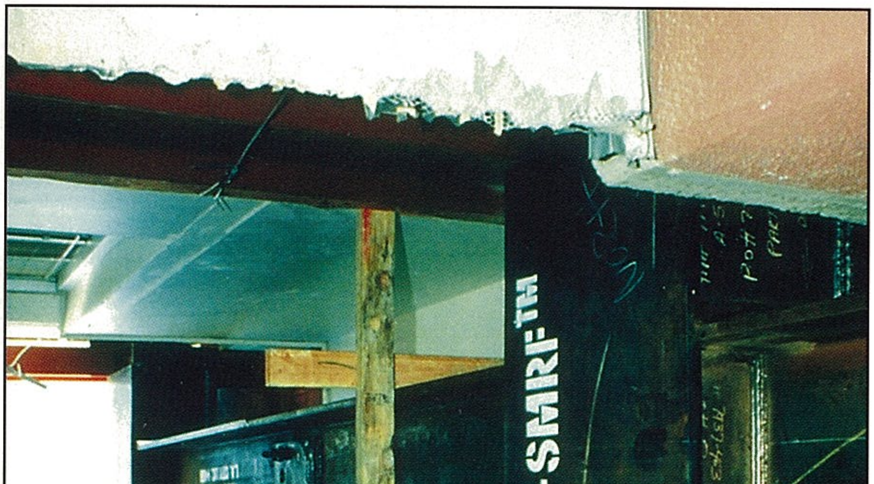
PROPRIETARY SOLUTION

One remedy for special moment-resisting frame problems is the use of a system developed by MNH-SMRF



Actual installation of MNH-SMRF connection showing a two-story, two-sided frame column.

By Ronald F. Nelson, S.E.

ON THE DAY OF THE NORTHRIDGE EARTHQUAKE, JANUARY 17, 1994, THE COUNTY OF LOS ANGELES HAD APPROXIMATELY 3 MILLION SQ. FT. of health care replacement and court facilities in either the final design phase or the final stages of plan check. These facilities were all designed using steel special moment-resisting frame (SMRF) pre-Northridge connections. However, the widespread discovery of premature brittle SMRF connection fractures following the Northridge earthquake left the County with an urgent need to quickly find an alternative design system.

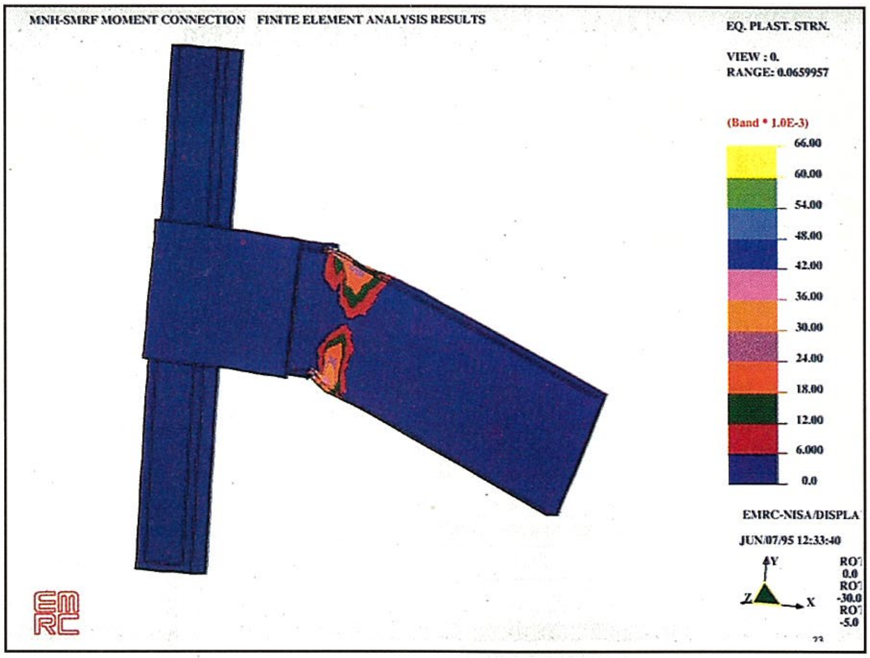
County engineers recognized that changing structural systems to a braced system (eccentric or concentric) was an acceptable technical alternative and would immediately resolve the structural problem. Unfortunately, the use of bracing members would drastically limit the flexibility of the programmed use of the facility for the life of the building, as well as immediately trigger the redesign of architectural and MEP systems with the associated expense and schedule/fiscal impact. Therefore, the search for an acceptable SMRF connection system became the most viable choice for resolving the crisis.

SEARCHING FOR SOLUTIONS

The swift actions by local jurisdictions and code agencies to abandon the pre-Northridge SMRF connection and prohibit its continued use only compounded the County's predicament. By September 1994, a solution still did not appear evident. Since that time, a number of modified connection alternatives have emerged, such as the MNH-SMRF System.

MNH-SMRF Systems, Inc. approached County officials in November of 1994 and presented their MNH-SMRF™ connection system. This proprietary system is designed to eliminate the major contributors to the brittle failures experienced in the Northridge earthquake: It eliminates the through-thickness loading of the column flange; eliminates the T-joint configuration complete joint penetration (CJP) groove welds and related adverse triaxial stress concentrations; and eliminates notch effects created by backing bars. The rotational performance achieved by the MNH-SMRF™ connection does not depend on column panel zone participation. Recent tests by university researchers indicate that current code limitations on panel zone strengths and stiffness are inadequate (Yang, Popov, UBC/ EERC -95/08).

The County stipulated that if full-scale prototype cyclic testing achieved or exceeded industry standards, and if this performance could be corroborated by three-dimensional non-linear finite element analysis and backed by a design methodology, they would introduce their design professionals of record to the MNH-SMRF™ connection technology and would request their evaluation of its use to resolve this SMRF connection problem. Three full-scale prototype specimens were fabricated by AISC-member Herrick Corp. in December 1994 and cyclic tests were conducted at the Charles Powell Structural Research Laboratories at the University of California, San Diego, under the direction of Professor Chia-Ming Uang. The test specimens were heavily instrumented at key locations, and consisted of a W36 x 150 beam connected to a W14 x 126 column with $1^1/_4$-in. side plates and $^3/_4$-in. fillet welds. According to Uang: "All three identical full-size specimens dissipated a significant amount of energy...no brittle failure in weldments or heat affected zones was observed, the average plastic rotation capacity was 5.2% radians...the activity of energy dissipation and the resulting failure were confined to the beam." The plastic rotational performance far exceeded the current industry standard of 3% radians.

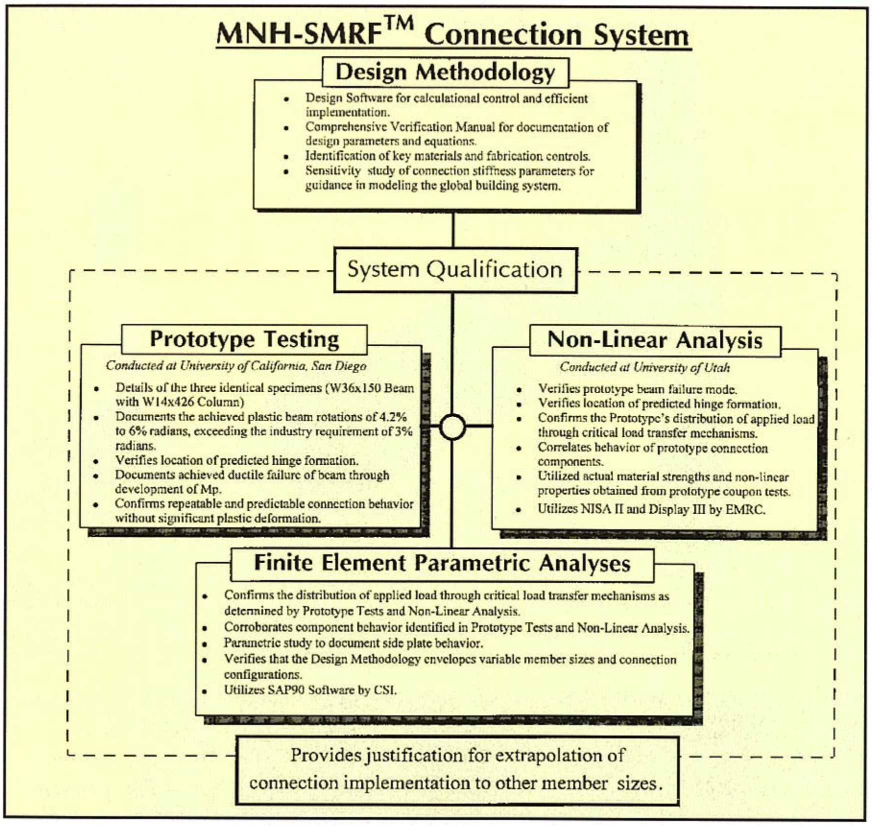


Above: Non-linear finite element analysis results, plastic strains at failure.

Left: Full scale test specimen showing beam hinge formation.

A three-dimensional non-linear finite-element analysis, using EMRC NISA II and Display III software, of the prototype test specimen was performed at the University of Utah, Department of Civil Engineering, under the direction of Professor Janice J. Trautner, who concluded "the non-linear finite element analysis of the prototype MNH-SMRF moment connection demonstrated the ability of the beam to develop a ductile mode of failure without significant yielding of the connecting elements."

MNH-SMRF Systems, Inc.'s development of a complete and clear design methodology satisfied the County's final requirement. Connection design software has been developed using the Microsoft Excel spreadsheet format for calculational control and efficient implementation. A detailed software user's manual is provided to the structural engineer of record. Electronic

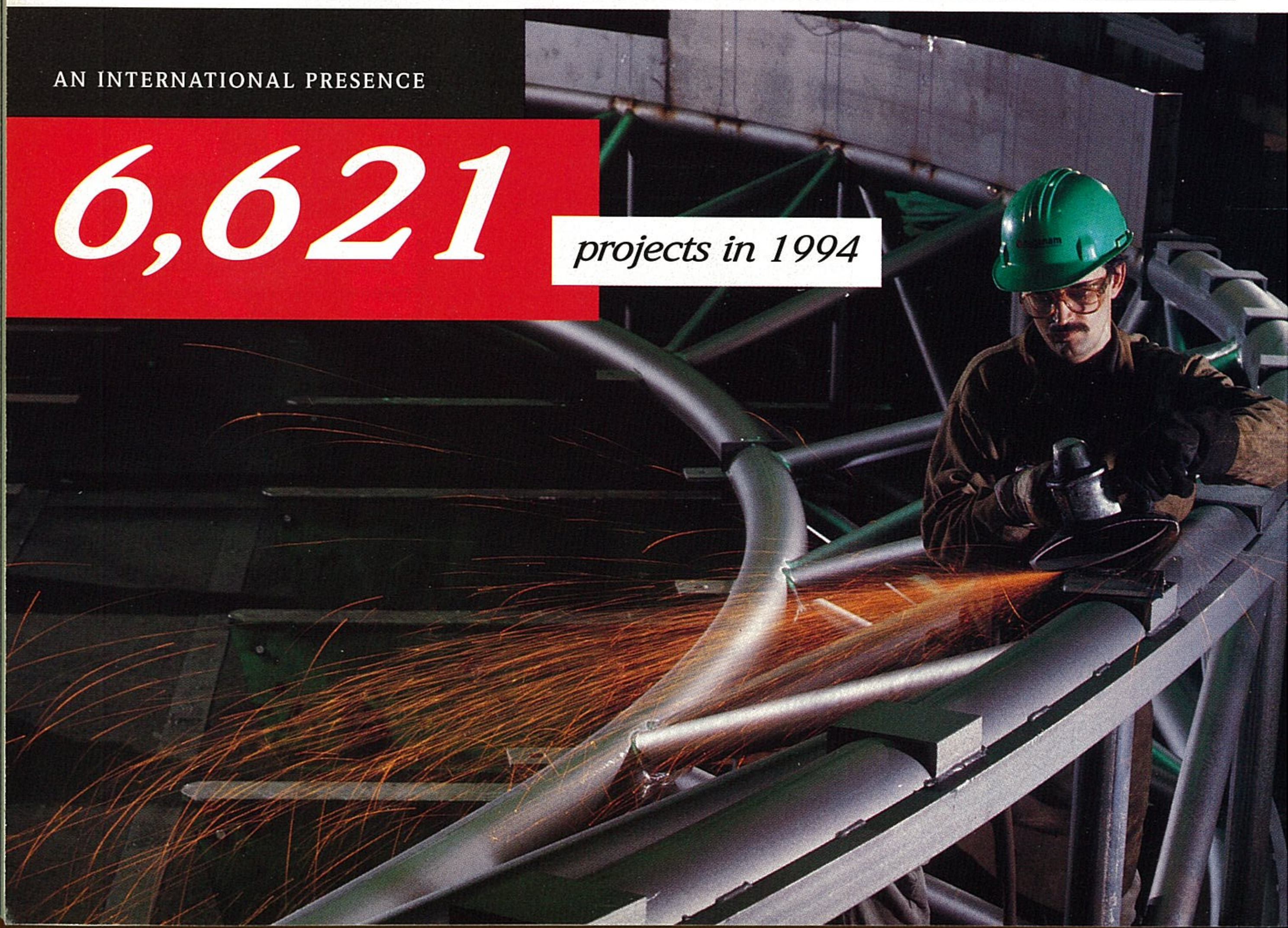


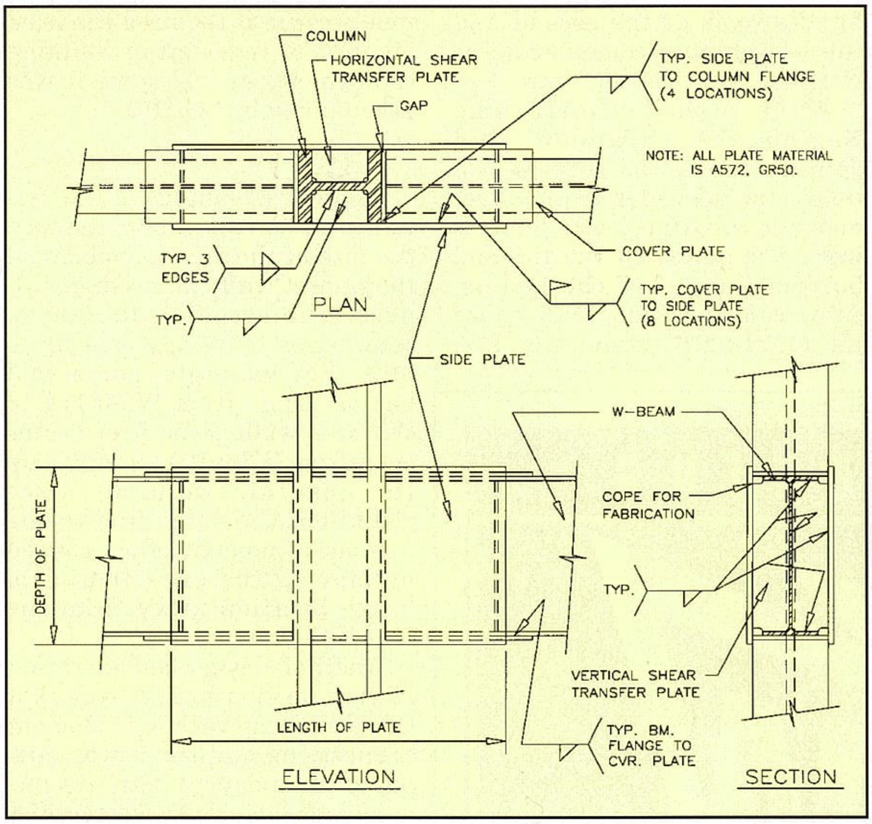
AutoCad files have been prepared to standardize and facilitate the detailing and scheduling of the connection system. The drawing package includes a detailed structural specification for fabrication and erection. The structural engineer is also provided with the results of a sensitivity study of connection stiffness parameters to provide user guidance in modeling the global building system.

The connection system was subject to extensive review and scrutiny by county engineers as well as renowned independent technical advisors and has undergone and successfully passed the acceptance process of California's Office of State Health Planning and Development (OSHPD).

Early Redesign

One of the first projects to use the system is the Rancho Los Amigos Medical Center,





Pictured at left: MNH-SMRF Systems two sided connection.

Replacement Facility, Bldg. B, which is expected to go out for bid in May. Structural engineer on the project is Bob Lyons, S.E., of Brandow & Johnston Associates and architect is Rochlin Baran Balbona. The 310,000-sq.-ft. project includes four steel moment framed levels above grade. The floors are $3^1/_4$-in. light weight concrete over metal deck (composite system/rigid diaphragm), while the basement and foundations are poured in place concrete. The project is a planned expansion to the recently constructed Building A and includes Patient Wing-North and Administration Wing-South. The two wings are separated by a seismic joint and the entire new addition is separated from the existing wings by seismic joints. The new wings were designed per the 1988 Uniform Building Code as supplemented by the California Title 24 provisions for hospitals. The north wing is considered a regular structure, while the south wing is designed to cascade on its west side from the roof to the second level above grade, which creates an irregular design. Additionally, the south wing was a dual design to allow for the roofs at the second and third levels to become partial or complete floors in the future.

After the Northridge Earthquake, Brandow and Johnston reviewed several systems and upgrades to the steel moment resisting joints, including cover plates on the top and bottom flanges of the beams. After consideration, they chose the MNH-SMRF connection system because it required the least amount of redesign of building components and because it was prequalified by OSHPD.

Smaller Member Sizes

Another advantage of the system is that it actually reduced the size of the steel members on the project while increasing stiffness. The actual reduction in beam sizes by weight was up to 39%. For example, some roof beams went from W33x118 to W27x84, while some floor beams went from W36x194 to W33x118. In general, column sizes remained the same due to the increased moment effect caused by moving the expected beam hinge location away from the face of the column.

Another design consideration of note on this project was that there were no weak axis moment connections and there was adequate redundancy. Both are recommended design characteristics that could become industry standards. This project also had some extremely high axial loads—200 kips plus—due to drag connections. For MNH-SMRF connections, the maximum capacity of the beams based upon interaction curves was developed for the joint. For gravity weak axis or non-moment resisting beam-to-column connections, the axial loads were transferred by details that did not depend upon the through thickness properties of any element of the connection.

Currently, seven County projects are in various stages of design using the MHN-SMRF system.

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