

STRUCTURAL LOAD DETERMINATION

UNDER 2009 IBC® AND ASCE/SEI 7-05

DAVID A. FANELLA, PH.D., S.E., P.E., F.ASCE



**Structural Load Determination
under 2009 IBC and ASCE/SEI 7-05
Second Edition**

ISBN: 978-1-58001-924-8

Cover Art Director:	Dianna Hallmark
Cover Design:	Dianna Hallmark
Project Editor/Typesetting:	Jodi Tahsler
Project Head:	John Henry
Publications Manager:	Mary Lou Luif

COPYRIGHT © 2009



ALL RIGHTS RESERVED. This publication is a copyrighted work owned by the International Code Council, Inc. Without advance written permission from the copyright owner, no part of this book may be reproduced, distributed or transmitted in any form or by any means, including, without limitation, electronic, optical or mechanical means (by way of example, and not limitation, photocopying or recording by or in an information storage retrieval system). For information on permission to copy material exceeding fair use, please contact: Publications, 4051 West Flossmoor Road, Country Club Hills, IL 60478. Phone 1-888-ICC-SAFE (422-7233).

The information contained in this document is believed to be accurate; however, it is being provided for informational purposes only and is intended for use only as a guide. Publication of this document by the ICC should not be construed as the ICC engaging in or rendering engineering, legal or other professional services. Use of the information contained in this book should not be considered by the user to be a substitute for the advice of a registered professional engineer, attorney or other professional. If such advice is required, it should be sought through the services of a registered professional engineer, licensed attorney or other professional.

Trademarks: "International Code Council" and the "International Code Council" logo and the "International Building Code" are trademarks of International Code Council, Inc.

Errata on various ICC publications may be available at www.iccsafe.org/errata.

First Printing: November 2009

PREFACE

The purpose of *Structural Load Determination under 2009 IBC and ASCE/SEI 7-05* is to provide a detailed guide to the proper determination of structural loads in accordance with the 2009 *International Building Code*® (IBC®) and *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI 7-05) with Supplement No. 2. The 2009 IBC references the 2005 edition of the ASCE/SEI 7 standard for many code-prescribed loads, most notably environmental loads such as flood, snow, wind and seismic load effects. In general, the IBC contains only the structural design criteria for environmental loads, while the technical design provisions for these loads are contained in the ASCE/SEI 7 standard.

This book is an essential resource for civil and structural engineers, architects, plan check engineers and students who need an efficient and practical approach to load determination under the 2009 IBC and ASCE/SEI 7-05 standard. The book is especially valuable to code users who are familiar with the structural load provisions of the previous legacy codes such as the *Uniform Building Code* (UBC). It has been reported that one of the most significant changes for code users transitioning from the UBC to the IBC is the way snow loads, wind pressures and earthquake ground motion load effects are determined under the IBC and ASCE/SEI 7-05 compared to previous legacy codes. *Structural Load Determination under 2009 IBC and ASCE/SEI 7-05* is a practical resource that will help code users make the transition quickly.

The book illustrates the application of code provisions and methodology for determining structural loads through the use of numerous flowcharts and practical design examples. Included are load combinations for allowable stress design, load and resistance factor (strength) design, seismic load combinations with vertical load effect and special seismic load combinations; dead loads, live loads and rain loads; snow loads, flood loads, wind loads and earthquake load effects. For wind load determination, flowcharts and design examples are presented for the simplified procedure (Method 1), the analytical procedure (Method 2) and the new alternate all-heights method in the 2009 IBC. Seismic design criteria, determination of seismic design category, the simplified method, equivalent lateral force procedure and nonbuilding structures are some of the topics illustrated through flowcharts and design examples.

This publication is an update to the previous publication, *Structural Load Determination under 2006 IBC and ASCE/SEI 7-05*. A new section has been added to Chapter 5 that covers the alternate all-heights wind design method in 2009 IBC Section 1609.6. This method is a simplified procedure based on Method 2 of ASCE/SEI 7-05 that applies to regularly-shaped buildings and structures that meet the five conditions given in IBC 1609.6.1. Net wind pressures p_{net} are calculated using design pressure coefficients C_{net} , which are given in IBC Table 1609.6.2(2) for main wind-force-resisting systems and components and cladding. A flowchart on how to determine p_{net} is provided along with examples on how to apply the alternate all-heights method.

A new Chapter 7 was added covering the determination of flood loads in accordance with IBC Section 1612, ASCE/SEI 7-05 and ASCE/SEI 24-05. Section 1612 of the IBC requires all structures sited in designated flood hazard areas to be designed and constructed to resist the effects of flood hazards and flood loads. Flood hazards may include erosion and scour whereas flood loads include flotation, lateral hydrostatic pressures, hydrodynamic pressures (due to moving water), wave impact and debris impact. Chapter 7 covers (1) identification of the various types of flood hazard areas and zones, (2) design and construction requirements and (3) determination of flood loads in accordance with IBC 1612, Chapter 5 of ASCE/SEI 7-05 and ASCE/SEI 24-05. Examples that clearly illustrate the provisions are included for residential structures in a Non-Coastal A Zone, a Coastal A Zone and a V Zone.

Load Determination under 2009 IBC and ASCE/SEI 7-05 is a multipurpose resource for civil and structural engineers, architects and plan check engineers because it can be used as a self-learning guide as well as a reference manual.

About the International Code Council

The International Code Council® (ICC®) is a nonprofit membership association dedicated to protecting the health, safety, and welfare of people by creating better buildings and safer communities. The mission of ICC is to provide the highest quality codes, standards, products and services for all concerned with the safety and performance of the built environment. ICC is the publisher of the family of the International Codes® (I-Codes®), a single set of comprehensive and coordinated model codes. This unified approach to building codes enhances safety, efficiency and affordability in the construction of buildings. The Code Council is also dedicated to innovation, sustainability and energy efficiency. Code Council subsidiary, ICC Evaluation Service, issues Evaluation Reports for innovative products and reports of Sustainable Attributes Verification and Evaluation (SAVE).

Headquarters: 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001-2070

District Offices: Birmingham, AL; Chicago, IL; Los Angeles, CA

1-888-422-7233

www.iccsafe.org

ABOUT THE AUTHOR

David A. Fanella, Ph.D., S.E., P.E., F.ASCE, is Associate Principal and Director of New Structures at Klein and Hoffman Inc., Chicago, Illinois. Dr. Fanella holds a Ph.D. in structural engineering from the University of Illinois at Chicago and is a licensed Structural Engineer in the State of Illinois and a licensed Professional Engineer in numerous states. He was formerly with the Portland Cement Association in Skokie, Illinois, where he was responsible for the buildings and special structures market. Dr. Fanella is an active member of a number of American Concrete Institute (ACI) Committees and is an Associate Member of the ASCE 7 Committee. He is currently President-Elect of the Structural Engineers Association of Illinois. Dr. Fanella has authored or coauthored many structural publications, including a series of articles on time-saving methods for reinforced concrete design.

TABLE OF CONTENTS

CHAPTER 1 – INTRODUCTION	1-1
1.1 OVERVIEW	1-1
1.2 SCOPE.....	1-2
1.3 REFERENCES	1-4
CHAPTER 2 – LOAD COMBINATIONS	2-1
2.1 INTRODUCTION	2-1
2.2 LOAD EFFECTS.....	2-1
2.3 LOAD COMBINATIONS USING STRENGTH DESIGN OR LOAD AND RESISTANCE FACTOR DESIGN	2-2
2.4 LOAD COMBINATIONS USING ALLOWABLE STRESS DESIGN	2-4
2.5 LOAD COMBINATIONS WITH OVERSTRENGTH FACTOR	2-8
2.6 LOAD COMBINATIONS FOR EXTRAORDINARY EVENTS.....	2-11
2.7 EXAMPLES	2-11
2.7.1 Example 2.1 – Column in Office Building, Strength Design Load Combinations for Axial Loads	2-12
2.7.2 Example 2.2 – Column in Office Building, Strength Design Load Combinations for Axial Loads and Bending Moments	2-13
2.7.3 Example 2.3 – Beam in University Building, Strength Design Load Combinations for Shear Forces and Bending Moments	2-14
2.7.4 Example 2.4 – Beam in University Building, Basic Allowable Stress Design Load Combinations for Shear Forces and Bending Moments.....	2-16
2.7.5 Example 2.5 – Beam in University Building, Alternative Basic Allowable Stress Design Load Combinations for Shear Forces and Bending Moments	2-18
2.7.6 Example 2.6 – Collector Beam in Residential Building, Load Combinations using Strength Design and Basic Load Combinations for Strength Design with Overstrength Factor for Axial Forces, Shear Forces, and Bending Moments	2-19
2.7.7 Example 2.7 – Collector Beam in Residential Building, Load Combinations using Allowable Stress Design (Basic Load Combinations) and Basic Combinations for Allowable Stress Design with Overstrength Factor for Axial Forces, Shear Forces, and Bending Moments	2-21
2.7.8 Example 2.8 – Collector Beam in Residential Building, Load Combinations using Allowable Stress Design (Alternative Basic Load Combinations) and Basic Combinations for Allowable Stress Design with Overstrength Factor for Axial Forces, Shear Forces, and Bending Moments	2-22
2.7.9 Example 2.9 – Timber Pile in Residential Building, Basic Allowable Stress Design Load Combinations for Axial Forces	2-23

CHAPTER 3 – DEAD, LIVE, AND RAIN LOADS	3-1
3.1 DEAD LOADS	3-1
3.2 LIVE LOADS	3-2
3.2.1 General	3-2
3.2.2 Reduction in Live Loads	3-3
3.2.3 Distribution of Floor Loads	3-9
3.2.4 Roof Loads	3-10
3.2.5 Crane Loads	3-11
3.2.6 Interior Walls and Partitions	3-12
3.3 RAIN LOADS	3-12
3.4 EXAMPLES	3-13
3.4.1 Example 3.1 – Live Load Reduction, General Method of IBC 1607.9.1	3-14
3.4.2 Example 3.2 – Live Load Reduction, Alternate Method of IBC 1607.9.2	3-24
3.4.3 Example 3.3 – Live Load Reduction on a Girder	3-32
3.4.4 Example 3.4 – Rain Load, IBC 1611	3-33
CHAPTER 4 – SNOW LOADS	4-1
4.1 INTRODUCTION	4-1
4.2 FLOWCHARTS	4-4
4.3 EXAMPLES	4-14
4.3.1 Example 4.1 – Warehouse Building, Roof Slope of 1/2 on 12	4-14
4.3.2 Example 4.2 – Warehouse Building, Roof Slope of 1/4 on 12	4-19
4.3.3 Example 4.3 – Warehouse Building (Roof Slope of 1/2 on 12) and Adjoining Office Building (Roof Slope of 1/2 on 12)	4-20
4.3.4 Example 4.4 – Six-Story Hotel with Parapet Walls	4-28
4.3.5 Example 4.5 – Six-Story Hotel with Rooftop Unit	4-33
4.3.6 Example 4.6 – Agricultural Building	4-35
4.3.7 Example 4.7 – University Facility with Sawtooth Roof	4-39
4.3.8 Example 4.8 – Public Utility Facility with Curved Roof	4-42
CHAPTER 5 – WIND LOADS	5-1
5.1 INTRODUCTION	5-1
5.2 FLOWCHARTS	5-3
5.2.1 Allowed Procedures	5-5
5.2.2 Method 1 – Simplified Procedure	5-7
5.2.3 Method 2 – Analytical Procedure	5-11
5.2.4 Alternate All-heights Method	5-30
5.3 EXAMPLES	5-32
5.3.1 Example 5.1 – Warehouse Building using Method 1, Simplified Procedure	5-32

5.3.2	Example 5.2 – Warehouse Building using Low-rise Building Provisions of Method 2, Analytical Method.....	5-43
5.3.3	Example 5.3 – Warehouse Building using Provisions of Method 2, Analytical Procedure.....	5-52
5.3.4	Example 5.4 – Warehouse Building using Alternate All-heights Method.....	5-60
5.3.5	Example 5.5 – Residential Building using Method 2, Analytical Procedure.....	5-69
5.3.6	Example 5.6 – Six-Story Hotel using Method 2, Analytical Procedure	5-87
5.3.7	Example 5.7 – Six-Story Hotel Located on an Escarpment using Method 2, Analytical Procedure	5-98
5.3.8	Example 5.8 – Six-Story Hotel using Alternate All-heights Method	5-105
5.3.9	Example 5.9 – Fifteen-Story Office Building using Method 2, Analytical Procedure	5-110
5.3.10	Example 5.10 – Agricultural Building using Method 2, Analytical Procedure	5-125
5.3.11	Example 5.11 – Freestanding Masonry Wall using Method 2, Analytical Procedure	5-131
CHAPTER 6 – EARTHQUAKE LOADS		6-1
6.1	INTRODUCTION	6-1
6.2	SEISMIC DESIGN CRITERIA.....	6-2
6.2.1	Seismic Ground Motion Values	6-2
6.2.2	Occupancy Category and Importance Factor	6-4
6.2.3	Seismic Design Category	6-5
6.2.4	Design Requirements for SDC A	6-5
6.3	SEISMIC DESIGN REQUIREMENTS FOR BUILDING STRUCTURES	6-6
6.3.1	Basic Requirements.....	6-6
6.3.2	Seismic Force-Resisting Systems.....	6-6
6.3.3	Diaphragm Flexibility, Configuration Irregularities, and Redundancy	6-7
6.3.4	Seismic Load Effects and Combinations.....	6-12
6.3.5	Direction of Loading	6-13
6.3.6	Analysis Procedure Selection	6-15
6.3.7	Modeling Criteria	6-15
6.3.8	Equivalent Lateral Force Procedure	6-15
6.3.9	Modal Response Spectral Analysis	6-18
6.3.10	Diaphragms, Chords, and Collectors.....	6-18
6.3.11	Structural Walls and Their Anchorage	6-20
6.3.12	Drift and Deformation	6-20
6.3.13	Foundation Design	6-20
6.3.14	Simplified Alternative Structural Design Criteria for Simple Bearing Wall or Building Frame Systems	6-21
6.4	SEISMIC DESIGN REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS	6-22

6.4.1	General	6-22
6.4.2	Seismic Demands on Nonstructural Components	6-23
6.4.3	Nonstructural Component Anchorage	6-23
6.4.4	Architectural Components	6-23
6.4.5	Mechanical and Electrical Components	6-24
6.5	SEISMIC DESIGN REQUIREMENTS FOR NONBUILDING STRUCTURES	6-24
6.5.1	General	6-24
6.5.2	Reference Documents	6-25
6.5.3	Nonbuilding Structures Supported by Other Structures	6-25
6.5.4	Structural Design Requirements	6-25
6.5.5	Nonbuilding Structures Similar to Buildings	6-25
6.5.6	Nonbuilding Structures Not Similar to Buildings	6-26
6.5.7	Tanks and Vessels	6-26
6.6	FLOWCHARTS	6-26
6.6.1	Seismic Design Criteria	6-28
6.6.2	Seismic Design Requirements for Building Structures	6-38
6.6.3	Seismic Design Requirements for Nonstructural Components	6-55
6.6.4	Seismic Design Requirements for Nonbuilding Structures	6-57
6.7	EXAMPLES	6-61
6.7.1	Example 6.1 – Residential Building, Seismic Design Category	6-61
6.7.2	Example 6.2 – Residential Building, Permitted Analytical Procedure	6-64
6.7.3	Example 6.3 – Office Building, Seismic Design Category	6-70
6.7.4	Example 6.4 – Office Building, Permitted Analytical Procedure	6-74
6.7.5	Example 6.5 – Office Building, Allowable Story Drift	6-84
6.7.6	Example 6.6 – Office Building, P-delta Effects	6-86
6.7.7	Example 6.7 – Health Care Facility, Diaphragm Design Forces	6-88
6.7.8	Example 6.8 – Health Care Facility, Nonstructural Component	6-93
6.7.9	Example 6.9 – Residential Building, Vertical Combination of Structural Systems	6-95
6.7.10	Example 6.10 – Warehouse Building, Design of Roof Diaphragm, Collectors, and Wall Panels	6-102
6.7.11	Example 6.11 – Retail Building, Simplified Design Method	6-112
6.7.12	Example 6.12 – Nonbuilding Structure	6-121
CHAPTER 7 – FLOOD LOADS		7-1
7.1	INTRODUCTION	7-1
7.2	FLOOD HAZARD AREAS	7-1
7.3	DESIGN AND CONSTRUCTION	7-3

7.3.1	General	7-3
7.3.2	Flood Loads	7-4
7.4	EXAMPLES	7-10
7.4.1	Example 7.1 – Residential Building Located in a Non-Coastal A Zone	7-10
7.4.2	Example 7.2 – Residential Building Located in a Coastal A Zone.....	7-14
7.4.3	Example 7.3 – Residential Building Located in a V Zone	7-18

ACKNOWLEDGMENTS

The writer is deeply grateful to John R. Henry, P.E., Principal Staff Engineer, International Code Council, Inc., for his thorough review of the second edition of this publication. His insightful comments and suggestions for improvement have added significant value to this edition.

Thanks are also due to Adugna Fanuel, S.E., LEED AP, Christina Harber, S.E. and Majlinda Agojci, all of Klein and Hoffman, Inc., for their contributions. Their help in modeling and analyzing some of the example buildings and their review of the text and example problems were invaluable.

