculated.

1.4.2 Site limitation for Seismic Design Categories E and F. The forces that result on a structure located astride the trace of a fault rupture that propagates to the surface are extremely large and it is not possible to reliably design a structure to resist such forces. Consequently, the requirements of this section limit the construction of buildings in Seismic Design Categories E and F on sites subject to this hazard. Similarly, the effects of landsliding, liquefaction, and lateral spreading can be highly damaging to a building. However, the effects of these site phenomena can more readily be mitigated through the incorporation of appropriate design measures than can direct ground fault rupture. Consequently, construction on sites with these hazards is permitted if appropriate mitigation measures are included in the design.

1.5 REQUIREMENTS FOR SEISMIC DESIGN CATEGORY A

Because of the very low seismicity associated with sites with S_{DS} less than 0.25 and S_{DI} less than 0.10, it is considered appropriate for Category A buildings to require only a complete seismic-force-resisting system, good quality of construction materials and adequate ties and anchorage as specified in this section. Category A buildings will be constructed in a large portion of the United States that is generally subject to strong winds but low earthquake risk. Those promulgating construction regulations for these areas may wish to consider many of the low-level seismic requirements as being suitable to reduce the windstorm risk. Since the *Provisions* considers only earthquakes, no other requirements are prescribed for Category A buildings. Only a complete seismic-force-resisting system, ties, and wall anchorage are required by these *Provisions*.

Construction qualifying under Category A may be built with no special detailing requirements for earthquake resistance. Special details for ductility and toughness are not required in Category A.

1.5.1 Lateral forces. This analysis procedure, which was added to the *Provisions* in the 1997 edition, is applicable only to structures in Seismic Design Category A. Such structures are not designed for resistance to any specific level of earthquake ground shaking as the probability that they would ever experience shaking of sufficient intensity to cause life threatening damage is very low so long as the structures are designed with basic levels of structural integrity. Minimum levels of structural integrity are achieved in a structure by assuring that all elements in the structure are tied together so that the structure can respond to shaking demands in an integral manner and also by providing the structure with a complete seismic-force-resisting system. It is believed that structures having this level of integrity would be able to resist, without collapse, the very infrequent earthquake ground shaking that could affect them. In addition, requirements to provide such integrity provides collateral benefit with regard to the ability of the structure to survive other hazards such as high wind storms, tornadoes, and hurricanes.

The procedure outlined in this section is intended to be a simple approach to ensuring both that a building has a complete seismic-force-resisting system and that it is capable of sustaining at least a

minimum level of lateral force. In this analysis procedure, a series of static lateral forces equal to 1 percent of the weight at each level of the structure is applied to the structure independently in each of two orthogonal directions. The structural elements of the seismic-force-resisting system then are designed to resist the resulting forces in combination with other loads under the load combinations specified by the building code.

The selection of 1 percent of the building weight as the design force for Seismic Design Category A structures is somewhat arbitrary. This level of design lateral force was chosen as being consistent with prudent requirements for lateral bracing of structures to prevent inadvertent buckling under gravity loads and also was believed to be sufficiently small as to not present an undue burden on the design of structures in zones of very low seismic activity.

The seismic weight W is the total weight of the building and that part of the service load that might reasonably be expected to be attached to the building at the time of an earthquake. It includes permanent and movable partitions and permanent equipment such as mechanical and electrical equipment, piping, and ceilings. The normal human live load is taken to be negligibly small in its contribution to the seismic lateral forces. Buildings designed for storage or warehouse usage should have at least 25 percent of the design floor live load included in the weight, W . Snow loads up to 30 psf (1400 Pa) are not considered. Freshly fallen snow would have little effect on the lateral force in an earthquake; however, ice loading would be more or less firmly attached to the roof of the building and would contribute significantly to the inertia force. For this reason, the effective snow load is taken as the full snow load for those regions where the snow load exceeds 30 psf with the proviso that the local authority having jurisdiction may allow the snow load to be reduced up to 80 percent. The question of how much snow load should be included in W is really a question of how much ice buildup or snow entrapment can be expected for the roof configuration or site topography, and this is a question best left to the discretion of the local authority having jurisdiction.

1.5.2 Connections. The requirements in this section are a simplified version of the material found in Sec. 4.6.1.1. For Seismic Design Category A, 5 percent is always greater than 0.133 times S_{DS} .

1.5.3 Anchorage of concrete or masonry walls. The intent of this section is to ensure that out-of-plane inertia forces generated within a concrete or masonry wall can be transferred to the adjacent roof or floor construction. The transfer can be accomplished only by reinforcement or anchors.

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