

Highlights of Recent Phase 2 Studies

A number of the initial Phase 2 investigations are nearing completion and Technical or Background Reports in preparation. The inserted SAC *Publications* sheet and SAC WWW Site (see p. 2) may be consulted for complete ordering information on currently available publications.

Model Building Designs Available

Consulting firms in three regions of the country have prepared designs for 3-, 9- and 20-story welded steel moment-resisting frame buildings. To date, two complete designs have been developed for each building in each region. Both design alternatives are based on lateral forces, drift limitations and other requirements as prescribed in locally applicable building codes. However, the first design in each region corresponds to code-prescribed details utilized prior to the 1994 Northridge earthquake. The second design utilizes proportions and details consistent with the *Interim Guidelines (FEMA 267)*. The building designs employ a common set of functional requirements, and are intended to be representative of local practices. Grade 50 steel is used for the beams and girders. These designs form the basis of numerous parametric analyses and cost studies being conducted in the course of the Phase 2 Steel Project. These designs (and detailed calculations) are available to others interested in carrying out similar studies. The participating consulting offices are: Brandow & Johnston (Los Angeles, CA), KPFF Consulting Engineers (Seattle, WA) and LeMessieur Consultants (Boston, MA).

These design firms are currently carrying out three additional parametric design studies in which (1) reduced (dog bone) section designs are employed for the beams; (2) Grade 65 steel is used for the columns and Grade 50 steel is utilized for the beams; and (3) the stiffness of the members is reduced to the point where drift requirements just become critical. Additional alternatives, such as those based on the use of bolted or partially restrained connections, will be explored during the course of the project.

Efforts are also underway in collaboration with Japanese researchers and engineers to assess the benefits of using special low yield strength (less than 30 ksi) steel in the plastic hinge regions of the beams. Comparative designs are also being prepared utilizing Japanese building codes and related design practices.

Ground Motion Suites Available

To analyze the model buildings and other alternate designs, a set of ground motion time histories (and corresponding elastic response spectra) have been compiled. These correspond to generic site conditions in the cities where the model buildings are located. Ten real or simulated earthquake records, with three components, are included in each set. In particular, ground motions or spectra are available for each

site corresponding to recurrence intervals of approximately 40, 70, 475 and 2500 years. Special sets of ground motions have also been compiled for each site corresponding to soft soil site conditions and to NEHRP design spectra for firm ground. A compilation of near-fault ground motion records has also been prepared. These records will be used consistently within the project to help assess the reliability of steel frame structures and to develop performance-based engineering procedures. The records will be publicly available soon through the SAC WWW site. The subcontractor for this effort is Paul Somerville of Woodward-Clyde Federal Services (Pasadena, CA).

As part of Phase 1, sets of records are also available for various sites throughout southern California for a simulation of the Northridge earthquake as well as for other scenario southern California events.

Benchmark Structure Available

To assess the accuracy and reliability of computer programs to be used in the project for nonlinear static and dynamic analyses, a simple benchmark structure has been established. The structure is derived from one of the three story model buildings. A common set of modeling assumptions and loading conditions has been established for a simple planar frame. Models are identified to assess the ability of programs to include various member and connection modeling options, loading conditions (static push-over and dynamic analyses), and the effects of material and geometric nonlinearities. Sets of results obtained using DRAIN-2DX are available for comparison, and additional results are now being generated by the System Performance team using ANSR, IDARC and other commonly available computer programs. Dr. Helmut Krawinkler, Team Leader for System Performance, has established benchmark structural analysis and developed a standard database for archiving response parameters of interest.

Assessment of the Performance of Steel Buildings in Past Earthquakes and Loma Prieta Notice

Investigations in this area are anticipated to begin in early 1997, with an initial focus on collection of both engineering and socioeconomic data; additional studies interpreting this data and providing recommendations will continue through 1997. Extensive information is available from the 1994 Northridge Earthquake. However, it has come to the attention of engineers and building officials in the San Francisco Bay Area that a number of steel moment frame buildings are likely to have suffered damage in the 1989 Loma Prieta Earthquake. SAC has issued a notification (September 1996, "Notice to Building Officials and Design Professionals in the San Francisco Bay Area") of these findings, but relatively little information has been made available to date. Any parties who have detailed information on steel structures damaged in the Loma Prieta Earthquake are encouraged to contact the SAC Technical Office.

SAC Steel Project Technical Office

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SAC is a joint venture of three non-profit organizations: The Structural Engineers Association of California, the Applied Technology Council, and California Universities for Research in Earthquake Engineering.



New Publications Available

The first of a series of planned Supplements to the Interim Guidelines (originally published in August 1995 and now in its second printing), Interim Guidelines Advisory No. 1, provides clarification of a number of issues related to steel moment frame design and construction, including variability of steel material properties, connection detailing, definition of plastic rotation for tested beam-column assemblages, and testing acceptance criteria. It also contains modified design procedures for strengthened connections and a new design procedure for reduced beam section (RBS, also referred to as “dog-bone”) connections.

The provisions incorporated in this Supplement, published by FEMA as “FEMA 267-A,” evolved from a Workshop on experiences implementing the original Interim Guidelines that was held in August 1996. Also newly available from FEMA are two SAC reports on Metallurgy, Fracture Mechanics, Welding, Moment Connections and Frame Systems Behavior (FEMA 288) and Connection Test Summaries (FEMA 289, described below).

Connection Test Summaries - Volume 1

A package of thirty four-page summaries of the full-size beam-column assemblage tests conducted in the Phase 1 Steel Project has been compiled and will be distributed by FEMA. These summaries provide concise reference material for practitioners, researchers, and building code officials that can be used for evaluating existing connection details, repair and retrofit techniques for damaged or vulnerable connections, or newly proposed configurations for new construction. A second release of connection test summaries is planned in approximately six months, with the intent of incorporating non-SAC tests from the past three years as well as tests which occur in the interim. Any individuals, agencies, or researchers who are interested in providing data for future summaries are requested to contact the SAC Technical Office.

Guidelines Supplement Available

Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment Frame Structures (FEMA 267) was produced in Phase 1 of the Steel Project. A *Supplement* to the Interim Guidelines (FEMA 267-A) is now being published by FEMA and should be available in April, 1997. If you previously ordered the *Interim Guidelines* from FEMA or received one in the mail, you should automatically receive the forthcoming *Supplement*. Other SAC publications are newly available, including two others being published by FEMA, one on Metallurgy, Fracture Mechanics, Welding, Moment Connections and Frame Systems Behavior, and the other on Connection Test Summaries.

To obtain a free copy of the *Interim Guidelines (FEMA 267)*, and the *Interim Guidelines Advisory No. 1 Supplement to Interim Guidelines (FEMA 267-A)*, or other FEMA reports, use the FEMA toll-free number:

1-800-480-2520

Enhanced SAC WWW Site Debuts

A new SAC World Wide Web site has been under development for the second phase of the SAC Steel Project and is now on line.



Planning for Phase 2 Testing in Progress

A large portion of the Phase 2 effort is devoted to testing of full-scale beam-to-column connections. This information is essential to identify the design and construction factors that control connection behavior and reliability and to validate design procedures. The Phase 2 test protocol and test plan are nearly complete. Preliminary results from studies by the System Performance team are being used along with other available information to refine loading histories. The connections are to be loaded to failure, but the histories used are intended to be consistent with analytically determined demands. An initial workshop to review past considerations for loading protocols was held in September 1996, and a follow-up workshop in January 1997 finalized the test protocol. Particular emphasis is being placed on recording the onset of behavior (such as local yielding, buckling, initial tearing) that would be useful in establishing performance-based engineering procedures.

In parallel, the Connection Performance Team and others have been examining available data, meeting with the Guideline Writing team, and conducting preliminary finite element and fracture analyses to help develop the Phase 2 test plan. Related test and analysis efforts being conducted outside of the SAC program are being carefully monitored to avoid unnecessary duplication of effort.

Several experimental projects will be starting soon in areas where available data is particularly sparse. These projects include a review of relevant literature, as well as integrated pre- and post-test analytical efforts to predict damage prior to the tests and to interpret the results obtained. The scope of the initial tests include:

- Unreinforced beam to column connections;
- Simple beam to column connections (including slab effects);
- Bolted connections and joints (based on typical t-stub connections).

As more information becomes available from the various topical investigations, additional connection configurations will be designed and tested. A calendar of tentative test dates and a synopsis of results will be maintained on the SAC WWW site.

Second US-Japan Workshop Held on Fracture of Steel Buildings in Earthquakes

Over 60 individuals from the US and Japan met in San Francisco February 2-4, 1997 at the Japan-US Workshop on Fracture of Steel Buildings in Earthquakes. Funding for the event, hosted by SAC, was provided by Japan Agency for Science and Technology, Building Research Institute, Kozai Club, and the National Science Foundation. Papers were presented and discussions occurred in the following general technical areas:

- Current Status of Research in Japan and the US;
- Design Issues and Codes;
- System Performance, Repair/Strengthening, and Modification;
- Steel Materials, Welds, and Connections;
- Working Group Presentations on:
 - Steel Materials and Welding;
 - Performance of Connections;
 - System Performance;
- Plans for Cooperative Work.

A number of opportunities for US/Japan cooperative effort were presented by the SAC Steel Project, including:

- Through-thickness tests on Japanese steels to parallel upcoming SAC tests;
- Application of "low-strength" steels in hinge regions;
- Strain rate tests on various materials and details;
- Welding testing parallel to those undertaken by SAC investigators, but comparing processes used in Japanese practice;
- Access hole/cope size investigations to parallel Japanese efforts with US details;
- Connection tests using Japanese details and US materials;
- Connection tests using US details and Japanese materials;
- Full-size multi-column frame testing;
- Complete building shake table testing;
- Column splice and base connection testing;
- Re-design of the SAC model buildings to meet Japanese code;
- Strong column-weak beam design and testing;
- Non-destructive testing methods and reliability;
- Translation and communication of information.

TAP's (Technical Advisory Panels) Meet

The Topical Team Leaders and Lead Guideline Writers met November 2, 1996 and February 5, 1996 in San Francisco.

A key organizational feature of the Phase 2 effort is close coordination between these two branches of the work, so that the topical investigations are accurately aimed at providing the answers needed to develop the project's final product, the *Seismic Design Criteria* document (the finalized version of the Interim Guidelines). The Phase 2 TAPs have now been constituted, and the members are listed below. In addition, a number of representatives of the construction and steel industry serve as corresponding members of the TAPs.

Materials and Fracture

Karl Frank (Topical Team Leader)
Raymond H. R. Tide (Lead Guideline Writer)
John M. Barsom
Frederick V. Lawrence
Robert F. Preece

Joining and Inspection

Stephen Liu (Topical Team Leader)
John W. Fisher
Duane K. Miller
Richard I. Seals

Connection Performance

Charles Roeder (Topical Team Leader)
John D. Hooper (Lead Guideline Writer)
Robert Dodds
Roger Ferch
Stanley Rolfe

System Performance

Helmut Krawinkler (Topical Team Leader)
C. Mark Saunders (Lead Guideline Writer)
Gary C. Hart
Andrei M. Reinhorn
Arthur E. Ross
John Theiss

Performance Prediction and Evaluation

Douglas Foutch (Topical Team Leader)
Thomas A. Sabol (Lead Guideline Writer)
Vitelmo V. Bertero
Theodore V. Galambos
Lawrence G. Griffis

Recent TAP Meetings

The most recent meetings of the TAPs are noted below:

Materials and Fracture: Chicago, November 26, 1996

Joining and Inspection: Denver, November 9, 1996

Performance Prediction: San Francisco, October 22, 1996

Connection Performance: Denver, October 15, 1996

System Performance: San Francisco, October 14, 1996

Mailing List

If you would like to be added to the SAC Steel Project mailing list to receive future *Updates* and notification of other reports as they become available, please mail or fax us the form below. (**You are already on the list if this *Update* was mailed to you.** If there is an error in your mailing label, please correct it below.)

name: _____

address: _____

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