

Section 1

Introduction

Concern over the possibility of damaging earthquakes in the eastern United States developed through the 1970's as a result of improved knowledge of both the history of eastern U.S. earthquake occurrences and effects and of the underlying tectonics. These subjects are treated elsewhere in this report. Of interest here is the fact that this improved knowledge led to changes in both national and local building codes through the 1970's. The 1973 Uniform Building Code (UBC, 1973) included northern New York State, Boston, Massachusetts and Charleston, South Carolina in the next to highest seismic zone. The subsequent ATC 3-06 (ATC, 1978) maps, developed for equal probabilities of occurrence and intensity nationwide, refined the zoning further. At the same time, the Nuclear Regulatory Commission was carefully evaluating the seismic hazards and risks at potential plant sites. In an advisory note (NRC, 1983), the Nuclear Regulatory Commission commented:

“Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not of itself sufficient ground for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886 (M=7). Although the probability of strong ground motion due to an earthquake in any given year at a particular location on the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites on the eastern seaboard to establish the seismic engineering parameters for critical facilities.”

The particular seismicity of New York City (NYC), where the seismicity is “moderate,” can be characterized as follows:

- Earthquakes with intensity of about MM (Modified Mercalli) Intensity VII have occurred every 100 years in the New York City area.
- Regional seismicity indicates that earthquakes of MM Intensity VII are likely to occur on average every 100-200 years (i.e., 20 to 40 percent probability of occurrence in 50 years).
- Larger earthquakes, with MM Intensity VIII-IX, or magnitude 5.75 to 6.75 (probable upper bound range) may occur.
- Even larger magnitude and/or higher intensities, at very low levels of probability, cannot be excluded.
- NYC seismicity is very similar to that of the Boston area, where seismic design requirements are in effect.

These were the conclusions, in 1986, of a Committee (Nordenson, 1987) of the New York Association of Consulting Engineers formed to assess the need for seismic design in New York City.

1.1 Issues

Several issues, or questions, merit continued consideration as seismic design requirements are evaluated for use in places such as New York City.

- What are the maximum probable (say with a 10 to 20% probability of occurrence in 50 years) and maximum credible (say with a 2% probability of occurrence in 50 years) earthquakes for the region, and what would be the nature of the resulting ground motion at varying types of sites?
- How difficult and costly is it to provide seismic resistance to buildings?
- What would the human and economic effects of an occurrence in New York City of the maximum probable or maximum credible earthquakes be, both locally and nationally?
- To what extent will improved building codes mitigate these consequences? What other measures are needed? Should these take precedence over improved building codes? (e.g., post disaster planning, upgrading medical or other emergency facilities and lifelines, abatement of hazardous buildings, etc.)?
- What corollary benefits are there to adopting seismic design requirements in improved design and construction practices?

Clearly it is necessary to assess the need for seismic code provisions alongside other human needs. With limited resources, is it right to allocate them to seismic resistance, given the infrequency of earthquakes, as against housing, or education? Especially as it will affect such a small percentage of the building stock? Yet can one ignore an event, with even a low probability, of such severe consequences?

1.2 Overview of the New York City Seismic Code

1.2.1 Background

The 1982 edition of the ANSI A58.1 *Minimum Design Loads in Buildings and Other Structures* (ANSI, 1982) included a new seismic design section, modeled after the UBC and ATC 3-06, which placed New York City in Seismic Zone 2 (vs. 4 for California). This would in turn have triggered the application of the ductile design provisions of the ACI-318 code for concrete design. The New York City Building Commissioner asked the New York Association of Consulting Engineers (NYACE) to review the matter. The initial response, in the summer of 1984, was to recommend that such requirements be omitted. However, after some discussion, it was decided that a group of seismologists and engineers review the issues and advise NYACE. The Committee's conclusions have been reported above. Following this, the NYACE Board unanimously recommended to the Commissioner, in June 1987, that seismic design be mandated in New York City, and that these should follow the 1988 UBC (UBC, 1973).

At the same time (1986), the National Center for Earthquake Engineering Research (NCEER) was established in Buffalo, New York. Several conferences were organized as a result (Jacob et al., 1987; Jacob and Turkstra, 1989) which addressed the particular issues of seismic hazard and design in the eastern U.S. Following these, the Commissioner appointed, in April 1989, a Seismic Code Committee to draft seismic code provisions for New York City. This Committee included engineers, seismologists, and representatives of the building industries and real estate community. The Seismic Code Committee voted

unanimously to submit its final report to the Commissioner in early 1991, and the report was submitted on 18 April 1991.

1.2.2 Principles and Approach

The development of the code has been guided by several agreed principles:

- to focus on provisions for the prevention of life threatening collapse of buildings and components and not the protection of property *per se*.
- to seek improvements, not radical changes in construction practices.
- to modify the characterization of the loading to reflect local seismicity.

The Committee divided its efforts into (1) Geotechnical (2) Loads and Systems (3) Detailing (4) Economic Implications and (5) Nonstructural Subcommittees. After several months deliberation, the Committee decided to adapt the 1988 UBC, following the above stated principles, for inclusion in the New York City Building Laws.

The Committee's work therefore consisted of preparing amendments to the provisions of the 1988 UBC, except that the steel provisions of the 1990 Supplement to the UBC were referenced. The following summarizes these changes as agreed by the Subcommittees. It should be noted that one and two-family dwellings not more than three stories in height are exempted from the provisions.

1.2.3 Geotechnical Subcommittee

- 1.1 Seismic Zone: NYC is deemed to be in Seismic Zone 2A with a factor, or effective zero period acceleration of 0.15 in S₁ type rock.
- 1.2 Site geology and characteristics: Soils are classified with reference to the New York City classification system. A new soil type, S₀, is introduced for hard rock, with a factor of 0.67. The Massachusetts code provisions for evaluating soil liquefaction potential are introduced.
- 1.3 Foundations: Pile caps and caissons are to be connected, unless the soil can provide equivalent restraint. Wood stud wall plates and sills are to be bolted to foundations.
- 1.4 Site specific response spectra: These may be used for design, and are recommended for S₄ soil type sites. However, the calculated base shear must be scaled to the equivalent static value (see 2.5 below).

1.2.4 Loads and Systems Subcommittee

- 2.1 Analysis method: The equivalent static lateral force procedure is accepted for all buildings except irregular buildings over 400 feet in height in Occupancy Categories I through III. These include emergency and hazardous facilities, and special occupancy structures, including those with more than 5,000 occupants. All regular buildings, of any height, can be designed by the equivalent static procedure.

- 2.2 Dual system: These are systems with shear walls or braced frames and moment frames working in parallel. The moment frames are required to carry at least 25% of the lateral load considered on their own. The system is intended to possess sufficient ductility by virtue of the moment frames. The New York City Seismic Code adds the provision that the walls or braced frame have sufficient shear capacity to carry 75% of the cumulative story shear (not overturning). This is in recognition of the interaction effects of tall frame/wall structures, and the desire to insure possible shear redistribution.
- 2.3 Period determination: The coefficients (C_1) for estimating periods have been revised for concrete moment frames, dual systems and eccentric braced frames.
- 2.4 Vertical component: The coefficient has been reduced in line with the local seismicity.
- 2.5 Scaling of dynamic analysis results: The UBC provisions have been adjusted to allow scaling to a reduced equivalent static coefficient for periods above 3 seconds. This reflects the lesser ordinates, at long periods, of response spectra developed for eastern U.S. sites. The coefficient C is calculated as $1.80 S/T$ for $T > 3$ seconds.
- 2.6 Building separation: Building separation is limited to 1 inch for every 50 feet of total building height. Thus, a building 400 feet tall would, at the typical 120 foot zoning setback elevation, be separated by 8 inches from the adjacent building. The provision notes that “smaller separation may be permitted when the effects of pounding can be accommodated without collapse of the building.” This provision is intentionally empirical to reflect the uncertain knowledge of the effects of pounding on building collapse.
- 2.7 Structural systems: Several new systems are recognized as follows:
- Ordinary concrete moment-resisting frames limited to sites with soils S_0 to S_2 and under 160 feet in height.
 - Dual systems combining concrete and reinforced masonry shear walls and braced frames with “Special,” “Intermediate” and “Ordinary” moment-resisting frames.

1.2.5 Detailing Subcommittee

- 3.1 Masonry: The ACI 530-88 *Building Code Requirements for Masonry Structures* has been used as a reference standard with modifications:
- All masonry bearing and shear walls shall be reinforced, regardless of whether they are designed as reinforced or unreinforced walls. Maximum spacing of vertical bars is 10 feet.
 - All nonbearing back-up or infill walls and nonbearing partitions shall have minimum one-way only reinforcement to supports.
- 3.2 Concrete: ACI 318-89 is referenced without modifications.
- 3.3 Steel: The 1988 UBC requirements of Section 2723 are referenced without major modifications. The use of LFRD is prohibited for the design of seismic resisting elements.

3.4 Timber: The AITC and APA provisions for seismic design of plywood or other diaphragms and shear walls are referenced.

1.2.6 Nonstructural Subcommittee

4.1 Part or portion of structures: UBC Table 23-P (see page 27) is revised for nonbearing walls so that only those around means of egress are to be designed for the specified lateral forces.

4.2 Exterior nonstructural components: Provisions for interior components (e.g., access floors, ceilings, etc.) have been eliminated. Exterior appendages, chimneys, stacks, trussed towers, tanks on legs and exterior tanks and vessels are to be designed for seismic effects.

1.3 Conclusion

Mayor Rudolph Guiliani signed the New York City Seismic Code, known as Local Law 17, on 21 February 1995 to take effect a year from that day.