American Concrete Institute

ACI 318/369/562
Code Meshing: How Does It Work?

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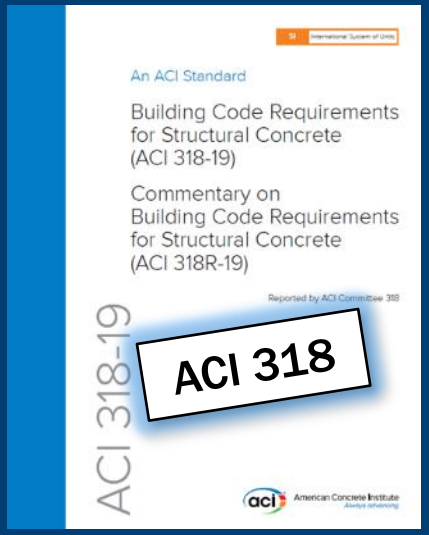
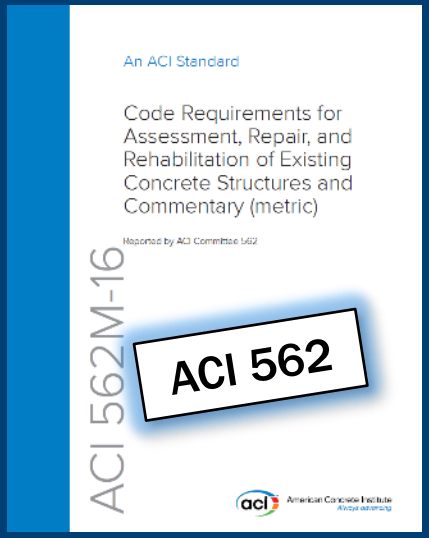
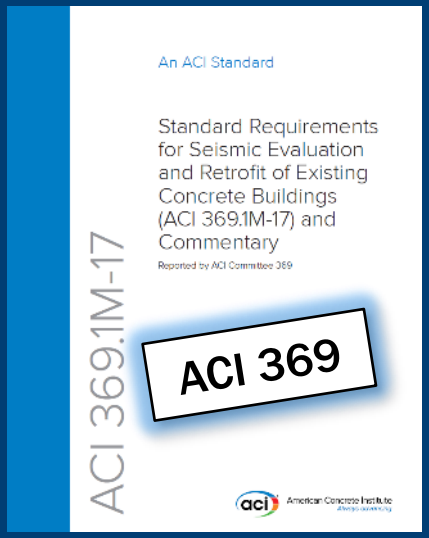
Introduction

Three ACI Building Codes - ACI 318, ACI 562, and ACI 369 – govern the structural design of new structures, evaluation and repair of existing structures, and seismic evaluation and retrofit of existing structures

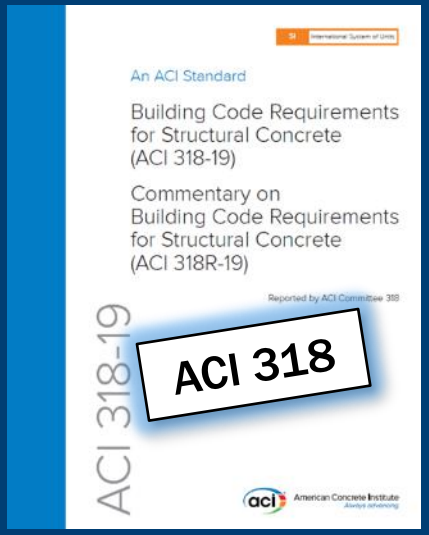


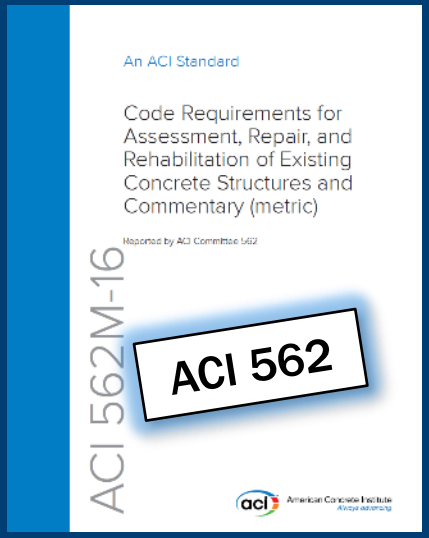


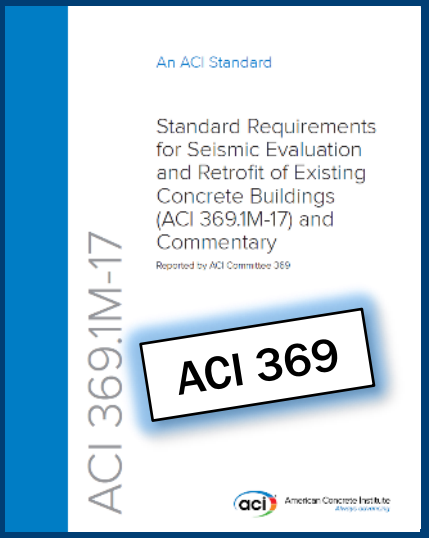


Introduction

These three codes are often used at the same time on one project, but they govern different aspects of the structural design. Thus, the codes must be coordinated, or “meshed,” so that they work together.







Topics

- Overview of U.S. building code system
- Brief description of ACI CODE 318
- Brief description of ACI CODE 562
- Brief description of ACI CODE 369
- Interactions of the three ACI Codes
- Design example
- Possible improvements in code coordination

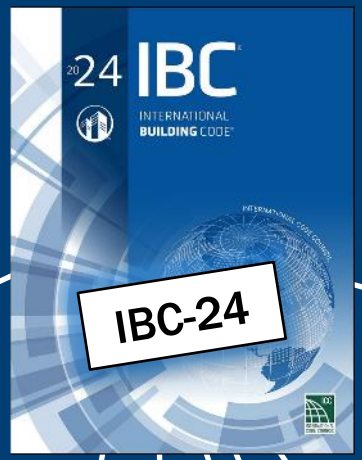
Overview of U.S. Building Codes

- The U.S. does not have a national building code authority, or a single national building code
- Instead, each of the 50 U.S. states adopts its own building codes
- Almost all states adopt “Model Codes” published by the International Code Council (ICC), but each state makes modifications to the Model Codes
- The ICC Model Codes are often referred to as the “i-codes”

ICC Model Codes

- The ICC Model Codes (“i-codes”) include
  - International Building Code (IBC)
  - International Existing Building Code (IEBC)
  - International Residential Code (IRC)
  - and many other codes related to building systems and planning.

New Building Construction: 2024 IBC



Loads

Many other design standards, including ASTM standards

Aluminum

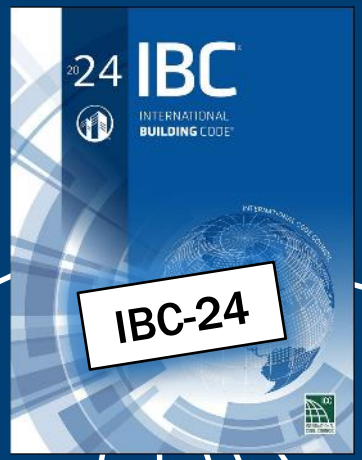
Masonry

Wood

Steel

Concrete

New Building Construction: 2024 IBC



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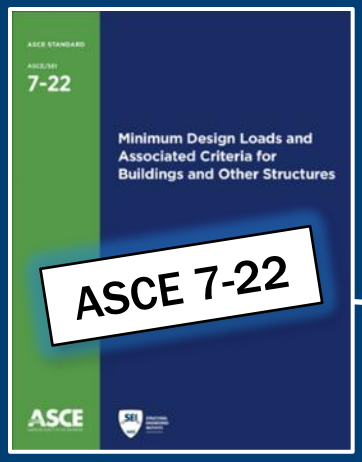
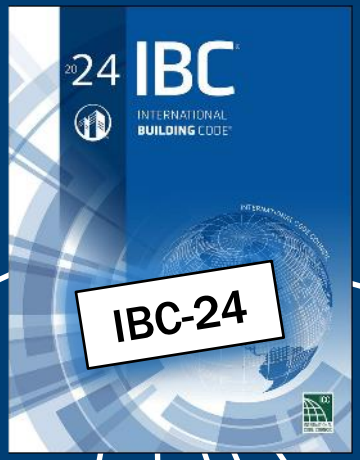


ASCE 7-22



IBC-24

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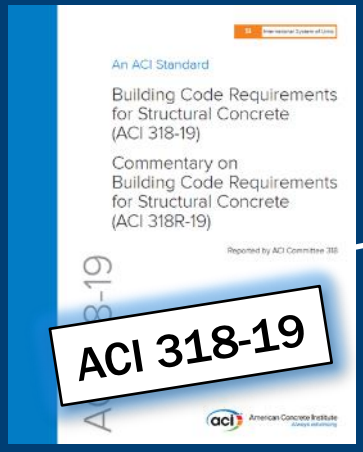


ACI 318-19

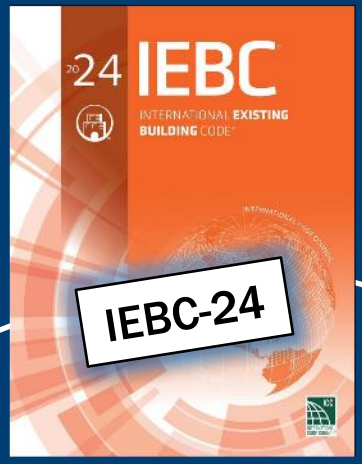
Steel

Wood

Aluminum

Masonry

Existing Building Rehabilitation: 2024 IEBC



Loads and Procedures

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Masonry

Aluminum

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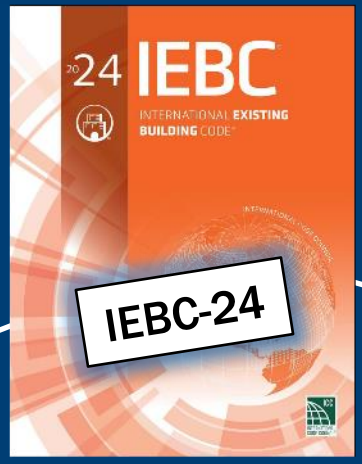

Loads and Procedures

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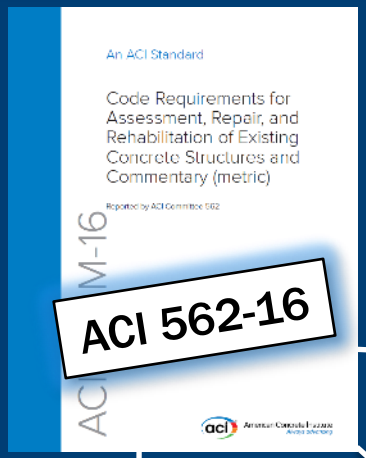
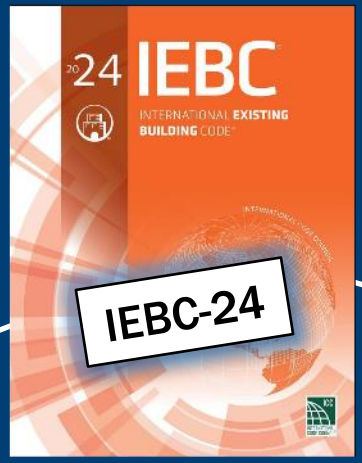
Existing Building Rehabilitation: 2024 IEBC





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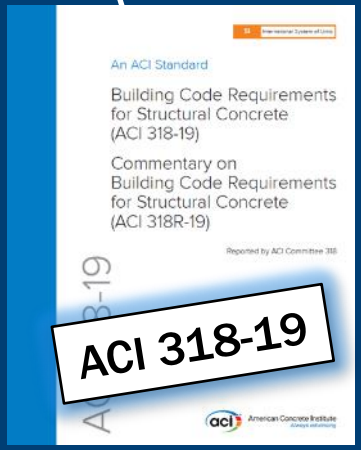
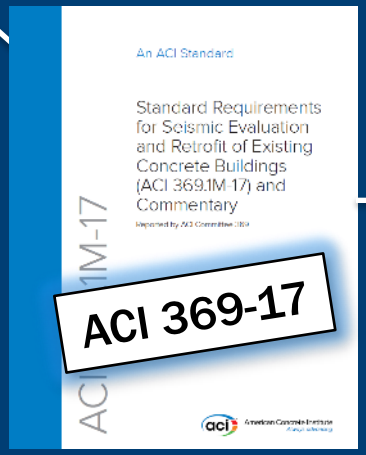
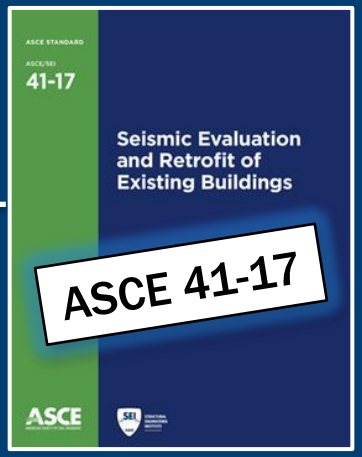
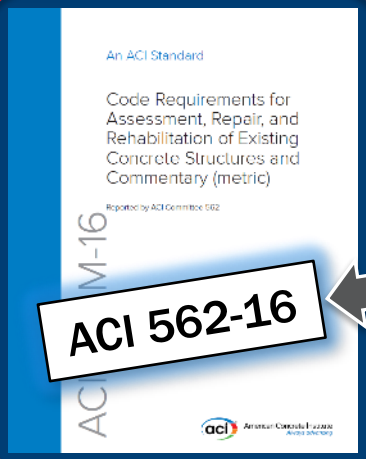


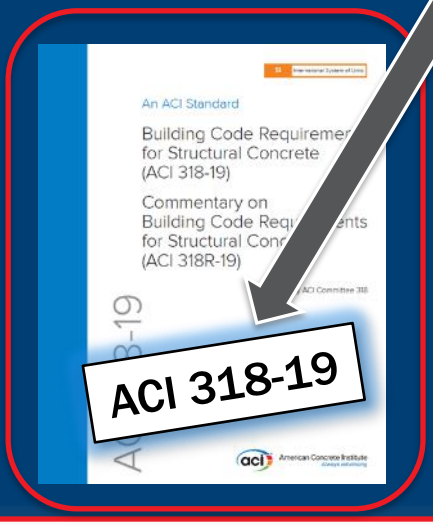


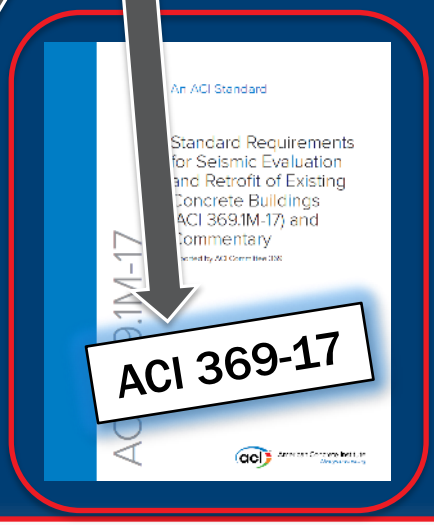


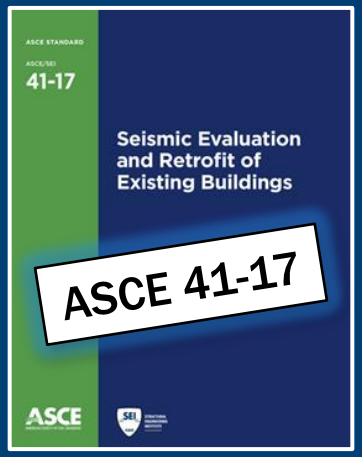
Existing Building Rehabilitation: 2024 IEBC

These three ACI codes must be coordinated, or “meshed” so that they all work together
General rehabilitation: ACI 562
New elements & connections: ACI 318
Seismic rehabilitation: ACI 369









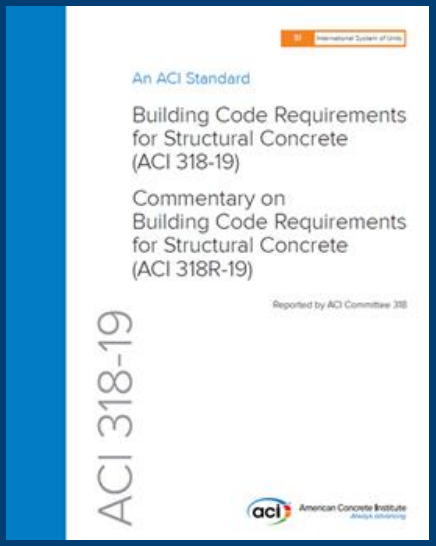
Prescriptive vs. Performance-Based Codes

- A **prescriptive building code** provides specific instructions for structural design, like a recipe

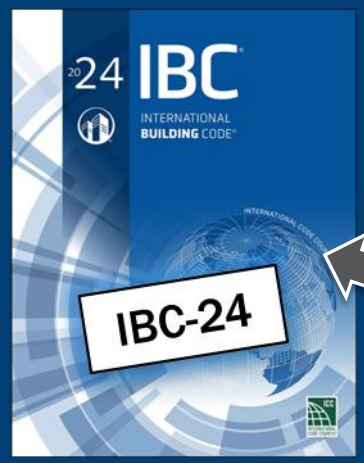
- A **performance-based building code** allows the engineer to pick from a range of load cases and a range of performance objectives, like a menu

ACI Code 318: Structural Concrete Building Code

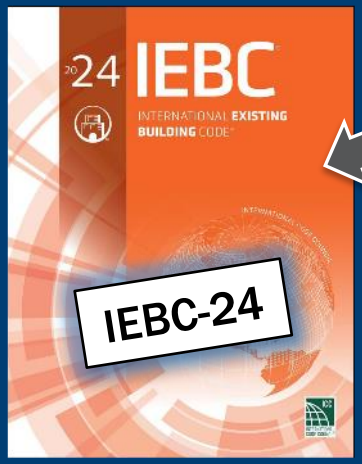
- Design for new concrete construction
- Design of new concrete elements and connections for repair and retrofit
- Prescriptive building code
- Recent editions: 2025, 2019, 2014, 2011, 2008
- Next edition: 2031



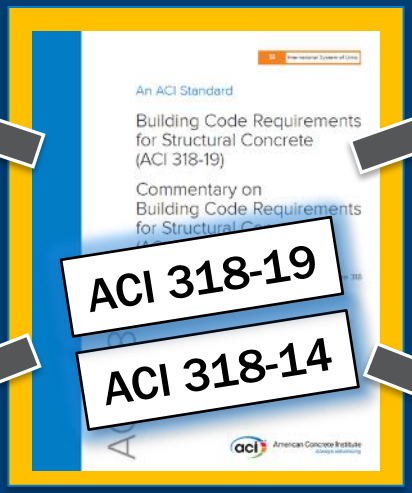
ACI Code 318: Interactions with Other Codes



New Buildings

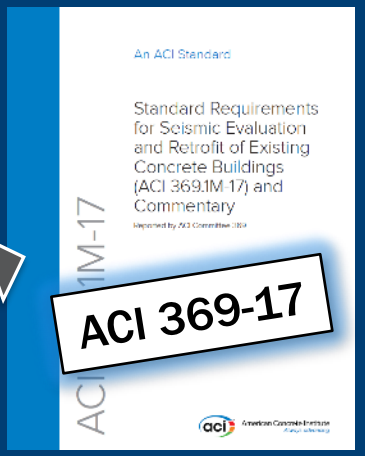


Existing Buildings

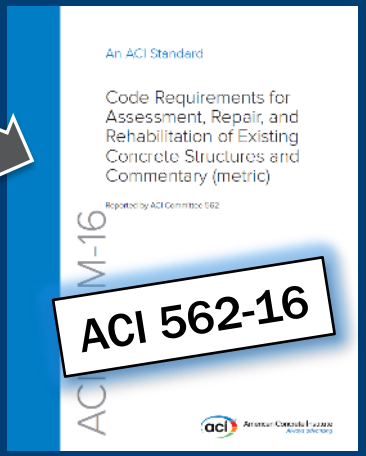


Design of New Concrete Elements

Seismic Evaluation and Retrofit

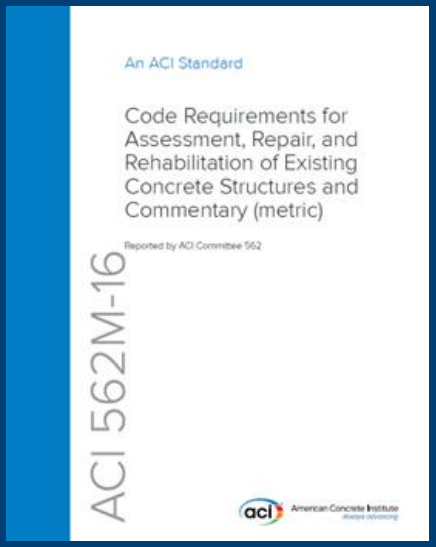


Assessment, Repair and Rehabilitation



ACI Code 562: Assessment, Repair, and Rehabilitation

- Assessment, repair and rehabilitation of existing concrete structures
- Does not include seismic evaluation and retrofit
- Can be used in combination with the IEBC, or as a stand-alone (independent) code
- Recent editions: 2025, 2021, 2019, 2016, 2013
- Next edition: 2028?



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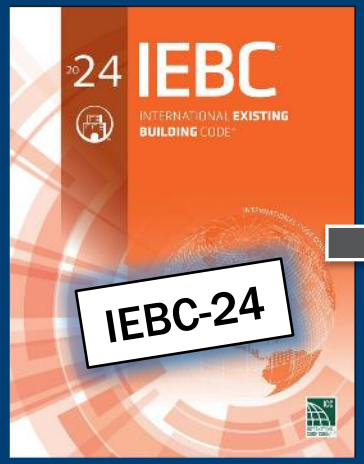
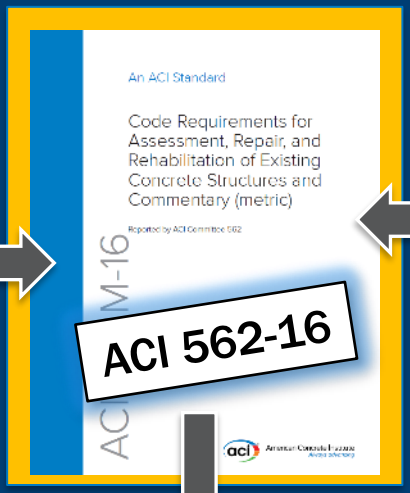


Code for Existing Buildings



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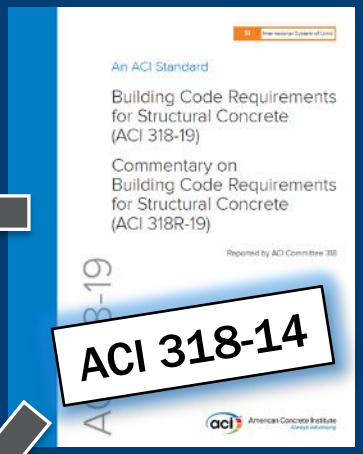
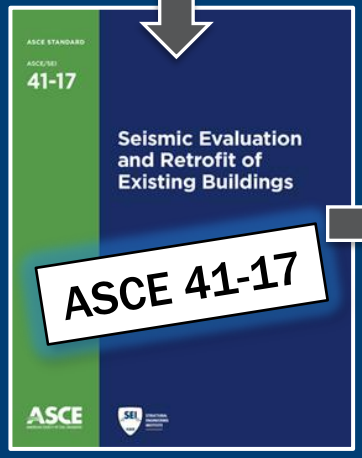
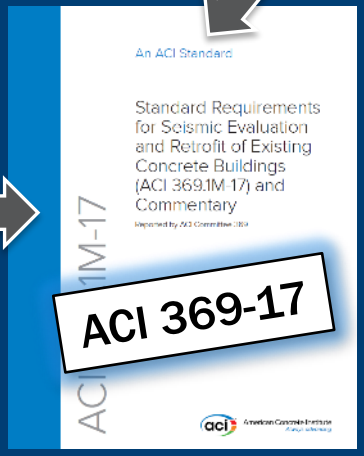


Design of New Concrete Elements



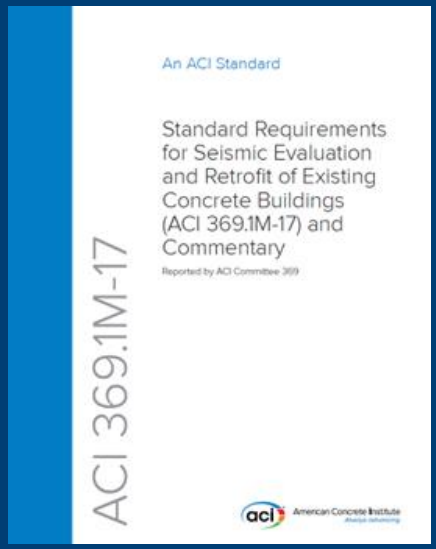
Seismic Evaluation and Retrofit of All Building Types



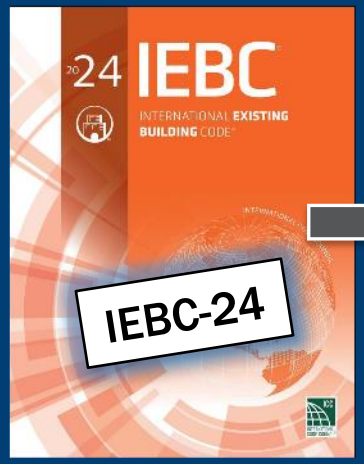
Seismic Evaluation and Retrofit

ACI Code 369: Seismic Evaluation and Retrofit

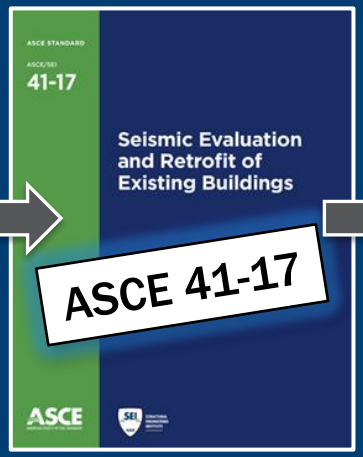
- Seismic evaluation and retrofit of existing structures
- Intended to serve as Chapter 10 (Concrete) of ASCE 41 “Seismic Evaluation and Retrofit of Existing Buildings”
- Performance-based building code
- Recent editions: 2022, 2017
- Next edition: 2028



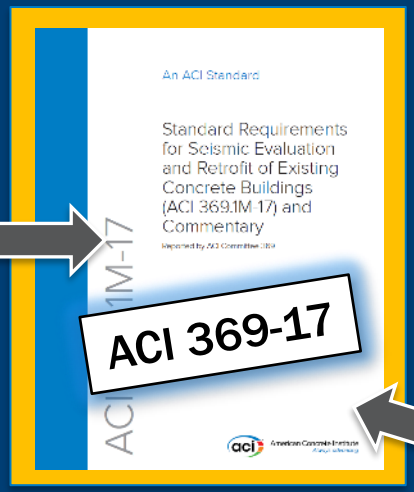
ACI Code 369: Interactions with Other Codes



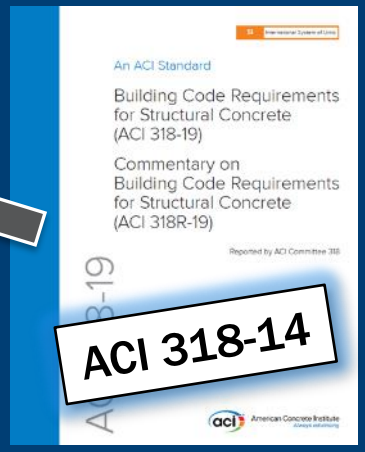
Code for Existing Buildings



Seismic Evaluation and Retrofit of All Building Types



Seismic Evaluation and Retrofit for Concrete Buildings (ASCE 41 Ch. 10)



Design of New Concrete Elements

Characteristics of the Three ACI Codes

Code	New or Existing Construction	General Assessment & Repair	Seismic Evaluation & Retrofit	Prescriptive or Performance Based
ACI 318: Structural Concrete Building Code	New (and Existing)	✓	✓	Prescriptive
ACI 562: Assessment, Repair, & Rehabilitation	Existing	✓	✗	Both
ACI 369: Seismic Evaluation & Retrofit	Existing	✗	✓	Performance Based

Example: Seismic Evaluation and Retrofit

10 Floors

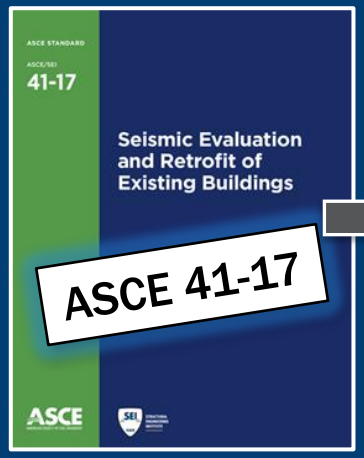
14 Years Old

Considerable structural and non-structural damage during the 2010 Maule, Chile earthquake.

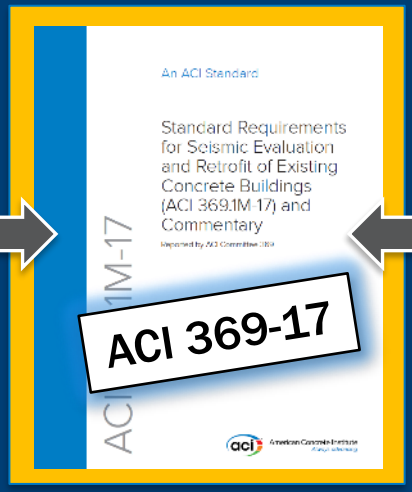
Slide courtesy Jose Pincheira

Example: Seismic Evaluation and Retrofit

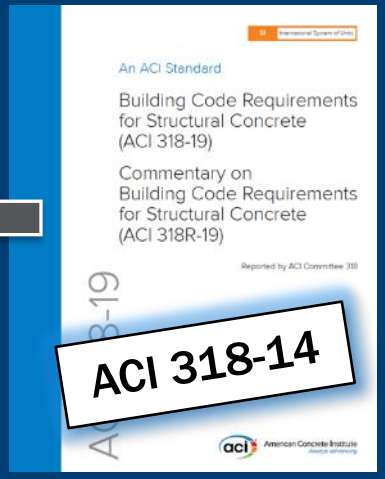
- Existing 10-story concrete building, in Chile
- Identify structural deficiencies and required retrofit using ASCE 41, ACI 369, and ACI 318



Seismic Evaluation and Retrofit of All Building Types



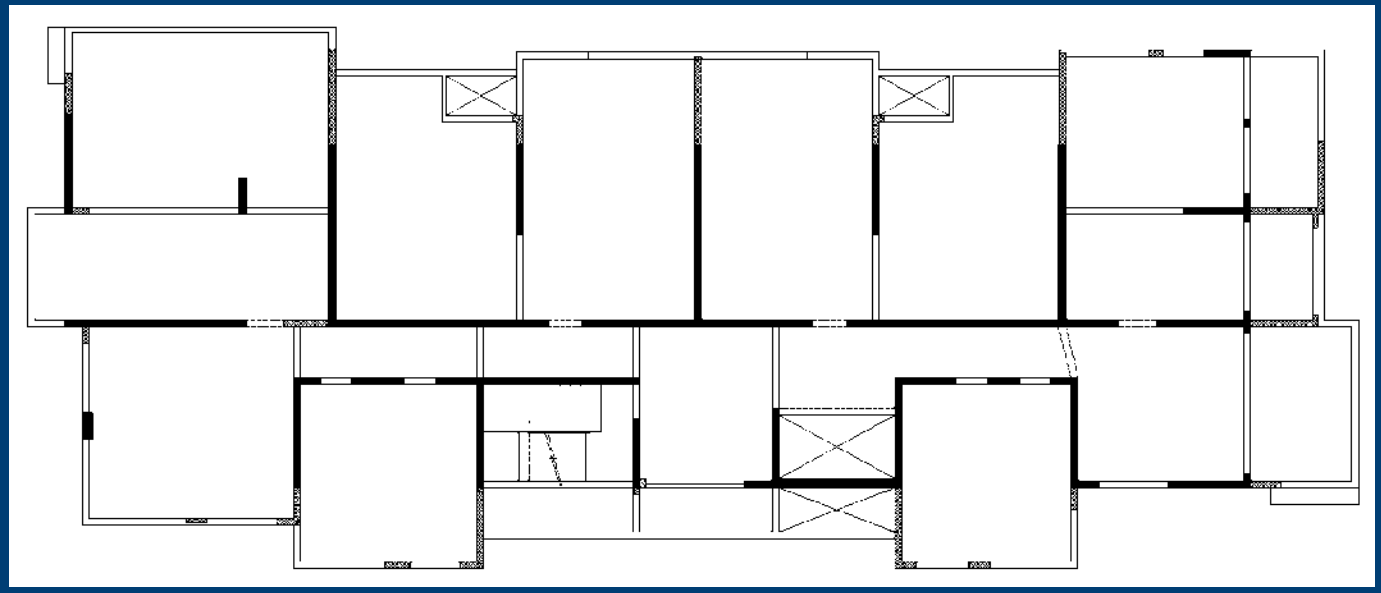
Seismic Evaluation and Retrofit for Concrete Buildings



Design of New Concrete Elements

Example: Seismic Evaluation and Retrofit

- ASCE 41 Tier 1: Identify possible deficiencies
- ASCE 41 Tier 2: Further analysis of deficiencies
- ASCE 41 Tier 3: Detailed analysis and design



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FIRST FLOOR PLAN

Slide courtesy Jose Pincheira

Example: Seismic Evaluation and Retrofit

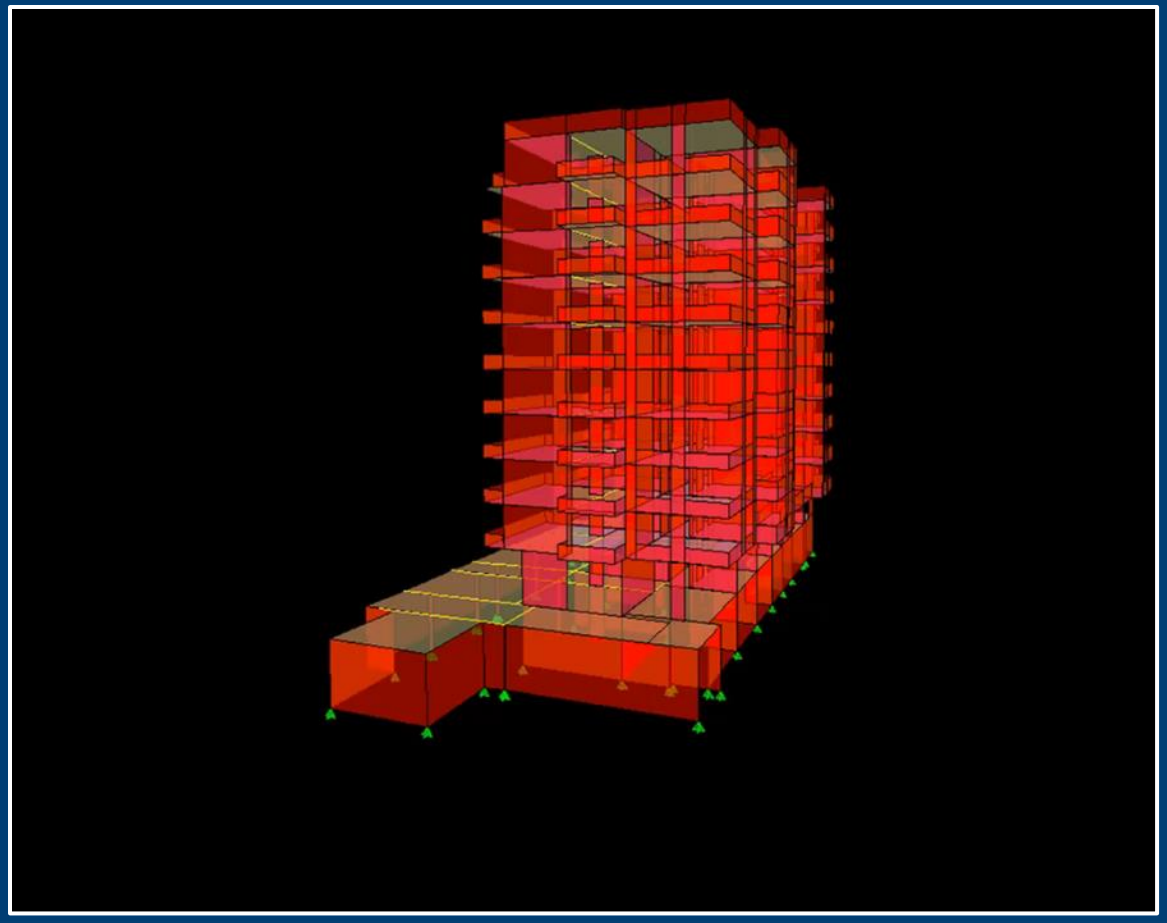
ASCE 41 Tier 1: Possible Seismic Deficiencies

- Average shear forces exceed the allowed limits on most levels
- Discontinuities and other irregularities in plan exceed the permitted limits
- Eccentricities in plan indicate that torsion effects can generate significant additional forces
- The horizontal reinforcement in the walls is below the allowed limits

Slide courtesy Jose Pincheira

Example: Seismic Evaluation and Retrofit

ASCE 41 Tier 2: Further Analysis of Deficiencies



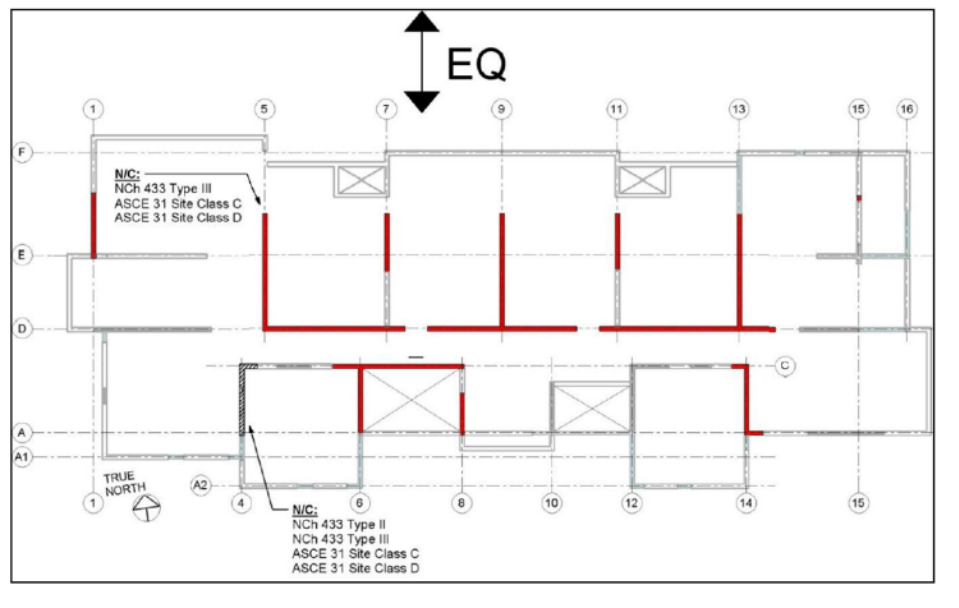
3D Modal Response Spectrum Analysis

Slide courtesy Jose Pincheira

Example: Seismic Evaluation and Retrofit

ASCE 41 Tier 2: Further Analysis of Deficiencies

- Most of the walls fail in flexure, combined with axial tension, in the north-south direction
- These walls fail in shear at the lowest four levels

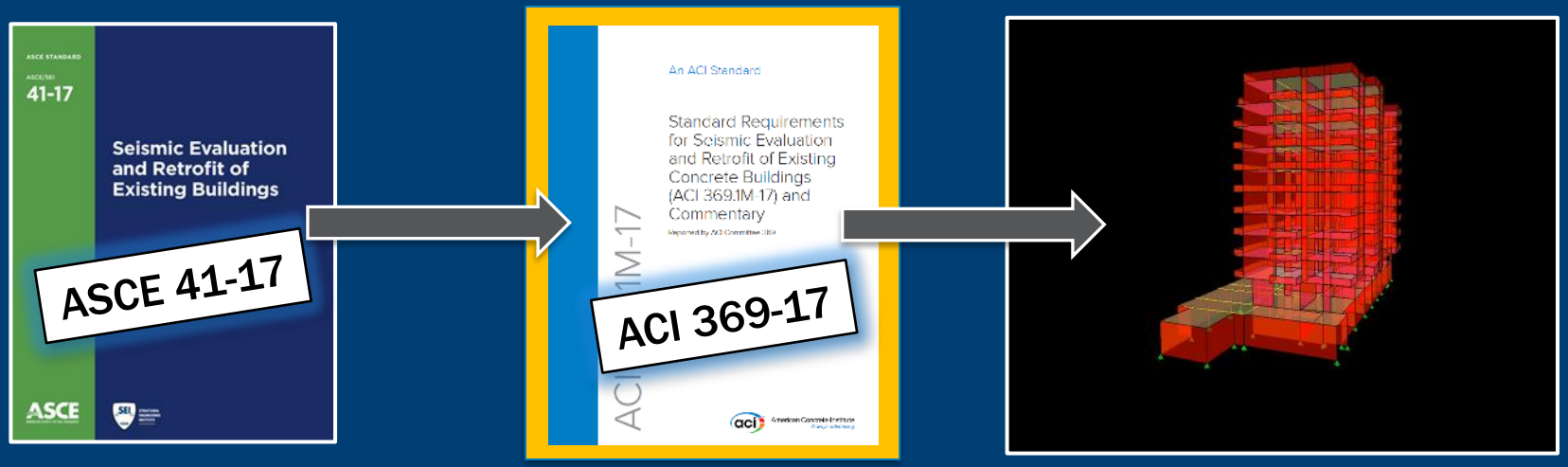


Slide courtesy Jose Pincheira

Example: Seismic Evaluation and Retrofit

ASCE 41 Tier 3: Detailed Analysis and Design

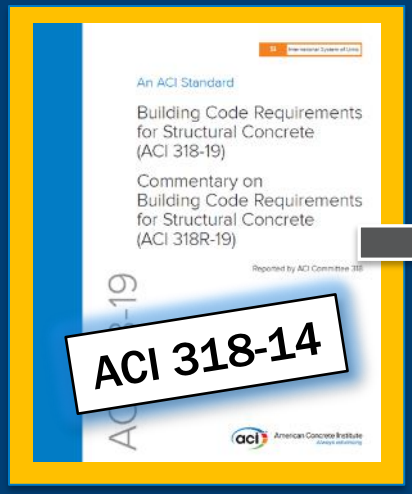
- To determine most effective retrofit design, perform 3D non-linear response-history analysis
- Use nonlinear modeling parameters and performance acceptance criteria from ACI 369



Example: Seismic Evaluation and Retrofit

ASCE 41 Tier 3: Detailed Analysis and Design

- From 3D non-linear analysis, determine that concrete encasement is the best retrofit option
- Design concrete encasement using ACI 318



Possible Improvements in Code Coordination

ACI Codes 318, 562, and 369 work together remarkably well, but coordination, or “meshing” between these and all other ACI codes could be improved. The same is true of coordination between all other U.S. building codes

It would be difficult to implement some of the changes necessary to improve coordination, but ideally these changes would include:

Possible Improvements in Code Coordination

- Synchronizing the calendar of code revisions

  This would require agreement among multiple organizations: ICC, ASCE, ACI, AISC, TMS, NEHRP, to name a few. Since there is no national building code authority in the U.S., synchronization has never been possible.

Possible Improvements in Code Coordination

- Improved planning and communications between committees

  - Convene a high-level planning committee. Within ACI, this function is fulfilled by the ACI Technical Activities Committee (TAC)

  - Promote overlapping membership between committees. Overlapping committee membership was implemented in the development of ACI Codes 318-25, 319-25, and 320-25

Possible Improvements in Code Coordination

- Develop a procedure for resolving discrepancies between building codes when conflicting provisions arise.
  - Code revision cycles are typically 3 to 6 years long. Discrepancies between codes cannot be allowed to persist for that long
  - Resolution of discrepancies may require mediation by a third party

Topics

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- Possible improvements in code coordination

Thank you

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