

American Society of Civil Engineers  
**Standard Calculation  
Methods for Structural  
Fire Protection**



Published by the American Society of Civil Engineers

## Library of Congress Cataloging-in-Publication Data

Milke, J. A. (James A.)

Standard calculation methods for structural fire protection :  
ASCE/SEI/SFPE 29-05 / James Milke.

p. cm.

Includes bibliographical references and index.

ISBN 0-7844-0874-2 (alk. paper)

1. Fire resistant materials—Standards. 2. Fire resistant materials—Mathematical models—Standards. 3. Engineering mathematics—Formulae. I. Title.

TH1065.M55 2006

693.8'2—dc22

2006024175

Published by American Society of Civil Engineers

1801 Alexander Bell Drive

Reston, Virginia 20191

[www.pubs.asce.org](http://www.pubs.asce.org)

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and are not intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document.

ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefor. This information should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

*Photocopies and reprints.* You can obtain instant permission to photocopy ASCE publications by using ASCE's online permission service ([www.pubs.asce.org/authors/RightslinkWelcomePage.htm](http://www.pubs.asce.org/authors/RightslinkWelcomePage.htm)). Requests for 100 copies or more should be submitted to the Reprints Department, Publications Division, ASCE (address above); e-mail: [permissions@asce.org](mailto:permissions@asce.org). A reprint order form can be found at [www.pubs.asce.org/authors/reprints.html](http://www.pubs.asce.org/authors/reprints.html).

Copyright © 2007 by the American Society of Civil Engineers.  
All Rights Reserved.

ISBN 13: 978-0-7844-0874-2

ISBN 10: 0-7844-0874-2

Manufactured in the United States of America.

# STANDARDS

In 2003, the Board of Direction approved the revision to the ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by the Society. All such standards are developed by a consensus standards process managed by the Society's Codes and Standards Committee (CSC). The consensus process includes balloting by a balanced standards committee made up of Society members and nonmembers, balloting by the membership of the Society as a whole, and balloting by the public. All standards are updated or reaffirmed by the same process at intervals not exceeding five years.

The following Standards have been issued:

- ANSI/ASCE 1-82 N-725 Guideline for Design and Analysis of Nuclear Safety Related Earth Structures
- ANSI/ASCE 2-91 Measurement of Oxygen Transfer in Clean Water
- ANSI/ASCE 3-91 Standard for the Structural Design of Composite Slabs and ANSI/ASCE 9-91 Standard Practice for the Construction and Inspection of Composite Slabs
- ASCE 4-98 Seismic Analysis of Safety-Related Nuclear Structures
- Building Code Requirements for Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02) and Specifications for Masonry Structures (ACI 530.1-02/ASCE 6-02/TMS 602-02)
- ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures
- SEI/ASCE 8-02 Standard Specification for the Design of Cold-Formed Stainless Steel Structural Members
- ANSI/ASCE 9-91 listed with ASCE 3-91
- ASCE 10-97 Design of Latticed Steel Transmission Structures
- SEI/ASCE 11-99 Guideline for Structural Condition Assessment of Existing Buildings
- ASCE/EWRI 12-05 Guideline for the Design of Urban Subsurface Drainage
- ASCE/EWRI 13-05 Standard Guidelines for Installation of Urban Subsurface Drainage
- ASCE/EWRI 14-05 Standard Guidelines for Operation and Maintenance of Urban Subsurface Drainage
- ASCE 15-98 Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)
- ASCE 16-95 Standard for Load Resistance Factor Design (LRFD) of Engineered Wood Construction
- ASCE 17-96 Air-Supported Structures
- ASCE 18-96 Standard Guidelines for In-Process Oxygen Transfer Testing
- ASCE 19-96 Structural Applications of Steel Cables for Buildings
- ASCE 20-96 Standard Guidelines for the Design and Installation of Pile Foundations
- ANSI/ASCE/T&DI 21-05 Automated People Mover Standards—Part 1
- ASCE 21-98 Automated People Mover Standards—Part 2
- ASCE 21-00 Automated People Mover Standards—Part 3
- SEI/ASCE 23-97 Specification for Structural Steel Beams with Web Openings
- ASCE/SEI 24-05 Flood Resistant Design and Construction
- ASCE/SEI 25-06 Earthquake-Actuated Automatic Gas Shutoff Devices
- ASCE 26-97 Standard Practice for Design of Buried Precast Concrete Box Sections
- ASCE 27-00 Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction
- ASCE 28-00 Standard Practice for Direct Design of Precast Concrete Box Sections for Jacking in Trenchless Construction
- ASCE/SEI/SFPE 29-05 Standard Calculation Methods for Structural Fire Protection
- SEI/ASCE 30-00 Guideline for Condition Assessment of the Building Envelope
- SEI/ASCE 31-03 Seismic Evaluation of Existing Buildings
- SEI/ASCE 32-01 Design and Construction of Frost-Protected Shallow Foundations
- EWRI/ASCE 33-01 Comprehensive Transboundary International Water Quality Management Agreement
- EWRI/ASCE 34-01 Standard Guidelines for Artificial Recharge of Ground Water
- EWRI/ASCE 35-01 Guidelines for Quality Assurance of Installed Fine-Pore Aeration Equipment
- CI/ASCE 36-01 Standard Construction Guidelines for Microtunneling
- SEI/ASCE 37-02 Design Loads on Structures during Construction
- CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data
- EWRI/ASCE 39-03 Standard Practice for the Design and Operation of Hail Suppression Projects
- ASCE/EWRI 40-03 Regulated Riparian Model Water Code

ASCE/SEI 41-06 Seismic Rehabilitation  
of Buildings  
ASCE/EWRI 42-04 Standard Practice for the Design  
and Operation of Precipitation Enhancement  
Projects  
ASCE/SEI 43-05 Seismic Design Criteria for  
Structures, Systems, and Components in Nuclear  
Facilities  
ASCE/EWRI 44-05 Standard Practice for the Design  
and Operation of Supercooled Fog Dispersal  
Projects

ASCE/EWRI 45-05 Standard Guidelines for  
the Design of Urban Stormwater  
Systems  
ASCE/EWRI 46-05 Standard Guidelines for  
the Installation of Urban Stormwater  
Systems  
ASCE/EWRI 47-05 Standard Guidelines for the  
Operation and Maintenance of Urban Stormwater  
Systems  
ASCE/SEI 48-05 Design of Steel Transmission Pole  
Structures

# CONTENTS

<b>Foreword</b> .....	<b>vii</b>
<b>Acknowledgments</b> .....	<b>ix</b>
<b>1.0 STANDARD CALCULATION METHODS FOR STRUCTURAL FIRE PROTECTION</b> .....	<b>1</b>
1.1 General .....	1
1.2 Scope .....	1
1.3 Purpose and Use .....	1
1.4 Referenced Standards .....	1
1.5 Definitions .....	2
<b>2.0 STANDARD METHODS FOR DETERMINING THE FIRE RESISTANCE OF PLAIN AND REINFORCED CONCRETE CONSTRUCTION</b> .....	<b>2</b>
2.1 Scope .....	2
2.2 Definitions .....	2
2.3 Concrete Walls .....	3
2.4 Concrete Floor and Roof Slabs .....	8
2.5 Concrete Cover over Reinforcement .....	8
2.6 Reinforced Concrete Columns .....	14
<b>3.0 STANDARD METHODS FOR DETERMINING THE FIRE RESISTANCE OF TIMBER AND WOOD STRUCTURAL ELEMENTS</b> .....	<b>14</b>
3.1 Scope .....	14
3.2 Notations and Definitions .....	14
3.3 Design of Fire-Resistive Exposed Wood Members .....	15
3.4 Component Additive Method for Calculating and Demonstrating Assembly Fire Endurance .....	15
<b>4.0 STANDARD CALCULATION METHODS FOR DETERMINING THE FIRE RESISTANCE OF MASONRY</b> .....	<b>17</b>
4.1 Scope .....	17
4.2 Definitions .....	17
4.3 Equivalent Thickness .....	18
4.4 Masonry Walls .....	19
4.5 Reinforced Masonry Columns .....	21
4.6 Masonry Lintels .....	21
<b>5.0 STANDARD METHODS FOR DETERMINING THE FIRE RESISTANCE OF STRUCTURAL STEEL CONSTRUCTION</b> .....	<b>23</b>
5.1 Scope .....	23
5.2 Structural Steel Columns .....	23
5.3 Structural Steel Beams and Girders .....	29
5.4 Structural Steel Trusses .....	31
<b>COMMENTARY</b> .....	<b>33</b>
C2.1 Scope .....	33
C2.2 Guide to Use of Procedures .....	35
C2.3 Concrete Walls .....	36
C2.4 Concrete Floor and Roof Slabs .....	40
C2.5 Concrete Cover over Reinforcement .....	41
C2.6 Reinforced Concrete Columns .....	42
References .....	42
C3.3 Design of Fire-Resistive Exposed Wood Members .....	43
C3.4 Component Additive Method for Calculating and Demonstrating Assembly Fire Endurance .....	44
References .....	48

C4.1 Scope .....	48
C4.3 Equivalent Thickness .....	49
C4.5 Reinforced Masonry Columns .....	52
C4.6 Masonry Lintels .....	52
References .....	52
C5.1 Scope .....	52
C5.2 Structural Steel Columns .....	52
C5.3 Structural Steel Beams and Girders .....	53
C5.4 Structural Steel Trusses .....	56
References .....	56
APPENDIX A .....	59
INDEX .....	61

The Structural Engineering Institute (SEI) of the American Society of Civil Engineers is committed to providing accurate, up-to-date information to its readers. To that end, SEI maintains a listing of errata at <http://www.seinstitute.org/publications/errata.cfm>.

## FOREWORD

In 2003, the Board of Direction approved the revision to the ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by the Society. All such standards are developed by a consensus standards process managed by the Society's Codes and Standards Committee (CSC). The consensus process includes balloting by a balanced standards committee made up of Society members and nonmembers, balloting by the membership of the Society as a whole, and balloting by the public. All standards are updated or reaffirmed by the same process at intervals not exceeding five years.

The material presented in this Standard has been prepared in accordance with recognized engineering principles. This Standard should not be used without first securing competent advice with respect to its suitability for any given application. The publication of the material contained herein is not intended as a representation or warranty on the part of the American Society of Civil Engineers, or of any other person named herein, that this information is suitable for any general or particular use or promises freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability from such use.



## ACKNOWLEDGMENTS

The Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE) acknowledges the devoted efforts of the Structural Design for Fire Conditions Standards Committee of the Codes and Activities Division. This group comprises individuals from many backgrounds, including consulting engineering, research, construction

Shuaib Ahmad, F.ASCE  
Farid Alfawakhiri, P.E., M.ASCE  
Paul Armstrong, M.ASCE  
James Peter Barris, P.E., M.ASCE  
Kenneth E. Bland, P.E.  
Delbert Franklin Boring, Jr., P.E., M.ASCE  
Richard W. Bukowski  
Joseph Michael Englot, P.E., M.ASCE  
Richard Alan Farthing  
Robert William Fitzgerald, Ph.D., P.E., F.ASCE  
Edward L. Fixen  
John Anton Fraunhoffer, P.E., M.ASCE  
Daniel F. Gemery  
Ram Autar Goel, P.E., F.ASCE  
Jeffrey H. Greenwald, P.E., M.ASCE  
Robert C. Jackson, P.E., M.ASCE  
Waseem A. Khan

industry, education, government, design, and private practice.

The development of this Standard was a joint effort between SEI and the Society of Fire Protection Engineers (SFPE). Although this Standard was developed through ASCE's consensus process, SFPE contributed greatly to its development.

Venkatesh Kumar R. Kodur, P.E., F.ASCE  
Donald Howard Landis, P.E., F.ASCE  
Barbara Lane  
Tiam T. Lie  
Edward F. Martella, P.E., M.ASCE  
John Herbert Matthys, Ph.D., P.E., M.ASCE  
Denis John McMullan, P.E., M.ASCE  
Joseph J. Messersmith, Jr., P.E., M.ASCE  
James A. Milke, P.E., M.ASCE  
Long T. Phan  
Walter J. Prebis  
Joseph E. Saliba, Ph.D., P.E., M.ASCE  
Amal Tamim  
Philip C. Terry, P.E., M.ASCE  
Roger H. Wildt, P.E., M.ASCE  
Robert Judson Wills, P.E., M.ASCE  
Peter J. Gore Willse



# Standard Calculation Methods for Structural Fire Protection

## 1.0 STANDARD CALCULATION METHODS FOR STRUCTURAL FIRE PROTECTION

### 1.1 GENERAL

Building codes specify the fire resistance required for structural members and barriers in identified occupancies and classifications of construction. The fire endurance is based on the test results of the American Society for Testing and Materials (ASTM) test designation E119, “Standard test methods for fire tests of building construction and materials.”

As an alternative to selection of tested assemblies, this Standard provides methods to calculate the fire resistance of selected structural member and barrier assemblies using structural steel, plain concrete, reinforced concrete, timber and wood, concrete masonry, and clay masonry. These methods are intended to provide architects, engineers, building officials, and others with calculation methods that will give the equivalent fire resistance that would have been achieved in the ASTM E119 standard fire test.

### 1.2 SCOPE

#### 1.2.1

The calculation methods provided in the document are intended to produce fire resistance rating times that are equivalent to the results obtained from the standard fire test, ASTM E119. The calculation methods of this Standard are for use as an alternative to the laboratory test results.

#### 1.2.2

These calculation methods are applicable only to structural steel, plain concrete, reinforced concrete, timber and wood, concrete masonry, and clay masonry. Limitations of applicability are identified in the individual chapters that describe the methods for each of the materials that compose this Standard.

### 1.3 PURPOSE AND USE

#### 1.3.1

While the fire resistance ratings calculated by the procedures specified in this Standard are equivalent substitutes for the results obtained by the ASTM E119 standard fire test, they do not necessarily describe the performance for natural fires having time-temperature relationships different from ASTM E119.

#### 1.3.2

The fire resistance results obtained by calculation methods are for use in building fire evaluations or for building code applications. It is the responsibility of the user of this Standard to establish appropriate technical or regulatory use for the results.

#### 1.3.3

The procedures for calculating the fire resistance ratings for structural members or assemblies for the different structural materials are organized under the following chapters:

Chapter 2. Standard Methods for Determining the Fire Resistance of Plain and Reinforced Concrete Construction

Chapter 3. Standard Methods for Determining the Fire Resistance of Timber and Wood Structural Elements

Chapter 4. Standard Calculation Methods for Determining the Fire Resistance of Masonry

Chapter 5. Standard Methods for Determining the Fire Resistance of Structural Steel Construction

### 1.4 REFERENCED STANDARDS

#### 1.4.1 American Concrete Institute (ACI)

ACI 318–95	Building Code Requirements for Structural Concrete
ACI 530–95/ASCE 5–95/TMS 402–95	Building Code Requirements for Masonry Structures

#### 1.4.2 American Society for Testing and Materials (ASTM)

ASTM C33–93	Standard Specification for Concrete Aggregates
ASTM C67–94	Standard Methods of Sampling and Testing Brick and Structural Clay Tile
ASTM C140–95a	Standard Methods of Sampling and Testing Concrete Masonry Units
ASTM C331–94	Standard Specification for Lightweight Aggregates for Concrete Masonry Units
ASTM C332–87	Standard Specification for Lightweight Aggregates for Insulating Concrete (Reapproved 1991)