New Requirements for Old Buildings

The IBC Provisions on Existing Building Renovations and Alterations

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How and Why IBC Provisions Affect Your Projects, Liability, Clients, and Nearly Everyone Else

Renovating or altering an existing building always presents design professionals with challenges, such as obtaining accurate field information and unexpected existing conditions discovered during construction. With the adoption of the International Building Code (IBC), designing and detailing to make existing buildings conform to the structural requirements of the Code became more difficult.

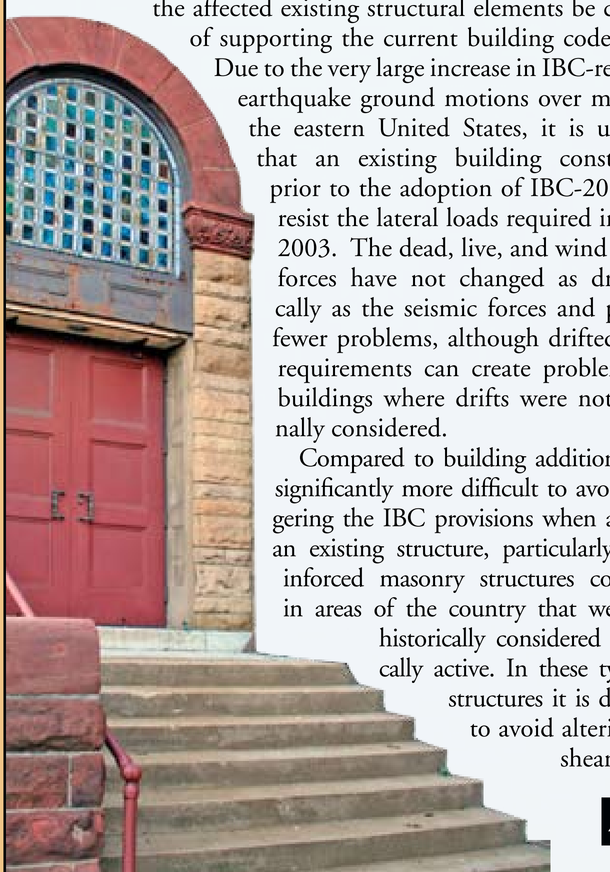
This article discusses some of the more important IBC structural provisions related to existing building renovation or alteration, provides examples to illustrate the provisions, and raises points for further consideration. Most importantly, it points out why structural engineers should proactively educate architects, developers, contractors, and building officials about the IBC provisions in order to avoid assuming a disproportionate share of the liability for non-compliance with the IBC building code.

Existing Structures

Chapter 34, *Existing Structures*, allows for two different "paths" to follow when evaluating an existing structure. The default is Section 3403.2, which states:

- additions or alterations "shall not increase the force in any structural element by more than 5 percent" unless the element can safely support the loads required by Chapter 16 of the Building Code,
- the "strength of any existing structural element [shall not] be decreased to less than that required by the building code",
- And, "uncovered structural elements…found to be unsound or otherwise structurally deficient…shall be made to conform to the requirements for new structures."

Section 3403.2 implies that it would be best to detail horizontal additions so that they are structurally separate from existing buildings. Significant additional gravity and/or lateral load from the addition resisted by the existing elements will require that the affected existing structural elements be capable of supporting the current building code loads. Due to the very large increase in IBC-required earthquake ground motions over much of the eastern United States, it is unlikely that an existing building constructed prior to the adoption of IBC-2000 can resist the lateral loads required in IBC-2003. The dead, live, and wind design forces have not changed as dramatically as the seismic forces and present fewer problems, although drifted snow requirements can create problems for buildings where drifts were not originally considered.



Compared to building additions, it is significantly more difficult to avoid triggering the IBC provisions when altering an existing structure, particularly unreinforced masonry structures common in areas of the country that were not historically considered seismically active. In these types of structures it is difficult to avoid altering the shear walls, because so many of the "partitions" are actually part of the lateral-force-resisting-system. Even small openings for man-doors, windows, or duct penetrations reduce the strength of the existing structural element and may require that the entire lateral force resisting system be checked for IBC-2003/2006 design loads.

Realizing that alterations to an existing structure will likely require significant retrofitting of the lateral-force-resisting-system if the provisions of 3403.2 are followed, the second available "path" is Section 3410, Compliance Alternatives. While this section appears to offer some respite from building height, area, and fire rating requirements contained in the IBC, there is no relief from the structural requirements. Section 3410.2.4 states that "An existing building...which does not comply with the requirements [of the IBC] for new construction, **shall not be altered in such a manner that results in the building being less safe or sanitary than such building is currently**" and, "If…the current level of safety or sanitation is to be reduced, **the portion altered or repaired shall conform to the requirements of Chapters** 2 through 12 and **14 through 33**" (emphasis added).

A second provision, Section 3410.4.1, states that "the Owner shall have a structural analysis of the existing building made to determine the adequacy of the structural systems for the proposed alteration, addition, or change of occupancy. The existing building shall be capable of supporting the **minimum load requirements of Chapter 16**" (emphasis added). This is very similar to a commonly used provision in the 1999 National Building Code (NBC), except that the NBC provision required only that the existing building be capable of resisting the *live load* requirements of Chapter 16; since live loads have changed little through the years, most existing buildings were adequate for the live loads and did not need to have their lateral-force-resisting-systems retrofitted. This small change from the BOCA National Building Code to the IBC has made it much more difficult to renovate existing buildings without needing to upgrade the lateral system to conform to the current IBC Code.

To summarize, seemingly minor modifications such as creating small openings in shear walls or the addition of seismic mass would technically make the building less safe and both 3410.2.4 and 3410.4.1 would require that the entire structure conform to the IBC chapter 16 requirements, including the seismic provisions as discussed above.

Earthquake Loads – General

The relevant provisions of Section 1614 are generally consistent with the Chapter 34 provisions. However, Sections 1614.1.1.3 and 1614.3 allow the seismic resistance of structural elements to be reduced up to 5%, a clear conflict with 3403.2 that allows no reduction in strength before the IBC loads must be considered. Further, Section 1614.3 states that the entire seismic-force-resisting system must conform to the current Building Code in the event that the seismic forces on an existing element are increased by more than 5% or the seismic resistance of an existing element is reduced by more than 5%, while Chapter 34 refers to upgrading only the affected elements.

In IBC-2006, the provisions in IBC-2003 Section 1614 that relate to additions and alterations have been moved to Chapter 34, but the conflict between the allowed reduction in seismic resistance and 3403.2 remains. In addition, the allowable increase in seismic force and reduction in seismic resistance has been increased to 10 percent "cumulative since the original construction", which can be difficult to determine since engineers are often hired for single projects and may not have any information on past building modifications.

Technical Challenges

There are a number of technical challenges in applying the IBC provisions to existing buildings. One of these is determining the "existing" seismic force to use to find the percentage increase in seismic force due to additions or alterations. Since many older buildings constructed prior to modern Codes were not explicitly designed for any lateral loads, and rely on the building mass for lateral stability, we generally revert to determining seismic force on the basis of seismic mass prior to the addition or alteration.

Code references in this article are to the IBC-2003 unless otherwise noted.

A significant question that is not addressed in the IBC is when to test if the strength of an existing element has been reduced by more than 5 percent and if the current IBC forces must be resisted. Is the strength measured after the existing element has been altered but before any new reinforcement is added, or after the existing element has been both altered and reinforced? Typically we are interested in the behavior of the completed project, but the IBC simply states that the IBC provisions must be applied if the strength is reduced and does not address when this is to be measured. Statements in the Code, such as requiring that the entire seismic-force-resisting system be upgraded if the strength of an existing element is reduced, make little sense if reinforcing the altered existing element prior to determining the strength reduction will result in never upgrading existing structures beyond the altered element.

Many other technical challenges are encountered when trying to avoid triggering the IBC provisions by providing additional lateral-force-resisting system elements to replace altered elements. These challenges include:

- For portions of a masonry shear wall that are removed, it is extremely difficult to supply a replacement element of sufficient stiffness, particularly if the replacement element will be fabricated from steel,
- How does one assume that the load is transferred to the new lateral-force-resisting system element in a structure built prior to the IBC requirement for collectors?
- How does one transfer the replacement element forces to the existing foundation when the foundation was not designed for the IBC loads, and does not appear to have been designed as part of a lateral-force-resisting system?
- Removing an existing shear wall element and replacing it with an element having sufficient strength but less stiffness may increase the forces applied to unaltered existing lateral-force-resist ing system elements.

Renovation and Alteration Examples

We have worked on several types of projects that have dealt with these complicated provisions. A common type of project involves reroofing an existing asphalt and gravel built-up roof with a ballasted membrane roof. Prior to the adoption of IBC-2000 we would have simply checked the existing roof members for the additional dead load, but now we would also have to check if the added ballast will result in a net seismic mass increase of more than 5%. If it does, the IBC Chapter 16 loads are triggered and it is likely that the existing lateral-force-resisting-system will fail under the new seismic loads.

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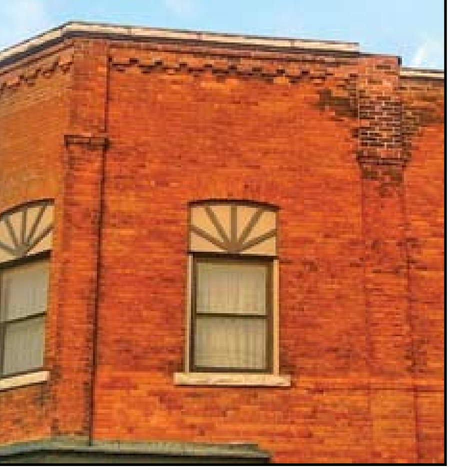

To try to avoid triggering the IBC Chapter 16 loads, we would then check the roof with a mechanically-fastened or adhered membrane roof to avoid adding the ballast. Unfortunately, stripping off all or a portion of the roofing material might reduce the dead load to the point that the wind-induced uplift will be net increased by more than 5% (or an actual net uplift might be created with compression introduced into the unbraced bottom flanges or chords) and the IBC Chapter 16 loads would be triggered. To stay within this narrow range, we often recommend using a mechanically-fastened or adhered membrane roof with sufficient roof pavers to avoid net uplift.

Another project involved adding 18 large rooftop units during tenant fit-up to a large 400-foot wide x 660-foot long tilt-up panel warehouse with steel roof joist girders and steel joist roof framing. The duct openings for each unit were approximately 6- x 8-feet and were arranged for maximum ductwork economy, meaning they were aligned across the building. Since we had designed this building just prior to the IBC-2000, increasing the force/decreasing the deck capacity by more than 5% and triggering the IBC provisions would have immediately overstressed the deck diaphragm by 25% since IBC-2000 eliminated the ⅓ allowable stress increase for wind loads.

We considered two options: the first option was to add a heavy steel tube frame at each opening to replace the deck strength and stiffness; the second option was to rearrange the units to reduce the strength reduction in the deck and take advantage of the excess strength in the deck at the more lightly loaded edges of each section of deck (the deck fastener pattern varied along the length of the building). It was found to be more cost-effective to rearrange the RTUs and pay for extra ductwork than it was to fabricate and install the heavy tube frames.

Change of Occupancy Example

Chapter 34 uses increased force to existing elements and/or reduced strength to determine when an existing structure needs to meet the requirements of the current building code, but Section 1614.2 states that "When a change of occupancy results in a structure being reclassified to a higher seismic use group, the structure shall conform to the seismic requirements for a new structure." While there are some potential terminology concerns that will be illustrated, this approach raises questions about the intent of the Code, and ways to balance the economic and life-safety concerns involved when renovating existing buildings.

An example using Section 1614.2 might involve renovating an existing office or similar building for use as a police station. The Seismic Use Group (SUG), based on the "nature of occupancy", for the existing Office use is SUG I, appropriate for an "ordinary" hazard to human life. The proposed Police use is SUG III "Essential Facilities". However, the Occupancy is B, Business for both. It could be argued that the building code does not require the existing building to be seismically retrofitted since the Occupancy (based on Chapter 3 provisions) did not change.

However, since the intent of SUG III is that the building needs to be fully functional after a design-level earthquake, wind storm, or snow accumulation, basing the upgrade requirement directly on the SUG or Category from Table 1604.5 rather than the occupancy seems to be a more accurate method to ensure public safety.

Intent of IBC

The intent of the IBC for existing buildings is not clear, and this makes it difficult to achieve a consistent interpretation. Although not directly stated, the IBC appears to intend for existing buildings to be upgraded incrementally as renovation occurs, such that, if all components are eventually altered, renovated, and upgraded, an existing building will eventually conform to the current building code. However, IBC-2000 Section 1614.3 changed from requiring an altered element to meet the provisions of the IBC to requiring "the entire seismic-force-resisting system…to conform to Sections 1613 through 1623 for a new structure" in IBC-2003. This also conflicts with Section 3403.2, which refers only to individual elements. These types of conflicts make it very difficult to get all of the interested parties to agree on what constitutes Code-compliance on individual projects.

Alternative approaches for Further Consideration

IBC chapter 34 uses applied force and/or reduced strength as the sole criteria for determining when an existing building must be "brought up" to meet the current Code provisions, but this does not distinguish between changes that make "unsafe" existing buildings somewhat less safe and minor changes in large structures. Is the public safety increased if an unreinforced brick masonry structure in a moderate seismic area has a shear wall that comprises less than 10% of the total length in one direction replaced with a ductile, steel reinforced, grouted concrete masonry unit shear wall so that a man-door can be installed? Certainly, but probably not sufficiently to prevent the building from collapsing during a Maximum Considered Earthquake, since 90% of the lateral-force-resisting system is entirely inadequate according to current seismic loading and detailing requirements. Similarly, adding a new window, duct penetration, etc. through an existing shear wall without upgrading the structure will make the building less safe, but arguably to an insignificant degree since the existing building might be several hundred percent overstressed (using IBC lateral loads) before any alterations are made.

The approach taken by IBC Chapter 16 and the International Existing Building Code-2003 seems to be a more rational way to determine when to retrofit, since they depend on the SUG of the occupancy to determine the need for updating the structure. Another possible consideration is an economic threshold for the work being done, similar to the "substantial improvement" provisions in Section 1612 Flood Loads. The basis for this method is that an older building undergoing a substantial renovation should be expected to last an additional 50 years, and having it comply with the current building code would be in the best interest of the public.

The goal with an older building undergoing a minor alteration would be to maintain approximately the same level of safety as when it was originally constructed (unless obviously unsafe conditions exist). A progressive approach sealed to the alteration might be taken in such a case: an altered element might require no upgrade (provided that there is a complete load path, for instance), upgrading the element to the capacity prior to the alteration, or upgrading the element to the level of the current building code.

Certainly these types of ideas and others were considered when the IBC was written, but the renovation and alteration of existing buildings affects so many different parties (municipalities, developers, design professionals, contractors, etc.) that it seems reasonable that these parties should be involved in this portion of the Code-writing process. Otherwise, the significant change in code requirements can be an unpleasant departure from what the Owner/Developer/Architect has experienced on past projects.

Conclusions

The IBC has taken a clear position that existing structural elements must be able to support the current IBC-required design loads if renovations and/or alterations increase the load by more than 5% or if there is any strength reduction, but this is a significant departure from prior building codes. Unfortunately, this was adopted into legally-binding building codes throughout the country without much of the design and construction community (design professionals, developers, contractors, and building officials) being aware of the potential implications when combined with the large increases in seismic loading in many areas of the country.

One result of these significant changes is that there have been design professionals, developers, and building officials who "know" the current IBC approach doesn't have any "common sense" when applied to older buildings and, therefore, they interpret the IBC very loosely. A possible scenario is one where an owner retains an architect to determine the feasibility of renovating an existing building and the potential code issues have already been discussed with the local Building Official prior to a structural engineer becoming involved in the project. If the Building Official has already determined that the structural modifications are minor, it can be difficult to convince the Owner that extensive and expensive modifications actually are required. However, the structural engineer of record (SER), not the Building Official, developer, or architect, assumes the liability for the decision to ignore the provisions in 1614, 3403.2, or 3410.

If the actual intent of the IBC is that existing buildings should be substantially upgraded for relatively minor increases in force to existing elements and/or any reduction in existing capacity, it would be very helpful to design professionals, building officials and the general construction community if this would be made more clear so that all parties can have more consistent expectations.

Enforcing the building code as written will make renovating large numbers of existing buildings prohibitively expensive and could hinder redevelopment efforts, particularly in older city centers and former industrial areas. Clearly, this creates a conflict between creating safer structures and redeveloping underused areas, two activities that are in the best interest of the public. Finding the proper balance will require discussion between many different groups, including structural engineers who are represented by several national and many local organizations.

On an individual level, the SER needs to understand the building code requirements and clearly communicate them to the other parties in order to protect everyone on the design team, especially himself or herself. The SER who chooses to dismiss or ignore the extensive retrofitting required by the IBC essentially accepts liability for a building that is not in conformance with the current Code.

A common challenge after the IBC-2000 was adopted was to convince clients that geotechnical engineers had to be brought into a project much earlier than previously because determining the Seismic Site Class was essential. The challenge now might be to convince clients that the structural portion of renovation projects must be considered at the earliest possible point.▪

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