various meetings starting in 2004. At that time the NYC population and especially the structural engineering community were still strongly under the impact of the events of September 9, 2001 and the subsequent FEMA and NIST reports. Introduction of significant new requirements usually faces opposition from developers afraid of potential increases in costs, but these new sections were adopted with minimal negotiations as they covered issues revealed by the recent disaster and that answered directly to the general consensus of increased safety. Of these three additional sections, the Peer Review section was the least subject to controversy. The finalization of the text was delayed by the discussions related to Structural Integrity – Key Element Analysis as previously it had been decided that the scope of both section would cover about the same type of buildings. Note that NYCDOB regulations mandate peer review in several other special cases (grade 100 high strength reinforcing bars, some wind turbine categories, etc.), but these are not discussed here.

The 2014 NYCBC that was adopted in the following code cycle modified the original 2008 text by excluding some types of seven story structures where bearing walls longer than 10 ft. support over 15% of the structure. All further references in this report refer to the 2014 edition of the code.

THE CODE REQUIREMENTS

Under the previous code (1968 NYCBC), the commissioner had the authority to order peer reviews on individual projects but this power had been exercised only rarely. The new section maintained the commissioner's authority to require a peer review when she saw fit, but also made peer review compulsory for several types of buildings.

The 2014 NYCBC Section 1617 Structural Peer Review indicates the categories of buildings that require peer review and specifies the items that need to be subject of the review. The code requirements are complemented by a Building Bulletin (BB 2015-031) that provides some clarifications on the formal procedure for submitting. BB 2015-031 states that the conclusions need to be clear and without any exclusion. The bulletin includes a standard form for the peer reviewer's final statement. Detailed instructions are provided for the specific steps required for those who elect a phased review submission (foundation and superstructure).

There are six categories of buildings that trigger a peer review report including mainly buildings with aspect ratio larger than seven, buildings taller than 600 ft. or with very large areas, stadiums or arenas for over 3000 occupants and essential facilities with of more than 50,000 sqft.

The NYCBC 1617 section lists a minimum of 11 design items that need to be evaluated by the peer reviewer such as compliance with code and engineering practice, conformance with architectural plans and major mechanical installations. The reviewer is supposed to perform a sufficient number of independent calculations to verify adequacy of the design. Verification of compliance with structural integrity provisions is required, but design of cladding and various architectural features are excluded.

SELECTION OF PEER REVIEWER AND DISPUTES

The peer review report is intended to benefit the building owner and therefore, the reimbursement and the selection of the reviewer are left to the owner. Despite recent conglomerations of consulting engineer companies, in New York City there are a good number of engineering companies with principals that meet the high level of technical knowledge expected for the performance of the review – principals from 12 different consulting firms prepared the 38 reports discussed here.

The peer reviewer's qualifications need to be acceptable to the Engineer of Record (EOR). It is most probable that to some extent this procedure allows the EOR to offer selection suggestions to the owner. In fact, we observed that when an engineering company had several projects peer reviewed, the reports tended to have same peer reviewer.

With one exception, it was not observed that the selection process has diminished the quality of the review. The one exception was a complicated project, where when confronted with DOB objections the peer reviewer started to act as an advocate for the project. Up to now, the engineers selected for the peer review were highly regarded in the community and the DOB has not been in position to contest the technical qualifications. In one case the department challenged the qualification because of doubtful New York State engineering registration. This occurred when an owner commissioned a reputed Canadian company to review. To be acceptable, the company had to exercise some special state law provisions that permit use of a temporary New York State professional license.

Aside from being competent in the subject, the reviewer must *not engage in any activities that may conflict with their objective judgment and integrity, including but not limited to having a financial and/or other interest in the design, construction, installation, manufacture or maintenance of structures or components that they are reviewing*. [BB 2015-031]

The present interpretation of this requirement is that there should be no conflict of interest in the particular project. This interpretation is necessary to allow local New York City professionals to collaborate on different aspects of a large project, but not the one under review. This mode of selection resulted in almost no need for the authority (DOB) to intervene in disputes as technical differences in opinion were solved prior to the submittal of the report.

THE REPORT SUBMISSION PROCESS

To start an approval process the first form submitted to the department is the Plan/Work Application. The form requires the applicant to mark a box that flags whether the project meets the code thresholds for structural peer review. The peer reviewer is identified by his New York State professional license number. The structural peer review report can be submitted any time during the plan review period, but the computer system will block final project approval in the absence of an accepted peer review report. In two cases it was found that the applicant failed to indicate the need for peer review. It was found that both cases involved height/base ratios larger than seven, and the error was caused by confusion in determining the building height – unlike architectural or zoning height calculations, a building's structural height is defined to include rooftop structures.

Each report and the accompanying structural set and reports are appraised by the Chief Structural Engineer who can accept or make inquiries on specific aspects. Generally, reviewers follow the BB 2015-031 recommendations to enumerate the design changes made following their initial structural peer review evaluation. The report format also allows the reviewers to note some issues of disagreement but only when such issues or recommendations do not reach a level that would contradict or place doubt on the final finding that the project generally meets the code requirements.

Where the wind loads were determined based on wind tunnel tests, the applicants were required to submit the wind reports. In all cases a soil report had to be submitted.

In NYC, the applications for many construction projects and especially those for new buildings are handled by expeditors, a specialized type of consultants who *submit, file, request, negotiate or otherwise seek the approval of applications for issuance of permits*. Their function is not of owner representative but of intermediaries between owner or professional applicants and the DOB. While they bring value by facilitating the application process, they present a problem when they try to mediate issues raised by the department in connection with peer review reports. The DOB expects technical communications to involve directly the professionals.

The reports are expected to be based on the structural set of drawings submitted to the department, but only rarely do the reports use as basis the final set of drawings. Starting the peer review only when final construction documents are ready would create serious delays. This is acceptable as long as the difference between the sets is limited to details as the review needs to be concerned with the primary structure and not with minor errors or omissions. To establish a baseline all reports are required to list each reviewed drawing, including revision dates. In about 2/3 of cases the applicants used the staged submission process that allowed early start of foundation work.

THE STRUCTURES

At the time when the structural peer review legislation went in effect in NYC there were 51 buildings over 700 ft. in height, including 9 built before WWII. With the exception of one residential concrete structure, all other 50 buildings were steel frame structures with office occupancy. The 2012-17 period under discussion was marked by very strong development in the city, especially for residential construction. For the first time residential skyscrapers reached over 1,000 ft. Residential buildings accounted for over 75% of the reviewed buildings. The height of 22 buildings exceeded 600 ft. and triggered peer review. For the population of peer reviewed buildings, the ratio of concrete to steel structures was about 9 to 1. Almost all of the concrete buildings were flat slabs with shear walls. The lack of available large lots in Manhattan, led to 12 structures less than 500 ft. in height to have ratios over the 7/1 limit that triggers peer review.

The most common foundation solutions involved caissons carried to rock. In a couple of cases it was possible to carry a flat slab foundation to rock. In nearly all cases the design was wind load driven. Overturning was prevented by rock anchors. Buoyancy had to be considered for the few cases where the buildings abutted rivers with corresponding flood potential.

In essence, for the reviewed buildings the main engineering effort was dedicated to limiting wind produced drift and vibrations. Several slender buildings were fitted with damping devices to assure occupant comfort. In no case was a damper used to insure the structural safety of the building and as a result no peer review of the damper was required. During this period no building fell in the review category because of structural design using nonlinear time history analysis or special seismic dissipation methods.

THE STRUCTURAL PEER REVIEW REPORTS

Immediately after the introduction of the code section requiring peer review there have been a number of submittals that contained only a succession of statements testifying compliance with each specific item listed in the section. These type of submittals probably followed procedures allowed by other jurisdictions but in NYC they faced objections from the DOB on grounds that the code actually required a report, not just a statement. In time the firm DOB position was acknowledged and it led to reports with sufficient details to demonstrate the review effort and also allow the department to understand the specific solutions. In many cases the peer review was performed on less than 100% complete documents and attesting adequacy was possible only in terms of "general completeness". Matters like adequacy of dowels or of cramming large amount of reinforcement in narrow spaces were left to the detailers.

Typically reports use tables to display differences in results between EOR and reviewers. Where the reviewer used computer models prepared by the EOR it was expected that the model was independently verified.

When examining the reports, the author was struck by the fact that reviewers never made observations on the design of caissons, piles or rock anchors even when the drawings showed only a simplified section of the caisson or rock anchor. In several cases drawing notes made reference to the soil report for caisson design, but that section of soil report was never reviewed. In other cases the soil report did not offer any specific data and the use of caissons was just a general recommendation. This lack of design of deep foundation elements might have been in line with the NYC construction management practice of bidding out (in post permit stage) design of piles or caisson work, but here it was producing designs that were not complete at the time of the peer review. Despite peer review statements deeming the design complete and code compliant, the department objected in each case and required complete caisson design.

This issue was brought up in a meeting with the structural engineering community. Most of the engineers protested on grounds that geotechnical design was outside their expertise. Their reluctance to review the soil report recommendations might have been a consequence of the terms of their professional liability insurance although the code text does not prevent the peer review to be performed by a team of structural and soil engineers.

In NYC, the typical soil report includes a description of soil conditions (as resulting from various borings and tests), recommendations for foundation solutions and determination of seismic characteristics (Site Class and resulting Seismic Design Category). Lately, as a result of repeated cases of damage to adjoining buildings during excavation, the soil reports include also recommendations for adjoining building protection. Excavation and related work, including details of protection of adjoining structures, are shown in a special Support of Excavation (SOE) set of drawings that might be prepared by the project's geotechnical engineer of record or by a different consultant. This SOE set is not required to be peer reviewed since the activities described do not affect the reliability of the new building. Most other recommendations in the soil report, including those related to seismic design, are capable of influencing the new building's structural reliability. Even more, most cases, especially when deep foundations are involved, the soil report may recommend solutions only in general terms, and these need further design and detailing.

The discussions revealed that the lack of geotechnical peer review stemmed from the following text *Review geotechnical and other engineering investigations that are related to the foundation and structural design and confirm that the design properly incorporates the results and recommendations of the investigations*, [NYCBC 1617] where review was interpreted as read or consult or be familiar with. To clarify and avoid systemic DOB objections, a bulletin is being prepared to direct that every element included in the foundation solution and design needs to be subject to peer review.

For most of the tall buildings the design wind pressure was established by wind tunnel tests. There were only two consulting companies that produced the wind tunnel reports. The principals of both these highly reputed companies had been major participants in the development of the ASCE 7 wind chapters. Nevertheless there were a number of hitches that had to be clarified in their first reports. One wind tunnel company was not aware that the NYCBC was lagging in ASCE 7 version (2014 NYCBC code used a slightly modified version of the ASCE 7-05). This company prepared at least one report that latter had to be revised to match the wind speed levels of NYCBC. It became also necessary to ensure that the EORs used load combinations consistent with the typical 50 years wind specified in the NYCBC (that is, the wind loads were to be multiplied by a 1.6 coefficient for strength design as per ASCE 7-05).

Ideally one would wish that the wind tunnel test reports were peer reviewed, but such requirement is made difficult by the extremely limited number of companies qualified for performing such tests and by the fact they all compete for the same jobs. This concern is alleviated when one considers the condition imposed by NYBC 1609.1.1.2.1 *Lower limits on main wind force resisting system that limit* base overturning moments determined from wind tunnel testing shall not *be less than 80 percent of the design base overturning moments determined in accordance with Section 6.5 of ASCE 7.*

For the tall buildings in our population, the wind tunnel loads hovered around 80% of ASCE and in some cases, several percentages lower. Not all reviewers verified this condition that assures a consistent minimum load for all buildings designed under the code provisions. The department had to raise objections. In only one case the structural peer reviewer demanded a separate peer review of the wind tunnel tests.

DISCUSSION AND CONCLUSIONS

In NYC there are about 300 buildings taller than 500 ft. The list includes several buildings built when the local building codes did not have any prescription for wind or other lateral loads. Another significant number of buildings in this height group were designed only for a constant wind pressure of 20 psf. Excluding façade issues, none of these buildings have known structural problems. Aside an added level of confidence for performance under extreme events, what added benefits does the independent structural peer review bring? As standard texts for peer review mandates are not suggested in national standards, the benefits can be measured only within the jurisdiction that oversees the locally crafted mandate. It is difficult to assess the peer review process in other jurisdictions since information is only accidental. For instance, although the city of Miami has adopted the text originated in NYC, the benefits there might be different.

As a result of a 1975 decision to concentrate examinations on compliance with fire regulations, the NYC DOB had not commonly performed review of structural designs since. Obviously the public expects unique or large buildings to undergo some level of review but the review of the mandated buildings requires a high level of technical knowledge difficult to find in a buildings department. The NYCBC 1617 provisions guarantee that highly competent engineers perform the review. Also given the size of their investment owners are likely to engage equally high competent professionals for the design but it is worth noting that at least in one occasion the review led to significant redesign.

The peer review gives companies the opportunities to analyze and compare each other's drawings and calculation methods. The companies participating in the peer review process gain knowledge from each other and the standards and quality of design are potentially raised. The introduction of advanced properties for concrete and steel that occurred during this period, most likely gained easier acceptance due to the quality of the review process.

The department's expectations cannot become effective mandates without understanding the capacity and the acceptance of the consulting community. Consulting firms want clarity in requirements so they can manage their exposure and liability. From discussions it became apparent that some code texts needed official clarifications.

In the author's opinion without a systematic appraisal of the reports by the agency having jurisdiction, these reports will tend to devolve into simple listings of statements. The DOB evaluation of the reports identified areas (e.g. deep foundation elements) that were not covered by the reviewers. Further assessment of the peer review process needs to concentrate on situations where the specific estimation of extreme loads (seismic or wind) are provided by third parties. It is the agency's obligation to maintain and improve the standard for peer review.

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An Overview of the Changes to AISC 341—Seismic Provisions for Structural Steel Buildings

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ABSTRACT

American Institute of Steel Construction (AISC) document 360, *Specification for Structural Steel Buildings*, is the basic reference for the design, fabrication, and erection of structural steel buildings and other "building-like" steel structures in the United States. When applied in conjunction with AISC 360, AISC 341, *Seismic Provisions for Structural Steel Buildings*, is the standard reference document for the seismic design of steel structures throughout the United States. Balloting is complete to update AISC 341-16 that will be incorporated with ASCE 7-16 and AISC 360-16 into the *2018 International Building Code*. The document will have significant technical modifications including new material specifications, use of steel braced diaphragms, new column splice details, requirements for SCBF gusset plate welds, and application of demands on columns that participate in intersecting frames. In addition, significant new provisions related to the seismic design of multi-tier braced frames will be provided. A new composite shear wall system has also been developed. This paper will summarize the changes proposed for AISC 341-16.

INTRODUCTION

The 2016 AISC Seismic Provisions introduce a number of new and updated provisions while remaining mostly unchanged from the 2010 edition. The overall organization of the standard is the same, with Chapters A-D containing analysis and connection requirements that apply to all seismic force-resisting systems, Chapters E-H addressing moment and braced frame and their composite counterparts, and Chapters I, J, and K covering fabrication and erection, QA/QC, and prequalification and qualification testing. The most significant changes include provisions for multi-tiered braced frames, an option to use partial-joint penetration welds in SMF column splices, and clearer provisions for continuity plates, doubler plates, and associated welding. Other changes include new and updated R_y values, new provisions for horizontal truss diaphragms, a new application of composite plate shear walls using concrete-filled steel panel walls, a requirement to consider simultaneous inelasticity in shared columns in orthogonal seismic force-resisting systems, updated welding requirements for SCBF gusset-plate edge welds, and a few updates to prequalification of moment frame connections.

NEW PROVISIONS FOR MULTI-TIER BRACED FRAMES

Multi-tiered braced frames are defined as braced frames with two or more levels of bracing between diaphragms or locations of out-pf plane support. This type of frame, shown schematically in Figure 1, was considered a K-braced frame in the 2010 Provisions and therefore prohibited. In the 2016 Provisions, this bracing configuration is permitted within the definition of either an OCBF, an SCBF, or a BRBF, and carries an extra set of requirements in each case.

Generally, these requirements include providing a strut in the plane of the frame at each tier level, torsionally bracing the columns, and designing the strut, column, and connections for amplified forces, which might be forces based on the capacity of the brace or on the ASCE 7 overstrength factor. The commentary explains some of the typical issues with this system, including stability of the column and the tendency for inelastic behavior to concentrate in one tier. The commentary also refers to the ongoing research on these systems.

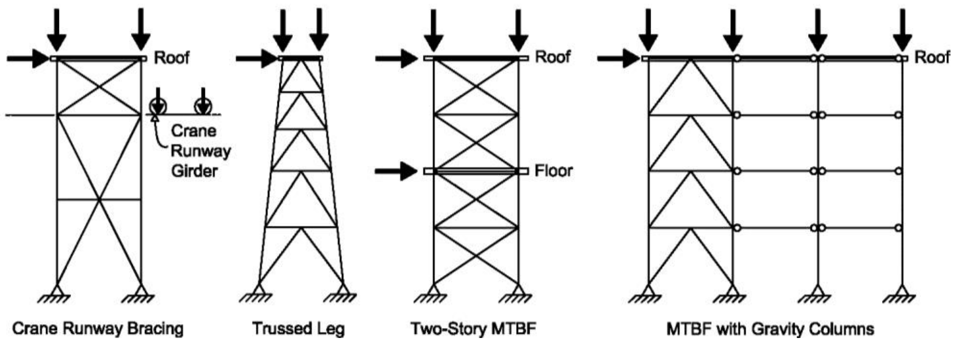

Figure 1. Multi-Tier Braced Frame Configurations

NEW PROVISION FOR PARTIAL JOINT PENETRATION COLUMN SPLICES

Previous to the 2016 edition of the Seismic Provisions, all Special Moment Frame (SMF) column splices, if welded, were required to be complete-joint-penetration groove welds. In the 2016 edition, partial joint penetration (PJP) welds are now permitted, thereby saving significant costs in welding and erection. Section E3.6g includes provisions for this weld, which require that the flange connection have a tapered transition between column shafts and that the effective throat of the weld be at least 85% of the thickness of the thinner flange. The PJP splice provision allows for several options including single- or double-bevel groove welds, depending on the member thickness, and whether web access holes are provided or not. Companion requirements for nondestructive evaluation of these welds are also included. Industry efforts are underway to validate proper approaches to these evaluations, since ultrasonic testing of PJP welds is not routinely done, due at least partially to the difficulty that can arise in interpreting results of the weld scans.

MODIFIED REQUIREMENTS FOR WELDING OF STEEL MOMENT FRAME PANEL ZONES

The 2016 Seismic Provisions clarify reinforcement and welding at SMF panel zones, which is often a difficult location to determine the flow of forces and avoid congestion. First, the decision about whether continuity plates are required more explicitly points to AISC Specification J10 local limit states in the column, although a prescriptive minimum is also required. The flange force, which wasn't specifically addressed in the 2010 Provisions, may be determined by the engineer or according to the User Note in Section E3.6f.1. The thickness of the continuity plate is as required for strength but not less than 75% of the beam flange thickness, whereas in the 2010 Provisions it was required to be 100% of the beam flange thickness for two-sided connections. Also at the panel zone, the requirements for doubler plates are more well-defined, with separate sections with and without continuity plates and whether the doublers are extended beyond or fitted between the continuity plates, as shown in Figure 2. This section of the Seismic Provisions makes reference to AWS D1.8 (AWS, 2009), which now includes a useful prequalified groove weld at the doubler-to-column location as shown in Figure 3.

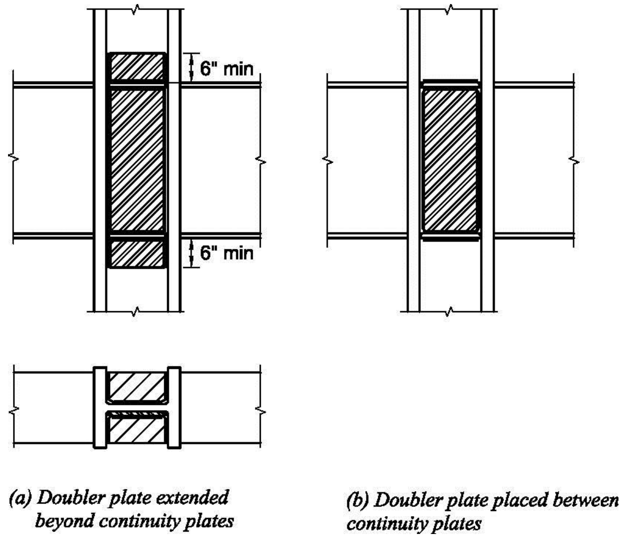

Figure 2. Doubler Plate Configurations

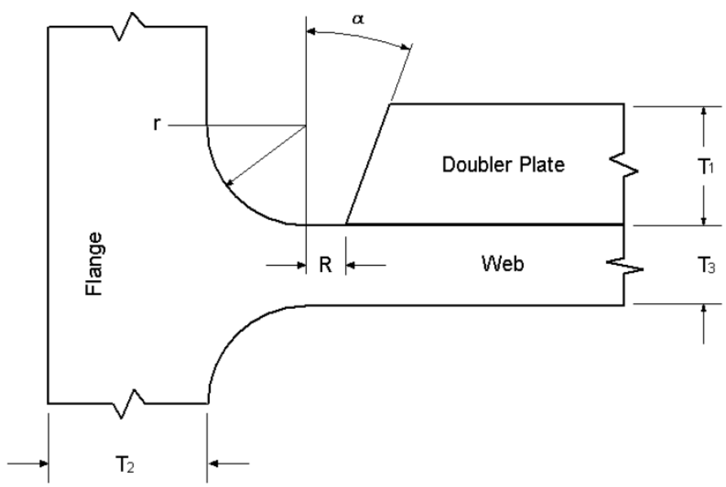

Figure 3. AWS D1.8 Doubler Plate Weld Definition

USE OF ASTM 1085 FOR HSS SHAPES

For the 2016 Seismic Provisions, values of Ry, the ratio of the expected yield stress to the specified minimum yield stress, were reviewed and minor updates and additions have been made. A new ASTM specification for HSS, A1085, was introduced in 2013 and uses Fy = 50 ksi and design wall thickness equal to the nominal thickness. In the 2016 Seismic Provisions, the Ry value for A1085 is given as 1.25 and the Ry for A500 Gr. C has been modified from 1.4 to 1.3. These changes will make HSS more attractive options as the yielding elements in seismic force-resisting systems.

NEW PROVISIONS FOR STEEL BRACED DIAPHRAGM DESIGN

A new Section B5 has been added to address diaphragms, chords, and collectors, and particularly horizontal truss diaphragms composed of structural steel members. The requirements for this truss diaphragm include designing the members and connections for overstrength seismic loads (Ωo), with exceptions for ordinary systems designed as three-dimensional systems, and for cases where the diaphragm truss members are designed to act as yielding elements.

NEW PROVISIONS CONCRETE ENCASED COMPOSITE PLATE SHEAR WALLS

Another completely new section has been added to the 2016 Seismic Provisions: Section H7, on composite plate shear walls – concrete filled (C-PSW/CF). This system is a second application of the C-PSW system, the other being the concrete encased option (C-PSW/CE) as addressed in Section H6. Concrete-filled C-PSW are highly ductile, easily and quickly constructed, and provide redundancy in the building. Two types of wall, with and without boundary elements, are shown in Figure 4.

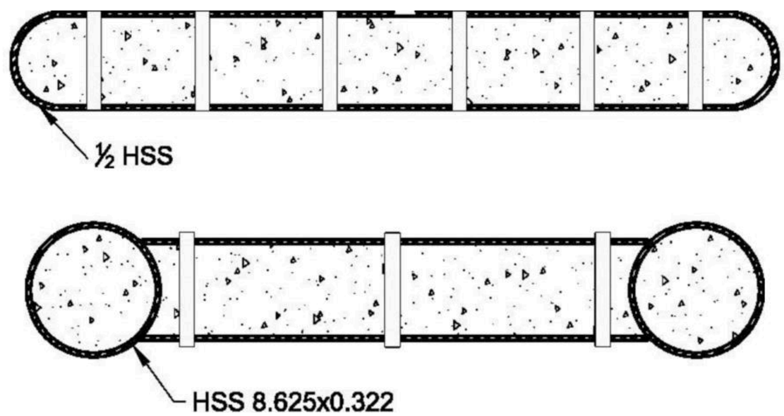

Figure 4. Configurations of Concrete Encased Composite Plate Walls

IDENTIFICATION OF ADDITIONAL CONSIDERATIONS FOR COLUMN DESIGN

Many engineers are familiar with the requirement in ASCE 7 to combine 100% of the seismic forces in one direction with 30% of the forces in the orthogonal direction when a column or other element participates in seismic resistance in both directions. This would be an appropriate approach for elastic response for a "diagonal" event. However, it is recognized that high R factor systems can yield at much lower demands than the elastic response spectrum would imply. The column design could therefore result in a non-conservative size by applying the 100/30 rule. To more properly consider the demands on these columns in steel systems, Section D1.4a of the Seismic Provisions adds that determination of the required axial strength for columns that are common to intersecting frames shall consider the potential for simultaneous inelasticity from all such frames. Columns that are part of ordinary systems are exempt from this consideration. The commentary to this section explains that the possibility of simultaneous yielding of orthogonal frames depends on the configuration and design and the story drift at which yielding is expected. It is likely that low-rise construction may be more susceptible to taller frames, since it is unlikely that all stories of a frame will be simultaneously yielding. A corresponding requirement is included in Section E3.4a for special moment frames when performing the "strong-column/weak-beam" check to ensure that beams are the weaker element.

REVISED PROVISIONS FOR SCBF GUSSET PLATES CONNECTIONS

In Special Concentrically Braced Frame (SCBF) gusset plates where the brace is designed to buckle out of the plane of the frame, the gusset-to-column-flange and gusset-to-beam-flange