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

3.5 Economic Impact Study

The following is a summary of an economic implication study of several buildings, located in New York City, based on conformance with New York City seismic regulations, as defined in Local Law 17 of 1995, effective February 21, 1995.

The study includes four basic types of construction; steel, reinforced concrete, masonry and precast. For steel and reinforced concrete construction, buildings heights ranging from low- to high-rise were considered. Masonry and precast construction were studied for low-rise buildings only.

3.5.1 Assumptions

In order to "fairly" compare the seismic impact on the buildings which are already designed for wind forces, the study was conducted based on the premise that the lateral system's configuration was not altered. The required additional weight was added without changing a member's depth or adding members, since adding a new member or increasing the depth of the existing member may intrude into architectural or functional space requirements. The review of those impacts are outside the scope of this study.

For this study, only the static lateral force method of the Code is used. The additional cost required for seismic conformance is evaluated as a percentage of the basic cost of the structural system only.

3.5.2 Results

A brief description of each type of building studied is given in the following sections. Table 3-1 summarizes the results of the study including the height, type of building and underlying soil type. It should be noted that the cost impacts were obtained for buildings where the lateral systems were selected solely based on wind criteria. However, if the structures were designed with wind as well as seismic criteria in mind from the conceptual phase of the project, the cost increases would most likely be lower than the reported values. Also, it should be mentioned that none of these buildings were highly sensitive to torsional effects, and as a result, the cost implications for torsional sensitivity or any other irregularity in general may not be reflected in these studies.

3.5.3 Conclusion

This study was limited to the so called "seismically simple buildings" which means that no set backs, soft stories, or any other type of irregularities so frequently in evidence in New York City were considered. As a result, the estimated additional cost impact does not reflect the effects of these irregularities.

Conversely, it should be emphasized that this research was done with regard to design of "yesterday's buildings" for "tomorrow's forces." In other words, if seismic and wind criteria are implemented from inception of the project and as the Architectural/Developer group became familiar with the cost implications of irregularities, etc., most likely the cost impact would be somewhat lessened although it would still exist.

Since there are numerous parameters and criteria involved in shaping the outcome of the study, the tabulated results should not be taken as "definitive". Variations from this mean can easily run ± 50%. Indeed, the study of a 3-story bearing wall project on the direct substitution basis proved impossible economically and was abandoned.

Based on the limited study of this three-story masonry building, it would appear that for six- to ten-story masonry buildings, the cost increment will be in the range of 15%.

3.5.4 Summary of the Study

A. Steel structures:

1. 2-Story Building

Two industrial buildings are studied. Building 1A has dimensions of approximately 150' x 194' x 38'. The lateral load resisting system in short direction is a series of one bay Ordinary Moment Resisting Frames, R_w=6. In the long direction it is a Braced Frame, R_w=8. Soil types of S_2 and S_4 were considered. The estimated cost increases are about 11.4% and 15.8% for S_2 and S_4, respectively. The ceiling value of 2.75 for "C" was reached for S_4.

Building 1B is a 2-story structure with overall dimensions of 127 x 82 x 28'. The lateral system in the short direction is a Moment Resisting Frame, and in the long direction is a Concentric Braced Frame. The wind system is designed to resist a lateral wind pressure of 44 psf. The seismic study indicated that there is no need for additional material for either of the soil types S_2 or S_4.

2. 5-Story Building

A 5-story office building utilizing an Ordinary Moment Resisting Frame in both lateral directions, R_w=6. The estimated cost increases are about 8%, 12%, and 15% for soil types S_0, S_1, and S_2, respectively.

3. 11- Story Building

An 11-story office building utilizing a dual lateral force resisting system comprising a Concentric Braced Frame and Special Moment Resisting Frame in both directions, R_w=10. The estimated cost increases are about 8% and 12% for soil types S_1 and S_3, respectively.

4. 25-Story Building

The lateral force resisting system in both directions is Concentric Braced Frame, R_w=8. The estimated cost increases are about 2.5% and 5% for soil types S_1 and S_3, respectively.

5. 32-Story Building

In one direction, Ordinary Moment Resisting Frame with R_w=6 is used, and in the perpendicular direction, Concentric Braced Frames with R_w=8 are utilized. The estimated cost increases are about 1.6% and 5% for soil types S_1 and S_3, respectively.

B. Concrete Structures:

1. 3-Story Building

A 3-story hospital is studied. The building dimension is 100' x 125'. The structural system comprises a 9" Flat Slab with 20" square columns a 25' o.c. grid with 34" x 34" x 7" drop panels. This is considered as an Intermediate Moment Resisting Frame system with R_w=7. The required additional materials are about 1.3 psf of rebars for soil types S_1 and S_4, respectively, which may be translated to an additional cost of 4.3% and 9% for S_1 and S_4, respectively.

2. 15-Story Building

The lateral force resisting system is a combination of shear wall core and perimeter Ordinary Moment Resisting Frame in both directions, R_w=5. The estimated cost increases are about 8% and 11% for soil types S_1 and S_3, respectively.

3. 24-Story Building

The lateral force resisting system is a combination of shear wall core and perimeter Ordinary Moment Resisting Frame in both directions, R_w=5. The estimated cost increases are about 5% and 9% for soil types S_1 and S_3, respectively.

4. 57-Story Building

The wind design was controlled by the wind tunnel test results. The lateral force resisting system is a combination of shear wall core and flat slab. The flat slab was considered both as an Ordinary Moment Resisting Frame with R_w=5 and alternately as an Intermediate Moment Resisting Frame with R_w=9. The minimum cost increase of the two alternate framing of R_w=5, and R_w=9 is reported as follows. The estimated cost increase are about 3.2% with R_w=5 for S_0 soil, 4.8% with R_w=5 for S_1 soil, 5.8% with R_w=9 for S_2 soil, and 5.8 for R_w=9 for S_3 soil. The lateral system with R_w=9 and soil S_3 is controlled by the floor limit of .075 x

R_w for parameter "C". Therefore, the floor limit would be the controlling value for all the soil types stronger than S_3, such as S_2, S_1 and S_0.

C. Masonry Structures:

1. 3-Story Building

A 3-story nursing home is studied. The floor system is made of 8" precast plank plus 3" topping. Eight inch solid concrete block is placed perpendicular to the exterior walls and spaced at 27 feet on center with openings for the central corridor. The 8" unreinforced solid concrete block is adequate for both gravity and wind loadings. Two different approaches are followed for seismic design of the long direction (parallel to the corridor) of the building. First approach: design the cross walls in the weak axis as a frame in conjunction with slab to resist the lateral forces. This requires thickening the masonry blocks to 12" and adding vertical reinforcing at an average of #4 @ 10'-0" #4 @ 16" for soil S_1 or #6 @16 for soil S_4. Also, plank joint reinforcement should increase accordingly. This yields an economically unacceptable solution. In a second approach, a 9 foot long section of exterior wall (between windows) for each 27 foot length of building is used with 8" reinforced concrete block to resist the seismic forces. Thus, the interior bearing wall reverted to its original design (8" solid concrete block). However, vertical reinforcing is required, at a minimum of 1 #4 @ 10'-0". The 9 foot long exterior walls also require vertical reinforcing at an average of 4 #6 for soil type S_1, and 6 #6 for soil type S_4. The estimated cost increases are about 9.7% for soil type S_1 and 11.3% for soil type S_4.

D. Precast Structures:

1. A 2-story parking structure is studied. Lateral forces are resisted by shear walls in both directions. Soil types of S_2 and S_4 are considered. The ceiling value of 2.75 for "C" is reached for both types of soils. The seismic force is 4 to 5 times higher than wind force. The cost difference is in wall reinforcement (minimal increase above normal) as well as increase in shear wall foundation, which is estimated as about a 3% cost increase for both types of soils.

2. 8-Story Building

An 8-story parking structure is studied. Lateral forces are resisted by shear walls in both directions. Only soil type S_3 is considered. The C value was close to the maximum value of 2.75. Seismic force is about 5 times larger than the wind force. The cost difference would be in wall reinforcement as well as increase in shear wall foundations, which is estimated as about a 3% cost increase for soil type S_3 as well as S_4 since "C" value was close to maximum value of "C".

3.5.5 Acknowledgments

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Table 3-1 Summary of Cost Impacts
(Ratio of Structural Cost Only)

Building Type	Lateral Load Resisting System	Number of Floors	Soil Condition				
			S_0	S_1	S_2	S_3	S_4
S1A Steel	OMRF, R_W=6 CBF, R_W=8	2			1.11		1.16
S1B Steel[1]	OMRF, R_W=6 CBF, R_W=8	2			1.00		1.00
S2 Steel	OMRF, R_W=6	5	1.08	1.12	1.15		
S3 Steel	CBF + SMRF R_W=10	11		1.08		1.12	
S4 Steel	CBF, R_W=8	25		1.03		1.05	
S5 Steel	OMRF, R_W=6 CBF, R_W=8	32		1.02		1.05	
C1 Concrete	IMRF, R_W=7	3		1.04			1.09
C2 Concrete	Shear Wall+ OMRF, R_W=5	15		1.08			1.11
C3 Concrete	Shear Wall+ OMRF, R_W=5	24		1.05			1.09
C4A Concrete	Shear Wall+ Flat Slab	57	R_W=5 1.03	R_W=5 1.05	R_W=9 1.06	R_W=9 1.06	
C4B Concrete[2]	Shear Wall+ Flat Slab	57	R_W=5 1.01	R_W=9 1.03	R_W=9 1.04	R_W=9 1.06	
M1 Masonry	Reinforced Masonry Wall R_W=5	3		1.10			1.11
P1 Precast	Shear Wall R_W=6	2			1.03		1.03
P2 Precast	Shear Wall R_W=6	8				1.03	1.03

Note: The base value of 1.00 is for non-seismic design structure.

1 Designed for twice the New York City wind pressure.

2 C min = 0.05 x R_W.