Guidelines

for the Structural Provisions for the

Repair, Alteration, Addition and Change of Use

of Existing Buildings

For Compliance with the 6th Edition of the
Massachusetts State Building Code

Boston Association Of Structural Engineers

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TABLE OF CONTENTS

GUIDELINES FOR THE STRUCTURAL PROVISIONS FOR REPAIR, ALTERATION, ADDITION AND CHANGE OF USE OF EXISTING BUILDINGS

For Compliance with the 6th Edition of the Massachusetts State Building Code

1.0 GENERAL INFORMATION

These guidelines were prepared to assist users of the structural provisions of Chapter 34 of the Sixth Edition of the Massachusetts Building Code: Repair, Alteration, Addition, and Change of Use of Existing Buildings. Users of this guideline must be aware that the guideline's content is the opinion of BASE and is not legally binding.

1.1 Development of Chapter 34 Structural Provisions

In around 1987, the Seismic Advisory Committee (SAC) decided to address deficiencies in Chapter 32 of the Massachusetts State Building Code. Members of the SAC are appointed by the State Board of Building Regulations and Standards (BBRS), and they are charged with advising the BBRS in code matters related to seismic design. Chapter 32 is the precursor of Chapter 34, the portion of the state building code containing detailed requirements for existing buildings. The SAC developed a first draft of revisions, and in 1991 the Loads Advisory Committee (LAC), another BBRS-appointed committee, which makes recommendations on the structural loads portions of the code, joined the development effort.

Meanwhile, in 1990 the Massachusetts Emergency Management Agency (MEMA) commissioned a study to assess the effects of the largest earthquake likely to occur in the Boston metropolitan area. There are historical records of two sizable earthquakes in Massachusetts: the 1727 Newburyport earthquake and the 1755 Cape Ann earthquake, with estimated Richter magnitudes of 5.5 and 6.0 respectively. The study assumed a 6.25 magnitude earthquake with an epicenter off Cape Ann.

The report concluded that property damage could range from $2 billion to $10 billion dollars and that there would be many deaths. One of the report's recommendations is that the Massachusetts Board of Building Regulations and Standards (BBRS) investigate improving the seismic requirements for existing buildings in the state building code.

Chapter 34 is unique to Massachusetts, with substantial modifications to the previous Massachusetts code (Fifth Edition) and the model code (BOCA). The new provisions were introduced in the Sixth Edition of the Massachusetts Building Code, which was promulgated in February 1998.

One impetus for the new provisions in the Sixth Edition was that the requirements for existing buildings in the Fifth Edition of the Code were very stringent and did not address existing materials. As a result there was little uniformity in their enforcement. For example, the Fifth Edition does not prescribe seismic loads for the case where a vertical addition is made to an existing structure. By default, the seismic loads applicable to new construction must be used. The new provisions relax this requirement by specifying a sliding scale of lateral seismic loads depending upon the size of the addition.

The Fifth Edition also required that existing buildings that have a change in use which results in an increase in hazard index of two or more meet the requirements for new construction. Structural engineers frequently made use of a “loophole” in the code that permits “compliance alternatives” where “compliance with the provisions of the code for new construction…is impractical because of structural or construction difficulties or regulatory conflicts.” As a result, few improvements were made to the lateral systems of these buildings, even in cases where the lateral system was grossly inadequate. The new provisions relax this requirement by tying the required lateral strength to the cost of the project, the change in hazard index, and the change in occupancy.

1.2 Intent of the Structural Provisions

The intent of the provisions is to:

- Improve the uniformity of code interpretation and application;
- Provide graduated lateral load requirements, dependent upon scope-of-work and change in life safety risk; and
- Establish minimum lateral strength requirements regardless of project size for structures where the useful life is extended or where the existing structural system is impacted in some manner.

1.3 Uniformity of Code Interpretation

Prior to the Sixth Edition, there were no provisions for reduced wind and seismic loads for alterations and additions to existing buildings; where improved resistance to lateral loads was required, the user was referred to the code for new buildings. The Sixth Edition attempts to improve the uniformity of interpretation by providing guidance in cases where archaic systems are present and by providing some relief from the new building design loads in certain cases. Furthermore, the Sixth Edition provides additional relief for fully and partially preserved historic buildings.

1.4 Graduated Lateral Load Requirements

The Sixth Edition provides relief from the lateral force requirements for new construction in several cases. When structurally unseparated additions (i.e. additions which impose loads on the original structure) are constructed, the required seismic loads vary depending upon the size of the addition. In the case of alterations, repairs, and changes of use, where a seismic analysis is required and there is no increase in building area or height, the seismic resistance need only be 75 percent of the resistance required for new construction and provisions are included for the use of archaic materials in the lateral load resisting system.

1.5 Minimum Lateral Strength Requirements

The Sixth Edition requires that existing buildings receiving additions or undergoing repairs or alterations meet minimum lateral strength standards. The intent of these provisions is to identify buildings which have poor lateral load resisting systems and which therefore pose a risk to life safety in the event of unusually high winds or earthquakes.

1.6 Additions (3408.4)

If a structurally separate addition is made, and no work to the existing building is proposed, no structural upgrade of the existing building is required. The structurally separate addition must meet all the code requirements for new buildings.

In the case of structurally attached additions, if both the area and the weight of the building are increased by less than 10%, the lateral system of the existing building only needs to be strengthened in certain cases where alterations are made to the existing lateral load resisting system. If no changes are made to the existing lateral system, no seismic strengthening is required (3408.4.3.2.1). If either the area or the weight of the building is increased from 10 to 100 percent, the required seismic resistance varies from 40 to 100 percent of the force required for new construction, and archaic systems may in some cases be used to resist lateral loads (3408.4.3.2.2). If the increase is greater than 100 percent, the building must meet all the requirements for new construction; no archaic systems may be used to resist lateral loads (3408.4.3.2.3).

The minimum wind load requirements for buildings receiving additions depends on the increase in load caused by the addition relative to the capacity of the existing lateral load resisting system (3408.4.2.1). All additions made since January 1, 1975 must be considered. If the additions cause “effects” that are more than 10% of the capacity of the existing lateral system, the system must be capable of resisting the wind loads specified by the code for new buildings; if the additions cause effects that are less than 10% of the capacity of the existing system, the system must be capable of resisting Exposure A wind loads. Exposure A wind loads are the lowest allowed by the code for new construction, and are normally only permitted in the “centers of large cities and very rough, hilly terrain.”

1.7 Alterations, Repairs, and Changes of Use (3408.5)

In the case of alterations, repairs, and changes of use, where a seismic analysis is required and there is no increase in building area or height, the seismic resistance need only be 75 percent of the resistance required for new construction (3408.5.4.6) and provisions are included for the use of archaic lateral load resisting systems (3408.6.1.1, 3408.6.4). Seismic analysis of a building undergoing alteration is required in certain cases when alterations are made to existing elements of the lateral load resisting system (3408.3.5) and in certain cases dependent upon the use, occupancy, and cost of repairs/alterations (3408.5.4.5).

When alterations, repairs, or changes of use requiring the involvement of a design professional are made to a building, the building must have at least the lateral capacity to resist Exposure A wind loads. The building official may waive this requirement only if the alterations are minor, there is no change in use, and there are no alterations to structural elements (3408.5.3).

DISCUSSION FOR PARTICULAR USERS

1.8 Building Officials

Building officials are responsible for understanding and enforcing the new provisions. Building officials must ensure that structural evaluations, as required by 780 CMR 3402.1.2, are submitted with the application for the building permit. They should review the evaluation to see how the structural engineer proposes to address code requirements such as design for wind and seismic loads.

1.9 Building Owners

Building owners should familiarize themselves with the new provisions to understand the impact that alterations and additions may have on their property. Certain types of work could trigger a code-required upgrade of the structure to resist seismic forces; in some cases such an upgrade could be more costly than the proposed alterations. Owners should be especially cautious when buying existing real estate, as planned alterations, additions, and changes of use could have implications for the lateral load resisting system which may be significant. Owners should realize that in any case where a building permit is required, the services of a structural engineer may be required to perform a structural evaluation of the building, even when there are no proposed structural alterations.

1.10 Architects

Architects should consider Chapter 34 in the early planning stages of any work on existing buildings, as Chapter 34 provisions could significantly effect any proposed work. For example, the amount of work required to improve the existing lateral load resisting system, which can be substantial, is dependent in part on the cost of proposed alterations and on the size of additions. A change in use from a low hazard index use to a high hazard index use, or any major work on an emergency-use building such as a fire station, may mean that the building must have the lateral strength to resist at least 75% of the seismic loads required for new buildings.

Chapter 34 requires that a structural engineer be retained for any work on existing buildings subject to construction control (see 3408.1.3). The structural engineer should be brought into the design process before any major planning decisions are finalized. The engineer can help evaluate the condition of the existing structure and the impact of any proposed modifications.

1.11 Structural Engineers

Structural Engineers should study the structural requirements of Chapter 34 and make sure their clients are aware of them. Engineers should ensure they are included in the early planning of any project which affects existing buildings. They should perform a comprehensive review of Chapter 34 provisions during the planning stage and inform their clients of possible impacts on the project. Structural engineers are required to perform an evaluation of an existing building and to submit a written report to the building official with the application for the building permit (see 3408.2).

1.12 Limitations to the Guidelines

These Guidelines are not intended to be and should not be interpreted as being a standard of care for the Structural Engineer of Record (SER). The application of these Guidelines requires professional judgment by the SER on a project-by-project and system-by-system basis. The recommendations in

these Guidelines do not necessarily represent the only proper procedures or methods for complying with the requirements of 780 CMR Chapter 34, and some of the recommendations may not be applicable to specific projects, structural systems, or structural components.

2.0 STATE BUILDING CODE REQUIREMENTS FOR REPAIR, ALTERATION AND CHANGE OF USE OF EXISTING BUILDINGS

The section of the State Building Code which contains the requirements for the repair, alteration, and change of use of existing buildings is 780 CMR Chapter 34. The sections, as revised on 9/19/97, which pertain to structural work are presented below in the left column. Only sections related to structural work are included.

A commentary by BASE is presented in the right column. This commentary contains recommendations for implementation of the Code requirements and explanatory comments opposite the applicable subsections of the Code.

780 CMR 3400.0 SCOPE

3400.1 General: The provisions of 780 CMR 34 are intended to maintain or increase public safety, health and general welfare in existing buildings by permitting repair, alteration, addition and/or change of use without requiring full compliance with the code for new construction except where otherwise specified in 780 CMR 34.

R3400.1: Work which decreases public safety, such as by weakening structural systems, or by imposing additional loads on existing non-compliant structures, is not permitted unless an analysis shows the systems still satisfy minimum code loading requirements.

3400.2 Compliance: Repairs, alterations, additions, and changes of use shall conform to the requirements of 780 CMR 34. Where compliance with the provisions of this code for new construction is required by 780 CMR 34, and where such compliance is impractical because of construction difficulties or regulatory conflicts, compliance alternatives as described in 780 CMR 3406.0 may be accepted by the building official.

Note: Specialized codes, rules, regulations and laws pertaining to repair, alteration, addition and change of use of existing buildings promulgated by various authorized agencies may impact upon the provisions of 780 CMR 34. Specialized state codes, rules, regulations and laws include, but are not limited to those listed in **Appendix A.**

R3400.2: Compliance with 780 CMR 34 is required. The design professional is to be the determiner of difficulties, which require satisfaction of code intent by alternative procedures. The design professional should not rely on the definition of difficult preferred by the owner, architect or contractor nor should they expect the building official to provide evidence in this area.

3400.3 Applicability: The provisions of 780 CMR 34 apply to repair, alteration, addition or change in use to existing buildings which qualify to use 780 CMR 34 (see 780 CMR 3400.3.1), based on the proposed continuation of, or change in use group, as follows:

1. Continuation of the same use group, or a change in use group which results in a change of hazard index of one or less as determined by 780 CMR 3403 shall comply with780 CMR 3404.0.
2. Change in use group to a use group with hazard index of two or more greater than the hazard index of the existing use shall comply with the requirements of 780 CMR 3405.0 and the code for new construction.
3. **Part change in use (Mixed use):** Portions of the

R3400.3:

building is changed to a new use group, shall be separated from the remainder of the building with fire separation assemblies complying with 780 CMR 313, or with approved compliance alternatives. The portion of the building changed shall be made to conform with the applicable provisions of 780 CMR 34.

4. **Additions:** Additions to existing buildings shall comply with all code requirements for new construction, except as otherwise provided in 780 CMR 34. The combined height and area of the existing building and the addition shall not exceed that allowed by 780 CMR 503.0 and Table 503 as modified by 780 CMR 504 and 506. Where a fire wall complying with 780 CMR 707.0 and 708.0 is provided, the addition shall be considered as a separate building.
5. **Ordinary repairs:** Ordinary repairs conforming to 780 CMR110.3 (4), 780 CMR 2, and 780 CMR 902 may be performed without a building permit.
6. **Assembly use groups:** A change from any other use groups to an assembly use group (A) or any alteration or change in occupancy within an assembly use group shall comply with the requirements of the code for new construction, except that earthquake requirements need only conform to 780 CMR 3408.
7. **Institutional use groups:** A change from any other use group to an institutional use group (I) or any alteration or change in occupancy within an institutional use group shall comply with the requirements of the code for new construction, except that earthquake requirements need only conform to 780 CMR 3408.
8. **Residential use groups:** A change from any other use group to a residential use group (R) or any alteration or change in occupancy within a residential use group shall comply with the requirements of the code for new construction, except that earthquake requirements need only conform to 780 CMR 3408.
9. **Historic Buildings:** Buildings which qualify as totally or partially preserved historic buildings in accordance with 780 CMR 3409 shall meet the provisions of 780 CMR 3409.
10. **Structural Requirements**: Structural requirements for additions, and for existing buildings subject to repair, alteration and/or change of use, shall be in accordance with 780 CMR 3408, except:

    A. *Totally Preserved Historic Buildings* need not comply with the wind load and seismic load requirements of 780 CMR 3408, and

5. Ordinary Repairs: Ordinary repairs may be performed without a permit, and therefore without construction control, since projects which do not require a permit do not require construction control (see 110.3 and 116.1). Chapter 34 structural engineering services are only required when construction control is required (3408.1.3). Thus ordinary repairs do not require the structural engineering services prescribed by Chapter 34. 780 CMR 202.0 defines ordinary repairs as "... any maintenance which does not affect the structure, egress, fire protection systems, fire ratings, energy conservation provisions, plumbing, sanitary, gas, electrical or other utilities."

6, 7, 8. Assembly, Institutional and Residential use groups: These sections of the code require the structural systems in affected areas *(that is, areas undergoing **any** alterations, change of use or change of occupancy)* to be designed under the code's provisions for new construction, except for the earthquake provisions, which may be designed in accordance with 780 CMR 3408.

9. Historic Buildings: Totally or partially preserved historic buildings are allowed relief from some of the requirements of Chapter 34 and must meet 3409 requirements. The extent of relief is described in 3409. 3409 does not contain specific structural requirements, aside from a requirement to verify floor live load capacities. However, a recent emergency code change for section 3400.3.10 requires that historic buildings comply with the structural requirements for existing buildings (3408), with the exception of some of the lateral load requirements. Partially preserved historic buildings do not need to comply with the seismic requirements of 3408, and fully preserved buildings are exempt from both wind and seismic requirements of 3408.

10. Structural Requirements: This section was revised as an emergency code change effective mid-January 2001, (note that the revisions shown are not reflected in the 26 April printing of the Code). Except for the lateral load requirements noted, totally preserved and partially preserved historic buildings are subject to the Structural Requirements for Existing Buildings (3408), despite the wording of paragraph 3409.1, which states that "780 CMR 3409.0 shall preempt all other regulations of 780 CMR..." Even though historic buildings are exempt

B. *Partially Preserved Historic Buildings* need not comply with the seismic load requirements of 780 CMR 3408.

3400.3.1 Buildings which qualify: The provisions of 780 CMR 34 shall apply to existing buildings which have been legally occupied and/or used for a period of at least five years. Any building for which there exists an outstanding notice of violation or other order of the building official shall not qualify to use 780 CMR 34 unless such proposed work includes the abatement of all outstanding violations and compliance with all outstanding orders of the building official. Buildings which do not qualify as existing buildings for the purposes of 780 CMR 34 shall comply fully with the applicable provisions of this code for new construction.

Exceptions:

1. Existing buildings or portions thereof which are changed in use from any other use group to day care centers (I-2 or E) shall not qualify as existing buildings for the purposed of 780 CMR 34, but shall comply with the requirements of 780 CMR 4, as applicable.
2. Existing buildings or portions thereof, which are changed in use from any use to a Group Residence, Limited Group Residence or Group Dwelling Unit shall not qualify as existing buildings for the purposes of 780 CMR 34, but shall comply with the provisions of 780 CMR 4, as applicable.

780 CMR 3401.0 DEFINITIONS

3401.1 General: Definitions shall, for the purposes of 780 CMR 3401.0, have the meaning shown herein.

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Historic buildings: (a) Any building or structure individually listed on the National Register of Historic Places or (b) any building or structure evaluated by MHC to be a contributing building within a National Register or State Register District. (c) any building or structure which has been certified by the Massachusetts Historical Commission to meet eligibility requirements for individual listing on the National Register of Historic Places. Historic building shall be further defined as totally or partially preserved buildings. All entries into the totally preserved building list shall be certified by the Massachusetts Historical Commission. The Board of Building Regulations and Standards shall ratify all buildings or structures certified by the Massachusetts Historical Commission to qualify for totally preserved listing (see Appendix H).

Partially preserved buildings: (a) Any building or

from certain lateral load requirements of 3408 (see paragraph 9 above), 3400.1 prevents changes to existing structures, such as reductions in lateral load resistance, which decrease public safety.

R3400.3.1: Buildings must have been legally occupied for **any** five year period, not necessarily the five year period immediately prior to the time of the Chapter 34 work.

R3401.0: Existing buildings within a National Register or State Register District whether individually designated or not, qualify as preserved buildings.

structure individually listed on the National Register of Historic Places or (b) any building or structure certified as a historic building by the Massachusetts Historical Commission and not designated a totally preserved building in Appendix H.

Restoration: Restoration is the process of accurately reconstructing or repairing the forms and details of a building or structure or portion thereof as it appeared at a particular period or periods of time by means of removal of later work/or the replacement of missing original work.

Totally preserved buildings: A totally preserved building is an historic building or structure. The principal use of such a building or structure must be as an exhibit of the building or structure itself which is open to the public not less than 12 days per year, although additional uses, original and/or ancillary to the principal use shall be permitted within the same building up to a maximum of 40% of the gross floor area. Totally preserved buildings shall be those listed in Appendix H. All entries into the totally preserved building list shall be certified by the Massachusetts Historical Commission. The Board of Building Regulations and Standards shall ratify all buildings and structures certified by the Massachusetts Historical Commission to qualify for totally preserved listing (see Appendix H).

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780 CMR 3402.0 IMPLEMENTATION

3402.1 Building Permit Application Requirement for Existing Buildings: A building permit shall be required for any work regulated by 780 CMR 34.

Exception: Ordinary repairs may be performed without a building permit.

R3402.1: Applicability of Chapter 34 with respect to construction control, building permit application and professional engineering or architectural services is discussed in R3408.1.3.

3402.1.1 Investigation and Evaluation: For any proposed work regulated by 780 CMR 34, which is subject to 780 CMR 116, as the condition of an issuance of a building permit the building owner shall cause the existing building (or portion there of) to be investigated and evaluated in accordance with the provisions of 780 CMR 34 (see Appendix F).

The investigation and evaluation shall be in sufficient detail to ascertain the effects of the proposed work (if any) on the structural, egress, fire protection, energy conservation systems and light and ventilation systems of the space under consideration, and, where necessary, the entire building or structure.

R3402.1.1: The investigation and evaluation does not need to encompass the ***entire building***. An evaluation is required for any work subject to Construction Control (780 CMR 116), even if no structural work is proposed *(refer to related comments on 3408.1.3 and 3408.2 below*).

3402.1.2 Submittal: The results of the investigation and evaluation, along with any proposed compliance alternatives, shall be submitted to the building official in written report form.

3402.1.3 Non Conformities and Compliance Alternatives: The application for a building permit shall identify all items of non or partial compliance with the requirements of 780 CMR 34, and compliance alternatives, if any are proposed, for approval by the building official. The building official shall respond to the acceptability of any proposed compliance alternatives within 30 days of the filing of the permit building application. Where proposed compliance alternatives are, in the opinion of the building official, unacceptable, or where issues of non-compliance remain, the permit applicant shall have the remedies prescribed by 780 CMR 122.0.

3402.1.5 Documentation of Compliance Alternatives: Whenever action is taken on any building permit application to repair, make alterations and additions, or change the use or occupancy of an existing building, and when said application proposes the use of compliance alternatives, the building official shall ensure that one copy of the proposed compliance alternatives, including applicable plans, test data, or other data for evaluation, be submitted to the BBRS, together with a copy of the building permit application and the building official's decision regarding the proposed compliance alternatives.

780 CMR 3403.0 HAZARD INDEX

3403.1 Hazard Index: In the implementation of the provisions of 780 CMR 34, the hazard index associated with a particular use group shall be as identified in table 3403 and Appendix F. In order to determine the applicable provisions of 780 CMR 34 the hazard index of the existing use group shall be subtracted from the hazard index of the proposed use. The algebraic difference shall be used to determine the applicable provisions of 780 CMR 34.

R3403.1: Table 3403 is a fire hazard index and may not make sense in some cases for measuring seismic hazard. For example, in a change of use from gas storage to a nightclub, the hazard level drops even though the life safety risk in a seismic event increases. The designer may wish to apply for a variance in cases where the hazard index does not appear to be appropriate.

Table 3403
HAZARD INDEX

Use Group[(1)]	Description	HAZARD INDEX NO.[(2)]
A-1	Theater with stage	6
A-2	Night Club	7
A-3	Theater without stage	5
A-3	Restaurant	5
A-3	Lecture halls, recreations centers, museums, libraries, similar assembly buildings	4
A-4	Churches	4
B	Business	2
E	Education (K through 12)	4
F	Factory and industrial	3
H	High hazard	8
I-1, I-3	Institutional restrained	5
I-2	Institutional incapacitated	4
M	Mercantile	3
R-1	Hotels, motels	2
R-2	Multi-family	2
R-3	One and two family	2
S-1	Storage, moderate hazard	3
S-2	Storage, low hazard	1

Notes to Table 3403:
(1) See 780 CMR 3 and 4 and Appendix F.
(2) Hazard Index Modifier for selected construction types as follows:

(a) When a building is classified in construction Type 1A, 1B, 2A or 2B, subtract one from the *Hazard index* shown in Table 3403 for the applicable proposed new use group only.

(b) When a building is classified in construction Type 2C or 5B, add one to the Hazard index shown in Table 3403 for the applicable proposed new use group only. Exception: *Partially Preserved Historic Buildings* (780 CMR 3409).

780 CMR 3404.0 REQUIREMENTS FOR CONTINUATION OF THE SAME USE GROUP OR CHANGE TO A USE GROUP RESULTING IN A CHANGE OF HAZARD INDEX OF ONE OR LESS

3404.1 General: The requirements of 780 CMR 3404.0 and applicable provisions of 780 CMR 3408 shall apply to all repairs and alterations to existing buildings having a continuation of the same use group or to existing buildings changed in use group of one or less hazard index.

3404.2 Requirements exceeding those required for new construction: Existing buildings which, in part or as a whole, exceed the requirements of 780 CMR may be altered in the course of compliance with 780 CMR 34, so as to reduce or remove, in part or completely, features not required by this code for new construction.

Exception: Pursuant to M.G.L C. 148, 27 A, fire protection devices, shall not be disconnected (temporarily or permanently), obstructed, removed or shut off or destroyed without first procuring a written permit from the head of the local fire department.

3404.3 New Building Systems: Any new building systems or portion thereof shall conform to 780 CMR for new construction to the fullest extent practical. However, individual components of an existing building system may be repaired or replaced without requiring that system to comply fully with the code for new construction unless specifically required by 780 CMR 3408.

R3404.3: This section applies to non-structural systems. See 3408.3.1 for structural systems.

3404.4 Alterations and Repairs: Alterations or repairs to existing buildings which maintain or improve the performance of the building may be made with the same or like materials, unless required otherwise by 780 CMR 3408. Alterations or repairs which have the effect of replacing a building system as a whole shall comply with 780 CMR 3404.3.

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780 CMR 3405.0 REQUIREMENT FOR CHANGE IN USE GROUP TO TWO OR MORE HAZARD INDICES GREATER

3405.1 General: When the existing use group is changed to a new use group of two or more hazard indices higher, the existing building shall conform to the requirements of the code for new construction, except as provided in 780 CMR 3408 or as otherwise allowed in 780 CMR 3407.0.

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780 CMR 3406.0 COMPLIANCE ALTERNATIVES

3406.1 General: Where compliance with the provisions of the code for new construction, required by 780 CMR 34, is impractical because of construction difficulties or regulatory conflicts, compliance alternatives may be accepted by the building official.

Examples of compliance alternatives which have been used are provided in Appendix F. The building official may accept these compliance alternatives or others proposed.

3406.2 Documentation: In accordance with 780 CMR 3402.1.5, the building official shall ensure that the BBRS is provided with information regarding compliance alternatives accepted or rejected by the building official.

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780 CMR 3408.0 STRUCTURAL REQUIREMENTS FOR EXISTING BUILDINGS

3408.1 General Requirements:

3408.1.1 Buildings constructed on or after January 1, 1975: The structural systems of existing buildings which were constructed under a building permit issued on or after January 1, 1975 shall conform to the requirements for new construction of either the current edition of 780 CMR (the Massachusetts State Building Code), or to the edition in effect on the date of the permit plus applicable provisions of 780 CMR 3408.0 of the current edition of the code. Provisions of 780 CMR 3408.0 which are less stringent than the code in effect on the date of the permit shall not apply.

R3408.1.1: The significance of January 1, 1975 is that it represents the effective date of the first Commonwealth of Massachusetts State Building Code. Seismic provisions were first introduced in this Code in Section 718.0, Earthquake Load. All buildings that were constructed after January 1, 1975 should have had seismic load resisting systems and therefore the upgrade requirements are less lenient than for buildings that were built prior to 1975. The last statement of this Article is critical in that graduated lateral load requirements do not apply if the seismic load criteria in effect at the time of the building was constructed is more stringent than the provision of 3408.

3408.1.2 Buildings constructed prior to January 1, 1975: The structural systems of existing buildings constructed under a building permit issued prior to January 1, 1975 shall conform to 780 CMR 3408.0 and the building code applicable at the time of the original building permit. In the event of conflict between the prior code and 780 CMR 3408.0, the provisions of 780 CMR 3408.0 shall govern.

R3408.1.2: The code allows Pre-1975 structures more leniency in so far as the seismic requirements are concerned. The graduated lateral load requirements of 3408 are the only seismic design criteria which need be applied and only where specifically required by 3408.

3408.1.3 Structural Engineering Services For buildings subject to construction control, as determined in 780 CMR 116, the Owner shall retain a registered professional engineer qualified in the structural design of buildings (hereinafter called the structural engineer) to perform all structural engineering required by 780 CMR. For purposes of determining applicability of construction control, the volume of enclosed space shall include the entire existing building and all proposed additions. (See 780 CMR 116.1 for buildings exempt from construction control).

R3408.1.3: Construction Control (Section 116): This section of 780 CMR defines the construction controls required for all buildings *and structures* that need professional engineering *or architectural* services. 110.8 CMR requires sealed drawings and specifications for all buildings and structures being submitted for permit application by a registered architect or engineer. 116 states that any work requiring the services of a registered engineer or architect must meet provisions of 116 with the following exceptions:

- Buildings less than 35,000 cubic feet
- One and two family dwellings
- Buildings for farm related purposes
- Retaining walls less than 10 ft. high

Therefore, owners must engage the services of a registered structural engineer for any permit-related work by an engineer *or architect*, with the above exceptions.

3408.2 Evaluation of Existing Buildings: The structural engineer shall make a structural evaluation of the existing building to determine the adequacy of all structural systems that are affected by alteration, addition, change of use, or damage to be repaired. The evaluation shall include review of relevant available documentation about the building design and construction, a field investigation of the existing conditions, and a structural analysis. When deemed necessary by the structural engineer, the evaluation shall also include detailed field surveys., testing and laboratory analysis. Refer to 780 CMR F-104 in Appendix F. When new structural elements or strengthening of existing elements is necessary, the evaluation shall include the effects of such new elements and strengthening. A report on the structural evaluation shall be submitted to the building official with the application for building permit.

R3408.2, R3408.2.1, R3408.2.2: These sections require the evaluation be made only on the parts of the structural system that are affected by the proposed work, and not necessarily the entire structure. Caution should be used in applying the various terms used to describe the tasks associated with the assessment, including investigation, analysis, testing and inspection, as each has different meanings. The ASCE *Guideline for Structural Condition Assessment of Existing Buildings* (SEI/ASCE 11-99) defines many of these terms. The extent and degree of investigation and analysis is as deemed to be "sufficient" by the engineer, which makes this requirement somewhat subjective. The last sentence of this article requires a report on the evaluation be submitted to the building official, however it does not mandate the exact content of the report. It is suggested that the report document the level of effort which is put into the evaluation, exactly what information is available to the Structural Engineer of Record, the general condition of the structure, and the extent of structural work to be performed on the structure. This should serve to protect all parties should disputes arise during construction.

3408.2.1 Field Investigation: The field investigation of an existing building shall be sufficient to determine the location, size, details and conditions of existing structural elements, and to verify structural

information on the drawings of the existing building, if said drawings exist.

3408.2.2 Structural Analysis: The structural analysis shall include analysis of all structural systems affected by the proposed alteration, addition, change in use or repair, or for which design loads are specified in 780 CMR 3408, and shall be adequate to demonstrate the ability of new and existing systems to support the required loads.

3408.2.3 Field Observations During Construction: The structural engineer shall make periodic field visits during the progress of the construction work on the existing building in order to observe and verify the assumed conditions on which the structural design was based. The structural engineer shall provide a written notification to the building official of changes to the contract documents as shown on the permit application.

3408.2.4 Geotechnical Explorations: Explorations shall be performed as necessary to determine the subsoils and the type and condition of existing foundations for the lateral load analysis of foundations required in 780 CMR3408.3.4 and for the liquefaction evaluation required in 780 CMR 3408.7.

R3408.2.4: A soils exploration program may be required should insufficient existing soils information exist, as determined by the registered professional structural engineer.

3408.3 General Structural Design Requirements: The provisions of 780 CMR 3408.3 shall apply to the structural analysis and design of additions, alterations, changes in use, and repairs to existing buildings. Specific requirements for additions, and for alterations or changes of use, or repairs are prescribed in 780 CMR 3408.4 and 3408.5 respectively. Additional requirements for earthquake analysis and design are prescribed in 780 CMR 3408.6.

R3408.3: Refer to the "General Information" section of these guidelines for the background and philosophy behind the use of Chapter 34 relative to the structural aspects of the work.

3408.3.1 New Structural Members and Systems: All new structural elements and systems, whether in new additions or in existing construction, shall be designed and constructed in accordance with the code requirements for new construction using the loads and criteria specified by 780 CMR 3408.0.

R3408.3.1: Where new framing is let into or added onto an existing structure it must be designed in accordance with the requirements for new construction as specified in 780 CMR 3408.0. As a practical matter, this reference could be 780 CMR 1600, insofar as all references to new construction in 3408.0 direct the designer to 780 CMR 1600. The work should include verifying the compatibility of the existing structure and the new system, as well as the capacity of the existing structure to support any new systems.

The criteria for new construction may be the same or nearly the same as required in earlier periods with respect to gravity live loads, but modern requirements also include loadings for snow drifts, seismic activity, wind suction, combinations of loadings, deflection limitations and so forth that may not have existed earlier

3408.3.2 Existing Structural Members and Systems: Strength of existing systems, elements, and

R3408.3.2: The first sentence of this paragraph states that modern engineering methods may be used to

connections shall be determined in accordance with current accepted engineering practice, using the actual strength and other physical properties of the existing materials. Alternatively, except for earthquake design, applicable design codes at the time of construction may be used to determine the strength of existing systems, elements and connections, provided that the allowable stresses specified in those codes are not exceeded, and provided the applicable provisions of those codes have not since been found to endanger public safety.

analyze existing members and systems provided their physical properties and strengths are known. Physical properties can be based on field measurements (see section 3408.2) and strengths can be based on tests of the actual materials or on historical records (subparagraph 3408.3.2.1).

Alternatively, the second sentence of the paragraph permits criteria generally accepted at the time of original construction to be used, provided it has not been found since then to be unsafe.

The use of material strength tests must be used with caution. The number of samples tested should be adequate to establish a statistical curve; however, taking and testing the proper number may not be economically feasible relative to the project budget. Therefore, test results from a few samples of old concrete that broke at extraordinary stress levels or from a few samples of old A7 steel that tested as high as modern A36 steel should be used with skepticism, especially considering that quality control a century ago was not as sophisticated as it is today.

Appendix "F" of the Massachusetts State Building Code provides reference data related to existing buildings. The allowable strengths and properties of materials can often be found in other references. These may include: original design drawings describing wood species, structural steel sizes, patented reinforcing steel systems or concrete mix designs; architect's and builder's handbooks describing common systems, allowable building code loads, allowable wood joist loads; steel mill handbooks (preceding American Institute of Steel Construction (AISC) manuals) with tables and formulae for built-up columns and beams; and, academic and government sponsored research results for material properties. AISC, the Steel Joist Institute (SJI) and the American Concrete Institute (ACI) have also published compendia of historic steel shapes, open web steel joist criteria and load tables, and patented rebar systems and ASTM rebar standards. If a structural member or system can be recognized and identified by its appearance, its properties and strength can be inferred from these contemporaneous sources.

3408.3.2.1 Strength of Existing Materials: The strength of existing materials shall be determined by tests or from generally accepted historical records.

R3408.3.2.1: The strength of most materials can be determined by coring or cutting out samples of the materials and testing them in accordance with ASTM standards to determine their actual strength. Modern load factors and limit methods of analysis should be used with caution, however, if the project budget or limited access prevents an adequate statistical sampling from being taken.

The strength of many materials and assemblies can be determined by performing tests at the location of the materials and assemblies.

3408.3.2.2 Reuse Of Existing Structural Members: Existing structural members in sound structural condition may be reused, providing analysis in accordance with 780 CMR 3408.3.2 demonstrates adequate capacity to support the loads required by 780 CMR 3408.0.

R3408.3.2.2: Structural materials in protected environments generally do not degenerate significantly with time. Concrete actually increases in strength over time, although long-term carbonation at its surfaces can affect the protective alkalinity surrounding reinforcing steel. Therefore, members that are sound, that is, unaffected by moisture intrusion, insects, excessive penetrations or cutouts may be used provided they were properly designed in the first place or can accept any changes in load proposed by the new work.

3408.3.3 Reinforcement and Repair of Existing Construction: Repair or reinforcement of existing structural elements or systems shall be designed and constructed in accordance with the code requirements for new construction, using the loads and criteria specified in 780 CMR 3408.0, and in the case of existing materials, using the actual physical properties of the existing materials. Alternatively, for other than earthquake design, design codes applicable at the time of construction of the existing building may be used, provided that the allowable stresses specified in those codes are not exceeded, and provided the applicable provisions of those codes have not since been found to endanger public safety.

R3408.3.3: The second sentence of 3408.3.3 simply repeats the requirements of 3408.3.2 and confirms that reinforcement and repairs can be governed by the same allowable stress requirements as intact, sound structural members (elements). The second sentence should be used only under narrow circumstances. In most circumstances, BASE does not recommend using antiquated allowable stresses or building code loads to design reinforcements of entire systems or members using new materials or members. Narrow circumstances may include the reconstruction of dilapidated masonry walls using replicated bricks and mortar and earlier rules of thumb for height to thickness ratios or allowable bearing stresses. (This second sentence specifically excludes even these circumstances if the wall needing repair is part of the lateral load system for resisting earthquakes).

3408.3.4 Lateral Load Analysis: Lateral load analysis of a building required by the provisions of 780 CMR 3408.0 shall:

1. Consider all walls, frames, diaphragms and other structural elements that may contribute to lateral load resistance.
2. Consider eccentricity of center of applied wind load from center of rigidity of the structure.
3. Consider relative stiffnesses of resisting elements.
4. Consider flexibility of diaphragms where appropriate.
5. Include calculations of total lateral earthquake force as prescribed in 780 CMR 3408.6.1.
6. Include calculations of distribution of lateral earthquake force as in 780 CMR 1612.5.2, of horizontal torsional moments as in 780 CMR 1612.5.3, of overturning as in 780 CMR 1612.5.4, and of lateral forces on foundations and retaining walls as in 780 CMR 1612.4.9.

R3408.3.4: The key phrase in the first sentence of this paragraph is "*required by the provisions of 780 CMR 3408.0*". The list of required considerations is a comprehensive checklist for the lateral load analysis of a new building. Whether or not each item in the list needs to be considered in depth depends on requirements found elsewhere in 3408.0 and also on engineering judgment.

A lateral load analysis conforming with 3408.3.4 is specified in the following sections of Chapter 34: 3408.3.5 (when altering existing lateral load resisting elements), 3408.4.2.1 (when checking a building receiving an addition for wind loads), 3408.4.3.2 (when checking a building receiving an addition for seismic loads), 3408.5.3 (when checking an altered building for wind loads), and 3408.5.4.5 (when checking an altered building in Seismic Hazard Category 3 for seismic loads).

3408.3.5 Existing Lateral Load Capacity: Alterations shall not be made to elements or systems contributing to the lateral load resistance of a building which would reduce their capacity to resist lateral loads, unless a structural analysis conforming to 780 CMR

R3408.3.5: This paragraph is one of the most important paragraphs in 3408.0 with respect to the continued acceptance and use of existing lateral load resisting systems.

There are three approaches for dealing with existing

3408.3.4 shows:

1. That the lateral load resisting system of the building as altered conforms to 780 CMR 1611.0 and 1612.0 of the code for new construction, or
2. That the lateral load resisting system as altered conforms to all applicable minimum load requirements of 780 CMR 3408, and that there is no reduction in the lateral load capacity of the building as a whole.

Existing elements or systems may be reinforced or replaced with new elements or systems of equivalent strength and stiffness, in order to meet these requirements.

A building which complies with 780 CMR 1611.0 and 1612.0 except that the lateral load resisting system does not conform to the detailing requirements of 780 CMR 19 through 23 for the structural materials and seismic load resisting system employed, may be considered to be in compliance with 780 CMR 3408.3.5 if the lateral load resisting system can safely resist a lateral force calculated in accordance with the formulae in 780 CMR 1612.4, but with lateral force factors (R) and force modification factors as stipulated in Tables 3408.2 and 3408.3, respectively.

3408.3.6 Load Combinations: The loads specified in 780 CMR 3408.0 shall be combined in accordance with 780 CMR 1616.0.

lateral load resisting systems.

The first approach simply avoids any alteration that would reduce the capacity of the system. Where repairs, changes of use, small scale additions and alterations would not require a more comprehensive reinforcement of the bracing systems, then no further analysis or construction work would be needed on the system. This interpretation is compatible with the concept of limiting the engineering and construction costs of smaller scale projects.

Note that alterations may be made to the lateral load resisting system which do not affect the capacity of the system. A portion of the system may be locally weakened as long as the system as a whole is not weakened.

The second approach is to prove that the altered system complies with 780 CMR for new construction.

The third approach is to replace altered portions with new elements or reinforcements such that the overall system capacity is not reduced.

For the second approach, a complete, detailed lateral load analysis would be needed, conforming to the items listed in 3408.3.4. For the third approach, the detail of analysis would depend on the scale of the alterations and as needed to establish loads and behavior for the replacement or reinforcement items.

If the engineer can prove that the altered system can resist the lateral loads for wind and earthquake defined in Chapter 16, the altered system (or the original unaltered system) may still be substandard in terms of its details, as defined in Chapters 19 through 23 for various materials. The Code is concerned about non-ductile and brittle substandard details that may experience a seismic event, even though they may be strong enough to resist a static load. However, the substandard details may be acceptable if they are so over-designed that yielding may not occur during an earthquake. This over-design must be verified by applying modified factors to the formulae of 780 CMR 1612.4. The Response Modification Factors listed in Table 3408.2 are similar to those of new systems, but the Force Modification Factors for Components listed in Table 3408.3 have the effect of increasing the seismic force on non-conforming systems.

The effect of the three choices in 3408.3.5 is that the first choice (do nothing) and the third choice (add systems or members to match subtracted systems or members) are much easier than trying to justify the reduction of existing lateral load resisting systems or members.

3408.3.7 Live Load Reduction: Live loads specified in 780 CMR 3408.0 may be reduced as permitted in 780 CMR 1608.0.

3408.3.8 Deficient or Damaged Structural Members: Existing structural members that are found to be deficient or damaged, either prior to or during an alteration or addition, shall be repaired, replaced, or reinforced so that their load capacities conform to the requirements of 780 CMR 3408.5. Existing structural members shall be considered deteriorated or damaged if their capacity is less than 85% of the strength required by 780 CMR 3408.1.1 or 3408.1.2, as applicable.

R3408.3.8: A structural member is not considered deficient or damaged if it has as least 85 % of its required strength. This somewhat arbitrary rule of thumb is a traditional recognition that structural materials and applied loadings are tested with time.

Where the original design is inadequate or where damage has reduced the original section properties so that a member's strength is less than 85% of the required strength (based on Codes at the time of construction), then the deficient member must be repaired, replaced or reinforced. Paragraph 3408.3.8 states that the altered member's capacity must conform to 780 CMR 3408.5 (Alterations, Repairs and Changes of Use), which in turn, refers the designer to various paragraphs in Chapter 16.

3408.4 Additions:

3408.4.1 Live Dead Snow and Special Loads: Additions shall be designed to support the live load, dead snow and special loads specified in 780 CMR 1605.0 through 1610.0 and 1613.0 through 1615.0, inclusive - Where additions are supported on existing construction, the existing structural elements shall be reinforced or replaced, if necessary, to support these loads.

3408.4.1.1 Snow Drifts and Sliding Snow: Where the geometry of an addition may cause snow drifting or sliding snow on existing adjacent construction, the affected existing construction shall be reinforced so that it will support the snow loads specified in 780 CMR 1610.0.

3408.4.2 Wind Loads:

3408.4.2.1 Structure-as-a-Whole: When the aggregate of all additions made to a building since January 1, 1975 produce effects due to the wind loads specified in 780 CMR 1611.0 that are more than 10% of the capacity of the existing lateral load resisting system of the building, a lateral load resisting system shall be provided so that the structure-as-a-whole will resist the wind loads specified in 780 CMR 1611.0. When such effects due to wind are less than 10% of the capacity of the existing lateral load resisting system, a lateral load resisting system shall be provided, where necessary, so that the structure-as-a-whole will resist the wind loads specified for Exposure A in 780 CMR 1611.0. Where portions of a building are structurally independent, the above requirement shall apply to each structurally independent portion.

R3408.4.2.1: The intent of this section is to ensure that all buildings receiving an addition are able to resist at least Exposure A wind loads, as defined by the code for new construction. Note that this includes even those portions of the existing building that are "structurally independent" of the portion which is receiving the new addition and which, therefore, for wind load, are unaffected by the addition.

Note, also, that if the sum of the wind load effects produced by all additions constructed since January 1, 1975, including the new addition, exceeds 10% of the capacity of the existing lateral load-resisting system, this system must be upgraded, supplemented, or replaced so as to be capable of resisting actual exposure category wind loads, which may be more severe than Exposure A noted above.

3408.4.2.2 Walls and Roofs: New parts of enclosure walls and roofs that are subjected directly to the wind, and their local supporting structural elements, shall be designed to resist the wind loads specified in 780 CMR 1611.0. Existing local supporting structural elements of enclosure walls and roofs that are not altered need not comply with 780 CMR 1611.0.

3408.4.3 Earthquake Loads: All new materials and portions of the structure shall conform to all applicable provisions of 780 CMR 1612.0. Compliance of existing portions of the structure to 780 CMR 1612.0 is not required, except as stipulated in 780 CMR 3408.4.3.1 and 3408.4.3.2.

3408.4.3.1 Structurally Separated Additions: Additions which are structurally separated from the existing portion of the building in accordance with 780 CMR 1612.4.8 shall be considered as separate structures for earthquake design purposes, and shall conform to all provisions of 780 CMR 1612.0. Existing portions of the structure need conform only to 780 CMR 3408.5.

R3408.4.3.1: Additions which are structurally separated from the existing building to which they are attached must conform to the seismic provisions of the code for new construction in all respects. The seismic resistance of the existing building need only comply with Section 3408.5 and exposure A wind loads. ("Structurally separated" usually means separated by a joint, such that the superstructure of each "building" acts independently when subjected to all load types and load conditions.)

3408.4.3.2 Additions Not Structurally Separated: Existing portions of buildings with new additions which are not structurally separated from the existing structure shall meet the following seismic design criteria:

1. If both the area and the weight of the building are increased by less than 10%, earthquake resistance of the existing portion of the building need only comply with the requirements of 780 CMR 3408.3.5.
2. If either the area or weight of the building is increased by 10% or more, but neither is increased by more than 100%, the following seismic design criteria shall apply:

    a) The structure shall be designed to resist a percentage of the base earthquake force, calculated in accordance with the requirements of 780 CMR 3408.6.1.1, not less than that given in Figure 3408.1.

    b) Existing structural elements not conforming to the detailing requirements of 780 CMR 19 through 23 may be considered effective in resisting lateral seismic loads, providing that their design seismic force is calculated in accordance with 780 CMR 3408.6.1.

    c) The existing building shall be investigated for the presence of special earthquake hazards as described in 780 CMR 3408.6.3, and all such

R3408.4.3.2: Additions which are not structurally separated from the existing building become part of a single, enlarged building which consists of the combination of the addition and the existing building to which it is attached. In this case, the seismic load requirements for this enlarged building are established by Section 3408 as follows:

- The new materials and systems must conform to all applicable seismic provisions of the code for new construction (3408.4.3).
- For small additions less than 10%, in both area and weight, of the existing building, the existing portion of the enlarged building must conform to the provisions of 3408.3.5. Definitions for both area and weight are given in 3408.4.3.2.4. If the small addition depends fully upon the existing structure to resist lateral loads, the existing system need only satisfy 3408.3.5 and wind load requirements. If the small addition includes a new lateral load resisting system, that system must be designed for its portion of the loads specified in Chapter 16, based on the mass of the addition.
- If either the weight or area of the enlarged building is between 10 and 100 percent greater than the original building, the enlarged building must be capable of resisting a percentage of the "Base Earthquake Force" determined from Figure

hazards as are present shall be corrected in accordance with the provisions of 780 CMR 3408.6.3

3. If either the area or the weight of the building is increased by more than 100%, the structure as a whole shall comply with the code for new construction. Existing elements that do not conform to the requirements of 780 CMR 19 through 23 shall not be considered effective in resisting lateral seismic loads.

4. For the purposes of 780 CMR 3408.4.3.2, "area" shall mean the total of all gross floor and roof areas supported by the building structure, and "weight" shall have the same meaning as "W" as defined in 780 CMR 1612.5.1. Percentage changes in building area and weight shall be calculated by dividing the total area or weight of the structure after the proposed addition by the total area and weight existing five years prior to the date of the current building permit application.

Figure 3408.1
MINIMUM PERCENTAGE OF LATERAL EARTHQUAKE LOAD

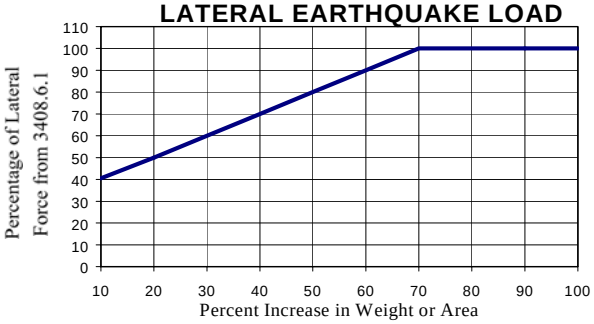
Percent Increase in Weight or Area	Percentage of Lateral Force from 3408.6.1
10	40
20	50
30	60
40	70
50	80
60	90
70	100
80	100
90	100
100	100

3408.4.4 Change in Use: If an addition is accompanied by a change in use, the more stringent requirements for addition or change in use apply.

3408.1. Also required for this range of addition area and/or weight is a review of specific detailing characteristics, and mitigation of "special earthquake hazards" (3408.6.3). New lateral load resisting systems in the addition must be designed for their portion of the loads specified in Chapter 16, based on the mass of the addition.

- For additions which result in an enlarged building which is more than 100 percent greater in either weight or area than the existing building, the existing portion of the enlarged building " shall comply with the code for new construction", per 3408.4.3.3. This includes the requirements of Chapters 19 through 23 for elements of the seismic-resisting system.

Figure 3408.1 MINIMUM PERCENTAGE OF LATERAL EARTHQUAKE LOAD



3408.5 Alterations, Repairs and Changes of Use: The following requirements apply to existing buildings which are altered or repaired, or for which there is a change of use.

R3408.5: This section does not apply to ordinary repairs, as defined in 780 CMR 2. ("Any maintenance which does not affect the structure, egress, fire protection systems, fire ratings, energy conservation provisions, plumbing, sanitary, gas, electrical or other utilities.")

Alterations are defined in 780 CMR 2 as "A change or modification of a building or structure, or the service equipment thereof, that affects safety or health and that is not classified as an ordinary repair."

3408.5.1 Floor Loads: Except as provided in 780 CMR 3408.5.2, the load capacity of all floors affected by alterations, repairs or changes of use shall be adequate to support the loads required by 780 CMR 1605.0 through 1608.0, 1613.0 and 1614.0, inclusive, or the floors shall be reinforced or replaced with new structural members.

R3408.5.1: In buildings with a partial change in use, this section does not apply to paths of egress, such as stairways, which are outside the area undergoing the change in use.

Roof loads are not mentioned in this paragraph. Many buildings constructed prior to 1975 were not designed for snow drifting. BASE recommends that the design professional enhance the strength of roofs particularly at conditions subject to snow drifting if there is a significant life safety issue.

3408.5.2 Posted Live Load: Except for Use Groups, F, I and S, any existing building in which a new use requires greater live loads may be posted for the originally approved live loads, provided that the use is controlled in a way acceptable to the building official, and so that the public safety is not endangered thereby.

R3408.5.2: The code does not address the situation where a structural analysis shows that a floor is capable of carrying a higher load than the originally approved load, but less than the currently required load. The building official may choose to permit the use of 3408.5.2 in this case as well.

3408.5.3 Wind Loads: The wind load capacity of the structure-as-a-whole shall not be less than that required for Exposure A in 780 CMR 1611.00. The existing lateral load resisting system shall be reinforced or new lateral load resisting elements or systems shall be added, as necessary to meet this requirement.

Exception: The building official may waive this requirement if the alterations are minor and if there is no change in use, and if the structural engineer certifies that there are no alterations to structural elements.

R3408.5.3: The lateral analysis may require a field investigation if inadequate documentation of the building's structural system is available. The investigation must be extensive enough to identify the location and size of the major lateral load resisting elements. The building history alone is not sufficient to demonstrate that the building satisfies this provision. It is difficult to demonstrate that the building has ever been exposed to the prescribed loads, and that the lateral load system has not changed over the life of the building.

BASE recommends that any evaluation include design

calculations by a structural engineer.

3408.5.4 Earthquake Loads:

3408.5.4.1 Seismic Hazard Category for Existing Buildings: The Seismic Hazard Category for existing buildings shall be determined from Table 3408.1 on the basis of the proposed change in use, change in occupancy and cost of alterations.

R3408.5.4:

R3408.5.4.1: When calculating the percent change in occupancy, the occupancy of the whole building should be used, not only those portions of the building affected by the change in occupancy.

If there is no assessment (as for buildings owned by tax-exempt organizations), a reasonable value must be assumed for the building. The selected valuation should be approved by the building official.

Table 3408.1
SEISMIC HAZARD CATEGORY

CHANGE IN USE	CHANGE IN OCCUPANCY OR COST OF ALTERATIONS	
	Occupancy increased by more than 25% and to a total occupancy of 100 or more; or total cost of alterations exceeds 50% of the assessed valuation of the building. (2)	All other changes in occupancy, and total cost of alterations less than or equal to 50% of assessed valuation of the building. (2)
Change from Use Group with Hazard Index less than 4 to Use Group with Hazard Index of 4 or greater; or Seismic Hazard Exposure Group III per table 1612.2.5.	3	2
All other changes in Use Group, or no change in Use Group	2 (3)	1 (3)

The first column deals with the change in use group Hazard Index (per Table 3403) or if the building is in Seismic Hazard Exposure Group III (per Table 1612.2.5). There is a question whether the upper row of the table applies to a building that is already in Seismic Hazard Exposure Group III or to building that is changing to that group.

BASE recommends that the upper row of the table be used for any building in Seismic Hazard Exposure Group III regardless of whether it is an existing condition or a change.

Note 1: refer to Table 3403 and Appendix F, Table F-1 for the Hazard Index of any use group. Adjustments to the Hazard Index indicated in the footnotes to Table 3403 shall not be applied for determination of Seismic Hazard Category.

Note 2: Total cost of alterations shall include the cost of alterations proposed under the current building permit application, plus the cost of any alterations covered by building permits in the two-year period preceding the date of the current permit application. The assessed valuation shall be as of the date of the current building permit application.

Note 3: When there is no change in use, the following costs may be excluded from the total cost of alterations:

a) Costs incurred by requirements for compliance with the following:
   i) American with Disabilities Act
   ii) Massachusetts Architectural Access Board Regulations, 521 CMR
   iii) M.G.L. c. 148, § 26A $^{1}/_{2}$ requiring sprinklers in existing high-rise structures.

b) Costs incurred for improvements in:
   i) Sprinklering
   ii) Smoke and heat detection
   iii) Fire alarm systems
   iv) Exit enclosures

3408.5.4.2 Partial Change of Use: For buildings in which more than 33% of the total floor area is classified as Seismic Hazard Category 2 or 3, the earthquake design of the entire building shall be governed by the requirements applying to that higher Seismic Hazard Category.

R3408.5.4.2: If the partial change in use affects less than 33% of the floor area, the applicable Seismic Hazard Category is selected from the "All other changes in Use Group, or no change in Use Group" row of Table 3408.1, and the applicable requirements are applied to the entire building.

3408.5.4.3 For Seismic Hazard Category 1: Earthquake resistance need only comply with the requirements of 780 CMR 3408.3.5.

R3408.5.4.3: If no alterations are made "to elements or systems contributing to the lateral load resistance of the building which would reduce their capacity to resist lateral loads," a seismic lateral analysis does not need to be performed for the building. Refer to 3408.5 for required wind load analysis.

3408.5.4.4 For Seismic Hazard Category 2: Earthquake resistance shall comply with the requirements of 780 CMR 3408.3.5, and the existing building shall be investigated for the presence of special earthquake hazards as described in 780 CMR 3408.6.3, and all such hazards that are present shall be corrected in accordance with the provisions of 780 CMR 3408.6.3.

R3408.5.4.4: Examples of special earthquake hazards are inadequately braced parapets, inadequately braced masonry walls, and inadequate precast concrete connections. Such elements must be reinforced to meet the requirements for new construction, except unreinforced masonry parapets may be designed using the special provisions in Section 3408.6.4.

If no alterations are made "to elements or systems contributing to the lateral load resistance of the building which would reduce their capacity to resist lateral loads," a seismic lateral analysis does not need to be performed for the building. Refer to 3408.5 for required wind load analysis.

3408.5.4.5 For Seismic Hazard Category 3: Full compliance with 780 CMR 1612.0 is required, except as provided in 780 CMR 3408.5.4.6 and 3408.6.4, and except that existing structural systems not conforming to the requirements of 780 CMR 19 through 23 may be considered to participate in resisting lateral seismic loads, but only if the seismic design force is calculated in accordance with 780 CMR 3408.6.1.1.

R3408.5.4.5: Structures in Seismic Hazard Category 3 must satisfy the requirements for new buildings with certain exceptions. A lateral load analysis must be performed in accordance with 3408.6. If the height and area are not increased, lateral loads required for new construction may be reduced 25%. Provisions in 3408.6.4 permit the continued use of unreinforced masonry walls so long as certain requirements are met. Lateral systems which do not satisfy current code provisions may remain provided they are able to resist loads calculated using the R factors in Table 3408.2.

3408.5.4.6 Maximum Lateral Earthquake Force: When the provisions of 780 CMR 3408.5.4 require compliance with the code for new construction, or otherwise require design for minimum lateral seismic force, and the building is not being extended in area or height, the design lateral seismic force need not exceed 75% of the base earthquake force calculated in accordance with 780 CMR 3408.6.1.1.

R3408.5.4.6: This provision applies to Seismic Hazard Category 3 structures and Seismic Hazard Category 1 or 2 structures where there are alterations to the existing lateral load resisting system which would require conformance with wind and seismic requirements for new construction (see 3408.3.5). If the height and area are not increased, lateral seismic loads need not exceed 75% of the earthquake forces calculated per 3408.6.1.1.

3408.6

3408.6.1 R Factors and Force Modification Factors for Existing Construction:

3408.6.1.1 Base Earthquake Force: Where the provisions of 780 CMR require calculation of earthquake design forces on existing buildings, a

R3408.6.1.1: A base earthquake force must be calculated when the building is classified as Seismic Hazard Category 3, when either the building mass or area

base earthquake force shall be calculated in accordance with one of the following methods:

1. Where the lateral load resisting system conforms to the requirements of 780 CMR 1612.0, the base earthquake force shall be calculated using 780 CMR 1612.4 and the appropriate response modification factor R from Table 1612.4.4.

2. Where the lateral load resisting system does not conform to the requirements of 780 CMR 1612.0, the base earthquake force shall be calculated in accordance with 780 CMR 1612.4 except that the appropriate response modification factor R from Table 3408.2 shall be used.

3. Where the lateral load resisting system does not conform to the requirements of 780 CMR 1612.0, and is not adequately described by one of the systems identified in Table 3408.2, the base earthquake force shall be determined be a properly substantiated analysis which takes into account the dynamic and ductility characteristics of the existing structure, and ground motion characteristics consistent with the requirements of 780 CMR 1612.0. The ductility characteristics used in the analysis shall be confirmed by physical tests. If the ductility characteristics of the existing structure cannot be determined, the structure shall be analyzed on the basis of an R factor of 1.25.

3408.6.1.2 Earthquake Design Force: The earthquake design force for the existing lateral load resisting system shall be equal to the base earthquake force calculated in accordance with 780 CMR 3408.6.1.1, multiplied by the appropriate reduction factor from 780 CMR 3408.4.3.2 or 780 CMR 3408.5.4.6, where applicable.

3408.6.1.3 Earthquake Force on Components of Lateral Resisting System: The earthquake design forces for components of the lateral load resisting system shall be determined from the lateral load analysis, based on the earthquake design force calculated in accordance with 780 CMR 3408.6.1.2.

Exception: When the design earthquake force is derived from a base earthquake force calculated in accordance with 780 CMR 3408.6.1.1, Method 2, design forces for components of structural systems which are listed in Table 3408.3 shall be multiplied by a force modification factor as set forth in that Table.

3408.6.2 Existing Rigid Elements in Earthquake Analysis: Existing rigid elements may be assumed not to participate in the lateral load

increases by more than 10% and for projects requiring a minimum earthquake load resistance to comply with 3408.3.5.

3408.6.1.1, Method #1: Section 1612 requires the lateral load resisting system to be supported on a foundation which conforms to Chapter 18. In order to use Method #1, such conformance must therefore be in effect. The intent of Section 3408.6.1.1 is that the lateral load resisting system must also conform to Chapters 19 through 23 for any structure analyzed by Method #1. The intent of Method #1 is to provide an analysis method for buildings whose lateral load resisting systems comply with Massachusetts State Building Code ductility requirements in effect during and after 1975.

3408.6.1.1, Method #2: Note that Method #2 requires the use of force modification factors from Table 3408.3 as well as response modification factors from Table 3408.2. This requirement is listed in Section 3408.6.1.3 under the heading “Exception”. The intent of Method #2 is to provide an analysis method for buildings constructed before 1975 whose lateral load resisting systems include non-ductile members or connections.

R3408.6.1.2: Provided full earthquake design loads are not required, the earthquake design force is reduced by up to 60% based on the size of the addition (Section 3408.4.3.2) or by 25% when there is no extension in height or area (Section 3408.5.4.6).

Section 3408.3.5 may also affect the required lateral earthquake load resistance. The influence of Section 3408.3.5 depends on the extent of alterations to the existing lateral load resistance system.

R3408.6.2: Where existing rigid elements are assumed not to participate in the lateral load resistance, and those rigid elements are load-bearing, the capacity to carry

resisting system, provided that their effect on the action of the system is considered and provided for in analysis and design. In addition, the effects of the lateral deflection on such rigid elements themselves and on their attachment to the building structure shall be considered. Where the existing rigid elements are load-bearing elements, such as walls or braced frames, which do not conform to the detailing requirements of 780 CMR 1903, 2104, 2203 or 2306, as applicable:

a) The value of R used in design shall not be greater than 4, and

b) The lateral stiffness of the building in any story, based on the elements assumed in the design to resist lateral loads, shall not be less than 1/2 of the stiffness that would pertain if all new and existing elements were considered to be fully effective in resisting lateral loads.

780 CMR 3408.6.2 shall not apply to buildings where the required lateral load resistance is controlled by 780 CMR 3408.3.5

3408.6.3 Reduction of Earthquake Hazards: Where the provisions of 780 CMR 3408.0 require correction of special earthquake hazards, the following measures shall be taken to reduce hazards from parapets, masonry walls, and/or precast concrete structural elements which do not conform to the requirements of 780 CMR 1612.0:

1. **Parapets:** All parapets not meeting the requirements of 780 CMR 1612.0 shall be removed, or braced so as to meet the requirements of 780 CMR 1612.7 and, for unreinforced masonry parapets, 780 CMR 3408.6.4.
2. **Masonry Walls:** All masonry walls shall be connected to floor or roof diaphragms, or other elements providing their lateral support, so as to conform to the requirements of 780 CMR 1612.7. The design force for the connection shall not be less than 100 pounds per linear foot

vertical loads must be maintained. Engineering knowledge gained from past earthquakes can be useful in evaluating the effects of lateral deflections on rigid elements. Specific criteria for this evaluation are not provided in the code. The Engineer of Record must exercise professional judgement.

Rigid elements which are excluded from the lateral load resisting system may affect the action of the system in a number of ways. Rigid elements may stiffen the building, decreasing its period, and thereby increasing the seismic base shear of the structure. They may also affect the torsional response of the structure. Spandrel infill panels with ribbon windows may affect the ductility and failure mode of the adjacent columns. Out-of-plane offsets between rigid vertical elements which are neglected may create high diaphragm stresses. Rigid elements affect the calculation of base shear and torsional moment and the treatment of certain localized conditions.

Section 1612 must be used in evaluating the effect of rigid elements on the action of the system for certain buildings. Conformance with Section 1612 is required for area or weight additions over 100% by sections 3408.4.3.2, Item #3. Conformance is required for buildings in Seismic Hazard Category 3 by Section 3408.5.4. Neglected rigid elements must be considered in evaluating structural irregularities listed in Tables 1612.4.5.1 and 1612.4.5.2 for conformance with Section 1612. Section 1612 does not affect neglected rigid elements in Seismic Hazard Categories 1 and 2 evaluated using 3408.6.1.1, Method #2.

Section 3408.6.2 applies to alterations, repairs and changes in use associated with Seismic Hazard Category 3 and additions exceeding 10% of area or weight. For buildings with existing unreinforced masonry bearing walls, part b may require the use of a very stiff lateral load resistance system.

R3408.6.3: In Seismic Hazard Category #2 for alterations, repairs, and changes in use or for additions not exceeding 100% of the existing mass or area, corrections to earthquake hazards must be implemented in accordance with 3408.6.3.

of wall. Connections shall not produce cross-grain bending in wood members.

3. **Precast concrete structural elements:** Interconnections of precast concrete structural elements shall be investigated, and reinforced if necessary. Connections shall conform to the requirements of 780 CMR 19.

TABLE 3408.2
RESPONSE MODIFICATION FACTOR "R"
FOR EXISTING BUILDINGS (1,2)

BUILDING LATERAL FORCE RESISTING SYSTEM	R	C_d
Wood Systems		
Light Framed Plywood Shear Walls 3 Stories or Less	6.5	4
Other Wood Buildings	5	3
Steel Systems		
Steel Moment Frame	4.5	4
Steel Braced Frame without Gravity Loads in Braces	5	4.5
Steel Braced Frame with Gravity Loads in Braces	4	3.5
Steel Frame with Concrete Shear Walls	5.5	5
Cast in Place or Precast Concrete Systems		
Concrete Moment Frame	3	2.5
Concrete Frame with Concrete Shear Walls	4.5	4
Unreinforced Concrete Shear Walls	1.5	1.5
Unreinforced Masonry Systems		
Infill Shear Walls in Complete Steel or Concrete Frame (3)	1.5	1.5
Shear Wall Systems with Partial Steel or Concrete Frame	1.38	1.38
Bearing Wall Systems	1.25	1.25

Note 1: See Table 3408.3 for Force Modification Factors applicable to Components of Lateral Force Resisting Systems

Note 2: For buildings deriving lateral load resistance from a combination of structural systems:

a) For vertical combinations with a regular flexible upper portion above a rigid lower portion, perform a two-stage analysis. Evaluate the flexible upper portion as a separate structure supported laterally by the rigid base. Evaluate the base structure as a separate structure, adding the base shear and overturning moment from the upper structures as lateral forces applied at the top of the base structure.

b) For combinations along different horizontal axes, use values R and C_d for the principal system in the respective directions, except in buildings deriving a significant portion of lateral resistance from bearing walls. For these buildings, use the values of R and C_d associated with the bearing wall system for all directions.

c) For other combinations, use the lowest value of R (and corresponding value of C_d) of all systems participating in lateral load resistance.

Note 3: To qualify for a R factor of 1.50, infill walls must bear tightly on surrounding frame members on all four sides. In all other cases, use a R factor of 1.38.

Table 3408.3
FORCE MODIFICATION FACTORS FOR COMPONENTS OF LATERAL LOAD RESISTING SYSTEMS

STRUCTURAL COMPONENT	FORCE MODIFICATION FACTOR (1)
Structural Steel Systems	
All forces in bracing connections not conforming to 780 CMR 2204.3.1	0.4R
All forces in column connections using partial penetration welds not conforming to relevant portions of 780 CMR 2203.0.	0.8 R
All forces in members and connections of open web steel joists resisting earthquake loads	0.8 R
Cast in Place and Precast Concrete Systems	
Moment at any cross-section of a flexible member where the reinforcing ratio is less than 200/fy, or where the reinforcing consists of less than two bars, or is less than 1/4 of the amount of reinforcing in the opposite face of the member.	0.8R
Moment and shear in any beam without closed stirrups at a maximum spacing of d/4 over a distance of 1 $^{1/2}$ d from each end of the clear span.	0.4R
Moment and shear in any column without ties as a spacing not exceeding the smaller of times the diameter of the smallest enclosed bar, 24 tie bar diameters, or 1/2 the smallest dimension of the member, over a distance from each end of a member not less than 1/6 the clear height of the column, the largest dimension of the member, or 18 inches.	0.8R
Force in concrete shear wall reinforcing with splices that do not develop the full yield stress of the reinforcing in tension.	0.8R
Shear in shear walls not conforming with minimum wall reinforcing requirements.	0.4R
Axial force in any column supporting a discontinuous stiff element, such as a shear wall, resisting axial loads, unless the column has special transverse reinforcement over its full height.	0.8R
All forces in precast concrete connections not conforming to the requirements of 780 CMR 19.	0.8R
All Systems Shear in any story where the strength of all shear resisting elements is less than 65% of the strength of all shear resisting elements in the story above.	0.8R

Note 1: Force Modification factor shall not be less than 1.0

The word, “as” in the second line should read, “at”. Also, the maximum tie spacing limitation related to the number of diameters of the smallest enclosed bar is intended to be “8 times the diameter of the smallest enclosed bar.”

3408.6.4 Existing Unreinforced Masonry Walls: Where compliance with the code for new construction is required by 780 CMR 3408.0, existing unreinforced masonry walls in sound condition may continue in service, providing:

1. They are adequately tied to the structural elements providing their lateral support; and,
2. The ratio of unbraced height or length to nominal thickness in at least one direction does not exceed 20 for walls spanning laterally between two supports, nor 4 for cantilever walls and parapets; and,
3. The wall is of sufficient strength to resist the required earthquake forces from 780 CMR 1612.7.

Masonry walls allowed to be unreinforced by the provisions of the code for new construction and which satisfy all provisions of the code for new construction need not satisfy 780 CMR 3408.6.4 item 2. Additional bracing or structural ties may be provided to meet these requirements. Unreinforced walls continuing in service under 780 CMR 3408.6.4 shall not be considered effective as shear walls resisting lateral earthquake force specified in 780 CMR 16, except where the provisions of 780 CMR 3408.0 specifically permit use of structural systems not conforming to 780 CMR 2104.

3408.6.5 Changes in Building Mass: A reduction in the weight of a building shall not be considered to offset a reduction in lateral load capacity of the building, in evaluating compliance with 780 CMR 3408.3.5, except that the weight of the building as altered shall be used in evaluating compliance with 780 CMR 1612.0. An increase in the weight of the building shall be considered as an addition, for purposes of determining earthquake resistance requirements (see 780 CMR 3408.4).

R3408.6.4: This section applies wherever "compliance with the code for new construction is required by 780 CMR 3408.0". This includes non-structurally separated additions exceeding 100% of the mass or area of the existing building and buildings in Seismic Hazard Category 3. The provisions of 3408.6.4 can be taken as an exception to 3408.4.3.2, item #3 although these provisions are not specifically mentioned in 3408.4.3.2, item #3.

Section 3408 permits the use of existing unreinforced masonry shear walls for certain types of buildings. Section 3408.1.1 generally prohibits the use of unreinforced masonry walls as shear walls in buildings constructed after 1975. Unreinforced masonry walls are also prohibited in additions which exceed 100% of the original building area or weight. Such walls are allowed to be considered in resisting lateral loads for buildings governed by 3408.3.5, for weight or area additions up to 100% of the original building, and for pre-1975 buildings in Seismic Hazard Category 3.

Flexure may subject unreinforced masonry shear walls to tensile stress. Possible ways to establish an allowable limit on tensile stresses include testing and reference to FEMA 273, ACI 530 or other available literature. ACI 530 lists allowable flexural tension stresses only for out-of-plane bending and allows no tension due to in-plane bending. Although not referenced in the Massachusetts State Building Code, FEMA 273 addresses tension due to in-plane bending. FEMA 273 considers the condition of the masonry and includes information on test methods, design values and useful references.

3408.7 Liquefaction Evaluation for Existing Buildings: The subsoils supporting the existing building shall be evaluated to determine the potential for liquefaction, and if necessary, the subsoils and/or foundations shall be improved to prevent failure in the event liquefaction occurs, as required below:

1. Existing buildings with Seismic Hazard category 1 (see 780 CMR 3408.5.4 and Table 3408.1) shall not require evaluation of liquefaction potential or compliance with 780 CMR 1805.3.
2. Existing buildings with Seismic Hazard Category 2 or 3 (see 780 CMR 3408.5.4 and Table 3408.1) shall comply with the requirements of 780 CMR 1805.3.
3. Existing buildings with structurally separate additions shall comply with 3408.7 item 1 or 2, based on the Seismic Hazard Category of the existing building.
4. Existing buildings with structurally attached additions which meet the requirements of 780 CMR 3408.4.3.2, item 1, and which are classified as Seismic Hazard Category 1 (see 780 CMR 3408.5.4 and table 3408.1), shall not require evaluation of liquefaction potential or compliance with 780 CMR 1805.3.
5. Existing buildings with structurally attached additions which meet the requirements of 780 CMR 3408.4.3.2, item 2, and which are classified as Seismic Hazard Category 1 or 2, shall comply with the requirements of 780 CMR 1805.3, except that the blow count scale in Figure 1805.3 may be multiplied by the appropriate reduction factor from Figure 3408.1.
6. Existing buildings with structurally attached additions which meet the requirements of 780 CMR 3408.4.3.2, item 3, shall comply with the requirements of 780 CMR 1805.3.

780 CMR 3409.0 HISTORIC BUILDINGS

3409.1 Scope: The provisions of 780 CMR 3409.0 shall govern all buildings and structures in the Commonwealth which are legally designated as historic buildings. 780 CMR 3409.0 shall preempt all other regulations of 780 CMR governing the reconstruction alterations, change in use and occupancy, repairs maintenance and additions for the conformity of historic buildings and structures to 780 CMR, with the exception of 780 CMR 122.0 for appeals, or unless otherwise specified (see Appendix H). There is no obligation for owners of historic properties to apply for 780 CMR 3409.0.

R3409.1: See comments under 3400.3.10.

3409.1.1 Key Definitions: The following five definitions are found in 780 CMR 3401.1, but are also presented here as such definitions form a significant portion of 780 CMR 3409.

Historic buildings: (a) Any building or structure individually listed on the National Registrar of Historic Places or (b) any building or structure evaluated by MHC to be a contributing building within a National Registrar or State Registrar District. (c) any building or structure which has been certified by the Massachusetts Historical Commission to meet eligibility requirements for individual listing on the National registrar of Historic Places. Historic building shall be further defined as totally or partially preserved buildings. All entries into the totally preserved building list shall be certified by the Massachusetts Historical Commission. The Board of Building Regulations and Standards shall ratify all buildings or structures certified by the Massachusetts Historical Commission to qualify for totally preserved listing (see Appendix H).

Partially preserved buildings: (a) Any building or structure individually listed on the National Registrar of Historic Places or (b) any building or structure certified as a historic building by the Massachusetts Histroical Commission and not designated a totally preserved building in Appendix H.

Restoration: Restoration is the process of accurately reconstructing or repairing the forms and details of a building or structure or portion thereof as it appeared at a particular period or periods of time by means of removal of later work/or the replacement of missing original work.

Totally preserved buildings: A totally preserved building is an historic building or structure. The principal use of such a building or structure must be as an exhibit of the building or structure itself which is open to the public not less than 12 days per year, although additional uses, original and/or ancillary to the principal use shall be permitted within the same building up to a maximum of 40% of the gross floor area. Totally preserved buildings shall be those listed in Appendix H. All entries into the totally preserved building list shall be certified by the Massachusetts Historical Commission. The Board of Building Regulations and Standards shall ratify all buildings and structures certified by the Massachusetts Historical Commission to qualify for totally preserved listing (see Appendix H).

3409.2 Totally preserved buildings:

3409.2.1 State Building Code Exceptions: A totally preserved building shall be subject to the following exceptions:

1. Repairs, maintenance and restoration shall be allowed without conformity to 780 CMR generally, if the provisions of 780 CMR 3409.2.2 have been met.

2. In case of fire or other casualty to a totally preserved building, said building may be rebuilt, in total or in part, using techniques and materials as are necessary to restore it to its original condition and use group.

3. If a historic building or structure, as a result of proposed work, would become eligible for certification as a totally preserved building and the Massachusetts Historical Commission so certifies by affidavit, such affidavit is submitted to the building official with the permit application, and the building official shall then allow the work to proceed under the provisions of 780 CMR 3409.2.

3409.2.2 Mandatory safety requirements: All totally preserved buildings shall comply to the following requirements:

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3409.2.2.3 Maximum occupancy: Occupancy shall be limited by the actual structural floor load capacity as certified by a qualified Massachusetts registered professional engineer or architect or in accordance with 780 CMR 1008.0, whichever is less. Said floor load shall be posted in accordance with the procedures set forth in 780 CMR 120.0, 780 CMR 1003.3 and 780 CMR 1617.2. The owner shall submit evidence of this certification and related computations to the building official upon request.

3409.2.2.4 Limited egress: Where one or more floors of a totally preserved building are limited to one means of egress, the occupancy load shall be computed as follows:

1. **Floors below the first story:** Not more than one occupant per 100 square feet of gross floor area with a maximum occupancy of 49.
2. **First story:** Not more than one occupant per 50 square feet of gross floor area.
3. **Second story and above:** Not more than one occupant per 100 square feet of gross floor area, or 30 occupants per unit of egress width, whichever condition results in the lesser occupancy load.

3409.2.2.5 Inspections: The building official and the fire official shall inspect all totally preserved buildings not less frequently than once every year in order to determine that the building or structure continues to conform to 780 CMR 3409.2. A qualified Massachusetts registered professional engineer or architect shall certify every five years thereafter as to the exact floor load capacity of the building or structure. The building official shall certify all totally preserved buildings not less frequently than once every year. Fees shall be established at $25.00 per building inspection.

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3409.3 Partially preserved buildings

3409.3.1 State Building Code provisions: A partially preserved building shall be subject to the following provisions:

1. **Existing Systems**- individual components of an existing building system may be repaired or replaced in kind without requiring that system to comply fully with the code for new construction. (See 780 CMR 34, 780 CMR 3404.3: New Systems)
2. **Replacement in kind**- where the repair of historic materials including patching, splicing, piecing-in, consolidating or reinforcing is not possible, compatible materials may be substituted which closely convey the form and design as well as the visual appearance of the existing feature.

3409.3.2 State Building Code exceptions: A partially preserved building shall be subject to the following exceptions: Repairs or in kind replacement of the following features will be allowed on partially preserved buildings so as to not compromise the architectural integrity of the historic characteristics and qualities which contributed to the eligibility for listing in the National Registrar for Historic Places.

1. **Roofing**- repair or in kind replacement of an existing historic roofing system (i.e. slate, wood, clay, tile, metal) shall be permitted without requiring structural compliance for equivalent new construction providing that dead and live loading requirements have not changed.
2. **Windows**- repair or in kind replacement of existing historic windows (i.e frames, sash, muntins, glazing, sills, molding, shutters) shall be permitted without requiring energy code compliance.
3. **Entries/Porches**- repair or in kind replacement of existing individual decorative features of an existing system (i.e. columns, balustrades, stairs, pilasters, doors, sidelights) shall be permitted.
4. **Wood Sliding/Decorative Elements**- repair or in kind replacement of an existing system including such items as clapboards, shingles, cornices, brackets and window and door surrounds shall be permitted.
5. **Masonry-** repair or in kind replacement of masonry units as part of an existing system (i.e. brick, stone, terra cotta, concrete and stucco) shall be permitted.
6. **Metals-** repair or in kind replacement of existing architectural metals (i.e. cast and wrought iron, steel, tin, copper and copper alloys, aluminum, zinc) shall be permitted.
7. **Interior features**- repair or in kind replacement of non structural interior features that are important in defining the overall historic character of a building (i.e columns, cornices, baseboards, fireplace mantels, paneling, window trim, doors, moldings, railings, flooring, plasterwork) shall be permitted.

3409.3.3 Applicability: 780 CMR 3409.3 and 780 CMR 34 shall apply to all partially preserved Historic buildings.

R3409.3.2:

5. This provision does not apply to the repair or in-kind replacement of entire masonry systems or system components such as parapets and walls. It applies only to isolated masonry *units* that are part of a larger system or component. When replacing entire systems or system components, the code requirements for new construction apply except for seismic requirements. (See 3400.3.10.)

3409.3.4 Continuation of use and occupancy: The legal use and occupancy of any partially preserved building may be continued without change or further compliance to 780 CMR. The provisions of 780 CMR 3409.2 shall be required for Historic buildings accessible to the public on more than 50 days per year.

3409.3.5 Inspection certification and fees: Partially preserved buildings shall not require annual inspection unless otherwise stipulated in 780 CMR 106.5 and Table 106.

3409.3.6 Fire damage: If a building or structure is damaged from fire or other casualty it may be restored to its original construction or it shall meet the requirements of 780 CMR provided these requirements do not compromise the features for which the building was considered Historic when listed in the National Registrar of Historic Places.

3409.3.7 Change in occupancy: See 780 CMR 34.

3409.3.8 New Systems: See 780 CMR 34.

3409.3.9 Lesser and equal hazard: See 780 CMR 34. A partially preserved building classified under unprotected construction Type 3C or 5B shall have waived the requirement to add one to the Hazard Index number (See 780 CMR 34, Table 3403).

3409.3.10 Greater hazard: See 780 CMR 34. A partially preserved building classified under unprotected construction Type 3C or 5B shall have waived the requirement to add one to the Hazard Index number (See 780 CMR 34, Table 3403).

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3.0 DESIGN EXAMPLES

Where these examples consist of specific case studies, they represent only one of any number of possible ways to satisfy the requirements of Chapter 34. These examples represent the opinion of BASE and are not legally binding. Engineers may opt to take a different approach to the design solution.

Design Example Synopsis

3.01 Example 1: Separate addition – An addition is being built adjacent to an existing building. A structurally independent addition is planned so as to minimize the impact on the existing construction. Changes to snow drift considerations for the existing building must be addressed.

3.02 Example 2: Contiguous addition – It is determined that an existing building is/or will be capable of supporting increased loads from an addition which is not structurally independent. Other issues such as lateral load, live load and snow drift are also reviewed.

3.03 Example 3: No existing lateral load system – Upon review of an existing building it is found that the existing lateral load resisting system is essentially non-existent. Who should be notified and how can this be best addressed?

3.04 Example 4: Party walls – It is proposed to alter an existing building which shares common walls with adjacent buildings for both gravity and lateral loads. Responsibility must be defined with respect to the work proposed and the existing systems.

3.05 Example 5: Partial change-in-use – A portion of a large multi-use building has a change in use to a higher hazard index as the result of a renovation.

3.06 Example 6: Pre 1975/Post 1975 code compliance – The actual date of construction for an existing building is unknown. A review of the existing building is performed for both “pre” and “post” January 1, 1975 construction dates.

3.07 Example 7: Addition with no lateral system (elevator shaft) – It is proposed to add an elevator shaft on an existing building. The elevator shaft is considered an addition to the building but does not have its own lateral load resisting system.

3.08 Example 8: Non-structural, low cost renovation – Low cost renovations are planned for an existing building. Structural alterations to existing members, elements, or systems are not planned. However, this does not eliminate the requirement of a Chapter 34 review.

3.09 Example 9: Non-structural, high cost renovation – Significant renovations are planned for an existing building, however, alterations to existing structural members, elements or systems are not planned. The cost of alterations exceeds 50% of the assessed building value.

3.10 Example 10: Rigid elements neglected.

3.01 Example 1: Separate Addition

Section 3400.3, #4 indicates that all additions, whether structurally separate or not, shall comply with the code for new construction, except as otherwise provide in 780 CMR 34.

As per 3408.4.1, all gravity loading, including floor and roof live loads, shall comply with the code for new construction. If the addition creates conditions where existing adjacent construction is subject to drifting and/or sliding snow, the existing construction must be investigated and reinforced if required in accordance with 3408.3.2 and 3408.3.3.

An expansion joint or other separation must be provided between the existing and the new construction to consider the buildings separate for the purposes of Chapter 34. This may require an analysis or estimation of the existing building's lateral load resisting system to determine the minimum acceptable expansion joint.

Section 3408.5 governs the extent to which the existing lateral load resisting system has to be reinforced or supplemented based on repairs, alterations, or changes of use within the existing building. The existing building must be capable of resisting, as a minimum, Exposure A wind loads as per 3408.4.2.1.

Additionally, the engineer must determine the Seismic Hazard Category of the existing building (Table 4308.1) and comply with the requirements associated with that Seismic Hazard Category (3408.5.4.3, 3408.5.4.4, 3408.5.4.5). If Seismic Hazard Category 2 or 3 applies, a liquefaction evaluation of the existing foundation subsoils is required (3408.7).

3.02 Example 2: Contiguous Addition – It is determined that an existing building is/or will be capable of supporting increased loads from an addition which is not structurally independent. Other issues such as lateral load, live load and snow drift are also reviewed.

Section 3400.3, #4 indicates that all additions, whether structurally separate or not, must comply with the code for new construction.

As per 3408.4.1, all gravity loading, including floor and roof live loads, shall comply with the code for new construction. If the addition creates conditions where existing construction is subject to drifting and/or sliding snow, the existing construction must be investigated and reinforced if required in accordance with 3408.3.2 and 3408.3.3.

Section 3408.6.5 indicates that a weight increase shall be considered an addition for the purposes of 3408.4. This could include such things as floor leveling with a lightweight concrete or additional mechanical equipment, etc.

As required by 3408.4.2, the combined existing and new structure must be capable of resisting, at a minimum, Exposure A wind loads. If the effects of the wind forces specified in 1611.0 on all additions made since January 1, 1975 exceed the capacity of the existing lateral system by 10% or more, then the entire structure must be designed to resist the wind forces specified in 1611.0 for the appropriate exposure condition. In either case, the new portions of the structure must be designed for the wind forces required by 1611.0 for the appropriate exposure.

All new portions of the structure shall comply with the earthquake requirements of 1612.0 as per 3408.4.3.

If the area or the weight of the addition is less than 10%, then the existing portion of the building lateral load resisting system need only comply with 3408.3.5. The new portion must comply with 1612.0.

If the area or weight of the building is increased 10% but less than 100%, than the building as a whole shall be designed to resist earthquake forces calculated in accordance with 3408.6.1. Provisions in Chapter 34 allow for systems not acceptable to the new code to be used for existing lateral load resisting systems provided the appropriate factors are used in analysis (Tables 3408.2 and 3408.3). Additionally, seismic hazards must be reduced in accordance with 3408.6.3.

If the area or weight is increased by 100% or more, the structure as a whole shall comply fully with the seismic requirements of the code for new construction.

Section 3408.5 may supercede the first two requirements. If the existing building is subject to repair, alteration, and/or a change in use, the appropriate Seismic Hazard Category must be determined. If the requirements of the Seismic Hazard Category are more stringent, then they will govern the design of the existing building.

If Chapter 34 requires a lateral analysis, a geotechnical investigation may be required (3408.2.4). Additionally, depending on the Seismic Hazard Category and size of the addition, a liquefaction evaluation of the existing foundation subsoils may be required (3408.7).

3.03 Example 3: No existing lateral load resisting system – Upon review of an existing building it is found that the existing lateral load resisting system is essentially non-existent. Who should be notified and how can this be best addressed?

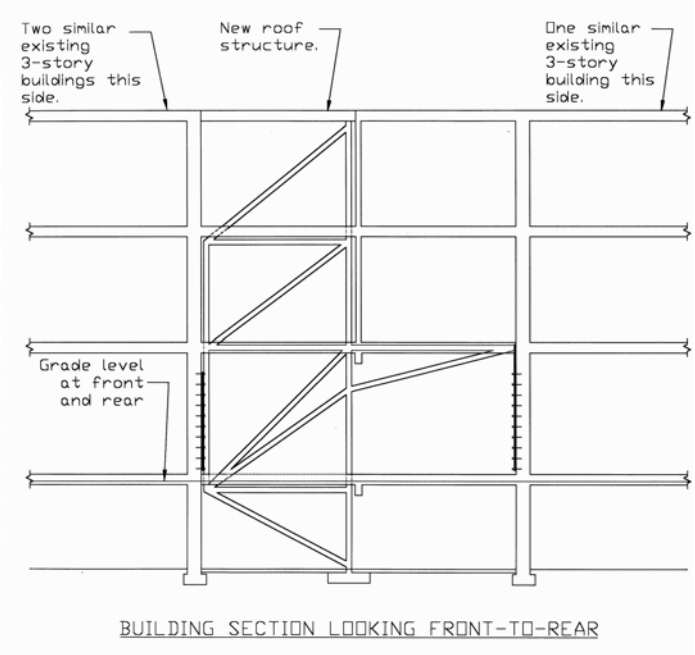
If it is discovered during the structural evaluation required by 3408.2 that there is no definable lateral load resisting system, the client and/or owner should be notified immediately. There will likely be a significant impact on the building program requirements. If the building was constructed on or after January 1, 1975, a lateral system must be added which satisfies the requirements of the current code or the code in effect on the permit date. Older buildings regulated by Chapter 34 must have a lateral system added which can resist at least Exposure A wind loads (and possibly higher loads, depending on the scope of work).

If there are signs of imminent collapse or other life safety concerns that require immediate attention, it may be appropriate to notify the local building official in conjunction with owner notification.

3.04 Example 4: Party Walls

An existing 19th century wood-framed / brick bearing wall building originally built as row house construction is to be enlarged and renovated. The existing side walls are imperforated solid brick bearing walls of considerable extent. The existing front wall is completely open at the first floor and perforated with window openings above the second floor. Numerous door and window openings exist in the rear wall.

The project scope includes an upper level addition. The present structure consists of two stories plus a basement on one side of a central intermediate bearing line and three stories plus a basement on the other side. A partial new roof structure will be provided such that the completed structure above the basement will be three stories throughout. The addition increases the area by 15 percent and the mass by a lesser percentage.



BUILDING SECTION LOOKING FRONT-TO-REAR

The project scope also includes alterations and a change in use. The prior use of the building was retail at the first floor and residential in the upper levels. The upper level space will be converted for office use. The project also includes revamping of the floor plan layout, a new basement slab on grade, enlargement of existing rear wall penetrations and other miscellaneous alterations.

The sharing of common walls in row house construction complicates the mass calculation for seismic design. It seems inappropriate to include the entire weight of the common walls. This procedure would lead to double counting of wall mass if identical renovations were to be implemented to adjoining structures. Two end walls and three common walls are included in the four adjoining buildings, for a total of five walls running front-to-back. For side-to-side earthquake loads, the engineer considers 62.5% of the party wall mass on each side. This approach recognizes the interaction of adjacent horizontal diaphragms at a modest cost increase over 50-50 sharing of party wall mass. The base shear considers one fourth of the total mass of all five brick bearing walls which run front-to-back.

The seismic design requirements are significantly affected by the addition. Item #2 of 3408.4.3.2 requires that the lateral load resisting system must resist 45% of the load calculated using 3408.6.1.1. The lateral load resisting system does not meet the requirements of code section 1612 and chapters 19 through 23 detailing requirements. Method #2 of 3408.6.1.1 is therefore applicable. The R value used in the design is 1.25, as indicated in Table 3408.2. Footnote 2b of Table 3408.2 requires the use of this R value in both directions. The common walls are found to be adequate for the front-to-back design load with strengthening of diaphragm connections. Loads parallel to the street are much too large to be resisted by the front and rear walls. New braced frames are required. The braced frames connect to the common walls for uplift resistance and to the new slab on grade for sliding resistance.

Other seismic design issues must be addressed. The large expenditure places this building in Seismic Hazard Category II. Special earthquake hazards must therefore be addressed (3408.6.3). Earthquake resistance must comply with 3408.3.5. The upgrades required for the addition are found to be sufficient for 3408.3.5 compliance.

3.05 Example 5: Partial change in use – A portion of a large multi-use building has a change in use to a higher hazard index as the result of a renovation.

According to 3400.3, #3, Part change in use (Mixed Use), the portion of the building being changed must conform to the applicable provisions of Chapter 34.

The governing section, based on the change of use, is 3408.5. This section requires that the existing floor construction be capable of supporting dead loads and live loads in accordance with the code for new construction. If they do not meet these requirements, the existing structural elements must be supplemented or reinforced. In some uses, a live load capacity may be posted which is less than that required by the code for new construction with the building official's approval.

Section 3408.5.3 requires the building as a whole to be able to resist the forces associated with Exposure A wind loads, regardless of the limits of the area undergoing a change in use. If the building does not meet this requirement, the lateral system must be strengthened.

In addition to the requirements for wind, the Seismic Hazard Category must be determined based on the change in Hazard Index (Tables 3403 and 3408.1), the change in occupancy, and the cost of alterations. If it is determined that the portion of the building experiencing a change in use is more than 33% of the total floor area and the Seismic Hazard Category is 2 or 3, then the entire building is governed by the earthquake requirements of that higher category (3408.5.4.2). Such work may be difficult with multiple tenants, making the intended change of use impractical.

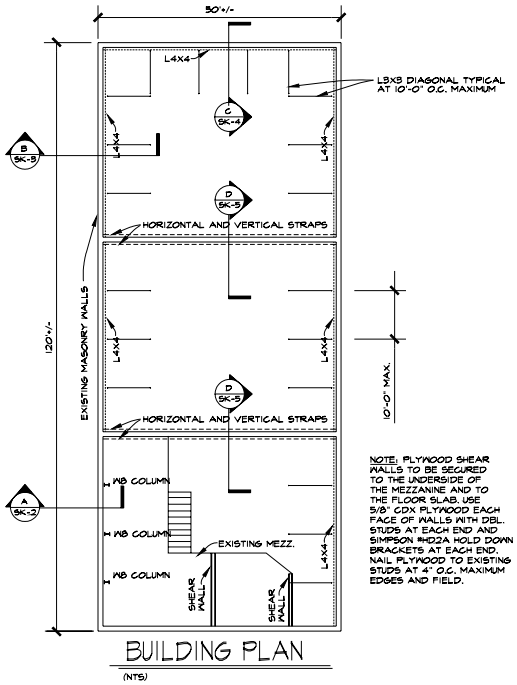
3.6 Example 6: Pre 1975/Post 1975 code compliance

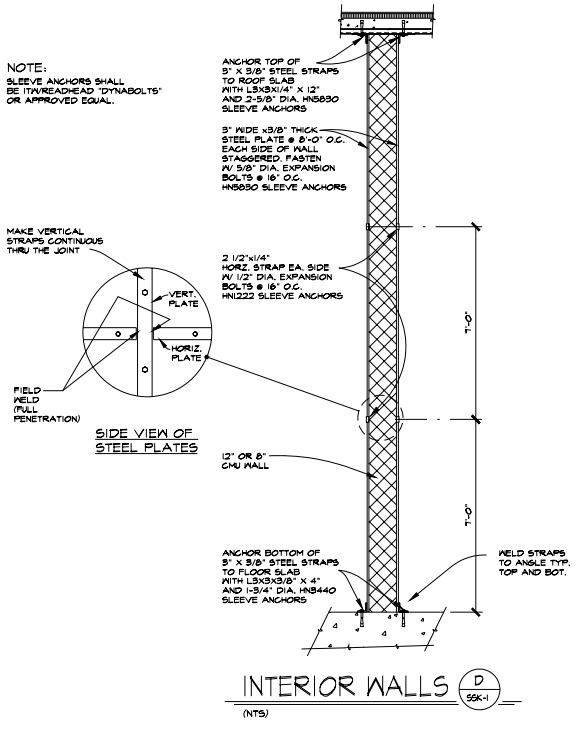
Renovations to an existing 50’ x 120’ single story building are being considered. The structure would be undergoing a change in use to “assembly use group.” Limited documentation exists relative to the structural composition of the building. No structural modifications are planned to the existing members, elements or systems. The general construction consists of poured gypsum fill on metal roof deck, supported by open web steel joists spanning 50’, bearing on unreinforced CMU exterior walls. Two interior unreinforced non-load bearing demising walls (50’ long) exist which divide the building into thirds.

If the building was constructed prior to 1975, the Chapter 34 review indicates that the building falls into seismic hazard category #3, due to the change in use and cost of renovations. Full compliance with Article 1612.0 is required with some exceptions; most notably, one may use 75% of the base earthquake force calculated in accordance with 3408.6.1.1 (3408.5.4.6 – No extension of area or height). The existing unreinforced masonry walls can be utilized as shear walls provided allowable stresses are not exceeded (article 3408.6.4). Wind resistance must conform to that required for new construction per Article 3400.3 item #6.

The analysis indicates the long exterior bearing walls can perform adequately as shear walls without reinforcing. However, the two interior cross walls need to be modified to resist earthquake loads. All exterior walls need to be braced to reduce the height-to-thickness ratio. The interior masonry walls may be reinforced externally (in two directions) on both sides, and anchored to the roof and floor. A liquefaction investigation is required (3408.7).

If the building was constructed after 1975, 3408.1.1 requires that one analyze the structure using the more stringent requirements of Chapter 34 or the code in effect at the time of permit. Although the lateral loads do not change significantly, the required work does. The most notable difference is that the existing unreinforced exterior shear walls must be reinforced in two directions. To qualify as reinforced masonry per the First Edition of the Massachusetts State Building Code (MBC), all bearing walls, shear walls and exterior walls must be reinforced in two directions. Since the interior masonry cross walls also participate in resisting lateral load, they need to be reinforced or modified as well. The masonry walls need to be rebuilt or reinforced in place to allow the proposed “Change in Use.” A liquefaction investigation is required.

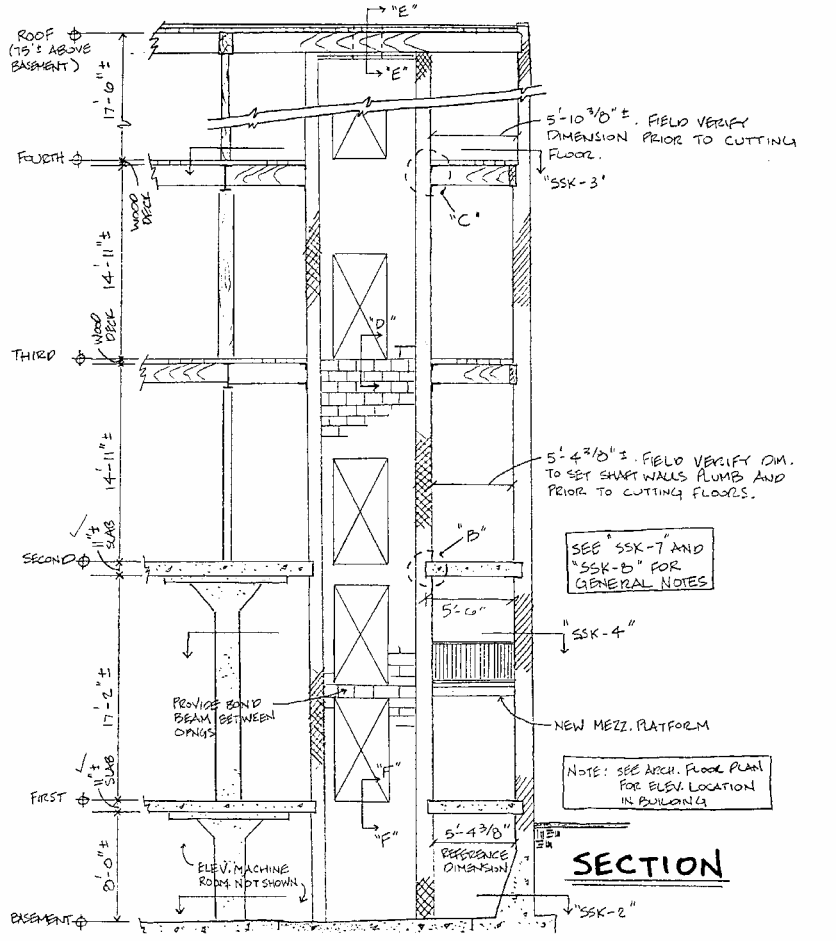




3.7 **Example 7:** Addition with no lateral system (elevator shaft)

An existing 100’ x 360’ 4-story unreinforced brick masonry mill building is retrofitted with a passenger elevator which services all levels. The proposed elevator is a hydraulic unit with reinforced concrete block shaft walls which carry gravity loads from the floor framing around the elevator. The elevator does not require a penthouse above the existing roof level. The lower two floor levels are comprised of reinforced concrete flat slabs with a bay size of roughly 24’ x 24’. The upper two floors are timber deck on heavy timber filler beams supported by steel girders. The shaft location is strategically positioned such that it is centered in the column bay to avoid cutting the column strips in the flat slab construction.

A Chapter 34 review of this elevator alteration is performed to evaluate the effect on the existing structure. Since an increase in mass is considered an addition (not structurally separated) we are directed to 3408.4.3.2, item #1. Since the increase is much less than 10% of the mass of the building, earthquake resistance need only comply with 3408.3.5. Although the existing lateral load resisting system is not altered, an exposure “A” wind load analysis of the entire structure is required per article 3408.4.2. Since the building is classified as Seismic Hazard Category #1, a liquefaction investigation is not required per 3408.7.



3.8 Example 8: Non-structural, low cost renovation – Low cost renovations are planned for an existing building larger than 35,000 cubic feet. Structural alterations to existing members, elements, or systems are not planned.

An existing 1960's masonry bearing wall and steel bar joist, two-story elementary school is being updated during the summer break. The updates consist essentially of cosmetic work only - new doors, windows, and carpet, painting, replacement of ceiling tiles and the like. The existing fire protection sprinkler system, however, is being repaired in areas that have stopped functioning properly.

The repair of the sprinkler system exceeds the requirement of ordinary repairs as defined in 3400.3, #5. Based on the construction control requirements of 3408.1.3, the services of a structural engineer are required. 3400.3, #1 requires a review of 3403.0 and 3404.0. The Hazard Index, for use in 3408.5, is determined to be 4 from Table 3403.1. Section 3404.0 is non-structural, and therefore, can be ignored.

The repair of the sprinkler system requires a review of 3408.5.

The repairs to the sprinkler system and the cosmetic work do not affect the existing floor structure. As such, they are not required to meet the new code dead and live load requirements outlined in 3408.5.1. However, a review of the original design documents is made to verify that the floor construction and its dead and live load capacities are not grossly inadequate based on current code loading requirements. Additionally, and although also not specifically required, the existing roof construction is checked for the current code snow loads, including snow drifting.

As the original building was designed as a school, the concrete filled metal deck on bar joists floor and metal deck and bar joist roof prove adequate for the current code floor and roof load requirements.

Section 3408.5.3 requires that the building have a lateral system capable of resisting Exposure A wind loads. The building has interior and exterior masonry bearing walls and masonry demising walls between classrooms. Although unreinforced, the walls are sufficient in number and length to be able to resist Exposure A wind loads.

In accordance with 3408.5.4.1, a Seismic Hazard Category must be determined. For this building the current and proposed Hazard Index is 4, there is no change in Use Group, the occupancy is not being increased by more than 25%, and the cost of alterations is less than 50% of the assessed value. Therefore, the Seismic Hazard Category is 1.

Section 3408.5.4.3 refers to 3408.3.5 for earthquake resistance requirements. As noted in the first paragraph, there are no modifications being made to the existing lateral load resisting system (unreinforced masonry block walls) and, therefore, the capacity of the system is not being reduced and can continue in use unmodified.

An evaluation of the potential for liquefaction is not required per 3408.7, #1.

A report of these findings was submitted to the building official with the permit application in accordance with 3408.2.

3.9 Example 9: Non-structural, high cost renovation – Significant renovations are planned for an existing building larger than 35,000 cubic feet. However, alterations to existing structural members, elements or systems are not planned. The cost of alterations exceeds 50% of the assessed building value.

An existing 1930's five story, exterior masonry bearing wall, steel superstructure with wood floor and roof framing building is undergoing a pre-purchase evaluation for the proposed change from a business to a charter school. The necessary updates, changes and modifications, although extensive, are not planned to include any structural work. The building will be gutted and new partitions, windows, doors and mechanical systems replaced. Existing stairs and elevators appear to be sufficient for the architectural requirements.

The complete rehabilitation of all systems exceeds the requirement of ordinary repairs as defined in 3400.3, #5. Based on the construction control requirements of 3408.1.3, the services of a structural engineer are required.

The proposed Hazard Index for Education (K-12) is determined to be 4 from Table 3403.1. The previous use, Business, had a Hazard Index of 2. This results in a change of 2. 3400.3, #2 requires a review of 3405.1. Because of the total change in Hazard Index, 3405.1 requires the existing building to conform to the code for new construction except as provided in 3408.0, Structural Requirements for Existing Buildings.

The replacement of the existing systems (life safety, fire ratings, plumbing, etc) and the change of use require a review of 3408.5.

The repairs to the existing systems do not affect the existing floor structure. As such, the floor framing is not required to meet the current code dead and live load requirements as outlined in 3408.5.1.

Section 3408.5.3 requires that the building have a lateral system capable of resisting Exposure A wind loads. The building has exterior masonry bearing/shear walls. There are significant openings in the front and rear walls. These walls are unreinforced and unlikely to be capable of resisting the minimum wind loads. However, earthquake requirements will govern.

In accordance with 3408.5.4.1, a Seismic Hazard Exposure Group must be determined. The building is changing from a Use Group with Hazard Index less than 4 to Use Group with Hazard Index of 4 or greater. The occupancy is being increased by less than 25%. The cost of alterations is expected to be greater than 50% of the assessed value. Therefore, the Seismic Hazard Category is 3.

Section 3408.5.4.5 requires compliance with the code for new construction except as noted in 3408.5.4.6 and 3408.6.4. Due to the previously noted openings in the exterior walls in one direction, a new lateral load resisting system (with new foundations) will be employed to resist seismic and wind loads in the direction parallel to the front and rear walls. Since this building has load-bearing walls, 3408.6.2 requires that the new lateral load resisting system have sufficient stiffness so that the stiffness of all of the elements assumed to be resisting the lateral loads is not less than one-half the stiffness of all new and existing elements if they were considered to be fully effective in resisting lateral loads. In this case, concentric braced frames do not have sufficient stiffness so a punched concrete shear wall system is selected. In the other direction, the unreinforced masonry walls will be utilized as shear walls, as permitted by 3408.6.1.1 #2. Response Modification factors for this system will be used, based on Table 3408.2. Footnote "2.b" in the table requires that values of R =1.25 and Cd=1.25 be used for the building in both directions. The 25% reduction in force outlined in 3408.5.4.6 is applicable. The engineer must check the drift of the revised building to insure that the existing masonry walls retain their capacity to carry vertical loads.

Because a lateral system analysis is required for Seismic Hazard Category 3, a geotechnical exploration is required to determine the site coefficient, the allowable bearing pressure and, as per 3408.7, #2, the susceptibility to liquefaction .

There is no code requirement to check floor and roof dead and live load capacities. However, because of the extent of lateral system analysis and other proposed upgrades, a review of the existing building gravity framing is made to verify that the floor construction is not grossly overstressed based on the current code dead and live load requirements. Additionally, the existing roof construction is checked for current code snow loads, including snow drifting.

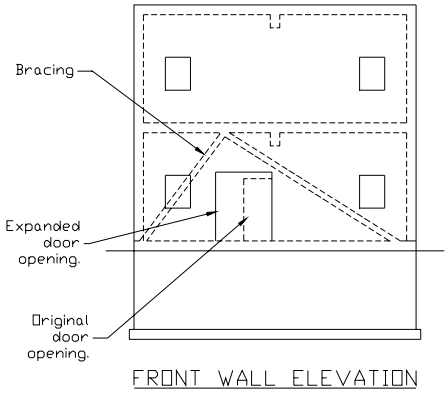
Based on the structural Chapter 34 requirements, the potential owner decides not to buy this building and searches for a building that requires less work.

3.10 Example 10: Rigid elements neglected.

A 30’-0” X 50’-0” office / warehouse building built in the 1950’s consisting of two stories plus a basement is to be renovated for a change in use. The building will be used as a restaurant and accessory basement food storage. The existing first floor front entrance wall opening will be enlarged. The existing lateral load resisting systems will otherwise be unaffected by alterations. The design for wind and earthquake loading must comply with 3408.5.

The existing building is steel framed with unreinforced concrete masonry exterior walls which provide lateral strength. The exterior walls are built of 12” concrete block except that the front wall consists of 8” block plus 4” face brick. Only the side walls serve as bearing walls. The roof structure consists of steel deck on open-web steel joists. A concrete slab on steel deck exists at the second floor and is supported on open-web steel joists. Existing steel post and beam construction runs front-to-back along the centerline to provide an intermediate bearing line for second floor and roof construction.

The change in use results in an increase in Hazard Index from 2 to 5 (Table 3403). The cost of the renovation exceeds 50% of the building’s assessed value. The building is therefore in Seismic Hazard Category 3. The capacity of the lateral load resisting system must comply with 1612 except that loads may be reduced by 25% in accordance with 3408.5.4.6. The lateral load resisting system does not meet the requirements of code section 1612 and chapters 19 through 23 detailing requirements. Method #2 of 3408.6.1.1 is therefore applicable. The R value used in the design is 1.25, as indicated in Table 3408.2. Footnote b of Table 3408.2 requires the use of this R value in both directions. The capacities of the side walls and the rear wall are found to be adequate for the front-to-back design load with strengthening of diaphragm connections. However, the first floor front wall has insufficient capacity due to the presence of existing window openings and the enlargement of the door opening.



The first floor front wall deficiencies require new structural work. A new single-story steel braced frame is designed to resist seismic shear loads at the front wall. The values of R and C_d are 1.25 as required by Table 3408.2 and footnote 2b of Table 3408.2. The stiffness of the braced frame is determined such that the deflection limitations of 1612.4.8 are satisfied. Calculated stresses in the first floor front masonry wall would be excessive if loads were shared with the braced frame based on relative stiffness. The lateral load capacity of the first floor front masonry wall is therefore neglected in the design.

The enlargement of the first floor door opening does not require consideration of 3408.3.5 because this wall is no longer part of the lateral load resisting system, due to the addition of the braced frame.

The neglected first floor front masonry must satisfy 3408.6.2. Although the calculated seismic deflection creates excessive stresses in the first floor masonry, the code-required deflection limit is satisfied. Items 1 and 2 of 3408.6.2 do not apply because the front wall is non-load-bearing. The effect of the neglected rigid element on the action of the system is adequately addressed by use of the low R value.