ASCE Manuals and Reports on Engineering Practice No. 114

Performance-Based Design of Structural Steel for Fire Conditions

A CALCULATION METHODOLOGY

ASCE

SEI
Structural Engineering Institute

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Prepared by the
Special Design Issues—Fire Protection Committee of the
Structural Engineering Institute of the
American Society of Civil Engineers

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ASCE American Society of Civil Engineers

SEI Structural Engineering Institute of the American Society of Civil Engineers

Library of Congress Cataloging-in-Publication Data

Performance-based design of structural steel for fire conditions: a calculation methodology /prepared by the Special Design Issues—Fire Protection Committee of the Structural Engineering Institute of the American Society of Civil Engineers; edited by David L. Parkinson, Venkatesh Kodur, Paul D. Sullivan.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-7844-0963-3

1. Building, Fireproof—Mathematics. 2. Building, Iron and Steel—Mathematics. 3. Structural engineering—Mathematics. 4. Steel, Structural—Mathematical models. 5. Buildings, Performance—Mathematical models. 6. Engineering mathematics—Formulae. 7. Numerical calculations. I. Parkinson, David L. II. Kodur, Venkatesh. III. Sullivan, Paul D. (Paul David) IV. Structural Engineering Institute. Special Design Issues—Fire Protection Committee.

TH1088.56.P47 2008

693.8'2—dc22

2008036681

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191

www.pubs.asce.org

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ISBN 13: 978-0-7844-0963-3
Manufactured in the United States of America.

16 15 14 13 12 11 10 09 1 2 3 4 5

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FOREWORD

Currently the designers of buildings in North America rely on the results of standard fire tests to ensure that building structures meet the fire resistance rating (FRR) requirements prescribed by national building codes. Under this approach there is generally no requirement to engineer a solution to the required structural fire safety of a building (i.e., a designer need merely demonstrate compliance with the solutions prescribed in the national building codes). In other areas of building design such as mechanical and structural, designers are permitted to rely on "good engineering practices." With the development of performance-based building codes throughout North America, it is important that the design community has the tools necessary to take advantage of these new codes, which should enable the fire protection design of structural systems based on "good engineering practices." In Europe, New Zealand, and Australia, performance-based requirements have been in place for several years. The benefit provided by these codes is to enable designers to create buildings that meet the implied safety standards of the historical prescriptive codes, which might otherwise prove to be a difficult task without a performance-based framework in place. Advanced research and development has resulted in the development of engineering tools that provide a real understanding of the structural response to fire. This allows a robust approach to designing structures to withstand fire.

In order to provide structural engineers with these tools, a method is being proposed here that will facilitate the design of structural steel for fire conditions using a performance-based approach. This approach is simplistic in nature and only considers a two-dimensional thermal response of structural steel to the fire. There are models available for the determination of the three-dimensional thermostructural response to fire that have been used in other areas of the world for many years. However, building designers and Authorities Having Jurisdiction in these areas have had more time to become familiar with the use of performance-based designs. It is felt that the use of a method that predicts performance on the basis of limiting temperature alone will be conservative. Attempts to predict the likelihood of failure through more complicated mechanical interactions could produce more exact results but may complicate the process at this initial stage in the transformation to a performance-based regime in North America. In time, these matters may be incorporated into the framework of this approach as they become more accepted.

The mathematical models presented here are not new and some date back to the 1960s; however, they do offer a simple engineering approach to building structural fire safety. These approaches have been shown in the past to correlate well to experimental data. The method proposed here allows the designer to predict the time–temperature relationship expected in a compartment fire with a reasonable level of conservatism. Based on the compartment fire time–temperature relationship, the time for structural steel to reach the critical temperature can be calculated for comparison to the FRRs prescribed in the building codes. This, in turn, can be used to determine the required level of protection so that the time taken to reach the critical temperature is greater than the prescribed FRR. Also, a method is presented here that will allow the user to predict the expected maximum suspended ceiling temperature, to verify that the ceiling will remain intact for the duration of the fire. Finally, a method is presented here to calculate the required FRR for non-load-bearing partitions that form part of a fire-rated partition.

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