ASCE STANDARD

ASCE/SEI

59-22

Blast Protection of Buildings

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

SEI
ASCE
STRUCTURAL
ENGINEERING
INSTITUTE

ASCE STANDARD

ASCE/SEI

59-22

Blast Protection of Buildings

AMERICAN SOCIETY OF CIVIL ENGINEERS

STRUCTURAL ENGINEERING INSTITUTE

PUBLISHED BY THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Library of Congress Cataloging-in-Publication Data

Names: American Society of Civil Engineers, author.
Title: Blast protection of buildings / American Society of Civil Engineers.
Description: Reston, Virginia : American Society of Civil Engineers, [2022] | "ASCE STANDARD" – t.p. | Includes bibliographical references and index. | Summary: "Standard ASCE/SEI 59-22 provides minimum requirements for planning, design, construction, and assessment of new and existing buildings subject to the effects of accidental or malicious explosions"– Provided by publisher.
Identifiers: LCCN 2022059934 | ISBN 9780784415719 (soft cover) | ISBN 9780784483336 (PDF)
Subjects: LCSH: Building, Bombproof–Standards–United States. | Buildings–Blast effects.
Classification: LCC TH1097 .A6 2022 | DDC 693.8/540973–dc23/eng/20230112
LC record available at https://lccn.loc.gov/2022059934

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/bookstore | ascelibrary.org

This standard was developed by a consensus standards development process that has been accredited by the American National Standards Institute (ANSI). Accreditation by ANSI, a voluntary accreditation body representing public and private sector standards development organizations in the United States and abroad, signifies that the standards development process used by ASCE has met the ANSI requirements for openness, balance, consensus, and due process.

While ASCE's process is designed to promote standards that reflect a fair and reasoned consensus among all interested participants, while preserving the public health, safety, and welfare that is paramount to its mission, it has not made an independent assessment of and does not warrant the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed herein. ASCE does not intend, nor should anyone interpret, ASCE's standards to replace the sound judgment of a competent professional, having knowledge and experience in the appropriate field(s) of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the contents of this standard.

ASCE has no authority to enforce compliance with its standards and does not undertake to certify products for compliance or to render any professional services to any person or entity.

ASCE disclaims any and all liability for any personal injury, property damage, financial loss, or other damages of any nature whatsoever, including without limitation any direct, indirect, special, exemplary, or consequential damages, resulting from any person's use of, or reliance on, this standard. Any individual who relies on this standard assumes full responsibility for such use.

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

Photocopies and permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an email to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (http://cedb.asce.org) or ASCE Library (http://ascelibrary.org) and using the "Permissions" link.

Errata: **Errata, if any, can be found at http://dx.doi.org/10.1061/9780784415719.**

Copyright © 2023 by the American Society of Civil Engineers.
All rights reserved.
ISBN 978-0-7844-1571-9 (soft cover)
ISBN 978-0-7844-8333-6 (PDF)

Manufactured in the United States of America.

27 26 25 24 23 1 2 3 4 5

ASCE STANDARDS

In 2016, the Board of Direction approved revisions to the ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by ASCE. All such standards are developed by a consensus standards process managed by the ASCE Codes and Standards Committee (CSC). The consensus process includes balloting by a balanced standards committee and reviewing during a public comment period. All standards are updated or reaffirmed by the same process every five to ten years. Requests for formal interpretations shall be processed in accordance with Section 7 of ASCE Rules for Standards Committees which are available at www.asce.org. Errata, addenda, supplements, and interpretations, if any, for this standard can also be found at www.asce.org.

This standard has been prepared in accordance with recognized engineering principles and should not be used without the user's competent knowledge for a given application. The publication of this standard by ASCE is not intended to warrant that the information contained therein is suitable for any general or specific use, and ASCE takes no position respecting the validity of patent rights. The user is advised that the determination of patent rights or risk of infringement is entirely their own responsibility.

A complete list of currently available standards is available in the ASCE Library (https://ascelibrary.org/page/books/s-standards).

CONTENTS

PREFACE xiii

ACKNOWLEDGMENTS xv

1 GENERAL 1
- 1.1 Scope 1
- 1.2 Definitions 1
- 1.3 Symbols and Notation 3
- 1.4 Qualifications 4
- 1.5 Information Sensitivity 4
- 1.6 Consensus Standards and Other Referenced Documents 4

2 DESIGN CONSIDERATIONS 7
- 2.1 Scope 7
- 2.2 Risk Assessment 7
  - 2.2.1 Consequence Analysis 7
  - 2.2.2 Threat Analysis. 7
  - 2.2.3 Vulnerability Analysis 7
  - 2.2.4 Risk Analysis. 7
- 2.3 Risk Reduction 7
  - 2.3.1 Consequence Reduction 7
  - 2.3.2 Threat Reduction 7
- 2.4 Risk Acceptance 8

3 PERFORMANCE CRITERIA 9
- 3.1 Scope 9
- 3.2 Design Objectives 9
  - 3.2.1 Limit Structural Collapse 9
  - 3.2.2 Maintain Building Envelope 9
  - 3.2.3 Minimize Flying Debris 9
- 3.3 Levels of Protection 9
  - 3.3.1 Structural Damage 9
  - 3.3.2 Component Damage 9
  - 3.3.3 Glazing Behavior. 9
  - 3.3.4 Door Behavior 10
- 3.4 Response Limits 10
  - 3.4.1 Flexural Members 10
  - 3.4.2 Compression Members. 11
- 3.5 Member or Element Strength 12
  - 3.5.1 Strength Increase Factors 12
  - 3.5.2 Strength Reduction Factors 12
  - 3.5.3 Remaining Strength 12

4 BLAST LOADS 15
- 4.1 General 15
  - 4.1.1 Scope 15
  - 4.1.2 Permitted Procedures. 15
- 4.2 Basic Procedure for External Blast 15
  - 4.2.1 Scope 15
  - 4.2.2 Directly Loaded Surfaces 15
  - 4.2.3 Indirectly Loaded Surfaces. 17

4.3 Basic Procedure for Internal Blast . . . 17
4.3.1 Scope . . . 17
4.3.2 Procedure . . . 20
4.4 Other Procedures . . . 20

5 FRAGMENTATION . . . 21
5.1 General . . . 21
5.1.1 Scope . . . 21
5.2 Design Requirements . . . 21
5.2.1 Fragmentation Impact Effects . . . 21
5.2.2 Secondary Fragment Sources . . . 21
5.3 Analytical Procedures . . . 21
5.3.1 Acceptable Analytical Methods . . . 21
5.3.2 Limits on Analytical Procedures . . . 22
5.3.3 Complex Modeling Methods . . . 22

6 STRUCTURAL SYSTEMS . . . 23
6.1 General Provisions . . . 23
6.1.1 Purpose . . . 23
6.1.2 Scope and Application . . . 23
6.2 Structural Modeling and Analysis
6.2.1 Analytical Methods . . . 23
6.2.2 Materials . . . 23
6.2.3 Modeling of Members . . . 24
6.2.4 Connections and Joints . . . 25
6.2.5 Application of Loads . . . 25
6.2.6 Mass . . . 26
6.3 Structural Design . . . 26
6.3.1 Structural Systems . . . 26
6.4 Response Characteristics . . . 27
6.4.1 Close-In Effects . . . 27
6.4.2 Far-Range Effects . . . 27

7 PROTECTION OF SPACES . . . 29
7.1 General Provisions . . . 29
7.2 Walls and Slabs Isolating Internal Threats . . . 29
7.2.1 Scope . . . 29
7.2.2 Threat Locations for Buildings with Controlled Access . . . 29
7.2.3 Design Provisions for Walls and Slabs Isolating Internal Threats . . . 29
7.2.4 Stairwell Enclosures . . . 29
7.2.5 Hardened Plenums . . . 29
7.3 Safe Havens . . . 29
7.3.1 Design Considerations . . . 29
7.3.2 Applicable Loads and Performance . . . 29
7.3.3 Resistance to Progressive Collapse . . . 30
7.3.4 Location within Building . . . 30
7.3.5 Accessibility to Egress . . . 30
7.3.6 Fire Rating . . . 30

8 EXTERIOR ENVELOPE . . . 31
8.1 Design Intent . . . 31
8.1.1 General . . . 31
8.1.2 Exterior Structural Components . . . 31
8.2 Design Procedures . . . 31
8.2.1 General . . . 31
8.2.2 Response Criteria . . . 31
8.2.3 Analytical Methods . . . 31
8.2.4 Balanced Design . . . 31
8.2.5 Flying Fragments . . . 31

8.3 Fenestration . . . 31
8.3.1 General . . . 31
8.3.2 Blast-Mitigating Window Systems . . . 31
8.3.3 Curtain Wall Systems . . . 32
8.3.4 Skylights . . . 32
8.3.5 Operable Windows . . . 32
8.3.6 Doors . . . 32
8.4 Non-Load-Bearing Exterior Walls . . . 33
8.4.1 General . . . 33
8.4.2 Cast-in-Place, Precast, and Tilt-Up Concrete Walls . . . 33
8.4.3 Pretensioned and Posttensioned Concrete Wall Panels . . . 33
8.4.4 Masonry Walls . . . 33
8.4.5 Steel Wall Systems . . . 33
8.4.6 Other Wall Systems . . . 33
8.5 Roof Systems . . . 33
8.5.1 General . . . 33
8.5.2 Flat Slabs . . . 34
8.5.3 Metal Deck . . . 34
8.5.4 Composite Construction . . . 34
8.5.5 Steel Joists and Joist Girders . . . 34
8.5.6 Other Roof Systems . . . 34
8.6 Other Exterior Envelope Elements . . . 34
8.7 Hazard-Mitigating Retrofits . . . 34
8.7.1 General . . . 34
8.7.2 Security Window Films . . . 34
8.7.3 Blast Curtains . . . 34
8.7.4 Catch Bar Systems . . . 34
8.7.5 Secondary Window System . . . 34
8.7.6 Window Replacement . . . 34
8.7.7 Geotextile Fabrics . . . 34
8.7.8 Fiber-Reinforced Polymers . . . 34
8.7.9 Secondary Wall System . . . 34
8.7.10 Other Retrofits . . . 35
8.8 Amplification and Reduction of Blast Loads . . . 35
8.8.1 Building Shape and Site . . . 35
8.8.2 Venting . . . 35

9 MATERIALS DETAILING . . . 37
9.1 General . . . 37
9.1.1 Scope . . . 37
9.1.2 Structural Interaction . . . 37
9.1.3 Materials . . . 37
9.1.4 Detailing . . . 37
9.1.5 Controlling Loads . . . 37
9.1.6 Achieving Design Intent . . . 37
9.1.7 Use of Reference Documents . . . 37
9.1.8 Special Inspection . . . 37
9.2 Concrete . . . 37
9.2.1 Scope . . . 37
9.2.2 General Reinforced Concrete Detailing Requirements . . . 37
9.2.3 Columns . . . 38
9.2.4 Beams . . . 38
9.2.5 Beam-Column Joints . . . 38
9.2.6 Slabs . . . 38
9.2.7 Walls . . . 39
9.3 Structural Steel . . . 39
9.3.1 Scope . . . 39
9.3.2 General Structural Steel Requirements . . . 39
9.3.3 Connections . . . 39
9.3.4 Open Web Steel Joists . . . 40
9.4 Steel/Concrete Composite . . . 40
9.4.1 Scope . . . 40
9.4.2 Concrete Slab on Metal Deck . . . 40

9.4.3 Composite Columns . . . 40
9.4.4 Steel-plate Composite Walls . . . 41
9.5 Masonry . . . 41
9.5.1 Scope . . . 41
9.5.2 General Design Requirements . . . 41
9.5.3 General Material Requirements . . . 41
9.5.4 General Detailing Requirements . . . 41
9.5.5 Walls . . . 41
9.6 Fiber Reinforced Polymer Composite . . . 42
9.6.1 Scope . . . 42
9.6.2 General . . . 42
9.6.3 Material Properties . . . 42
9.6.4 Strengthening of Structural Members . . . 42
9.6.5 Confinement of Structural Members . . . 42
9.7 Other Materials . . . 42
9.7.1 Aluminum . . . 43
9.7.2 Wood . . . 43
9.7.3 Cold-Formed Steel . . . 43

10 PERFORMANCE QUALIFICATION . . . 45
10.1 Scope . . . 45
10.2 Peer Review . . . 45
10.3 Site Perimeter Components . . . 45
10.3.1 Performance Qualification by Full-Scale Testing . . . 45
10.3.2 Performance Qualification by Analysis and Design . . . 45
10.4 Building Structural Components . . . 45
10.4.1 Performance Qualification by Full-Scale Testing . . . 45
10.4.2 Performance Qualification by Analysis and Design . . . 46
10.5 Shielding Structures . . . 46
10.5.1 Performance Qualification by Full-Scale Testing . . . 46
10.5.2 Performance Qualification by Analysis and Design . . . 46
10.6 Building Façade Components . . . 46
10.6.1 Glazing and Glazing Systems . . . 46
10.6.2 Doors . . . 47
10.7 Building Nonstructural Components . . . 48
10.7.1 Performance Qualification by Full-Scale Testing . . . 48
10.7.2 Performance Qualification by Analysis and Design . . . 48

COMMENTARY FOR BLAST PROTECTION OF BUILDINGS

C1 GENERAL . . . 49
C1.1 Scope . . . 49
C1.4 Qualifications . . . 49

C2 DESIGN CONSIDERATIONS . . . 51
C2.1 Scope . . . 51
C2.2 Risk Assessment . . . 51
C2.2.1 Consequence Analysis . . . 51
C2.2.2 Threat Analysis . . . 51
C2.2.3 Vulnerability Analysis . . . 52
C2.2.4 Risk Analysis . . . 52
C2.3 Risk Reduction . . . 52
C2.3.1 Consequence Reduction . . . 52
C2.3.2 Threat Reduction . . . 53
C2.4 Risk Acceptance . . . 55

C3 PERFORMANCE CRITERIA . . . 57
C3.2 Design Objectives . . . 57
C3.2.1 Limit Structural Collapse . . . 57
C3.2.2 Maintain Building Envelope . . . 57

C3.2.3 Minimize Flying Debris . . . 57
C3.3 Levels of Protection . . . 58
C3.3.1 Structural Damage . . . 58
C3.3.2 Component Damage . . . 58
C3.4 Response Limits . . . 58
C3.4.1 Flexural Members . . . 58
C3.4.2 Compression Members . . . 62
C3.5 Member or Element Strength . . . 63
C3.5.1 Strength Increase Factors . . . 63
C3.5.2 Strength Reduction Factors . . . 63
C3.5.3 Remaining Strength . . . 64

C4 BLAST LOADS . . . 67
C4.1 General . . . 67
C4.2 Basic Procedure for External Blast . . . 67
C4.2.1 Scope . . . 67
C4.2.2 Directly Loaded Surfaces . . . 67
C4.2.3 Indirectly Loaded Surfaces . . . 67
C4.3 Basic Procedure for Internal Blast . . . 67
C4.4 Other Procedures . . . 68

C5 FRAGMENTATION . . . 69
C5.1 General . . . 69
C5.1.1 Scope . . . 69
C5.2 Design Requirements . . . 69
C5.2.1 Fragment Impact Effects . . . 69
C5.2.2 Secondary Fragment Sources . . . 71
C5.3 Analytical Procedures . . . 71
C5.3.1 Acceptable Analytical Methods . . . 71
C5.3.2 Limits on Analytical Procedures . . . 75
C5.3.3 Complex Modeling Methods . . . 75

C6 STRUCTURAL SYSTEMS . . . 77
C6.1 General Provisions . . . 77
C6.1.1 Purpose . . . 77
C6.1.2 Scope and Application . . . 77
C6.2 Structural Modeling and Analysis . . . 78
C6.2.1 Analytical Methods . . . 78
C6.2.2 Materials . . . 80
C6.2.3 Modeling of Members . . . 80
C6.2.4 Connections and Joints . . . 83
C6.2.6 Mass . . . 84
C6.3 Structural Design . . . 84
C6.3.1 Structural Systems . . . 84
C6.4 Response Characteristics . . . 85
C6.4.1 Close-In Effects . . . 85
C6.4.2 Far-Range Effects . . . 86

C7 PROTECTION OF SPACES . . . 87
C7.2 Walls and Slabs Isolating Internal Threats . . . 87
C7.2.3 Design Provisions for Walls and Slabs Isolating Internal Threats . . . 87
C7.2.4 Stairwell Enclosures . . . 87
C7.3 Safe Havens . . . 87
C7.3.1 Design Considerations . . . 87
C7.3.2 Applicable Loads and Performance . . . 87
C7.3.4 Location within Building . . . 88

C8 EXTERIOR ENVELOPE . . . 89
C8.1 Design Intent . . . 89
C8.2 Design Procedures . . . 89

C8.2.1 General . . . 89
C8.2.2 Response Criteria . . . 90
C8.2.3 Analytical Methods . . . 90
C8.2.4 Balanced Design . . . 90
C8.2.5 Flying Fragments . . . 90
C8.3 Fenestration . . . 90
C8.3.1 General . . . 90
C8.3.2 Blast-Mitigating Window Systems . . . 91
C8.3.3 Curtain Wall Systems . . . 96
C8.3.4 Skylights . . . 96
C8.3.5 Operable Windows . . . 96
C8.3.6 Doors . . . 97
C8.4 Non-Load-Bearing Exterior Walls . . . 97
C8.4.1 General . . . 97
C8.4.2 Cast-in Place, Precast, and Tilt-Up Concrete Walls . . . 98
C8.4.3 Pretensioned and Posttensioned Concrete Wall Panels . . . 98
C8.4.4 Masonry Walls . . . 98
C8.4.5 Steel Wall Systems . . . 98
C8.5 Roof Systems . . . 99
C8.5.2 Concrete Slab Roofs . . . 99
C8.5.3 Metal Deck . . . 99
C8.5.4 Composite Slab Construction . . . 99
C8.5.5 Steel Joists and Joist Girders . . . 99
C8.5.6 Other Roof Systems . . . 99
C8.7 Hazard-Mitigating Retrofits . . . 99
C8.7.2 Security Window Films . . . 99
C8.7.5 Secondary Window Systems . . . 100
C8.7.8 Fiber-Reinforced Polymers . . . 100
C8.8 Amplification and Reduction of Blast Loads . . . 100
C8.8.1 Building Shape and Site . . . 100
C8.8.2 Venting . . . 100

C9 MATERIALS DETAILING . . . 101
C9.1.1 Scope . . . 101
C9.1.2 Structural Interaction . . . 101
C9.1.3 Materials . . . 101
C9.1.7 Use of Reference Documents . . . 101
C9.1.8 Special Inspection . . . 101
C9.2 Concrete . . . 101
C9.2.1 Scope . . . 101
C9.2.2 General Reinforced Concrete Detailing Requirements . . . 101
C9.2.3 Columns . . . 103
C9.2.4 Beams . . . 103
C9.2.5 Beam-Column Joints . . . 103
C9.2.6 Slabs . . . 103
C9.2.7 Walls . . . 103
C9.3 Structural Steel . . . 103
C9.3.1 Scope . . . 103
C9.3.2 Structural Steel Materials . . . 103
C9.3.3 Connections . . . 104
C9.3.4 Open Web Steel Joists . . . 105
C9.4 Steel/Concrete Composite . . . 105
C9.4.1 Scope . . . 105
C9.4.2 Concrete Slab on Metal Deck . . . 105
C9.4.3 Composite Columns . . . 105
C9.4.4 Steel-plate Composite Walls . . . 106
C9.5 Masonry . . . 107
C9.5.1 Scope . . . 107
C9.5.2 General Design Requirements . . . 107
C9.5.5 Walls . . . 107
C9.6 Fiber Reinforced Polymer . . . 107
C9.6.1 Scope . . . 107
C9.6.2 General . . . 108
C9.6.3 Material Properties . . . 109

C9.6.4 Strengthening of Structural Members . . . 109
C9.6.5 Confinement of Structural Members . . . 109
C9.7 Other Materials . . . 109
C9.7.1 Aluminum . . . 109
C9.7.3 Cold-Formed Steel Framing . . . 109

C10 PERFORMANCE QUALIFICATION . . . 111
C10.1 Scope . . . 111
C10.2 Peer Review . . . 111
C10.3 Site Perimeter Components . . . 111
C10.3.1 Performance Qualification by Full-Scale Testing . . . 111
C10.3.2 Performance Qualification by Analysis and Design . . . 111
C10.4 Building Structural Components . . . 111
C10.4.1 Performance Qualification by Full-Scale Testing . . . 111
C10.4.2 Performance Qualification by Analysis and Design . . . 112
C10.5 Shielding Structures . . . 112
C10.5.1 Performance Qualification by Full-Scale Testing . . . 112
C10.5.2 Performance Qualification by Analysis and Design . . . 112
C10.6 Building Façade Components . . . 112
C10.6.1 Glazing and Glazing Systems . . . 112
C10.6.2 Doors . . . 112
C10.7 Building Nonstructural Components . . . 112
C10.7.1 Performance Qualification by Full-Scale Testing . . . 112
C10.7.2 Performance Qualification by Analysis and Design . . . 112

REFERENCES . . . 115

INDEX . . . 119

PREFACE

The material presented in this publication has been prepared in accordance with recognized engineering principles. This standard and commentary should not be used without first securing competent advice with respect to their suitability for any given application. The publication of the material contained herein is not intended as a representation of warranty on the part of ASCE or of any person named herein, or 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 for such use.

The intent of the committee that prepared this standard was to present current practice in the analysis and design of structures for blast resistance. To accomplish that goal, the committee called on its collective experience in the practice of blast resistant design and also consulted persons not on the committee. As such, this is a consensus document and does not reflect the specific practice of any individual.

This is the second edition of this standard. Its need had been identified in advance of the events of September 11, 2001. In fact, key individuals of the original nucleus of the committee and the Structural Engineering Institute (SEI) were on a conference call to discuss development of this standard as the events of that day began to unfold. In the months following SEI's announcement that a committee would be formed to prepare this standard, numerous experts stepped forward to volunteer for the effort. Hence, this standard represents approximately 20 years of dedicated work by a knowledgeable committee.

The process started with subcommittees preparing "white papers" covering the information to be included in the standard. Once circulated for comment, those documents were reformatted into the first drafts of chapters of the mandatory and commentary sections of the standard. Then, throughout the development process the full committee reviewed and balloted numerous drafts of the standard. At each ballot cycle, subcommittees proposed resolutions for members' comments, ultimately leading to the full committee's approval of the text in ASCE/SEI 59-11. The same basic process has been followed to prepare and incorporate the revisions that resulted in this volume.

ACKNOWLEDGMENTS

Donald Dusenberry, P.E., F.SEI, *Chair*
Farid Alfawakhiri, Ph.D., P.E., M.ASCE
Amjad J Aref, Ph.D., M.ASCE
Scott Fine Arnold, P.E., M.ASCE
James Thomas Baylot, Ph.D., P.E., F.SEI, F.ASCE
Timothy Richard Brewer
James Timothy Brokaw, P.E., M.ASCE
Robert Sturdivant Browning IV, Ph.D., M.ASCE
Jakob C Bruhl, Ph.D., P.E., M.ASCE
Scott Campbell, Ph.D., P.E., M.ASCE
Aerik Carlton, S.M.ASCE
James Robert Casper, P.E., M.ASCE
Bradford Keith Douglas, P.E., M.ASCE
William R Earl, P.E., M.ASCE
Ayman Elfouly, P.E.
Moty Emek
J. Mikhael Erekson, P.E., M.ASCE
Simon Foo
Feng Fu, Ph.D., C.Eng, F.ASCE
Daniel Green
Andrew Hart, Ph.D., Aff.M.ASCE
Douglas Lloyd Heinze, P.E.
YeongAe Heo, Ph.D., EIT, A.M.ASCE
J. Paul Hobelmann, P.E.
Jennifer Lyn Holcomb, P.E., M.ASCE
Song F. Jan, P.E., M.ASCE
David Edwin Keller, P.E., M.ASCE
Gerald King, P.E., M.ASCE
Kevin Lee Kirkley, P.E., M.ASCE
James Michael Lintz, P.E., M.ASCE
Anatol Longinow, P.E., M.ASCE
Luca Magenes, P.E., P.Eng.
Aldo Enrique McKay, P.E., M.ASCE
Richard McLain III, P.E., M.ASCE
Paul Francis Mlakar, P.E., F.SEI, Dist.M.ASCE
Mostafa Emad Mobasher, Ph.D.
Daniel T Mullins, P.E., M.ASCE
Lawrence Charles Novak, S.E., F.SEI, M.ASCE
George N Olive, P.E., M.ASCE
Glen John Pappas, Ph.D., P.E., M.ASCE
Paul Charles Perrin, P.E., M.ASCE
Nabil M Rahman, Ph.D., P.E.
Ralph Dean Rempel, P.E., M.ASCE
Shady Hesham Salem, Ph.D.
Hani A Salim, P.E., M.ASCE
Jon Alan Schmidt, P.E., M.ASCE, *Chapter Leader, Chapters 1, 2, and 3*
William Seipel
Mohammadreza Sharafbayani, P.E.
Robert Smilowitz, P.E., F.SEI, M.ASCE, *Chapter Leader, Chapters 6, 7, and 8*
Steven John Smith, *Chapter Leader, Chapter 9*
Rob Joseph Smith, C.Eng, P.E., S.E., M.ASCE
Lauren Krista Stewart, Ph.D., P.E.
Peggy Van Eepoel, P.E., F.SEI, M.ASCE
Gregory Lester Varney, P.E., M.ASCE
Johnny Harry Waclawczyk Jr., P.E., M.ASCE
Mark Weaver, P.E., M.ASCE, *Chapter Leader, Chapter 5*
David C Weggel, Ph.D., P.E., A.M.ASCE
James Westphal
Christopher Michael Whiting, P.E., M.ASCE
Andrew S. Whittaker, Ph.D., P.E., S.E., F.SEI, F.ASCE, *Chapter Leader, Chapters 4 and 10*
Takayuki Yokoyama
William H Zehrt Jr., P.E., M.ASCE

CHAPTER 1
GENERAL

1.1 SCOPE

This voluntary standard provides minimum planning, design, construction, and assessment requirements for new and existing buildings subject to the effects of individual accidental or malicious explosions, including principles for establishing appropriate threat parameters, levels of protection, loadings, analysis methodologies, materials, detailing, and test procedures. However, this standard is not applicable for the mitigation of multiple explosions, intentional explosions such as weapons testing, or potential accidents involving ammunition or explosives during their development, manufacturing, testing, production, transportation, handling, storage, maintenance, modification, inspection, demilitarization, or disposal.

This standard is intended to supplement and not supersede the requirements of the governing building code and other applicable standards and laws. The omission of any specific material or system does not necessarily preclude its use in accordance with this standard, as long as all applicable provisions are satisfied. This standard does not prescribe requirements or guidelines for the mitigation of progressive collapse or other potential postblast behavior.

1.2 DEFINITIONS

The following definitions apply to the provisions of the entire standard.

Aggressor: Person or organization that may initiate an attack against an asset.

Approved: Acceptable to the authority having jurisdiction.

Asset: Unit or collection of people or property that requires protection.

Attack: Attempt by an aggressor to cause the loss or compromise of an asset or group of assets.

Authority Having Jurisdiction (AHJ): Organization, political subdivision, office, or individual charged with the responsibility of administering and enforcing the provisions of this standard. It shall be permissible for the AHJ to be established by contractual agreement, when appropriate.

Average Strength Factor (ASF): Factor applied to nominal material strengths to account for the difference between the specified minimum and expected actual values. Also known as a **Static Increase Factor (SIF)**.

Balanced Design: Controlled failure of a system with an established hierarchy of component failures, where connections are designed for the maximum strength of the connecting components and members supporting other members are designed for the maximum strength of the supported members. For window systems, the glazing shall fail before all other components.

Blast: Synonym for **Explosion**.

Building Envelope: Exposed elements on the exterior of the building, including (but not limited to) exterior walls, roofs, fenestration, exterior columns, spandrel and cantilever beams, and the exposed underside of occupied floors.

Buildings: Structures, usually enclosed by walls and a roof, constructed to provide support or shelter for an intended occupancy.

Component: Part of an architectural, mechanical, electrical, or structural system of a building.

Compression Member: Member that carries an axial compression load greater than 10% of its axial compression strength. The factored load resulting from effects other than blast shall be determined in accordance with Section 3.5.3, and the effective strength shall be determined in accordance with Sections 3.5.1 and 3.5.2.

Connection: Link that transmits actions from one component or element to another component or element, categorized by type of action (moment, shear, or axial). Steel connections are assemblies that include, but are not limited to, welds, bolts, rivets, angles, and plates. Reinforced concrete connections are often integral, consisting of the concrete and the reinforcement at the end of one component or element and extending into the other.

Consequence Factor: Numerical measure of the relative impact of the loss or compromise of a specific asset within a building, including its occupants, often expressed in terms of quantity or cost.

Constrained Fragment: Secondary fragment whose velocity in an airblast is reduced by the amount of energy required to tear it from its connected component or element.

Daylight Installation: Retrofit method for existing windows where security window film is applied to the interior vision surface of the glass without any additional attachment at the edges.

Dead Load (*D*): Weight of materials of construction incorporated into the building including, but not limited to, walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment including the weight of cranes.

Design Basis Threat: Explosive type and charge size for which the building is intended to provide a specified level of protection.

Diagonal Tension Shear: Shear associated with the flexural response of a member and the formation of diagonal cracks in reinforced concrete or masonry sections.

Direct Shear: Shear associated with the nearly instantaneous reaction force at the interface between connected members in response to blast loading.

Ductile Flexural Member: Member that develops its plastic moment capacity and is capable of reliably sustaining deformation at or above this load level.