

# Reorganizing ACI 318

A look at reasons for and against

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BY RANDALL W. POSTON AND CHARLES W. DOLAN

**T**hrough its adoption into virtually all U.S. model building codes, ACI 318, “Building Code Requirements for Structural Concrete and Commentary,” plays a leading role in many areas related to concrete, including education, design, production, construction, and repair. It’s arguably one of the most influential concrete codes in the world and a primary reason for ACI’s reputation as a leading source of technical information on the use of concrete.

The basic framework of the current Code was established in 1963, when the document was crafted to introduce and provide guidance for the use of strength design. At that time, working stress design was the norm, prestressed concrete was in its infancy, and the Code contained no provisions for seismic design or connections to concrete. Subsequent editions of the Code have reflected changes in design practice, increased understanding of material and structural behaviors, and development of new materials and construction techniques. The fundamental organization of the code remained unchanged, however, as the Code and Commentary grew from 78 to 430 pages, from 750 to 2500 provisions, and from 250 to more than 1500 internal references (provisions that refer to other provisions) between the 1971 and 2005 editions.

To ensure that the Code continues to serve as a primary resource for the construction industry, ACI Committee 318 has elected to step back and examine the document’s organization. This article presents the case for reorganizing the Code and discusses why it may be prudent to do so at this time. To provide a balanced perspective, counter arguments are also reviewed. Organizational structures that might improve, and

possibly simplify, structural concrete design will be discussed in a second article.

## THE PURPOSE OF THE CODE

*“Well, the main function of the Code is to keep people out of trouble, to make structures safe, to make it difficult for somebody to design an unsafe structure.”<sup>1</sup>*

—Chester P. Siess (1998)

ACI Committee 318 consists of design professionals, industry and government representatives, and researchers assembled to maintain a balance of user, general, and producer interests. The committee actively debates whether a proposed new or revised provision in the Code is truly a minimum requirement or serves to improve performance. Anyone who has participated in or visited the deliberations has often heard ACI 318 members ask “Is this a lab condition or a field condition?” This question is at the core of code development.

A building code represents minimum requirements to ensure safety, serviceability, and durability. It isn’t an all-encompassing instruction manual meant to cover all circumstances and situations encountered in design. Literally hundreds of journal articles suggest changes to the Code, yet few of the recommended changes address minimum requirements for safe and functional performance. The role of the Committee is to determine what minimum provisions are needed to assure public safety and performance. The engineer remains responsible for the design.

The Code is both a leading and a lagging document. At times, research identifies new requirements that will

enhance public safety, and these are included in the Code prior to incorporation by the design profession. At other times, changes in design practice will occur as the result of external events, such as earthquakes, or new technologies, such as computer software, and these are incorporated into the Code to reflect revisions to historical practice.

Committee 318 moderates a continual discussion among safety and change. It's this constant interaction among practice, innovation, and research that leads all professional societies to stress lifelong learning skills.

## THE COMPLEXITY CONUNDRUM

*"Many code users feel the pendulum has swung too far towards complexity and the time has come for simplification and consolidation of ideas."*<sup>2</sup>

—James G. MacGregor (1981)

Complexity is an interesting concept. While most people would agree that today's cell phones are far more complex than the rotary dial phones of 40 years ago, few would go back to the old technology. Why? Because the benefits gained using the new technology are worth the extra time and effort required to understand its intricacies. The same is true in concrete structures. Today's flat-slab post-tensioned buildings, for example, with columns spaced 40 ft (12 m) on center and span-depth ratios of 40 are more complex and require more engineering attention than typical flat-slab buildings of 40 years ago, with columns spaced at 20 ft (6 m) on center and span-depth ratios of 20. In this case, engineers have learned to apply new technologies so they can design structures providing added value and performance for their clients.

Many designers want exact instructions for all situations, thus reducing the time required to select and optimize systems and allowing building officials to readily verify that a design reflects the current state of practice. Other designers may yearn, however, for the days when building codes provided only limited design rules and allowed engineers the freedom to express a structural design based on fundamental principles, experience, and judgment. So there will always be those who complain that the Code is too complex.

## REORGANIZATION SEEDS

*"Because supporting sciences do not always provide crisp answers to engineering problems, building requires the use of judgment. Judgment has soft boundaries and is influenced strongly by what is considered to be acceptable risk."*<sup>3</sup>

—Mete Sozen (2006)

The ACI document IPS-1, "Essential Requirements for Reinforced Concrete Buildings,"<sup>4</sup> developed under the

leadership of Luis E. García, generated considerable attention as a simplified approach to Code provisions in both North and South America. The success of this document and the PCA *Simplified Design* manual<sup>5</sup> suggest that an alternative Code organization may be beneficial.

The most recent seed for examining whether the Code should be reorganized was planted in 2003 when James Wight, Chair of ACI 318-08, asked James Jirsa, Chair of ACI Subcommittee 318-F, New Products, Ideas and Materials, to explore the idea. ACI Subcommittee 318-F reviewed the overall organization and drafted a number of concepts that might be used for general reorganization. Based on a voice vote of the ACI 318 membership in 2005, the general concept of code reorganization gained traction. Wight then appointed a task group to specifically study the issue in more detail, with the charge of identifying and refining the most promising concepts.

Beginning in 2006, this task group has been engaged in a methodical process to address whether the stakeholders were truly interested in a reorganization of the Code. To this end, ACI retained a consulting firm to assist in developing independent and objective information that would guide a potential reorganization. The deliberate steps to obtain the information included:

- An online Web site survey open to the general membership of ACI;
- A focused online questionnaire (e-survey) sent to selected purchasers of the 2005 Code;
- Focus group meetings with end users of the Code, held in Seattle, WA, and Chicago, IL; and
- A workshop of selected ACI Committee 318 members, practitioners, contractors, material suppliers, and other interested parties that provided a forum for individual and collective strategic thinking related to organizational concepts that had been developed by the task group.

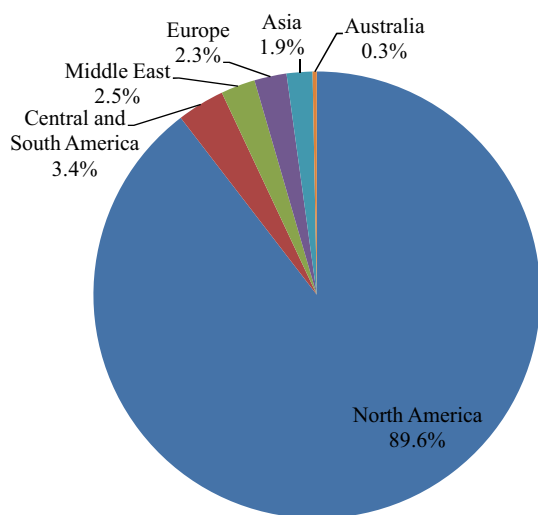
## REASONS FOR CHANGE

*"The possibility of a two level code has been investigated. ... The code would be written in a 'what-to-do' format as opposed to the present 'how-to-do-it' provisions."*<sup>6</sup>

—Eugene P. Holland and William Cromartie (1977)

## E-survey

The electronic survey (e-survey) was sent to more than 4100 people who purchased the 2005 edition of the Code. Responses were received from 641 individuals. For a population of this size, 350 respondents were needed to achieve results with a statistical 95% confidence. The average number of years a respondent had used the Code was 22, and over 60% used the Code on at least a weekly basis. This indicated that responses were from a large pool of seasoned Code users.



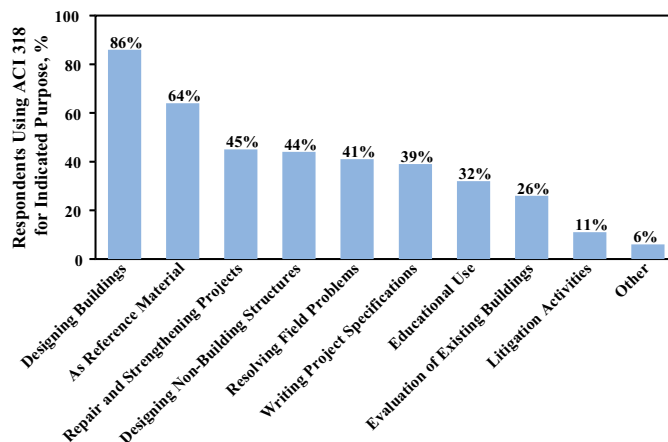
**Fig. 1: Geographic distribution of respondents to an e-survey sent to individuals who purchased ACI 318-05**

The geographical distribution of the respondents is summarized in Fig. 1. Naturally, the largest percentage was from North America (U.S., Canada, and Mexico) followed by Latin America, the Middle East, Europe, Asia, and Australia.

One of the more interesting data sets from the e-survey was the reason respondents had for using the ACI Building Code (Fig. 2). As expected, design of buildings was the principal reason; however, almost half of the respondents used the Code for repair and strengthening projects and the design of structures other than buildings. Thus, the Code functions well beyond its primary function of providing criteria for new building construction.

When asked which Code subjects were most difficult to apply, the topics that appeared to be most troublesome for the respondents were shear and torsion (Chapter 11) and special seismic design provisions (Chapter 21), followed by two-way slabs (Chapter 13), development and splice lengths (Chapter 12), post-installed anchors (Appendix D), and the strut-and-tie approach (Appendix A). Chapter 21 underwent extensive revision for 2008, so the expressed difficulties of its use have already been addressed. The topics that appeared to be most understandable to the respondents were general considerations for analysis and design (Chapters 8 and 9) and design for flexure and axial loads (Chapter 10). This indicates that the goal of the 1963 and 1971 editions of the Code—to instill strength design concepts—has been successfully accomplished.

Probably the most important idea gleaned from the e-survey was that the Code should be organized parallel to the design process. What this means exactly is open to



**Fig. 2: E-survey respondents' reasons for using ACI 318**

broad interpretation, but at a minimum, the respondents indicated that provisions for member design and detailing should be grouped together or bookmarked for easier identification. An improved organization would help assure the users that all necessary provisions of the Code have been satisfied. The other item that was high on the wish list was a mechanism by which new technology and materials could be approved by building officials without the extensive vetting and lengthy timeline that seems to have been required in the past for introduction into the Code.

## REORGANIZATION WORKSHOP

*“Because codes have such a great effect on practice—sometimes restrictive and sometimes stimulating—we must be extremely careful when making changes in them.”*

—Chester P. Siess (1960)

At a workshop held in Chicago on February 20, 2007, three presentations were made outlining possible reorganization concepts and formats. Because change must provide a benefit, Siess’s comments from 1960 were at the forefront of the discussion. The three formats presented and the presenters were:

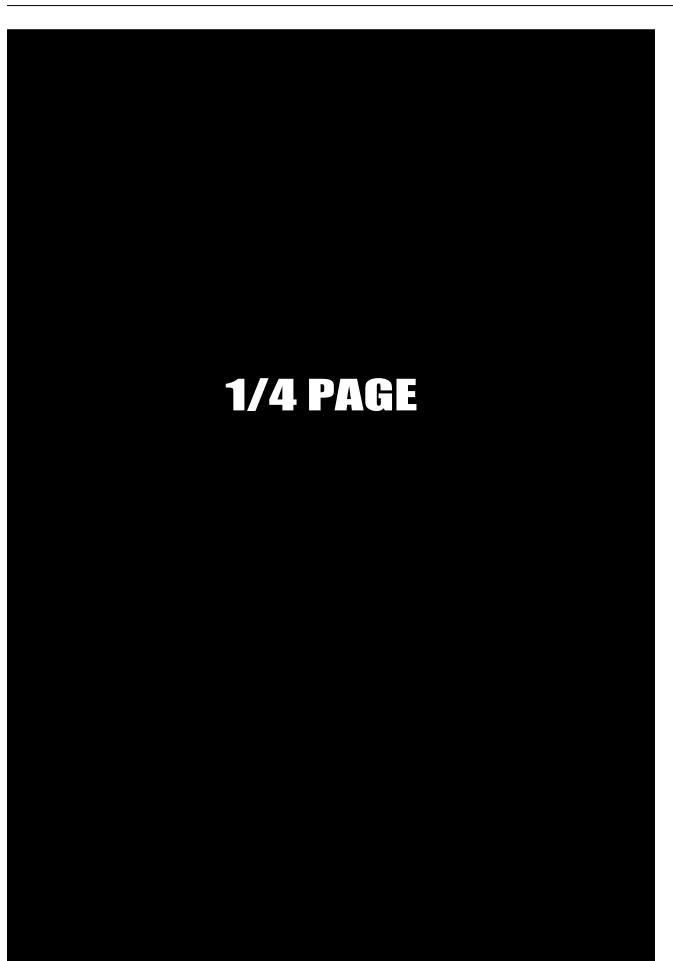
- A behavior-based format—Charles Dolan;
- A member-based format—Luis García and Gustavo Parra-Montesinos; and
- A “stay-the-course” format—Sharon Wood.

The presentations were conceptual in nature and meant to stimulate discussion. The participants were asked to focus on the potential advantages and disadvantages of each format. The behavior-based format included the concept of performance-based provisions that seem to be

a driving force in the development of other codes around the world. There was also some positive feedback about the alignment of Code provisions in this way from respondents to the e-survey.

The member-based format was an outgrowth of the e-survey respondents asking for a Code organized parallel to the design process. In this organization, loads are determined, gravity and lateral systems are defined, the structure is analyzed, and finally, members are designed and detailed in the general order of slabs, beams, columns, and foundations.

The presentation on a “stay-the-course” format didn’t advocate doing nothing to the Code. Rather, it described a comprehensive top-to-bottom review of all existing provisions with an adaptive structure that would lend itself to an electronic format in which necessary provisions for a particular aspect of design could be grouped by search-generated layering. The concept was to review every Code provision, improve logical connections with related provisions, and increase the uniformity of presentation.



CIRCLE READER CARD #0

After extensive discussion in smaller breakout groups, workshop participants agreed to focus on Code usability and navigation. Areas for improving the Code were tied to three main goals:

1. Increase the distinction between design and construction requirements in the Code;
2. Streamline the organization of detailing provisions; and
3. Increase the ease of navigation for beginning users.

Code complexity, as described by the workshop participants, is related to the large quantity of information and the many inter-relationships between information in different sections or chapters of the Code. This resulted in the general sentiment that there may be a more intuitive Code organization that would simplify routine design tasks but include supplemental language for more multifaceted projects.

The challenge of adapting the Code to changing technologies and methods was the subject of repeated discussion during the workshop. What became clear is that the current framework, which was invaluable for the introduction of strength design, will need adjustment to accommodate the next 40 years of knowledge expansion. Because a new item or concept introduced in the Code may require fine tuning across numerous existing provisions, ACI 318 subcommittees proposing a change must essentially review the entire Code to assess its impact. While clarity is an objective of the Code, this type of painstaking and overlapping review for each and every Code change can result in decisions that fragment the Code. Even with the best intentions, the net result of decades of change over several Code cycles and hundreds of individual decisions by the collective committee is a document that is less than fully synchronized. The workshop participants suggested that a different organizational structure of the Code could enhance the ability to add new material into the Code.

### **REASONS FOR MAINTAINING THE CURRENT FORMAT**

*“It is not to be expected that every 6 to 8 years there will be basically new developments.”*<sup>8</sup>

—George Winter (1982)

What Winter perhaps did not foresee was the accelerated development of technology affecting the design of concrete structures. Enhanced computational tools, advanced seismic behavior laboratories, and innovative engineers have lead to design-related changes that occur much faster than in the previous generation. Despite many positive comments from designers indicating that Code reorganization would be beneficial, there is still an undercurrent that changes to the Code are already too frequent for practitioners to absorb. The sentiment is that just when a user is comfortable with the provisions

in the current Code, they have to learn the Code all over again. Maintaining the current structure, perhaps following an extensive review, capitalizes on the investment that the current users have made in learning the current Code structure.

Maintaining the current structure will not eliminate changes and updates but may lead to a perception that designers need not learn or relearn a new Code. To many, the time necessary to study and learn a new Code appears counter-productive to design, especially considering the very competitive nature of structural design services. Shrinking design fees and a patchwork of jurisdictional acceptance of different versions of the Code are often arguments for maintaining a familiar format where change is more easily absorbed by the current users. There is also the rhetorical question that the current provisions seem adequate, so why do Code provisions need to be changed or new provisions added?

Engineers have learned lessons from the performance of concrete buildings in extreme events like earthquakes, and building designs are surpassing the threshold of what is known from past experience and research. Thus, the Code needs to evolve to ensure public safety. What was considered a safe design in the past may not be deemed as safe as currently required for building design, especially as engineers push the envelope and incorporate emerging technologies. The Code must be responsive to new challenges for concrete to continue to be safe, economical, and at the forefront of construction technology. Technology continues to advance in concrete construction at an ever more rapid pace. The Code must have the ability to address rapid advances in materials, design methods, and construction practices.

## IT'S TIME

Although many would argue that change is counter to human nature, it is sometimes necessary to effect strategic change to make a measurable leap in efficiency and productivity. It's believed that making a structured reorganization of ACI 318 at this time will result in this type of measured change that is responsive to public concerns while still maintaining the public trust. A strategic reorganization will improve understanding of the design process for structural concrete and will provide a platform for future change. In any case, a systematic review will be beneficial. As with any ACI technical committee document, Committee 318 consensus will be reached before significant decisions are made.

In the next article, reorganized Code concepts will be presented. Regardless of future format, the objective of the Committee is to keep ACI 318 at the forefront of code development.

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Selected for reader interest by the editors.



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