ACI 318 PLUS: A Digital Interactive Tool for Teaching Concrete Design Courses

by Benjamin Z. Dymond, Brock D. Hedegaard, Andrea J. Schokker, Trey Hamilton, and Michael L. Tholen

In 2021, ACI launched ACI 318 PLUS, an annual subscription service providing interactive access to ACI CODE-318-19: Building Code Requirements for Structural Concrete and Commentary (the Code),[1] the *ACI Detailing Manual*,[2] and numerous design examples in the *ACI Reinforced Concrete Design Handbook*.[3] The ACI 318 PLUS platform was designed to:

- Provide Code users with greater ease of access and utility than traditional print- or PDF-based manuals; and
- Link many valuable ACI resources to appropriate Code and Commentary provisions.

While ACI 318 PLUS initially opens like a PDF copy of the Code on a computer screen, major enhancements soon become evident. Users quickly find that the platform includes in-document links to related resources, enhanced search capabilities, and robust digital note-taking capabilities.[4] Specifically, the digital note-taking functionality allows subscribers (such as the structural engineering division of a consulting firm or students enrolled in a collegiate concrete design course) to create and maintain up to 10 unique digital note sets (unlimited sets for ACI Faculty Network members) that are attached to the appropriate ACI CODE-318-19 provision and Commentary section, as shown in Fig. 1. Further, note sets can be shared with other ACI 318 PLUS subscribers.

Note Sets

Print

Course materials required for students in university-level concrete structural engineering courses may vary widely, from traditional printed textbooks to free, open-access online digital

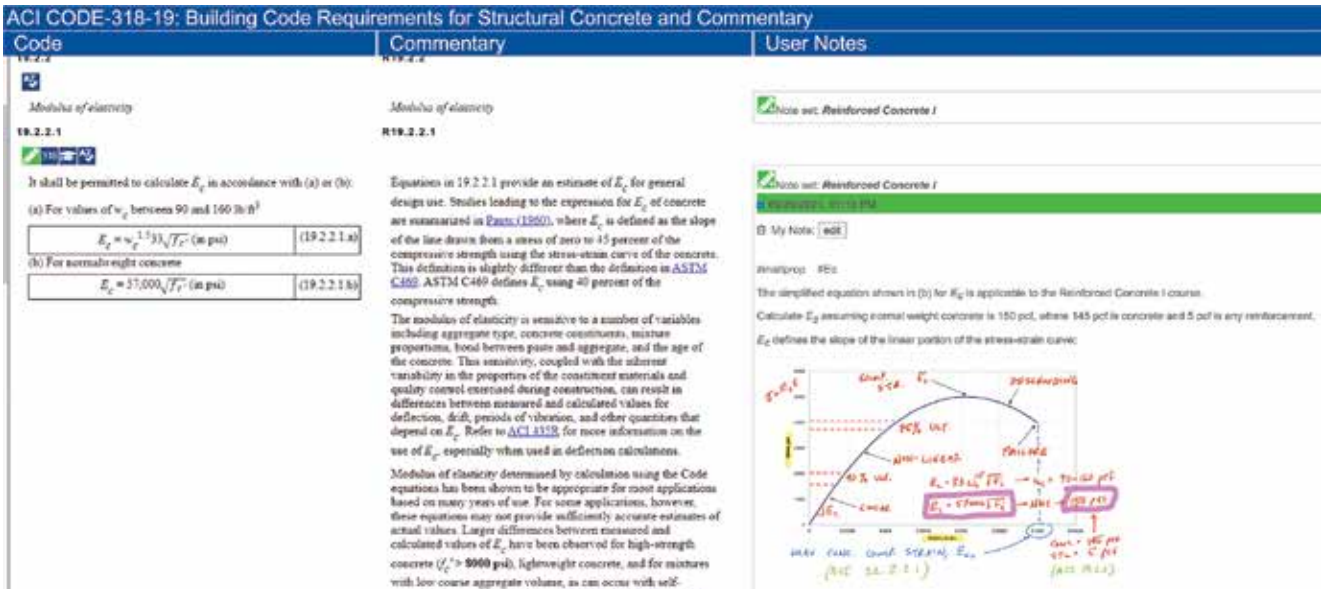

Fig. 1: Screenshot from ACI 318 PLUS showing the Code (left), Commentary (middle), and User Note Set (right) associated with Section 19.2.2.1 for the note set titled Reinforced Concrete I

textbooks. Some instructors require that students purchase a print copy of ACI CODE-318 at the student membership pricing level (approximately 40% cheaper than the member price and 65% cheaper than the nonmember price). Students with print copies of the Code can annotate and sticky-note their volume throughout several courses (for example, while completing in-class work or individual homework assignments or while preparing for an open-book exam) before graduating and entering the workforce. As entry-level employees, these former students maintain access to a wealth of personalized material from several courses in a single document.

Print plus

Every purchaser of a print copy of ACI CODE-318 receives a free, 1-year subscription to ACI 318 PLUS, and this benefit extends to students. This online platform makes it possible to maintain personalized, digital sets of user notes. Graduating students entering the workforce can maintain access to their personalized material in a single, online repository, including notes accumulated from several courses. Further, if their employer subscribes to ACI 318 PLUS and maintains a user note set, these entry-level employees will be able to access their company's concrete engineering knowledge base from any continent at any time.

Faculty capabilities

Faculty members teaching concrete classes can leverage ACI 318 PLUS to augment the classroom learning experience. Faculty can produce course note sets that can be shared with students as a reference. More innovative teaching methods are also possible, such as embedding notes within the Code and Commentary for in-class quizzes, Code provision hunts, or worked examples. Members of the ACI Faculty Network are eligible to receive free access to ACI 318 PLUS.[5]

To explore the concept of implementing ACI 318 PLUS in a multicourse university format, note sets were created for three university-level concrete structural engineering courses in the 2021-2022 academic year. At the conclusion of the project, the note sets were vetted by ACI staff and approved for distribution to the ACI Faculty Network. The three courses were:

- Reinforced Concrete I—covering introductory topics in concrete materials, structural loads, and reinforced concrete design;
- Reinforced Concrete II—covering advanced structural concrete design topics; and
- Prestressed Concrete—covering introductory topics in prestressed concrete materials and structural design.

The goal of creating these note sets was threefold:

- Provide students digital access to their instructor's course notes, directly linked to the relevant section of ACI CODE-318;
- Allow students to copy or modify a faculty member's note sets into a personalized note set with their own annotations that could be carried forward to successive concrete courses. For example, notes created in Reinforced Concrete I could be accessed while enrolled in Reinforced Concrete II or Prestressed Concrete; and
- Generate complete note set templates for these three courses and distribute them to interested ACI Faculty Network members who can subscribe to ACI 318 PLUS for free.

Note Set Access and Management

Subscribers can manage and create note sets in ACI 318 PLUS through the navigation bar, as shown in Fig. 2. Clicking on the "Manage Notes" button takes users to a separate notes management web page. The various sections of the notes management web page are discussed in depth in the following sections.

Copying Faculty Network Note Set Templates

ACI Faculty Network members are allowed to copy the three note set templates created and vetted as a part of this project for implementation in their own courses, as shown in Fig. 3. Once copied, the note sets become part of the user's collection and are available for access and editing in ACI 318 PLUS. Copying one of these note sets creates a separate, individualized note set within the user's profile. While users can make and save changes, the modifications do not affect the original note set templates.

Fig. 2: Screenshot of ACI 318 PLUS navigation toolbar where users can search by keyword (#matlprop in this figure), manage notes, and select which user notes to display

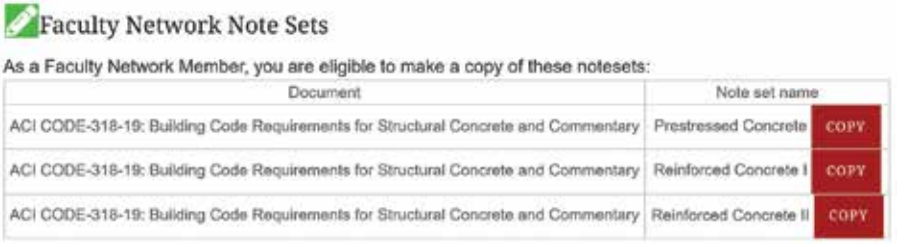

Fig. 3: Screenshot of ACI 318 PLUS notes management interface where ACI Faculty Network members can copy existing note sets vetted by ACI staff

Creating New User Notes

ACI Faculty Network members are allowed to create an unlimited quantity of new (or copied) note sets (versus a limit of 10 note sets for other users). The first step is to create and name an individual note set, as shown in Fig. 4. This will automatically populate into ACI 318 PLUS, which is where the content of each note set is generated, viewed, and saved. The content of each note set is generated in ACI 318 PLUS through the use of editing software that creates content in a form that resembles its appearance when displayed as a finished product (a "what you see is what you get," or WYSIWYG, system); this style of editing system is similar to university learning management systems such as Canvas.

Sharing User Notes

Once created (or copied from the note set template), note sets can be shared with any user that has access to ACI 318 PLUS, which can include students, colleagues, or co-workers within the same engineering firm. Invitations to share (or stop sharing) note sets are sent through the notes management interface, as shown in Fig. 5. Invitations are sent by entering the email address of each individual person. Invitations are rescinded by deleting each individual user, as shown at the bottom of Fig. 5. These shared note sets update automatically when changes are made by the original author but cannot be modified by the person with whom they are shared. ACI 318 PLUS users can also manage (remove) the note sets that have been shared with them, as shown in Fig. 6.

Fig. 4: Screenshot of ACI 318 PLUS notes management interface where users can create new note sets

Applying ACI 318 PLUS and User Notes

Users can access note sets by selecting and showing user notes in the ACI 318 PLUS interface, as shown in Fig. 7. For example, Fig. 8 and Fig. 1 display the ACI 318 PLUS interface with Reinforced Concrete I notes shown. Due to the length and complexity of the ACI 318 Code and Commentary, finding information in a completed ACI 318 PLUS note set is most easily done with an advanced topic search using the navigation toolbar. To facilitate this process, the first entry in any note set should be located alongside the cover (frontmatter) of ACI 318 PLUS. This initial entry should describe the content within the note set, and it should specifically delineate keyword search terms associated with each topic using a hashtag (#), as shown in Fig. 8. For example, the list of topics by subject and the corresponding search hashtag shown in Fig. 8 indicate that note set information associated with concrete or steel reinforcement material properties can be found with the hashtag #matlprop. Thus, ACI 318 PLUS users can conduct an advanced keyword search within their note set to find all the locations where material properties are discussed, as shown in Fig. 2, where the keyword search entry is #matlprop. Figure 1 shows an example result from the #matlprop keyword search within the note set, where the ACI 318 PLUS user has navigated to ACI 318-19, Section 19.2.2.1 and Commentary Section R19.2.2.1, and the associated note set entry to read about the modulus of elasticity of concrete (E_c). This method of navigation is efficient for any ACI 318 PLUS user who knows the topic of interest but may not know the relevant section within the Code or Commentary. Alternatively, the user can navigate the Code and Commentary by chapter titles and first-level headers, as shown in Fig. 9; headers lower than the first level do not display the associated section titles.

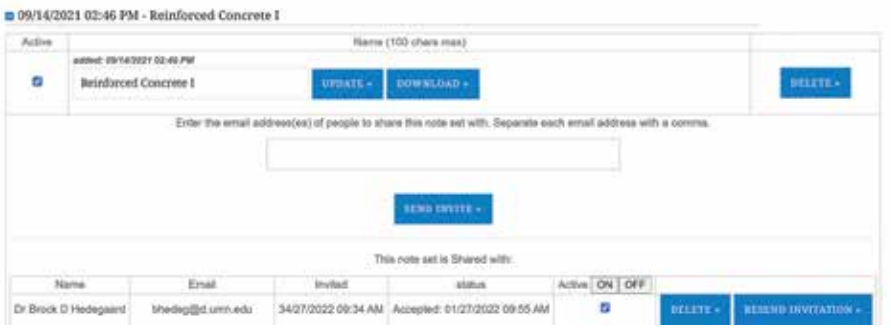

Fig. 5: Screenshot of ACI 318 PLUS notes management interface where users can share or rescind note sets

Fig. 6: Screenshot of ACI 318 PLUS notes management interface indicating which note sets are shared with the ACI 318 PLUS user

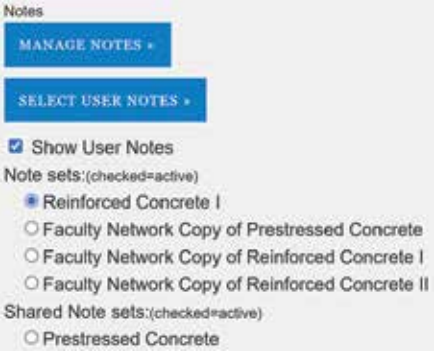

Fig. 7: Screenshot of ACI 318 PLUS navigation toolbar where users can select and show note sets; Reinforced Concrete I user notes are selected in this figure

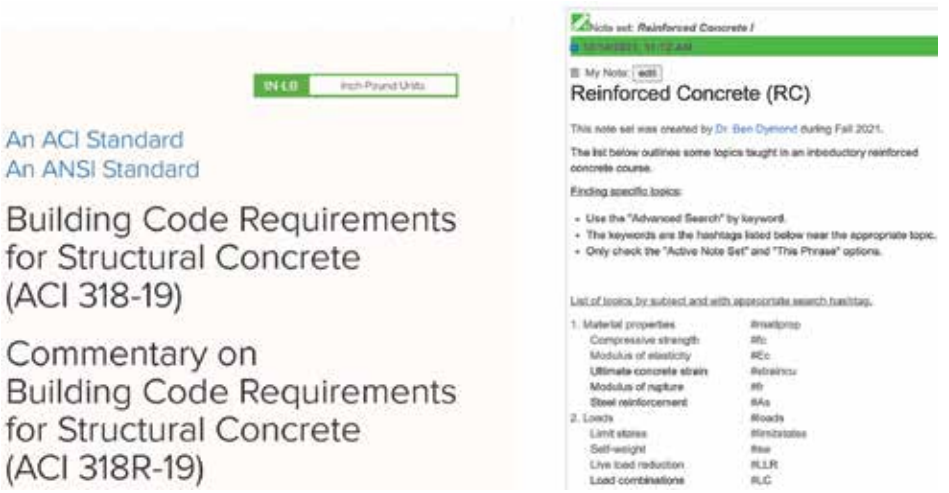

Fig. 8: Screenshot of ACI 318 PLUS with a Reinforced Concrete I note set shown; the right side of this figure displays the initial note set entry, which describes the keyword search terms associated with each topic using a hashtag (#)

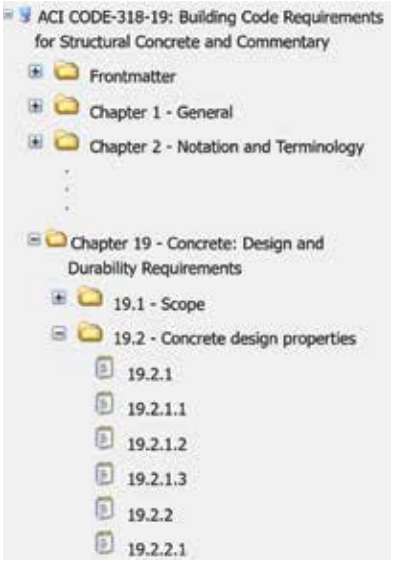

Fig. 9: Screenshot of ACI 318 PLUS navigation toolbar open to ACI CODE-318-19, Section 19.2.2.1

Summary

ACI 318 PLUS provides users with subscription-based digital interactive access to ACI CODE-318-19, the *ACI Detailing Manual*, and *ACI Reinforced Concrete Design Handbook*. Within this platform, users can access in-document links to related resources, take advantage of robust digital note-taking capabilities, and perform advanced searches of the Code, Commentary, or user notes. Note set templates for three university-level concrete structural engineering courses (Reinforced Concrete I, Reinforced Concrete II, and Prestressed Concrete) have been vetted by ACI staff and are available for use by members of the ACI Faculty Network. For more information on subscribing to ACI 318 PLUS or joining the ACI Faculty Network, readers are encouraged to access the links provided in References 4 and 5.

References

1. ACI Committee 318, "Building Code Requirements for Structural Concrete and Commentary (ACI CODE-318-19) (Reapproved 2022)," American Concrete Institute, Farmington Hills, MI, 2019, 624 pp.

2. *ACI Detailing Manual* (MNL-66(20)), American Concrete Institute, Farmington Hills, MI, 2020, 500 pp.

3. *ACI Reinforced Concrete Design Handbook* (MNL-17(21)), American Concrete Institute, Farmington Hills, MI, 2021.

4. "ACI 318 PLUS," American Concrete Institute, Farmington Hills, MI, 2023, www.concrete.org/publications/aci318plus.aspx.

5. "Faculty Network," www.concrete.org/educatorsandresearchers/facultynetwork.aspx.

Selected for reader interest by the editors.

ACI member **Benjamin Z. Dymond** is an Associate Professor in the Department of Civil Engineering, Construction Management, and Environmental Engineering at Northern Arizona University, Flagstaff, AZ, USA. He is Chair of ACI Committee S802, Teaching Methods and Educational Materials, Secretary of ACI Committee 342, Evaluation of Concrete Bridges and Bridge Elements, and a member of several other ACI committees. His research interests include design and analysis of concrete structural systems and their components, experimental investigations, long-term structural monitoring, and engineering education. He received his BS and MS in civil engineering from Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA, USA, and his PhD from the University of Minnesota, Twin Cities, Minneapolis, MN, USA.

ACI member **Brock D. Hedegaard** is an Associate Professor of civil engineering at the University of Minnesota Duluth, Duluth, MN. He is a member of ACI Committees 209, Creep and Shrinkage in Concrete; 342, Evaluation of Concrete Bridges and Bridge Elements; 435, Deflection of Concrete Building Structures; and 444, Structural Health Monitoring. His research interests include the time-dependent behavior of concrete structures, structural health monitoring, and multiscale modeling. He received his PhD from the University of Minnesota, Twin Cities.

Andrea J. Schokker, FACI, is an ACI Engineer and Senior Technical Consultant and Advisor to the Board for NEU: An ACI Center of Excellence for Carbon Neutral Concrete. She received her BS and MS in civil engineering (structures) from Washington University in St. Louis, St. Louis, MO, USA, and her PhD from The University of Texas at Austin, Austin, TX, USA.

Trey Hamilton, FACI, is an ACI Engineer and serves as Secretary of Joint ACI-PCI Committee 319, Precast Structural Concrete Code, and Joint ACI-PTI Committee 320, Post-Tensioned Structural Concrete Code. He received his bachelor's and master's degrees from the University of Florida, Gainesville, FL, USA, and his PhD from The University of Texas at Austin. He is a licensed professional engineer in Florida and Wyoming.

Michael L. Tholen is the ACI Senior Managing Director of Technical Operations. He serves as Secretary to the ACI Technical Activities Committee (TAC) Construction Standards Committee and Staff Liaison to the ACI TAC Productivity and Constructability Subcommittee. He received his BS in architectural engineering and his MS and PhD in civil engineering from the University of Kansas, Lawrence, KS, USA. Tholen is a licensed professional engineer in the state of Kansas.