Section 3
Commentaries

The commentaries in the following subsections were provided by committee members with expertise in particular technical disciplines. The titles and authors of each subsection are as follows:

- 3.1 **Geotechnical and Seismological Aspects** by Klaus Jacob
- 3.2 **Loads and Load Procedures** by Joseph Kelly
- 3.3 **Seismic Design of Nonstructural Components, Elements of Structures and Non-Building Structures** by Leo E. Argiris
- 3.4 **Application to Building Additions and Alterations** by Ramon Gilsanz
- 3.5 **Economic Impact Study** by Irwin Cantor

3.3 Seismic Design of Nonstructural Components, Elements of Structures and Non-Building Structures

The New York City Seismic Code provides for the design for seismic forces for all elements of structures and for selected nonstructural components supported on the structure. The seismic force shall be distributed in proportion to the mass distribution of the element or component and shall be considered to act in any horizontal direction.

3.3.1 Nonstructural Components

All nonstructural components and their attachments whose failure in an earthquake would constitute a life-safety hazard must be designed to resist seismic forces as defined by Equation 12-10 (see page 17). Components are permanent assemblies not having a structural function. Components deemed to present a life safety hazard include:

1. Exterior ornamentation and appendages including cornices, ornamental statuaries or similar pieces of ornamentation.
2. Exterior chimneys, stacks, trussed towers, tanks on legs and exterior signs and billboards.
3. Cantilevered parapets.
4. Interior non-loadbearing walls and partitions around vertical exits including offsets and exit passageways.
5. Non-loadbearing partitions and masonry walls in areas of public assembly with an occupancy of greater than 300 people.
6. Interior ornamentation and appendages in areas of public assembly. These items include cornices, ornamental statuaries and other ornamentation.
7. Masonry and concrete fences at grade over 10 feet in height.

The code also requires that all equipment and machinery necessary for life-safety operations be anchored to the structure for a seismic force as defined by Equation 12-10. Included in this category is also equipment which contains a sufficient quantity of potentially explosive or toxic substances which, if released, threatens the safety of the general public. These items include, but are not limited to:

1. Pumps for fire sprinklers
2. Motors and switchgears for sprinkler pumps
3. Transformers
4. Control panels
5. Major conduit ducting and piping serving such equipment and machinery

The code primarily focuses on equipment anchorage and attachments because past earthquakes have demonstrated that most mechanical and electrical equipment is inherently rugged and performs well provided it is properly attached to the structure. However, mechanical equipment components required to maintain containment of flammable or hazardous material should themselves be designed for seismic forces.

The reliability of equipment components after an earthquake can be increased if the following items are also considered:

1. All internal assemblies are attached in a manner that eliminates the potential of impact with other internal assemblies and the equipment wall.
2. Operates, motors, generators, and other such components functionally attached mechanical equipment by means of an operating shaft or mechanism are structurally connected or commonly supported with sufficient rigidity such that binding of the operating shaft will be avoided.

Some large equipment such as boilers or turbines may be constructed within a structure but be isolated from that structure. In such cases, the equipment, necessary for life-safety operations, should be considered as a non-building structure.

The code excludes seismic design for all equipment weighing less than 400 pounds, furniture, temporary equipment and movable equipment. No seismic design is required for access floors, raised floors or hung ceilings.

The interrelationship of components and their effect on each other shall be considered so that the failure of a life safety related component or non-essential nonstructural component shall not cause the failure of another life safety related component.

3.3.1.1 Calculation of Seismic Force (F_p)

Values F_p, the seismic force required to attach a nonstructural component to the structure is calculated based on Equation 12-10. In this equation, the zone factor (Z) and the importance factor (I) are the same factor used in the design of the building structure. Values of C_p are given in Table 23-P. These values have been set considering the results of analyses based on the linear elastic response of multi-story buildings with generally regular configurations. These analyses indicate that for most buildings:

1. The peak acceleration of the upper stories can be three or more times the peak ground acceleration.
2. The peak measured accelerations of the upper stories (as a percentage of gravity) are generally between 1.6 to 2.3 times the peak base shear coefficient.
3. The peak acceleration for the upper half to two-thirds of a building are nearly constant.

These peak accelerations do not occur simultaneously on each floor, but occur at different times since the modes of vibration combine differently for each story. C_p valves are assumed not to vary in accordance with building height leading to a constant seismic force for a given component regardless of its location in the building.

The code only requires that the seismic force (F_p) be considered acting only in horizontal directions. It is held that vertical ground motion effects are adequately covered by gravity load design.

Equipment and components are defined to be either rigid and rigidly supported or non-rigid or flexibly supported. Rigid and rigidly supported components are those having a fundamental period, including their attachment of less than or equal to 0.6 seconds. Non-rigid or flexibly supported equipment has a fundamental period of greater than 0.6 seconds.

Rigid components are assumed to experience the same acceleration as the building structures at the point of attachment. Non-rigid components experience an amplified acceleration. The code provides for a C_p value of two times the value listed in Table 23-P for non-rigid or flexibly supported items where an analysis considering the flexibility of the component and attachment is not performed. If such an analysis is performed, the value of C_p shall not be less than the value listed in Table 23-P.

3.3.1.2 Anchorage of Components

Where design for seismic forces is mandated, positive anchorage to the structure must be provided. For anchored equipment, friction resistance resulting from gravity loads cannot be used to resist seismic forces. However, frictional resistance resulting from seismic overturning forces or from clamping action may be used.

3.3.1.3 References and Standards

The New York City Seismic Code is based on the 1988 UBC code with all supplements through 1990. As such, the code provides a force level for the design at anchorage of nonstructural components.

Considerable development has occurred in seismic codes since the introduction of the 1988 UBC. One trend in this development has been toward incorporation of prescriptive recommendations for detailing of nonstructural components within building structures. The *NEHRP Recommended Provisions for the Seismic Design of New Buildings, 1994* compiles provisions for detailing of nonstructural components. Following is a partial list of references containing similar guidelines. While compliance with any one of these guidelines does not imply conformance with the New York City Seismic Code force design requirement, these guidelines and standards can be a useful reference:

American Petroleum Institute (API), *API STD 650, Welded Steel Tanks For Oil Storage*, 1993.

American Society of Mechanical Engineers (ASME), *ASME A-17.1, Safety Code For Elevators and Escalators*, 1993.

American Society of Mechanical Engineers (ASME), *ASME B31, Power Piping-ASME Code For Pressure Piping, B31, An American National Standard*, 1995.

American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code*, including addendums through 1993.

American Society For Testing and Materials (ASTM), *ASTM C635, Standard Specification For The Manufacturer, Performance, and Testing of Metal Suspension Systems For Acoustical Tile And Lay-in Panel Ceilings*, 1995.

American Society For Testing And Materials (ASTM), *ASTM C636, Standard Practice For Installation Of Metal Ceiling Suspension Systems For Acoustical Tile And Lay-in Panels*, 1992.

American Water Works Association (AWWA), *D100, Welded Steel Tanks For Water Storage*, 1989.

Ceilings and Interior Systems Construction Association (CISCA), *Recommendations for Direct-Hung Acoustical Tile and Lay-In Panel Ceilings, Seismic Zones 0-2*, 1991.

Ceilings and Interior Systems Construction Association (CISCA), *Recommendations for Direct-Hung Acoustical Tile and Lay-In Panel Ceilings, Seismic Zones 3-4*, 1990.

Institute of Electrical and Electronic Engineers (IEEE), *Standard 344, Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations*, 1987.

Manufacturers, Standardization Society of the Valve and Fitting Industry (MSS), *SP-8, Pipe Hangers and Supports-Materials, Design, and Manufacture*, 1993.

National Fire Protection Association (NFPA*), NFPA-13, Standard for the Installation of Sprinkler System*. 1996.

Rack Manufacturers Institute (RMI), *Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks*, 1990.

Sheet Metal and Air Conditioning Contractors National Association (SMACNA), *HVAC Duct Construction Standards, Metal and Flexible*, 1985.

Sheet Metal and Air Conditioning Contractors National Association (SMACNA*)*, *Rectangular Industrial Duct Construction Standards*, 1980.

Sheet Metal and Air Conditioning Contractors National Association (SMACNA), Sheet Metal Industry Fund of Los Angeles, and Plumbing and Piping Industry Council, *Guidelines for Seismic Restraint of Mechanical Systems and Plumbing Piping Systems*, 1992.

3.3.2 Elements of Structures

All parts and portions of structures and their attachments are required to be designed to resist a seismic force as defined by Equation 12-10. These provisions apply to all load-bearing interior and exterior walls, floor slabs, diaphragms, framing members, and other structural elements.

3.3.3 Non-Building Structures

Non-building structures include all self-supporting structures other than buildings which carry gravity loads and resist the effects of earthquakes. Non-building structures include, but are not limited to:

1. Tanks, vessels and pressurized spheres

2. Silos
3. Chimneys
4. Stacks
5. Trussed towers
6. Cooling towers
7. Inverted pendulum type structures
8. Signs and billboards
9. Bins and hoppers
10. Storage racks supported at grade
11. Amusement structures
12. Monuments

Non-building structures differ from nonstructural components of buildings by having independent foundations. Non-building structures experience ground accelerations unaffected by building structures. Nonstructural components experience accelerations at the point of attachment to the building structure which are amplified from the ground acceleration.

Structures which are not covered by this section include:

1. Transportation related structures including:

    - bridges
    - elevated roadways
    - tunnels

2. Marine Structures

    - piers
    - bulkroads
    - offshore platforms
    - dams

Non-building structures shall be designed for a lateral force as defined by section 2312(d) where the value of R_w is based on Table 23-Q (see page 28). For rigid non-building structures, those with a fundamental period including their anchorage of less than 0.06 seconds, equation 12-12 may be used to calculate the lateral seismic force. In general, R_w values assigned to non-building structures are less than those assigned to building structures. This is because buildings tend to have structural redundancy due to multiple bays and frame lines and curtain nonstructural and non-considered resisting elements which effectively give the building greater damping and strength during strong ground motion response.