SAC
Steel Project

Background Document

Through-Thickness Properties of Structural Steels

Report No. SAC/BD-97/01

SAC Joint Venture
A partnership of
Structural Engineers Association of California (SEAOC)
Applied Technology Council (ATC)
California Universities for Research in Earthquake Engineering (CUREe)

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Submitted for distribution to
SAC Joint Venture
650-595-1542
http://www.sacsteel.org

July 1, 1997

DISCLAIMER

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THE SAC JOINT VENTURE

SAC is a joint venture of the Structural Engineers Association of California (SEAOC), the Applied Technology Council (ATC), and California Universities for Research in Earthquake Engineering (CUREe), formed specifically to address both immediate and long-term needs related to solving performance problems with welded, steel moment-frame connections discovered following the 1994 Northridge earthquake. SEAOC is a professional organization composed of more than 3,000 practicing structural engineers in California. The volunteer efforts of SEAOC's members on various technical committees have been instrumental in the development of the earthquake design provisions contained in the *Uniform Building Code* and the 1997 *National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions for Seismic Regulations for New Buildings and other Structures*. ATC is a nonprofit corporation founded to develop structural engineering resources and applications to mitigate the effects of natural and other hazards on the built environment. Since its inception in the early 1970s, ATC has developed the technical basis for the current model national seismic design codes for buildings; the *de facto* national standard for postearthquake safety evaluation of buildings; nationally applicable guidelines and procedures for the identification, evaluation, and rehabilitation of seismically hazardous buildings; and other widely used procedures and data to improve structural engineering practice. CUREe is a nonprofit organization formed to promote and conduct research and educational activities related to earthquake hazard mitigation. CUREe's eight institutional members are the California Institute of Technology, Stanford University, the University of California at Berkeley, the University of California at Davis, the University of California at Irvine, the University of California at Los Angeles, the University of California at San Diego, and the University of Southern California. These laboratory, library, computer and faculty resources are among the most extensive in the United States. The SAC Joint Venture allows these three organizations to combine their extensive and unique resources, augmented by subcontractor universities and organizations from across the nation, into an integrated team of practitioners and researchers, uniquely qualified to solve problems related to the seismic performance of steel moment-frame buildings.

ACKNOWLEDGEMENTS

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PREFACE

Several investigations in Phase II of the FEMA/SAC Steel Project are concentrated on defining the expected material properties of rolled steel sections and the scatter in these properties, and evaluating their influence on the behavior of beam-column connections. This work is under the direction of the Materials and Fracture team and involves tests of materials from various producers to evaluate yield point and yield stress, ratio of yield stress to ultimate stress, Charpy V-notch values, through-thickness behavior, etc. The results of these studies will be incorporated in updated seismic design criteria for steel moment frame structures and will be used to identify desired properties for future generations of steel materials.

Of particular concern is the characterization of yield strength and ultimate strength in the through-thickness direction of column flanges. One of the failure modes observed in a number of buildings after the Northridge Earthquake and reproduced in subsequent large scale connection tests involved so-called "divots" being torn from the column flange in the vicinity of the bottom beam flange-to-column flange weld. Prior to these observations, there were no specific guidelines or limitations on the allowable stresses in column flanges in their through-thickness direction. The Interim Guidelines and Supplement No.1 (FEMA 267 and FEMA 267-A) were the first documents to contain such provisions, and at the time of this writing the through-thickness stress is limited to 0.9 times the measured longitudinal yield stress.

Improved characterization of the through-thickness properties of flanges in rolled sections is the subject of an experimental study now underway at Lehigh University under the direction of Professor Robert Dexter at the University of Minnesota with funding from the SAC Joint Venture. The majority of the tests being conducted involve "T -stubs" in which plate material having very high yield values (approximately 100 ksi) is welded with overmatched welds to the flanges of column sections. Continuity plates are also typically present in the column sections to reproduce field conditions. Direct tension is applied to the plate with the intent of producing a fracture in the through-thickness direction of the column flange; later tests will also investigate combined tension and bending in similar T-stub connections. It is expected that these tests will identify allowable through-thickness design values to be used in detailing beam flange-to-column flange connections. The majority of the data from this test program will be available in mid-1998 and will be incorporated into analytical studies identifying the influence of geometry and material properties on connection behavior.

The report presented here summarizes a series of tests on plate materials conducted in the 1970's with the goal of characterizing through-thickness behavior. While it does not specifically address the properties of rolled sections, this is one of the few studies available on this topic and provides preliminary information on the anticipated relationships between longitudinal, transverse, and through-thickness properties and the scatter in these relationships. The summary was written by John M. Barsom and Sjaan Korvink at the U.S. Steel Group and has been provided to SAC for publication and distribution. Their contribution is greatly appreciated.