For seated connections, the required bearing length for the beam, $l_{b,req}$, is determined as the larger value of l_b required for the limit states of web local yielding and web local crippling. From AISC *Specification* Section J10.2, the required length of bearing cannot be taken as less than k. Typical seated connections have a seat width of at least 4 in. For a gap between the beam end and the column face of ½ in., consider a bearing length of:

$$\begin{aligned} l_b &= 4.00\text{ in.} - \tfrac{1}{2}\text{ in.} \\ &= 3.50\text{ in.} \end{aligned}$$

From AISC *Specification* Section J10.2, the nominal strength of the beam for web local yielding, when the concentrated force is applied at the beam end, is:

$$\begin{aligned} R_n &= F_{yw} t_w (2.5k + l_b) \qquad \text{(}\textit{Spec}\text{. Eq. J10-3)} \\ &= (33\text{ ksi})(0.653\text{ in.})[2.5(1.831\text{ in.}) + 3.50\text{ in.}] \\ &= 174\text{ kips} \end{aligned}$$

Determine the available strength and compare to the required strength:

LRFD	ASD
$\phi R_n = 1.00(174\text{ kips})$ $= 174\text{ kips} > 165\text{ kips}$ **o.k.**	$R_n/\Omega = (174\text{ kips})/(1.50)$ $= 116\text{ kips} > 110\text{ kips}$ **o.k.**

The web local crippling strength is determined from AISC *Specification* Section J10.3. The compressive force is at the end of the member, and therefore:

$$\begin{aligned} l_b/d &= 3.50\text{ in.}/20.0\text{ in.} \\ &= 0.175 < 0.20 \end{aligned}$$

Therefore, the applicable equation for the nominal web local crippling strength is AISC *Specification* Equation J10-5a:

$$\begin{aligned} R_n &= 0.40 t_w^2 \left[1 + 3\left(\frac{l_b}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_{yw} t_f}{t_w}} Q_f \qquad \text{(}\textit{Spec}\text{. Eq. J10-5a)} \\ &= 0.40(0.653\text{ in.})^2\left[1 + 3\left(\frac{3.50\text{ in.}}{20.0\text{ in.}}\right)\left(\frac{0.653\text{ in.}}{0.917\text{ in.}}\right)^{1.5}\right]\sqrt{\frac{(29{,}000\text{ ksi})(33\text{ ksi})(0.917\text{ in.})}{(0.653\text{ in.})}}(1.0) \\ &= 260\text{ kips} \end{aligned}$$

Determine the available strength and compare to the required strength:

LRFD	ASD
$\phi R_n = 0.75(260\text{ kips})$ $= 195\text{ kips} > 165\text{ kips}$ **o.k.**	$R_n/\Omega = 260\text{ kips}/2.00$ $= 130\text{ kips} > 110\text{ kips}$ **o.k.**

Therefore, the existing beam is adequate for web local yielding and web local crippling with a bearing length of $l_{b,req} = 3.5$ in.

A stiffened seated connection can be designed by using AISC *Manual* (AISC, 2017) Table 10-8. Considering a ½-in. gap between the beam end and column face, the minimum required seat width, W, is:

$$\begin{aligned} W_{min} &= l_{b,req} + \tfrac{1}{2}\text{ in.} \\ &= 3.50\text{ in.} + \tfrac{1}{2}\text{ in.} \\ &= 4.00\text{ in.} \end{aligned}$$

From AISC *Manual* Table 10-8, select a seat width of $W = 4$ in., a seat depth of $l = 14$ in., and a weld size of ⅝₁₆ in. The available strength is:

LRFD	ASD
$\phi R_n = 173 \text{ kips} > 165 \text{ kips}$ **o.k.**	$R_n/\Omega = 115 \text{ kips} > 110 \text{ kips}$ **o.k.**

Also from AISC *Manual* Table 10-8, the minimum stiffener thickness is:

$$
\begin{aligned}
t_{min} &= \left(\frac{F_{y,beam}}{F_{y,stiffener}}\right) t_w > 2w \\
&= \left(\frac{33 \text{ ksi}}{36 \text{ ksi}}\right)(0.653 \text{ in.}) > 2(\tfrac{5}{16} \text{ in.}) \\
&= 0.599 \text{ in.} > 0.625 \text{ in.} \\
&= 0.625 \text{ in. controls } \rightarrow \text{use } \tfrac{3}{4}\text{-in. thickness for the stiffener and the seat plate}
\end{aligned}
$$

From AISC *Manual* Figure 10-10(b), the welds between the seat plate and column must have a length of at least $0.2L = 2.8$ in., therefore use 3-in.-long welds.

From AISC *Manual* Part 10, the supported beam must be bolted to the seat plate with high-strength bolts to account for the prying action caused by rotation of the connection. Welding the beam to the seat plate is not recommended because welds may lack the required strength and ductility.

The final design of the strengthened connection using a bolted/welded stiffened seat is shown in Figure 6-39.

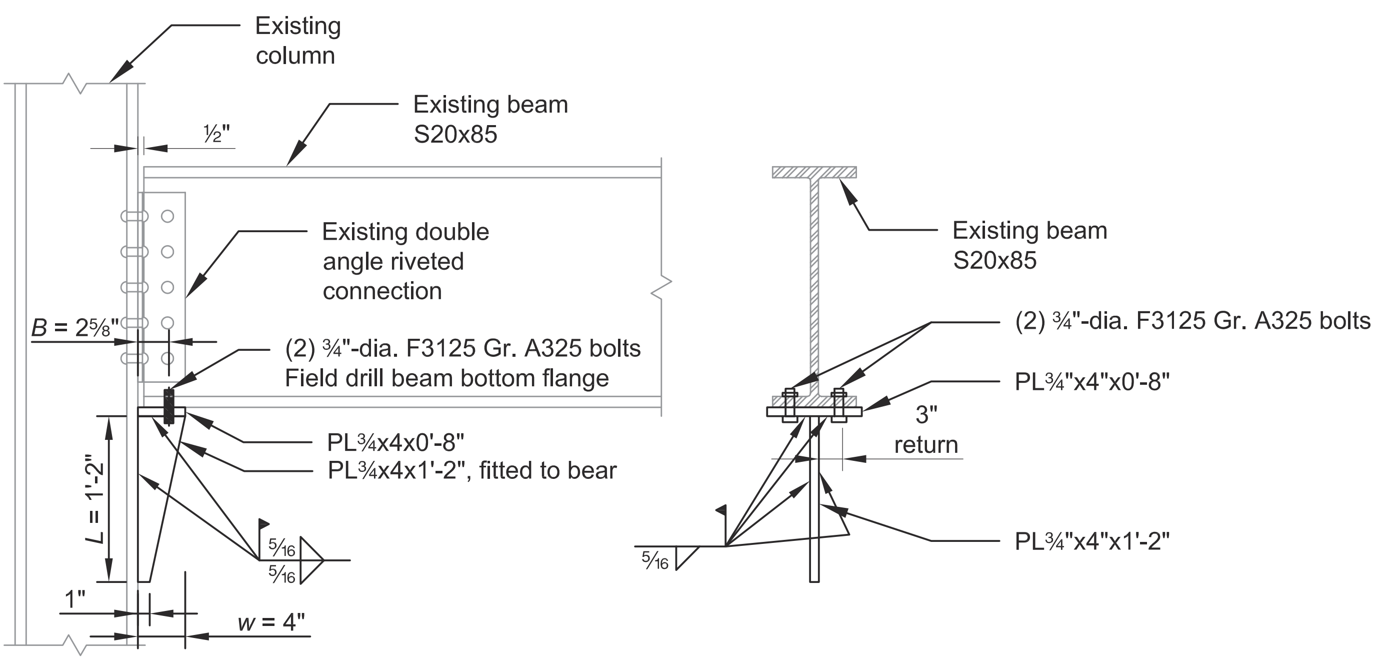

Fig. 6-39. Final connection reinforcement design for Example 6.3.4 using stiffened seat.

Chapter 7
Summaries of References

For the convenience of the user of this Design Guide, summaries of selected references are provided below under three categories: general retrofit, retrofit case studies, and seismic retrofit.

7.1 GENERAL RETROFIT

Avent, R.R. (1992), "Designing Heat Straightening Repairs," *Proceedings of the National Steel Construction Conference*, AISC, Las Vegas, NV.

Summary: Experiments were conducted on heavily damaged steel plates and rolled shapes subjected to heat straightening. Effects of the repair process on tensile properties and residual stresses were determined. Design guidelines were developed regarding the use and limitations of heat straightening with regard to degree of damage, repetitive damage, detrimental effects of steel properties caused by certain heating patterns, and analytical prediction of movement.

Avent, R.R. (1995), "Engineered Heat Straightening Comes of Age," *Modern Steel Construction*, AISC, February.

Summary: Based on completed analytical and experimental studies on heat straightening, basic concepts are presented and heating patterns recommended for repairs. Limitations on temperatures and jacking forces are given. Examples of bridge repairs and cost savings are cited.

AWS (2015), *Structural Welding Code—Steel*, ANSI/AWS D1.1/D1.1M, American Welding Society, Miami, FL.

Summary: Retrofit is addressed in Chapter 8, "Strengthening and Repairing Existing Structures." Subjects covered include suitability of the base metal for welding, design for strengthening and repair, fatigue life enhancement, workmanship and technique, and quality.

Brown, J.H. (1988), "Reinforcing Loaded Steel Compression Members," *Engineering Journal*, AISC, Vol. 25, No. 4.

Summary: A method is developed for calculating the ultimate capacity of a column reinforced under load based on rational analysis but not substantiated by testing. The paper treats the reinforced column as a frame with two members, the reinforcement and the unreinforced column, joined to each other by rigid links. It is shown that both the geometry of the reinforcement and the initial load can affect column capacity.

Dalal, S.T. (1969), "Some Non-Conventional Cases of Column Design," *Engineering Journal*, AISC, Vol. 6, No. 1.

Summary: The author presents a method for determining the compression strength of columns with nonuniform cross section. The equations and tables presented in this paper can be used to determine the strengths of columns reinforced over only a portion of the column length.

Dowswell, B. (2014), "Reinforcing the Point," *Modern Steel Construction,* AISC, January.

Summary: There are several ways to incorporate structural reinforcement into a building or other structure. Sometimes the simplest method is to change the load path by adding new members. If a concrete floor is present, shear connections can be added to engage the concrete in composite action. Another method is the addition of prestressing. Finally, one can employ member reinforcement, which is accomplished by enlarging the member to increase the section properties. Whichever method is used should consider safety and any potential negative effects on the structure during erection. Key factors to consider when reinforcing beams and columns are rviewed, including welding and tolerances.

Gustafson, K. (2007), "Evaluation of Existing Structures," *Modern Steel Construction*, AISC, February.

Summary: Structural documentation of an existing building can help in assessing a structure's capacity and making renovation decisions. Working with existing structures may often seem like a daunting task at the outset. However, if engineers are cognizant of the historical nature of the construction materials and techniques used in the original structure, and are able to take advantage of the tools available in evaluating the structure, they can gain some confidence knowing that they've started off on the right foot.

Hanagan, L.M. and Murray, T.M. (1998), "Experimental Implementation of Active Control to Reduce Annoying Floor Vibrations," *Engineering Journal*, AISC, Vol. 35, No. 4.

Summary: When excessive levels of floor vibration disturb the occupants or impair the function of a facility, repair measures are often sought. This paper discusses the role of damping and the application of active control in reducing unacceptable floor motion. The practical implementation of active control, using an electro-magnetic force actuator in a computer control velocity feedback loop, is also described. Finally, experimental results for two temporary installations, an office floor and a chemistry laboratory floor, are presented to illustrate the effectiveness of the active control scheme.

Hill, R., Conroy, R.D. and Hutchinson, J. (1994), "Welding Solutions for Turbine Generator Plant Repair, Upgrade, and Life Extension," *IEE Conference Publication No. 401*, IEE.

Summary: Opportunities are presented to power generation plant operators and manufacturers by the development of methods for the repair and refurbishment of turbines and ancillary plant equipment. The philosophy and experiences

of the authors are presented to demonstrate the important role that welding plays in the provision of cost effective solutions for ensuing plant availability, improvement of operational integrity, and life extension.

Kocsis, P. (1997), "Strengthening of Existing Composite Beams Using LRFD Procedures," *Engineering Journal*, AISC, Vol. 34, No. 3.

Summary: Discussion of paper by Miller, J.P. The method presented by Miller requires sufficient headroom to add the reinforcement below the existing beam. However, Kocsis presents an alternative method using steel cables located within the beam profile instead.

Marzouk, H. and Mohan, S. (1990), "Strengthening of Wide-Flange Columns Under Load," Department of Civil Engineering, University of Arizona.

Summary: The paper presents the formulation of theoretical and analytical methods for determining the strength of columns that are reinforced under load. The authors find that residual stresses from the welding of reinforcing plates will increase the column strength. The effect is greatest when the welds are closest to the tips of the existing column flanges.

Miller, J.P. (1996), "Strengthening of Existing Composite Beams Using LRFD Procedures," *Engineering Journal*, AISC, Vol. 33, No. 2.

Summary: Often the capacity of an existing composite steel floor beam must be increased, such as to accommodate a change in occupancy. One of the many advantages of a steel-framed structure is the relative ease and economy with which this retrofit can be made. This paper describes a procedure for the rapid direct solution for the required steel reinforcement to be added to resist a given bending moment in such cases. A design aid and example hand calculations are given, using a flat plate or a WT for reinforcement. The procedure is LRFD based but may be used for LRFD or ASD and with solid concrete slabs or slabs on metal deck. [See discussion by Kocsis (1997).]

Nagaraja Rao, N.R. and Tall, L. (1963), "Columns Reinforced Under Load," *Welding Journal*, AWS, Vol. 42, April.

Summary: Tests were conducted on a W8×31 column with a slenderness ratio of 48. The tests showed that welding on reinforcing flange plates, while the column was subjected to a 91.2-kip load, resulted in an ultimate strength no less than the same column reinforced under no load. It was seen that the column strength could be increased by the beneficial effects of an improved residual stress distribution.

Rabun, J.S. (2000), *Structural Analysis of Historic Buildings*, John Wiley & Sons, Inc.

Summary: This text addresses restoration, preservation, and adaptive reuse applications for architects and engineers. Included are the following chapters:

1. Assessment Methodology: Material Chronology, Early Building Laws, and Loads
2. Foundation Systems of American Historic Buildings
3. Historic American Building Systems: Walls and Columns
4. Historic American Floor Systems: Beams
5. Historic American Roof Systems: Lateral Bracing of Buildings
6. The Historic Material Assessment

The author states the following: "The designer in charge of the work must exercise professional judgment in deciding how much analysis is to be done. The recommended approach is to use the modern methods of analysis, the historic member section properties (its geometric properties), and the allowable stresses of the period. This method is still conservative and may require the designer to modify allowable stresses in cases where good engineering judgment permits. For instance, early structural steel allowable stresses were specified at 50% of the yield stress of the material. We have been utilizing two-thirds of the yield value since the 1950s, with remarkable success. Specific design dimensions, character of end conditions, bearing, among other factors, require that certain modifications of allowable stresses be made and engineering judgment is again required."

Rabun, J.S. (2009), *Building Evaluation for Adaptive Reuse and Preservation*, John Wiley & Sons, Inc.

Summary: This text emphasizes evaluation for restoration, preservation, and adaptive reuse applications for architects and engineers. Included are the following chapters:

1. Architectural Character
2. Survey of Existing Conditions
3. Electrical Systems: Background
4. Mechanical Systems
5. Plumbing, Bathrooms, Accessibility and Fire Systems
6. Sustainability
7. Pro Forma Analysis
8. Testing

The author states the following: "An architect and engineer must consider many aspects of any building that is being evaluated for an adaptive reuse project. Careful and precise evaluation of an existing building's structure, systems, and materials are necessary for both design considerations and for financial feasibility analysis. This professional guide to evaluating structural and material integrity of existing buildings covers everything from foundation issues to decorative details, identifying the causes of building failures as well as techniques for repair. The book considers building assessment issues for structures of different scales: midsize commercial, small commercial and residential buildings. Building repairs on adaptive reuse or historic preservation projects are an essential consideration in the financial outlook of a project, and this book details each step in the assessment process in an easy-to-understand way."

Ricker, D.T. (1988), "Field Welding to Existing Steel Structures," *Engineering Journal*, AISC, Vol. 25, No. 4.

Summary: Field welding to existing members is becoming increasingly common. During the recycling of older structures, new performance requirements often necessitate the addition of reinforcing material to increase load-carrying capacity, to restore areas eroded by corrosion, to strengthen fire-weakened members, or perhaps to alter the appearance of a member by changing its shape for aesthetic reasons. One of the many advantages of a steel frame structure is that it can be reworked more readily than structures using other materials. Field conditions are often far from ideal, and it is necessary to ascertain the effects of the fieldwork on the existing structure, especially the common method of attachment—welding. Safety, economic considerations, and the endless search for understanding and refinement require us to seek deeper into the subject of field welding to existing steel structures. The following items merit attention: weldability of existing and new steel, selection and design of welds, anatomy of welds, heat input, position of weld, surface conditions, weather conditions, nature of the load, nature of the reinforcing, shoring and stress relieving, reinforcing connections, effect of field alterations on entire structure, fire hazards and precautions, and testing and inspection.

Ruddy, J.L. (1987), "Reinforcing In-Plane Structural Elements," *Proceedings of the National Engineering Conference and Conference of Operating Personnel*, AISC, New Orleans, LA.

Summary: This paper examines the various alternatives available to a structural engineer when confronted with the problem of reinforcing the beams and girders of an existing floor. The floor was analyzed by both methods, allowable stress design (ASD) and load and resistance factor design (LRFD). Four different types of bottom cover plates were tried using three approaches: (1) maintain the extreme fiber stress at or below the specified allowable, recognizing dead load (ASD), (2) shore to relieve dead load stresses and maintain the extreme fiber stresses below specified allowable stresses (ASD), and (3) neglect the existing dead load stress and ensure the plastic moment capacity of the section is adequate (LRFD). The paper discusses the results of the study and the significance of the assumption in each of the solutions.

Spraragen, W. and Grapnal, S.L. (1944), "Reinforcing Structures Under Load," *Welding Journal*, AWS, Vol. 23, Research Supplement 65-S, February.

Summary: This early article suggests that a safe condition exists in a reinforced member as long as the maximum stress in the original member does not exceed 4⁄3 of the average stress in the combined section. The average stress in the combined section is limited to the usual allowable stress for the member.

Tall, L. (1989), "The Reinforcement of Steel Columns," *Engineering Journal*, AISC, Vol. 26, No. 2.

Summary: The author addresses the reinforcement of columns under load. Methods include the addition of cover plates, changing the residual stress distribution across the column cross section, or both. For columns carrying design loads, reinforcement is both possible and safe. The strength of columns reinforced under load and reinforced under no load is identical. The maximum effect of reinforcement is obtained when the reinforcing weld is as close as possible to the edge of the flange of the base shape.

Thornton, C.H., Hungsproke, U. and DeScenza, R.P. (1991a), "Vertical Expansion of Vintage Buildings," *Modern Steel Construction*, AISC, June.

Summary: An understanding of the design practices employed in the past can greatly simplify a renovation project. Review of as-built drawings, field observations and measurements, and comparison of analysis methods and codes used at the time of construction with present requirements, are all important. The writers divide the 20th century into six vintage periods and characterize design practices.

Tide, R.H.R. (1987), "Basic Considerations when Reinforcing Existing Steel Structures," *Proceedings of the National Engineering Conference and Conference of Operating Personnel*, AISC, New Orleans, LA.

Summary: This paper discusses the key issues that must be considered to arrive at a solution that is practical and safe to implement, and at the same time reasonably economical. Field conditions often present a less than ideal working environment, and limitations on the length of shutdown time may also be a factor. Attaching reinforcement components by welding to existing members poses several problems. The pertinent items to be considered when retrofitting existing structures are identified. An evaluation of the distribution of forces in both the original member and new components is discussed.

Tide, R.H.R. (1990), "Reinforcing Steel Members and the Effects of Welding," *Engineering Journal*, AISC, Vol. 2, No. 4.

Summary: The author reviews and disagrees with several papers that propose methods for designing reinforcement for columns under load. The author suggests that the following questions should be addressed in the design of reinforcement: (1) Are current and future loads static or cyclically applied? (2) What is the ratio between the in-situ load and the original design load? (3) What is the type and condition of the steel? (4) Is local buckling a possibility? (5) How does the stability of each individual compression member affect the overall stability of the whole system? (6) What safety factor must be maintained during the reinforcing operation?

Tide, R.H.R. (1998), "Integrity of Structural Steel after Exposure to Fire," *Engineering Journal*, AISC, Vol. 35, No. 1.

Summary: This paper describes procedures for evaluating steel structures exposed to fires. The writer confirms in his conclusions that, if a member is still straight after a fire, the steel is okay.

Wu, Z. and Grondin, G.Y. (2002), "Behaviour of Steel Columns Reinforced with Welded Steel Plates," Structural Engineering Report 250, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, Canada.

Summary: This paper presents the result of a parametric study of 317 finite element models of steel columns reinforced with steel plates. The authors find that the slenderness and initial out-of-straightness of the columns are important factors in determining the strength of the compression members. The column load prior to welding of reinforcement, or preload, did not significantly affect the strength of the reinforced columns.

7.2 RETROFIT CASE STUDIES

Agassi, N., Kamen, S., Keaveney, D. and Agassi, O. (2008), "Inspired Innovation," *Modern Steel Construction,* AISC, February.

Summary: This 1929 12-story New York hotel was built with a terra cotta façade. Usage had changed to include commercial space on the first floor and residential apartments above. Initial façade inspection identified two main issues: the extensive spalling of the salmon exterior brick and the deterioration and instability of the building parapets. Subsequently discovered was severe corrosion of the spandrel steel at the main roof level and a spalling roof cinder concrete slab, which was supported by the corroded structural steel frame. Load reduction was achieved by implementing a plan to eliminate 3 in. to 15 in. of cinder fill used to slope the roof toward the roof drains, approximately 3 in. of cinder concrete topping, and 2 in. of built-up roofing. This was accomplished by adding 13 more drains in addition to the two original drains and by using a waterproofing membrane that did not require the roof to be sloped. Further details are described in the article.

AISC (1991), "Schoolroom Expansion," *Modern Steel Construction*, American Institute of Steel Construction, October.

Summary: A steel-framed high school built in the 1960s was easily expanded to accommodate large science classrooms. The school district wanted to convert several small classrooms into larger laboratory spaces. The plan was to add six 32- × 20-ft bays to the first floor and leave the second floor alone. The solution was to fabricate trusses from hollow structural sections, weld them to the existing line of columns, then remove every other column in the first floor wall.

AISC (1992b), "Special Design Isolates Vibration," *Modern Steel Construction*, American Institute of Steel Construction, January.

Summary: Almost all of the construction for a large expansion of a hospital surgery building in Illinois was to occur over occupied space while the hospital remained fully functional. To eliminate noise and vibration to the space below, the designers developed a special stub column consisting of a hollow structural section topped with a neoprene pad. These short columns were installed directly over the existing concrete columns, and the new steel columns were erected on top.

AISC (1992c), "Historic Expansion," *Modern Steel Construction*, American Institute of Steel Construction, March.

Summary: The conversion of a former Albany, New York, museum to office space required the addition of mezzanines to increase occupancy space and improve acoustics. A 520-ft long, load-bearing Corinthian colonnade, reportedly the world's largest, distinguishes the five-story 1908 building. In this project, the fifth floor, which had been a museum for many years, was converted to office space. Mezzanines were inserted into each of the three exhibit wings to increase usable space. To support them, columns were extended and outriggers attached. Heavy nonstructural concrete floors were removed and replaced with lightweight concrete to reduce dead weight. To reduce vibrations, weight was added to the mezzanines at critical locations.

AISC (1992d), "Renovation without Disruption," *Modern Steel Construction*, American Institute of Steel Construction, March.

Summary: A walkway connection between the ninth floor of an existing building and two new buildings had to be constructed with minimal worker disturbance. It was determined that an opening could be made in the end walls of the existing building, but vertical bracing was needed for seismic Zone 2 compliance. This included adding bracing between the ninth and tenth floors to form hat trusses running the width of the building to increase overturning resistance. The final solution utilized bolted Vierendeel trusses.

AISC (1992e), "Updating a Sports Institution," *Modern Steel Construction*, American Institute of Steel Construction, March.

Summary: The renovation of Madison Square Garden included adding skyboxes and a sky-lobby, constructing a mezzanine over a taxi plaza, and enlarging a theater. This had to be accomplished without disrupting the many scheduled events. The Garden's design features a 425-ft-diameter cable-supported roof, which was designed with a larger safety factor than current codes require. Therefore, to provide column-free space, it was possible to hang the new sky-boxes and sky-lobby from the existing cable structure. The new mezzanine was also hung but, in this case, from existing overhead girders.

AISC (1993b), "Top-Down Construction Renews Historic Construction," *Modern Steel Construction*, American Institute of Steel Construction, January.

Summary: Converting a deteriorated office building into a new parking facility while retaining its elegant brick bearing wall exterior required the coordination of the entire building team. This five-story 1868 Syracuse office building was converted into six levels of parking while the exterior was restored to its original condition. To accomplish this, the team decided to remove one bay around the periphery of the structure and replace it with a steel frame, then remove and replace the rest of the structure. To keep the exterior wall braced, they threaded columns through the roof, inserted beams through window openings, and built the outside bay from the top down while continuously keeping the rest of the internal wood structure intact.

AISC (1998b), "Bombs Away," *Modern Steel Construction*, American Institute of Steel Construction, February.

Summary: This radical renovation included a seismic update and a complete cosmetic makeover to an existing 50-year-old, one-story, unreinforced masonry building near downtown Los Angeles. The unusual design called for deactivated World War II bombs that appeared to penetrate glass windows without visible support. Unusual steel space frames were key parts of the renovation.

AISC (1999b), "University of Northern Iowa Air Dome Retrofit, Cedar Falls, Iowa," *Modern Steel Construction*, American Institute of Steel Construction, June.

Summary: The UNI-Dome, completed in 1975, was the first indoor stadium with a full-size, air-supported fabric roof system. Removal of heavy snowfalls from such domes has proven to be a major drawback and, in this case, led to a rip in the fabric and deflation. The retrofit consisted of a system of arch trusses with tensioning cables. There are four main arches, 400 ft long, and 16 secondary arches, 107 ft long. The structure's periphery was prestressed with post-tensioning cables to form a tension ring. This project was a Merit Winner in AISC's Engineering Awards of Excellence program.

AISC (2000a), "Carmel High School, Carmel, Indiana," *Modern Steel Construction*, American Institute of Steel Construction, March.

Summary: A durable steel-framed system was selected to replace a deteriorating wood bowstring truss roof structure over a gymnasium. Curved W36×170 beams were erected 10 ft above the existing roof to achieve a tied arch configuration over a 176-ft span. Construction was carefully planned so that the basketball season was unaffected. This project was a Merit Winner in AISC's Engineering Awards of Excellence program.

AISC (2000c), "Pacific Place, San Francisco, California," *Modern Steel Construction*, American Institute of Steel Construction , March.

Summary: This project was a major reconstruction and seismic upgrade of a Category 1 historic building. When built in 1908, it was the largest concrete office building in the United States. The structure was a ten-story nonductile concrete frame, 192 × 144 ft in plan, with columns on a 16- × 16-ft grid. To provide prime retail space, the lower four stories were completely demolished and three floors reconstructed in their place. Of the original 86 columns, 74 were removed, 12 were strengthened, and 15 new columns were added. Concrete shear walls and steel-braced frames were mixed in the seismic upgrade. Friction dampers were added, utilizing sandwiched brass shims, pretensioned bolts, and slotted holes. This project was a National Winner in AISC's Engineering Awards of Excellence program.

Andrews, W.A. (1991), "Renovating for the Future," *Modern Steel Construction*, AISC, January.

Summary: An eight-story building in Oakland, California, was damaged by the Loma Prieta earthquake. It had been constructed in two phases, beginning in the 1920s with a three-story concrete frame and shear wall structure. In 1956, an eight-story steel frame structure was built adjacent to the existing structure, with two stories extending over and supported on the old concrete structure. For compatibility, a concrete shear wall was added in the bottom three stories of the steel building. To provide lateral bracing for the penthouse, X-braces of hollow structural sections were welded to the existing framing. Some beam-to-column connections were strengthened by fillet welding plates to the beam flanges and complete penetration welding to the column. Various other retrofits were also made to bring the lateral system up to 1988 UBC requirements.

Aniol, R.J. and Platten, D.A. (2002), "Bear Heights," *Modern Steel Construction*, AISC, February.

Summary: Floyd Casey Stadium, home of the Baylor Bears, recently completed a major upgrade to help the Waco, Texas, university's football program remain competitive. The renovation increased the stadium's capacity to 50,000 seats while also providing VIP suites and new areas. The existing concrete skybox floors were left in place. New skybox floor framing was hung from ten 9-ft-deep, cantilevered vertical steel truss bents, extending the skybox floor area in all four directions.

Arbitrio, V., Goya, R. and Hausch-Fen, J. (2008), “Stepping Back in Time,” *Modern Steel Construction,* AISC, October.

Summary: A complete renovation of an existing six-story building was necessary to meet the needs of an academic facility. The first and second floors were retrofitted and adapted to house various exhibition and study rooms. The remaining floors, which had suffered both poorly conceived and poorly executed alterations, required significant work and creative redesign for adaptive reuse as a library and offices. To maximize the ceiling height in the second floor exhibit space below the library, a new third floor was built, and W24×68 or W24×76 girders were fabricated to transfer the new library columns to the original building columns below. Steel was also used to reinforce much of the original structure to accommodate new loads.

Ayoubi, T. and Calafell, R. (2009), “Stealing the Show,” *Modern Steel Construction,* AISC, October.

Summary: The flexibility of structural steel and tensile fabric combined to allow the rapid replacement and expansion of a landmark amphitheater. The requirement of creating a large open space using members with long spans made structural steel an ideal material for both the original and expanded structures. Laced steel struts and masts were used to ensure the feeling of openness under the canopy, to minimize impact on the sightlines, and for acoustical purposes. In addition, the use of structural steel improved constructability of the project, as members were fabricated in the shop and lifted into place in the field using a tower crane. With the complex geometry of the structure, the construction process was like putting together the pieces of a puzzle—everything had to fit together perfectly. Installation of the 13 fabric panels (82,000 sq.^{2}) was completed over a 51-day period ending less than a week before opening night.

Bouffard, T.A. (1993), “Urban Transformation,” *Modern Steel Construction*, AISC, April.

Summary: An addition to a nearly half-century-old department store allowed the creation of a modern urban mall in Silver Spring, Maryland. The final design utilized the lower four stories of the existing concrete structure for retail space and the upper two stories for office space. Also, a large five-story horizontal addition was erected with retail space and a theater. Steel was chosen as the structural system because of the flexibility it offered in design.

Brown, G.O. and Dolf, T. (2004), “Capitol Improvements,” *Modern Steel Construction*, AISC, September.

Summary: A design-build effort topped off Oklahoma’s nearly 90-year-old State Capitol building with a crown of steel. Prior to architectural design and engineering, the existing condition of the Capitol was verified by a detailed structural exploration using historical information. Existing framing members and structural systems were verified, core samples were taken, and steel reinforcing bars were removed for testing. The general plan consisted of an 80-ft-diameter exterior dome rising 140 ft high above the existing roof. The dome would be capped with a 17-ft-tall, 6,000-lb bronze statue. The concrete ring-beam from the existing dome served as the base for the new structure’s 48 columns. Since designing and constructing a dome on an existing Capitol had not been attempted in the United States since the U.S. Capitol in 1865, this was a once-in-a lifetime project.

Buell, E. and Carroll, D. (1998), “Rebuilding Wood Trusses with Steel,” *Modern Steel Construction*, AISC, January.

Summary: Moisture damage to structural elements required an innovative solution to preserve a historic structure. The original wood trusses in the 1909 administration building at Kentucky State University were creeping and deflecting, causing large cracks in the drywall of the second floor and ceiling. The retrofit included new steel trusses, built inside the chords of the existing trusses, one at a time. The new members were inserted through small temporary openings in the finished roof.

Calabrese, F. (2006), “Holding Court,” *Modern Steel Construction*, AISC, July.

Summary: A late 19th-century warehouse provided the framework for a modern courthouse. The structure of the original building consisted of perimeter brick masonry walls, which carry their own weight but little of the floor and roof loads. A framework of structural steel beams, girders and columns supported segmental clay tile arch floors. Foundations of the masonry walls and columns were constructed with stone blocks, with pyramid-shaped isolated footings for the columns. The original steel members were typically built-up sections, with rolled sections present only at the roof structure. The built-up beams and girders consisted of flange angles riveted to web plates. The existing columns were Phoenix columns, a historic, proprietary design consisting of flanged quarter-circles riveted together. In addition to a new atrium façade, roof, and floor framing, steel was also used to frame the mechanical penthouse. Welding to the existing steel required special considerations for members where relatively high amounts of phosphorous and sulfur were found.

Cedro, R. (2004), “Green Again,” *Modern Steel Construction*, AISC, February.

Summary: The renovation of an innovative 1970s building in Zeeland, Michigan, demonstrates a commitment to sustainable design with its Gold-level LEED™ rating. Preservation and internal expansion of the building shell was central to the design and sustainability strategy. The existing steel structure was extended to deck over acoustically troublesome double-height spaces, creating additional office square footage. Steel’s inherent flexibility, lightness, quick erection, and ability to be erected in tight spaces allowed this phase of construction to remain on schedule. The steel members did not require a fire-protective coating, but sprinklers and an integrated alarm system were added to the building.

Chhibber, K.L. (1992), "New Roof Enclosure Extends Plant Life," *Modern Steel Construction*, AISC, December.

Summary: Putting a new roof on top of an existing boiler plant superstructure reduced life cycle costs. The original roofs were suspended 200 ft above grade from a superstructure, and leakage was causing deterioration. In the retrofit, the superstructures were enclosed with new steel roof framing, standing seam metal roofing, and partial siding.

Conway, G. (2000), "Yale Music Library Addition," *Modern Steel Construction*, AISC, January.

Summary: In this innovative expansion project, an interior courtyard was converted to an attractive three-floor space for library facilities. The architectural focal point of the new addition was the roof structure erected over the old courtyard. It was designed to resemble the gothic window and arch shapes in the original building. Six 10-ton exposed arch-trusses, with bottom chords made up of tapered and curved plates, were designed to span the 53-ft courtyard.

Cook, M. (2008), "Shining Through," *Modern Steel Construction,* AISC, June.

Summary: A recent renovation project in Dresden, Germany, sheds new light on the interior of the city's Main Station. Dresden Main Station is one of the grandest and busiest pre-war train stations in Germany. The vision was to replace the vast but gloomy spaces over the tracks with a soaring, translucent fabric roof and bring additional light into the station. A structural overhaul was necessary so that the new roof would not add excessive loads to the fragile supports, which had suffered damage at the end of World War II and inadequate repairs in subsequent years. To support the loads from the membrane roof, much of the steel had to be repaired or replaced, including entire bays of arches.

Covi, L. (2014), "National Treasure," *Modern Steel Construction,* AISC, September.

Structural renovations brace the 1881 Smithsonian Institution's Arts and Industries Building for the future. With knowledge of the original construction time frame, the architects were able to successfully depict an overwhelming majority of elements, despite the fact that many were hidden in three to five wythes of masonry. A new roof framing structure was designed to support the additional weight of a new roofing system and to improve seismic, wind, blast and snow load performance.

Dannels, D. (2015), "Off the Grid," *Modern Steel Construction,* AISC, February.

A vertical addition to a university building was offset from the building below to meet site requirements. HSS members terminated by welded T-sections serve as diagonal truss webs. At the top ends of the diagonals, connections were concealed above finished ceilings and the webs welded to gussets to allow for field adjustment.

Daw, M.J. and Weko, A.G. (2014), "Rescue Mission," *Modern Steel Construction,* AISC, December.

A carefully restoration was made of an historic building in the wake of a devastating earthquake. Steel was used to reinforce damaged heel joints in the attic's timber roof trusses. New internal steel framing was added in the partially deconstructed tower.

DeBartolo, J., Jr. and Moson, F.B. (1980), "On-Site Development Optimizes Hospital Efficiency," *Modern Steel Construction*, AISC, February.

Summary: The original buildings of this hospital in Tucson were constructed before 1880 and were the first such facilities in Arizona. Expansion called for four new stories with a connection to the old hospital. The second story of the addition was planned to facilitate the mechanicals. The interstitial space was contained between the top and bottom chords of steel trusses, fabricated with wide-flange chords and hollow-structural-section webs.

DeBoer, C.J. (1989), "Trinity Church Good for Another 250 Years!" *Modern Steel Construction*, AISC, January.

Summary: A heavy timber frame building built in 1726 was reinforced with steel. The work had to be completed without onsite welding due to the fire hazard. After rehabilitation, the wood frame had to carry only its self-weight, as the new steel frame resisted the wind loads.

DeOliveira, C., Gray, M. and Verhey, T. (2014), "Jacks of All Trades," *Modern Steel Construction,* AISC, March.

Summary: A former factory in an historic industrial area becomes a new office tower in a revitalized entertainment district, thanks to a unique structural support system inspired by children's jacks. Cast steel nodes were used to connected multi-story delta frames.

Douglass, D.C., Andrews, C.M. and Pollak, B.S. (2003), "Home Court Advantage," *Modern Steel Construction*, AISC, January.

Summary: Teamwork was the key to a high-speed roof replacement at Clemson University's Littlejohn Coliseum. In spring 2002, the 34-year-old stadium was in the midst of a renovation when it was discovered that the roof was damaged to the point that it could no longer function safely. Confronted with an enormous challenge to solve before the next basketball season, a team of engineers, fabricators and erectors removed the stadium's roof and replaced it with a new one, in just over three months.

Ennis, M. (2001), "Steel Revives Historic Structure," *Modern Steel Construction*, AISC, January.

Summary: This article describes the restoration and