CREATING AN ONLINE CONCRETE MASONRY COURSE FOR ACCESSIBILITY

A Project Report

In partial fulfillment of the requirements for the degree

Master of Science in Architectural Engineering

by

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I. Introduction

In the span of two quarters, Fall 2020 and Winter 2021, an online undergraduate course in masonry design was created by an architectural engineering (ARCE) student in the blended Bachelor of Science + Master of Science program under the careful supervision of their faculty advisor. This report will outline the process of creating the course and discuss the lessons learned about masonry construction and structural engineering industry practices used. This project could not be successful without the support of two generous sponsors: the Concrete Masonry Association of California and Nevada (CMACN) and the Masonry Institute of America (MIA). Special thanks is given to another architectural engineering student, Jacob Morgan, who peer reviewed this work.

A. *Purpose*

The main purpose of this project is to create an undergraduate online course in reinforced masonry design that achieves two goals: (1) the course is in an asynchronous delivery format, and (2) the course content fulfills web accessibility requirements. Additionally, the architectural engineering student is to reinforce and increase their current knowledge of reinforced masonry design and learn more about masonry construction. The student is to familiarize herself with structural engineering industry practices as well as build "soft skills" in graphic software and communication.

B. *Background*

In this section, important aspects of the project are defined, such as the relevance of building a course in an online format, the meaning of "asynchronous" and "accessible" content, and the significance of studying masonry design as an undergraduate structural engineering student. Structural engineering practices are introduced as standard operating procedures of the project. Lastly, graphic software and communication skills are discussed for professional development.

Create an Online Course

Online courses are growing more prevalent with the ubiquity of video-oriented platforms like YouTube and Khan Academy. Video-learning has its advantages by allowing immediate access to information to the viewer, who can watch and re-watch lessons from the comfort of a smartphone. Video lessons are also relatively short in duration with the added option to adjust playback speeds. Khan Academy is an example of a platform where content is delivered *asynchronously*, which means learning does not require in-person or real-time meetings between students and instructors. An online course delivered asynchronously leaves the pace of learning up to the discretion of the student. However, an asynchronous format requires all content to be available upfront.

In addition to providing flexibility to the learner, online courses must be created with accessibility in mind to eliminate barriers to learning. In the state of California, Section 508 of the Rehabilitation Act of 1973 requires websites and other electronic sources to be accessible for individuals with disabilities. These disabilities range from “visual, auditory, physical, speech, cognitive, language, learning, and neurological” (“Web Content Accessibility Guidelines (WCAG) 2.1.”). In addition, the Web Content Accessibility Guidelines (WCAG) 2.1 Level AA Standards list the requirements for web accessibility.

Accessible content includes but is not limited to:

- text that can be read at an acceptable font type and size
- text and annotated figures that can be read by screen readers
- figures and text with foreground and background colors that adequately contrast for visual disabilities
- closed captioning for videos and other audio/visual media

The WCAG 2.1 standards were used to format course content for publishing on Canvas (“Canvas Overview”) as the host platform.

Reinforce and Increase Current Knowledge of Reinforced Masonry Design

Masonry design is not commonly offered as a structural engineering course in undergraduate curricula. Since much of masonry design theory parallels concrete design theory, many graduates rely on their knowledge of concrete design to learn masonry design on the job. Fortunately, at Cal Poly, the Architectural Engineering undergraduate curriculum has a course in masonry design theory (ARCE 305) and a hands-on design laboratory for timber combined with reinforced concrete masonry (ARCE 451). In these courses, students familiarize themselves with the design of structural members including beams, columns, and walls for axial, flexural, shear, and combined forces. They also utilize the *TMS 402/602 Building Code Requirements and Specifications for Masonry Structures* (TMS 402/602 Committee 2016) and the *Design of Reinforced Masonry Structures* (DORMS) design aide (Brandow et al 2015). Mastering masonry design theory helps structural engineers predict performance of masonry structures, which is relevant for structures built in high seismic areas, intense weather conditions, and with prescribed architectural constraints.

The significance of learning masonry design comes with the fact that masonry is still a prevalent structural material around the world today. Many architectural feats such as the Washington Monument, the Taj Mahal, and the Roman Coliseum are unreinforced and freestanding masonry structures that also prove the long-lasting life cycle of masonry construction. The evolution of reinforced masonry design in California is a product of the history of performance of masonry structures through each major earthquake event. Unreinforced masonry structures are not allowed to be constructed today due to its poor performance with the high seismic activity on the continental west coast. Masonry is a nonlinear material that is governed by the limit states of Ultimate Strength and Service Loading (Deflection). A goal for the architectural engineering student is to reinforce and increase their knowledge of reinforced masonry design as they completed ARCE 305 and ARCE 451 prior to this project.

Structural Engineering Industry Practices

The Architectural Engineering Department Vision Statement is to:

> *"Empower people through a balance of theory and practice to thrive professionally and to collaboratively engineer tomorrow's built environment."*

This project seeks to capture this vision by developing a course based in reinforced masonry design theory and utilizing structural engineering industry practices. Guidance was given by the faculty advisor, who has many years of experience from industry and as a full-time architectural engineering professor. Professional standards were established between the architectural engineering student and faculty advisor. For example, regular meetings were established to stay on track with progress on the course: one mandatory meeting at the beginning of the week to discuss deliverables, and a second optional meeting near the end of the week to discuss questions and concerns. Meeting minutes were upheld to record conversations regarding deliverables, the timeline of the project, and deadlines. The architectural engineering student was able to gain "soft skills" in graphic presentation and communication, which are often overlooked in undergraduate engineering curricula. Through the Cal Poly "Learn By Doing" motto, the architectural engineering student developed these soft skills by creating course content and through teaching structural engineering concepts. In industry, these skills are growing seemingly lacking in new engineers. Therefore, soft skills have become highly sought after by leading companies, who desire engineers who demonstrate effective communication in highly collaborative environments.

II. Online Course: Creating Content

This section explains how lectures, example problems, assignments, and solutions were created for the online course. This section also discusses how software and communication skills were required to deliver the course content and how these skills translate well into the structural engineering practice.

A. *Creating Lecture Videos*

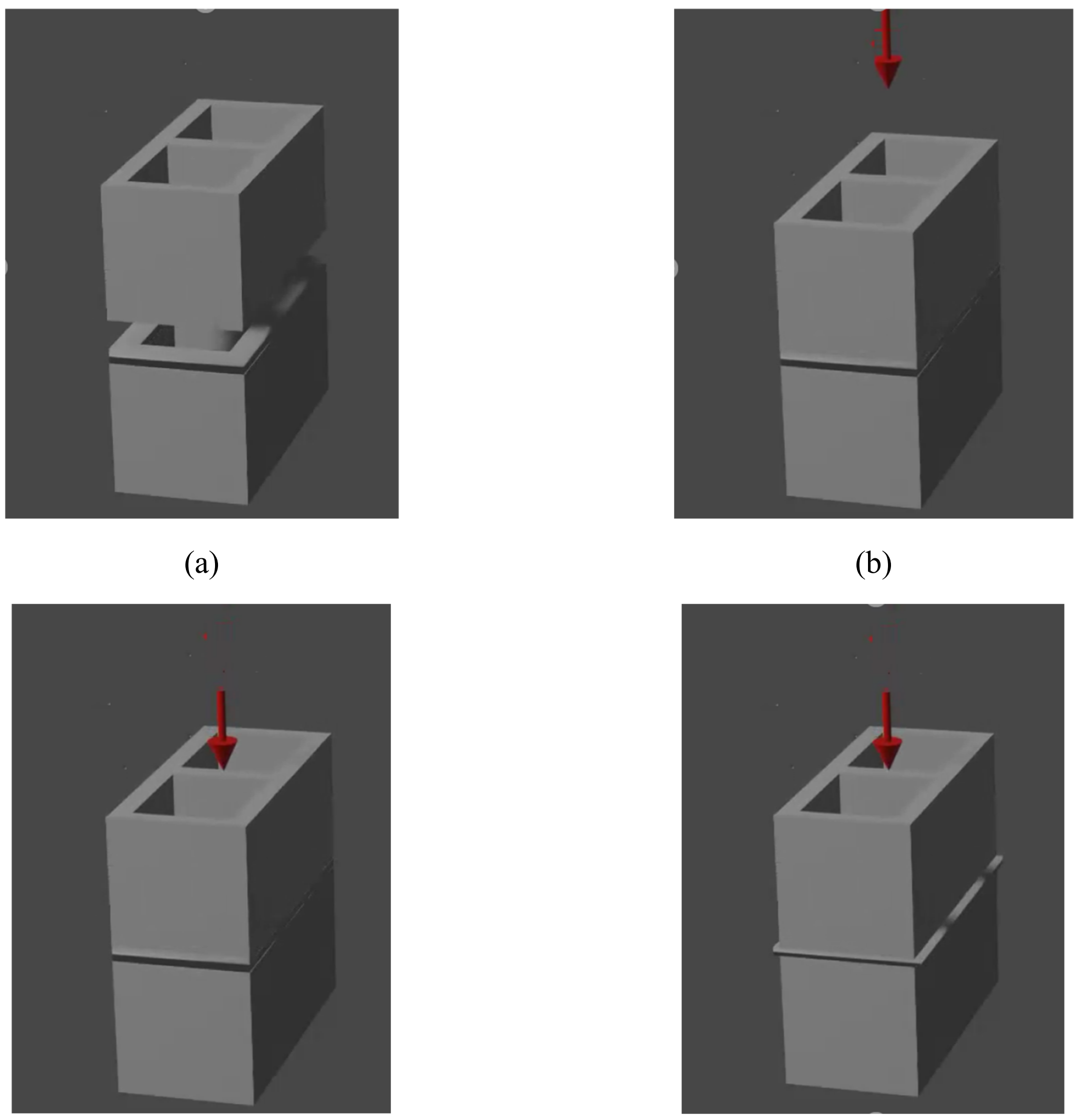
The lecture content of the masonry course largely consisted of the faculty advisor's previous course content in combination with references from industry associations and organizations, TMS 402/602, and DORMS.

The following are major masonry industry associations in California:

- The Masonry Society (TMS)
  masonrysociety.org
- Concrete Masonry Association of California and Nevada (CMACN)
  cmacn.org
- National Concrete Masonry Association (NCMA)
  ncma.org
- Masonry Institute of America (MIA)
  masonryinstitute.org
- Brick Industry Association (BIA)
  gobrick.com

Lessons include how to utilize resources from each of these industry associations. For example, one lesson explains how to research Tek Notes published by the National Concrete Masonry Association. The TMS 402/602 is published by The Masonry Society and regularly cited in lecture videos when introducing students to code formulas and excerpts. Other code references are cited from the American Society of Civil Engineers' *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE/SEI 7 2016). Students learn to reference the code and specifications when completing design problems, formula derivations, and other assignments.

To further explain conceptual topics, new figures and animations were created or referenced to fit the visual format of video learning. The student was encouraged to learn new graphic software to create animations. Blender and Adobe Animate were two applications learned to create animations like Figure 1, which depicts an improper mechanical bond between a mortar joint and CMU. Figure 1 was part of a lecture explaining the Tri-Axial Effect, a phenomenon that results in a higher compression strength of masonry although a component (in this case, the type of mortar) has a lesser strength. In order for the Tri-Axial Effect to occur, the masonry components must have a proper mechanical bond and mortar joint thickness in order to prevent the mortar joint from bulging.



(a) (b) (c) (d)

Figure 1: Animation Stills of an Improper Mechanical Bond created in Blender software

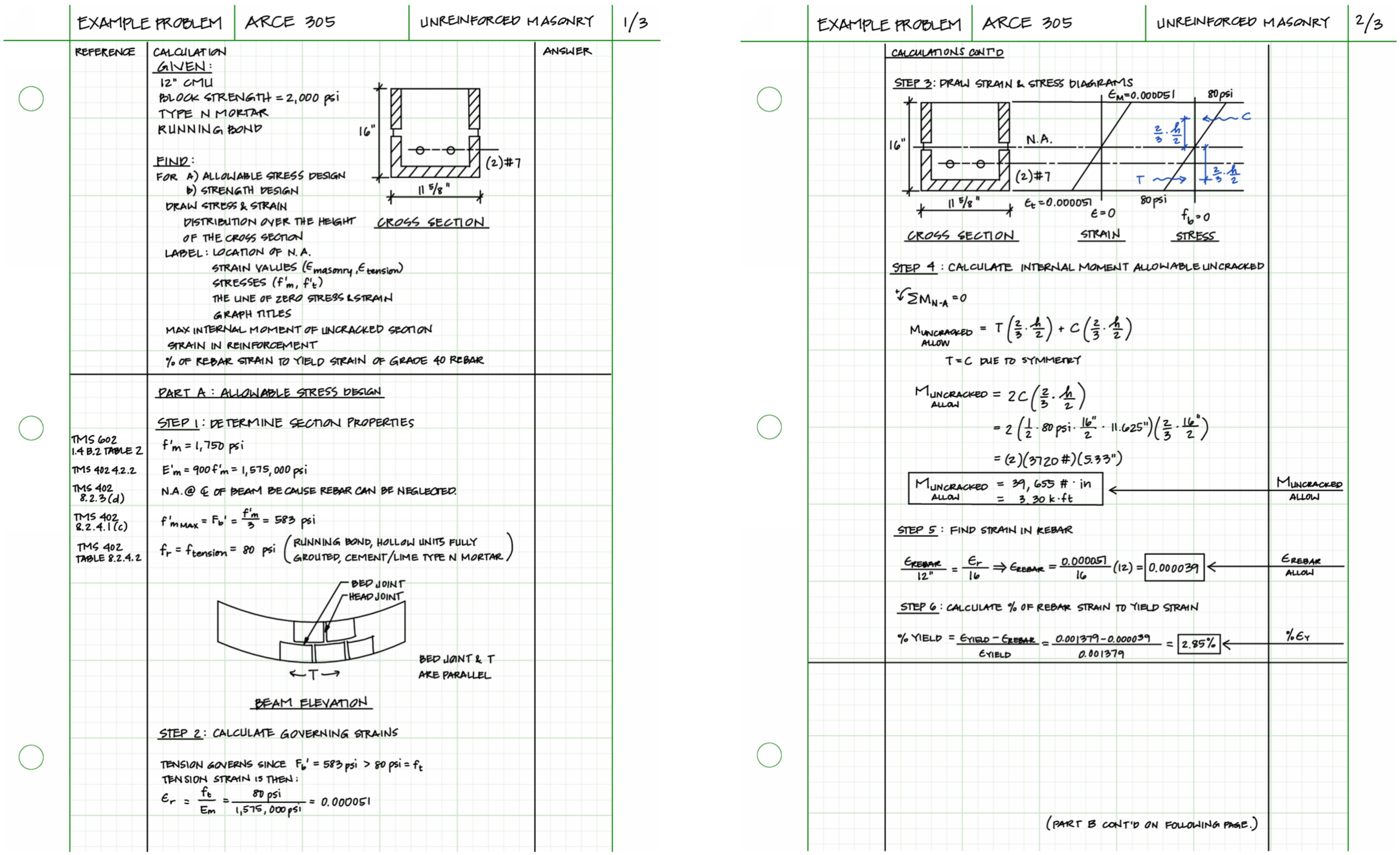
In total, 22 lecture videos were created on the following topics:

- History of Masonry
- Masonry Properties
- CMU Drawing Example
- Mortar
    - Lecture 1: Mortar Properties
    - Lecture 2: Tri-Axial Compression
    - Lecture 3: Mortar Joint Weathering
- Masonry Grout
- Masonry Flexural Theory
    - Lecture 1: Limit States
    - Lecture 1a: The Bell Curve
    - Lecture 2: Non-Linear Behavior
    - Lecture 3: Non-Linear Stress Block
    - Lecture 4: Moment Capacity Equation
- Masonry Beam Design
    - Balanced Condition
    - Rebar Placement
    - Design Equations
- Lintel Beams: Lintel Loading
- Shear Theory
- Shear Design
- Beam Deflection
- Beam Deflection Example Calculation
- Reinforced Columns
- Column Interaction Diagram

An example set of slides can be found in the Appendix for the lecture on Masonry Properties. Each video lecture concluded with a note of thanks and appreciation to our sponsors: the Concrete Masonry Association of California and Nevada and the Masonry Institute of America.

B. *Creating Example Problems, Assignments, and Solutions*

Example problems were written to provide students with sample criteria for formatting and organizing future homework submissions. Figure 2 shows a sample problem for an unreinforced masonry beam analysis. Three columns separate calculations, code references, and final answers or designs so that work can be easily reviewed. The column of code references also becomes a reference for future projects. Students are taught effective written communication by organizing their thought process in homework assignments and other structural calculations. This is a highly sought skill in industry since structural calculations are commonly checked by overseeing engineers and plan checkers.



(a) (b)

Figure 2: Example Problem Unreinforced Masonry Beam

Homework assignments laid the backbone for what students should do to prioritize organization and clarity. In Figure 3, the steps are stated for students to receive full credit for completeness. The homework solution is provided in Figure 4.

ARCE 305 HW Derive M_n Masonry Design

1. (10 pts) Derive the Ultimate Strength Moment Capacity Equation (M_n). In deriving the equation, follow the steps below, and use the steps are headings in the derivation

Ultimate Stress State @ Ultimate Strength with Whitney Stress Block

- Draw the Ultimate Stress State: Section, Strain diagram, Stress diagram
- Fully and Properly Label

Calculate the Internal T and C Forces

- From the stress distribution calculate the T and C force
- show location on the stress diagram

Apply Internal Equilibrium

- $\Sigma Fx = 0$
- Solve for depth of compression block "a"

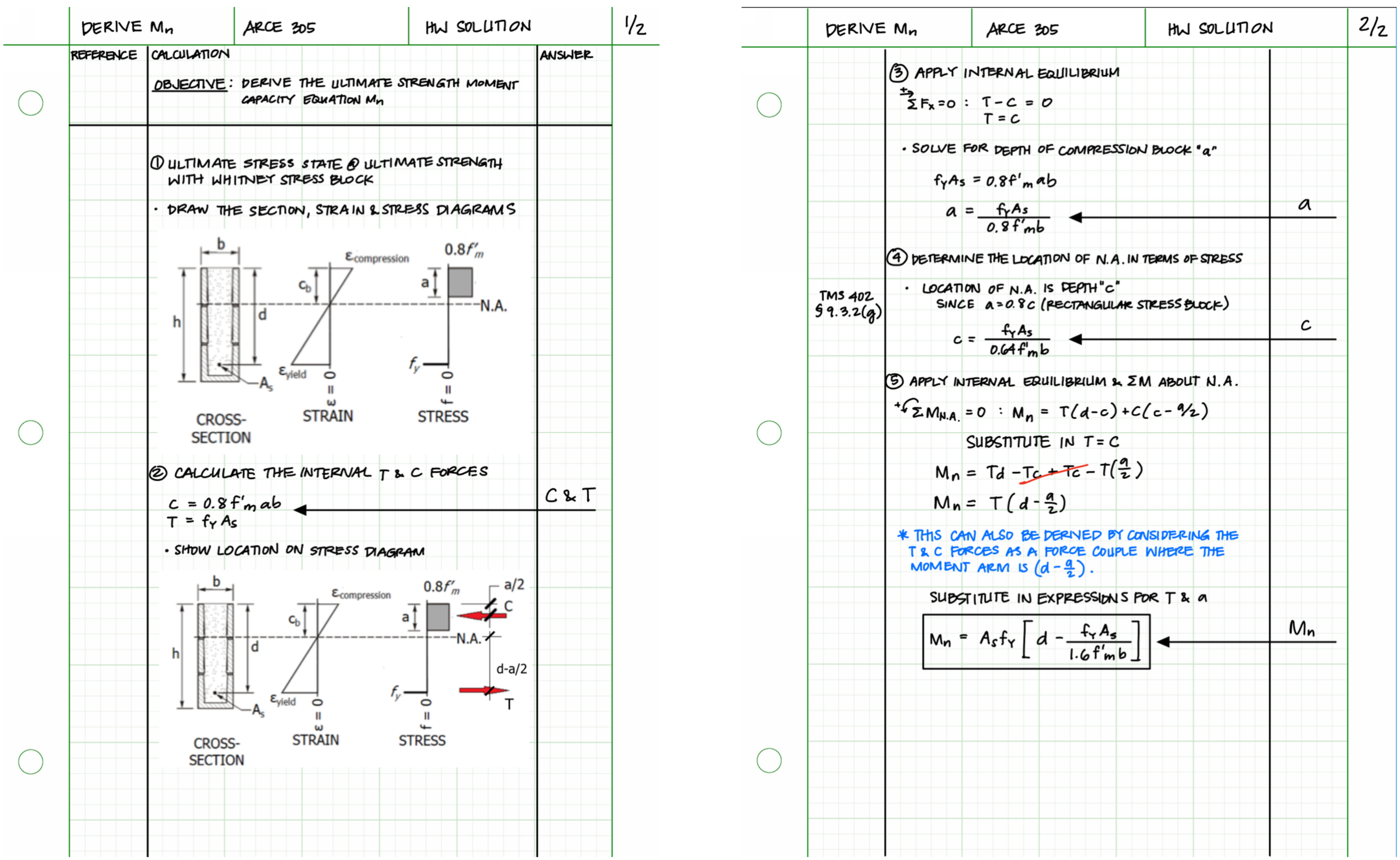
Determine the Location of N.A. in Terms of STRESS

- The compression stress block has depth of "a", but the location of the neutral axis is depth "c".
- Reference the code section that has the "a" to "c" relationship (see TMS 402 §9.3)
- Solve for the distance to the N.A. ("c").

Apply Internal Equilibrium and ΣM about N.A.

- Solve for M_n in terms of A_s, f_y, f'_m, d, and b
- Box the final answer

Figure 3: Example Homework Assignment Derive M_n



(a) (b)

Figure 4: Example Homework Solution – Derivation of Ultimate Strength Moment Capacity Equation M_n

C. *Software and Communication Skills*

For successful conversion to the online format, strong graphic and communication skills were needed to convey concepts in masonry design and structural engineering. First, lecture content was created in Microsoft PowerPoint with special attention given to content organization, graphic design, and visual aids and figures. The other goals for the lecture presentations were consistency and web accessibility. A PowerPoint template was curated with specified font types, font sizes, type weights, and foreground and background colors that conform to web accessibility requirements.

Lecture recordings required the presenter to articulate concepts clearly and concisely for each lecture topic. This allowed most video recordings to remain close to 10 minutes in duration. The video-editor also had to have knowledge of structural engineering concepts to check the video content for quality assurance. Screencast-O-Matic was the software used to record voiceovers with PowerPoint slides followed by video editing and captioning ("Screen Recorder & Video Editor: Screencast-O-Matic"). An added advantage of using Screencast-O-Matic is its publishing options to share videos in an MP4 file format or as an html link. Html links of video lectures were then embedded into Canvas ("Canvas Overview") within modules.

The development of software and communication skills is essential in the structural engineering industry. Structural engineers engage daily with architects, construction managers, and other built professionals, and their work dictates the design of structural systems, majority of the project cost, sequence of construction, and project timeline. In this age of technological advancement, structural engineers must be quick to build skills in new software in structural analysis, plan review and markup, and graphic presentation. They must also be effective communicators in verbal and written form. Public speaking is a weak point for young engineers, so teaching engineering concepts is a way of practicing effective communication and mastering these concepts. Teaching has both verbal and visual components through the use of figures, pictures, and animations.

III. Online Course: Complying with Accessibility Guidelines

The creation of accessible content for this online course was guided by Section 508 of the Rehabilitation Act of 1973 and the Web Content Accessibility Guidelines (WCAG) 2.1 Level AA Standards. It is assumed that students with disabilities will use assistive technologies and/or seek further accommodations from the campus Disability Resource Center and the instructor.

A. *Web Content Accessibility Guidelines (WCAG) Compliance Requirements*

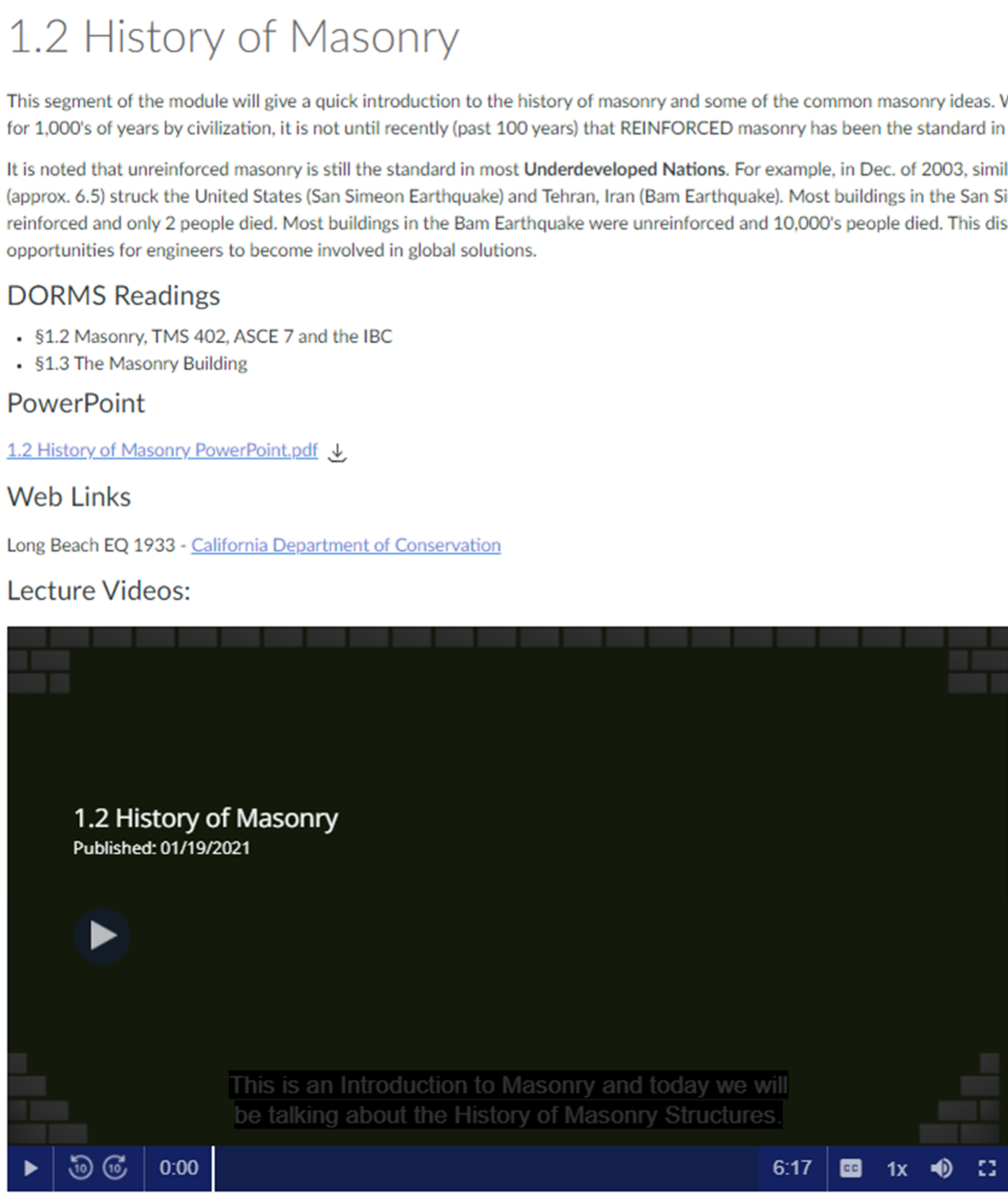
The WCAG requirements were intended to accommodate individuals with disabilities for web access. The lecture videos paid special attention to visual and auditory requirements since assistive technologies would not be used to listen or view the content. The TPGi Colour Contrast Analyser (CCA) was a free-to-download software used in order to check the color contrast of text and images to the background color of the PowerPoint slides ("TPGi Color Contrast Checker"). The minimum contrast for images is 3:1 while the minimum contrast for text is 4:1. However, Cal Poly uses a minimum 4.5:1 contrast ratio for text, so this was the set standard. In the case where text or other objects did not satisfy the color contrast requirement, a white box was placed behind the object to correct the contrast.

While the WCAG requirements do not specify a list of accessible font types, sans serif fonts are better suited for computer and mobile devices ("Best Fonts To Use for Website Accessibility", 2017). The font type chosen for lecture videos was Tahoma while the font type chosen for Canvas was the default Lato. Previous updates in Canvas accounted for accessibility laws and requirements, so default font types and sizes are compliant. In addition, Canvas has an accessibility checker within its page editor for instructors who may not want to use the default settings. In PowerPoint, the maximum font size was 32 point for title headers. Body text were 24 point while the minimum font size anywhere was 18 point. For future purposes, font types like Read Regular, Lexie Readable, and Tiresias should be used to consider students with dyslexia ("Typefaces for Dyslexia").

Closed captioning was provided for all lecture videos during the video-editing process. In Screencast-O-Matic, captions consist of white text with a black background to ensure color contrast and visibility. Screencast-O-Matic has the capabilities to auto generate captions or insert captions from text files. Captions were auto generated as a starting point but checked for accuracy and synchronization with the audio. An alternative option for time and labor efficiency would be to write a script prior to recording, save the script as a text file, and upload the text file into Screencast-O-Matic as captions. This option still requires the editor to check the synchronization of the captions with the audio.

B. *Beyond Accessibility Requirements*

The course content was organized in Canvas pages and modules to ensure easy navigation for students. Modules were built so lessons did not need to be viewed chronologically, but students were able to stay on track with assignment deadlines. Lessons were structured within Canvas pages and consisted of the topic background, assigned readings, a pdf copy of the lecture slides, external web links for further learning, the embedded lecture video, and extra notes. Figure 5 is an example of a lesson on the History of Masonry within a Canvas page.


1.2 History of Masonry

This segment of the module will give a quick introduction to the history of masonry and some of the common masonry ideas. While masonry has been used for 1,000's of years by civilization, it is not until recently (past 100 years) that REINFORCED masonry has been the standard in **Developed Nations**.

It is noted that unreinforced masonry is still the standard in most **Underdeveloped Nations**. For example, in Dec. of 2003, similar magnitude earthquakes (approx. 6.5) struck the United States (San Simeon Earthquake) and Tehran, Iran (Bam Earthquake). Most buildings in the San Simeon Earthquake were reinforced and only 2 people died. Most buildings in the Bam Earthquake were unreinforced and 10,000's people died. This disparity allows for opportunities for engineers to become involved in global solutions.

DORMS Readings

- §1.2 Masonry, TMS 402, ASCE 7 and the IBC
- §1.3 The Masonry Building

PowerPoint

1.2 History of Masonry PowerPoint.pdf

Web Links

Long Beach EQ 1933 - California Department of Conservation

Lecture Videos:

Figure 5: History of Masonry Lesson Page (Screenshot)

Related lessons were grouped into Canvas modules with an overview of each module that outlined the learning objectives, learning outcomes, and list of assignments. Figure 6 provides an example of the Module 1 structure. The advantage of utilizing Canvas modules allows students to progress through lessons uninterrupted in Canvas.

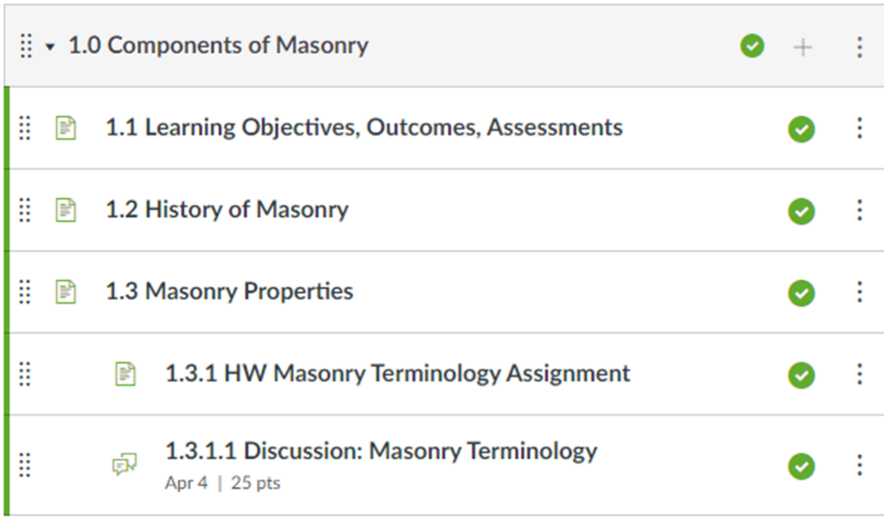


Figure 6: Module 1 Organization

Links to Student Resources were also provided within Canvas for student support and success. The reason to list these links is to provide equitable support for students who may not know of the resources available to them and to show allyship for accessible education from the perspective of an educator. Demonstrating allyship to students creates a positive learning environment, which can feel distant to students due to the virtual format. Although the course is asynchronous, students should feel welcomed to interact with their instructor via office hours, email, and phone. The list of student resources and other basic needs initiatives at Cal Poly can be found in the Appendix.

IV. Reinforcing and Increasing Knowledge of Masonry Construction, Theory, and Design

Lifelong learning in the practice of structural engineering is discussed in this section with respect to this project. The importance of receiving feedback is also explained to ensure the course was qualitatively effective from the perspective of industry professionals and students.

A. *Lifelong Learning*

> *The mission of the architectural engineering program at Cal Poly is to educate students to enter and be successful in the practice of structural engineering. The program focuses primarily on the California practice of structural engineering, that emphasizes seismic design. As an architectural engineering program the curriculum goes beyond traditional structures program to give students an understanding of architecture and construction management as it relates a total project design.*

The goals of this project have allowed the blended BS+MS ARCE student to transition from the mentality of a student to that of a mentee, which mimics the typical work environment of a structural engineering consulting firm. Entry-level engineers must gain experience by working under a supervisory engineer who is often a licensed Professional Engineer. The student was able to strengthen their knowledge of reinforced masonry design and construction by working under their faculty supervisor, who has both academic and industry experience with masonry design and construction. For example, the student learned the different effects water has on clay masonry compared to concrete masonry. The reaction between water molecules and clay cause an expansion while for concrete masonry, a hydrolysis reaction occurs between water and cement to cause shrinkage. This is an important consideration for a project that may have a clay masonry facade over concrete masonry. Typically, a gap should be provided between clay masonry and concrete masonry. However, if for example, the concrete masonry is allowed to sit for one year then it is acceptable to add the clay masonry after without a gap. These discussions with Dr. Baltimore provided valuable examples of masonry construction practices that the student had not known from their previous coursework.

Moreover, the student was able to test their competency of structural engineering topics by positioning themself as an instructor. This forced the student to become a more effective communicator in written and verbal language, and it increased their expertise in the academic field. Though the student had taken ARCE 305 and ARCE 451 prior to this project, they were able to expand upon their knowledge and contribute to the undergraduate education of their peers and future ARCE students to come.

B. *The Importance of Feedback*

Receiving feedback on the content, graphic presentation, and structure of this online course was an essential component of this project. This project could not have been successful without the help of the following individuals:

- John Chrysler, MIA Executive Director
- Kurt Siggard, CMACN Executive Director
- Craig Baltimore, Ph.D., S.E., Advisor, Cal Poly (ARCE Faculty)
- Jacob Morgan, senior-level ARCE Student

Dr. Baltimore's vision guided the project as he is one of the ARCE faculty who typically teaches ARCE 305. Dr. Baltimore provided mentorship to define deliverables, keep the student on track with making actionable progress, and explain masonry design theory and construction practices. As he had to transform previous courses into an online format, he knew from experience the strengths and weaknesses of transitioning from in-person classes to the virtual environment. Dr. Baltimore also added the goals for this course to be web accessible and asynchronous. An underlying reason for these goals is so that the course could be offered in future terms including summer, thus allowing students more flexibility in planning their undergraduate coursework.

Dr. Baltimore's connections to Executive Directors John Chrysler and Kurt Siggard proved to be essential in providing feedback from industry professionals who are constantly up-to-date with building code, construction practices, and technical expertise about masonry design. John and Kurt reviewed each lecture video for accuracy and provided comments for review. They also provided sponsorship to support this project and the ARCE undergraduate program.

Jacob Morgan, a senior-level undergraduate ARCE student, provided an extra student perspective to ensure that the course content was accessible and comprehensible for those new to masonry design. Jacob helped research the web accessibility requirements for online courses, and he helped choose the font types and colors to satisfy the visibility requirements for readability and color contrast. Jacob was able to develop skills in Screencast-O-Matic to edit and caption lecture videos for his personal learning. He also helped build introductory Canvas modules to develop an organizational structure for the rest of the course.

V. Structural Engineering Industry Practices.

The structural engineering industry practices that were executed during the span of this project contributed to the project's success. One such practice was holding weekly meetings to keep up with deliverables. Weekly meetings consisted of one required meeting at the start of the week to act as deliverable deadlines and one optional meeting near the end of the week for questions and inquires about deliverables. The optional meeting required prior notice to be cancelled but provided flexibility to meeting attendees during the busy school year. These meetings were 30 minutes to 1 hour in duration to be considerate of everyone's schedules.

During every meeting, the discussion was documented in Meeting Minutes, which would later serve as a resource for future reference. The Meeting Minutes were reviewed by each attendee, so that everyone was able to confirm the discussion notes. Following each meeting, the notetaker concisely summarized the discussion and re-organized the notes by topic. A record of what, when, and who was always taken with the record of deliverables, so that each person has assigned responsibilities to complete the project deliverables. The deliverables were listed near the bottom of the Meeting Minutes in a table and referenced previous discussion items.

Phraseology in the Meeting Minutes was emphasized because using professional language and jargon is the standard in industry. Informal and familiar expressions in the discussion notes received red marks from the faculty advisor upon review. Maintaining Meeting Minutes is an industry standard. Therefore, upholding these expectations will help the students thrive professionally post-graduation, capturing the ARCE Vision Statement. An example of Meeting Minutes with markups early in the project as well as an example of Meeting Minutes near the end of the project are provided in the Appendix.

VI. Outcomes/Discussion

The main deliverable was the creation of an asynchronous online masonry course ready to be beta tested by Spring 2021. By the end of the Winter 2021 quarter, the masonry course was ready for its rollout on Canvas with all the lecture videos recorded and captioned, the assignments and solutions written, and the modules in Canvas built. The majority of Fall 2020 was spent making sure the accessibility standards were achieved by focusing on the creation of the lecture videos with adequate font types, color contrast, and captioning. In addition to meeting the WCAG 2.1 requirements, student resources and basic needs initiatives were provided in Canvas to further accessibility beyond web interface. While these resources are provided in the Appendix, having these resources within the Canvas interface allows for easy sharing with other faculty within Canvas.

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Much of my knowledge about masonry design was increased throughout the course of this project. I was able to review concepts such as beam, column, and wall design theory for axial, flexural, shear, and combined loads. However, I was able to solidify my knowledge through teaching, which had an added challenge of translating what I know to students who are new to learning masonry design and construction. Under Dr. Baltimore's guidance, I learned much more about masonry design and construction than I did in taking ARCE 305 the first time. Although ARCE 305 is focused primarily on design theory of masonry, I was able to gain a better sense of the construction management of masonry projects and more complex topics like the chemical processes that occur between the components of masonry.

I think the best industry practice that contributed to the success of the project was the execution of writing Meeting Minutes. By holding weekly meetings, regular discussion moved the project along with trackable progress. Meeting Minutes acted as a record of accomplished deliverables and deliverables set to finish. Having a steady flow of small deadlines each week made the project feel easier to accomplish. Meeting Minutes were also great references to review what was discussed in previous meetings. By having Dr. Baltimore review Meeting Minutes, any discrepancies in the discussion were clarified and it provided more opportunities for me to ask questions in future meetings.

VII. Lessons Learned

The lessons learned throughout the span of the project are discussed in this section by the blended ARCE student.

A. *Building an Online Course*

Switching roles from a student to an instructor exposed me to the hard work that comes with being an instructor. Lessons can be curated based solely on textbook or other academic sources, but the effectiveness of the lesson can be increased by including visuals and examples from personal or work experience. Creating the lecture videos were probably the most difficult part of the project because of the quantity and quality we expected. The most valuable takeaway from creating the lectures was gaining experience with Screencast-O-Matic and PowerPoint. I had to think about the lesson from start to finish: from the content in the slideshow to the explanations for each code equation or table.

From the perspective of an instructor, I can also see how building an online course to be asynchronous would be a great investment. Although majority of the work must be done upfront, having lessons completely structured means less “maintenance” down the line. Lessons can be adjusted as the code or construction practices change over time, but this work is easier to upkeep the course.

B. *Accessibility*

I understand the need for web accessibility because virtual classes are becoming more common with distance learning. I think that web accessibility becomes a minimum requirement on the educator’s side when it is already assumed that students have adequate internet access, devices, and spaces for online learning. Promoting and executing accessible practices levels the playing field for students to perform at their best. I think in the future, I would learn more about learning disabilities and other hindrances students may face and how to make accommodations. For example, I think it would be worthwhile to avoid specific colors for those who may be color blind and research fonts for those with dyslexia.

I think it would be fair for the university to support faculty with experts to set up templates, caption videos, and review other items for accessibility. Otherwise, I think that this is a lot of work on the part of the instructor, and they should be justly compensated for working beyond what is required of them. Providing equitable support to students should always reflect positively on instructors in performance and course evaluations.

C. *Masonry Design and Construction*

I gained a greater appreciation of masonry design and construction from working on this project. Although other structural materials may seem more advantageous to use in a building, masonry has arguable advantages, such as its architectural aesthetics, long lifespan, and durability. Masonry has a high thermal mass, which means it can absorb and store heat. The benefit of this is that it can absorb heat energy during the day and release that heat at night when a building would need it. While ARCE 305 focuses on reinforced concrete masonry design, masonry can be constructed with brick, stone, and concrete masonry units. Structures like vaults, domes, and arches can be constructed with masonry without the need for formwork or machining processes. When considering project costs, masonry construction could rival concrete construction if material transport and labor costs are less expensive than formwork costs.

At times, I had to remember that I was explaining concepts that are new to my audience, so I had to be careful with my word choice. Being able to explain a concept in multiple ways helped me master that concept. I think this gives me an added advantage in industry when I will mostly likely engage in discussions with an architect or other professional on a project. Structural engineering graduates from other institutions may not have learned masonry design in their undergraduate curriculum, and this sets me and other ARCE graduates apart from the masses.

D. *Industry Practices*

Using industry practices created good habits toward the completion of deliverables. Meeting weekly helped me gain confidence in completing deliverables, and it was easy to see this continuous progress made throughout the two quarters. I think seeing the progress encouraged me to keep the pace since there were many tasks that were somewhat repetitive. Writing Meeting Minutes kept me accountable to incorporate all discussion comments into my work. Relying on my memory would not be reliable when we often discuss detailed changes into creating lecture videos, captioning videos, writing assignments, and building the Canvas. Reading over the discussion notes from Meeting Minutes was extremely helpful because they were already organized by topic and I could focus on individual tasks. It also helped that Dr. Baltimore would review the Meeting Minutes so that any miscommunications could be addressed. These industry practices built good time management skills in an otherwise long project. It ensured that every task had special attention to detail and that our standards were met. I applied the practice of writing Meeting Minutes in my other co-curricular activities, and it immensely improved my productivity. I learned that though these are standard structural engineering industry practices, they could easily be used to complete any sort of project.

VIII. Citations:

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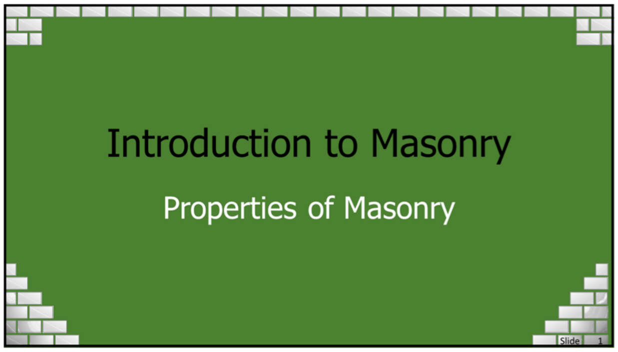
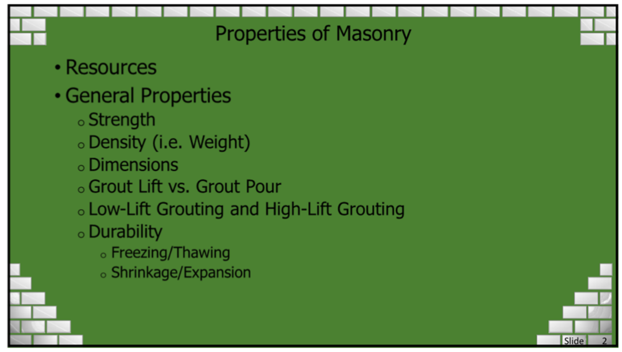
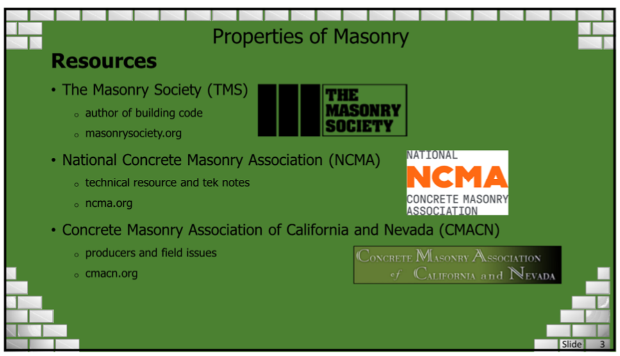
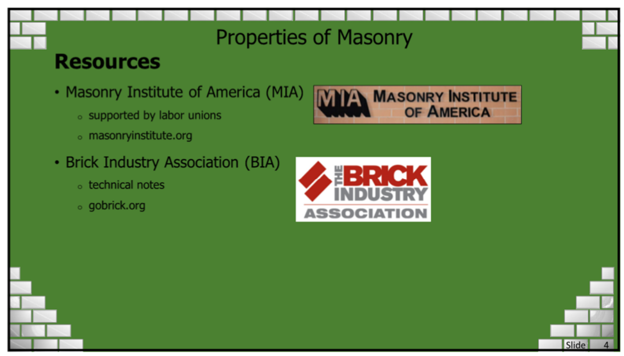
IX. Appendix

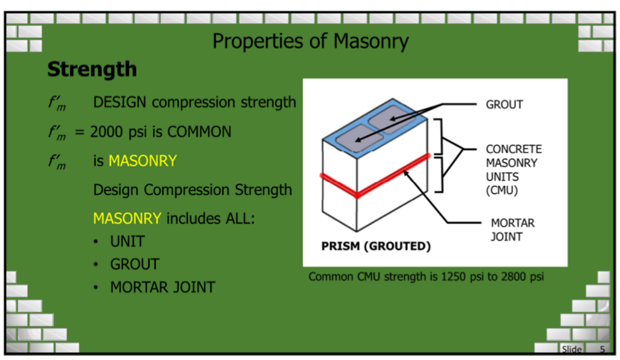
A. *Sample PowerPoint Slides*

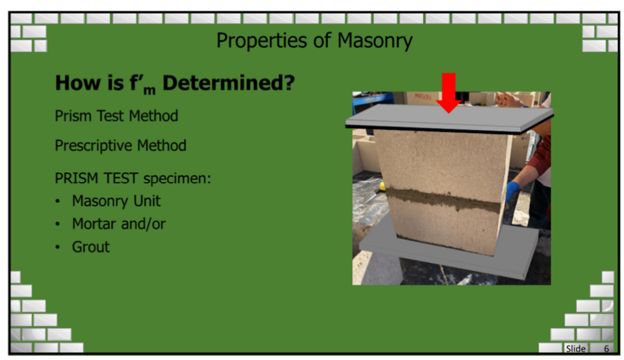












Properties of Masonry

Strength - Example: CMU of 3,250 psi with 2,500 psi Type M Mortar

TMS 602-16 Section 1.4 B.2 *Table 2*

Table 2 — Compressive strength of masonry based on the compressive strength of concrete masonry units and type of mortar used in construction

Net area compressive strength of concrete masonry, psi (MPa)[1]	Net area compressive strength of ASTM C90 concrete masonry units, psi (MPa)	
	Type M or S mortar	Type N mortar
1,750 (12.07)	--	2,000 (13.79)
2,000 (13.79)	2,000 (13.79)	2,650 (18.27)
2,250 (15.51)	2,600 (17.93)	3,400 (23.44)
2,500 (17.24)	3,250 (22.41)	4,350 (28.96)
2,750 (18.96)	3,900 (26.89)	-----
3,000 (20.69)	4,500 (31.03)	-----

[1] For units of less than 4 in. (102 mm) nominal height, use 85 percent of the values listed.

f'_m = 2,500 psi

Slide 7

Properties of Masonry

Strength – Modulus of Elasticity

DORMS Section 1.6.2 & TMS 402 Section 4.2.2

E_m Modulus of Elasticity in compression

determines the stiffness of masonry for calculating deflections due to flexure or compression

From TMS 402 Table 4.2.2:

Concrete Masonry	$E_m = 900f'_m$
Clay Masonry	$E_m = 700f'_m$

*Alternative: Take the slope between $0.05f'_m$ and $0.33f'_m$ on the Stress vs. Strain diagram

Slide 8

Properties of Masonry

Density

- CLAY BRICK
  - 80 pcf – 140 pcf
  - 120 pcf is used in general
- CONCRETE BLOCK
  - Light Weight – 105 pcf or less — NOT common on West Coast
  - Medium Weight – 105 pcf to 125 pcf — choice for high seismic zones
  - Normal Weight – 125 pcf and higher — least cost of unit itself

Slide 9

Properties of Masonry

Density

LABOR - $$$

HEAVIER units mean MORE LABOR - $$$

LIGHTER units use non-natural aggregate - $$$ LW & MW

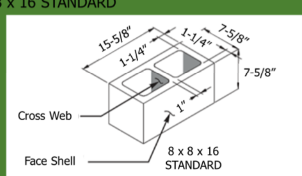
Slide 10

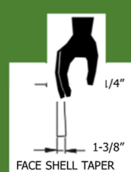
Properties of Masonry

Dimensions

CONCRETE MASONRY UNIT (CMU)

8 x 8 x 16 STANDARD





Slide 11

Properties of Masonry

Grout Lift vs. Grout Pour

- Grout Lift: the amount of grout placed in a single, continuous operation.
- Grout Pour: total height of masonry grouted prior to erecting additional masonry.

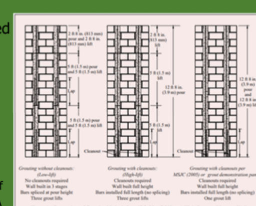


Figure courtesy of NCMA Tek 03-02A

Slide 12

Properties of Masonry
Grout Lift vs. Grout Pour

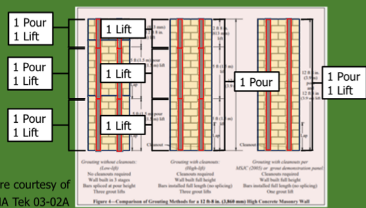
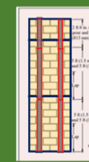


Figure courtesy of NCMA Tek 03-02A

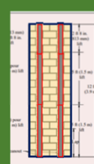
Properties of Masonry
Low-Lift Grouting and High-Lift Grouting

- Low-Lift Grouting: additional courses of masonry are constructed AFTER each lift of ~5′ – 4″ is cured.
  - Simplest method of grouting concrete masonry
  - Rebar projects above top course to ensure lap splice length



Properties of Masonry
Low-Lift Grouting and High-Lift Grouting

- High-Lift Grouting: masonry units constructed UP TO a story height or higher and grout is placed in lifts of ~5′ – 4″ in height.
  - Mason can lay blocks continuously before grout is poured – can be more economical
  - A major concern is the prevention of blowouts



Properties of Masonry
Durability: Freezing/Thawing

Grades to measure durability

- SW – Severe Weathering, exposure to de-icing salts determines this
- MW – Moderate Weathering
- NW – Negligible Weathering

CLAY BRICK has 3 Grades: SW / MW / NW

CONCRETE has 2 Grades: SW / MW

Must specify the Grade!

Properties of Masonry
Durability: Shrinkage/Expansion

- **CLAY MASONRY** EXPANDS
- **CONCRETE MASONRY** SHRINKS

Therefore, DO NOT attach a clay brick directly to concrete! Leave a GAP!

Thermal Expansion Coefficient (TMS 402 Table 4.2.3)

Clay Masonry	$k_t = 4 \times 10^{-6}$ in/in/°F
Concrete Masonry	$k_t = 4.5 \times 10^{-6}$ in/in/°F

Properties of Masonry
Durability: Shrinkage/Expansion

- **CLAY MASONRY** EXPANDS
- **CONCRETE MASONRY** SHRINKS

Therefore, DO NOT attach a clay brick directly to concrete! Leave a GAP!

Shrinkage Coefficient (TMS 402 §4.2.5.1)

Concrete Masonry $k_m = 0.5s_l$ → s_l = total linear drying shrinkage of concrete masonry units (ASTM C426)

Creep Coefficient (TMS 402 Table 4.2.6)

Clay Masonry	$k_c = 0.7 \times 10^{-7}$ per psi
Concrete Masonry	$k_c = 2.5 \times 10^{-7}$ per psi

This video/presentation was made possible with generous support from the masonry industry.

Appreciation and Thank you to the Sponsors

Concrete Masonry Association of California and Nevada — http://cmacn.org/

Masonry Institute of America — https://www.masonryinstitute.org/

B. ***Student Support and Basic Needs***

Basic Needs

Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live, and believes this may affect their performance in the course, is urged to contact the Cal Poly Assistant Dean of Students, Joy Pedersen: Phone: 805-756-6749; Email: jmpeders@calpoly.edu or the Dean of Students, Kathleen N. McMahon: Phone: 805-756-0327; Email: deanofstudents@calpoly.edu.

Find information about the Cal Poly Cares Initiative

Find information about the Cal Fresh Initiative

Find information about the Cal Poly Food Pantry

Food Pantry Hours: Monday - Friday: 10:00AM - 2:00PM

Location: The Pantry is located in the Lower Level of the Health Center at the PULSE office (Bldg 27, Rm 10).

Phone: (805)-756-6181

Student Support Services

Below you will find a full list of Student Support Services at Cal Poly. I encourage each of you to explore the services that will best meet your needs (links open in new tabs):

- Academic Advising
- Career Services
- Disability Resource Center
- Dream Center
- Food Pantry
- Gender Equity Center
- Getting Good Grades with Gadgets
- Health and Wellbeing Counseling Services
- Multicultural Center
- Mustang Success Center
- Cal Poly Canvas Support
- Pride Center
- Safer
- Student Academic Services
- Tutoring Resources and Supplemental Workshops
- Veterans Success Center
- Writing Center

C. *Early Sample Meeting Minutes with Comments*

Online Summer Course Weekly Meeting Notes

Date: October 5, 2020 **Time**: 2:00 PM – 2:30 PM

Location: Office 108-B, Building 21, Engineering West, Cal Poly San Luis Obispo

Project Name: CMACN Online Summer Masonry Course

Attendees:

Name	Position	Email
Dr. Craig Baltimore (CVB)	Advisor	cbaltimo@calpoly.edu
Dolores Herrera (DH)	Student	doherrer@calpoly.edu
Jacob Morgan (JM)	Student	jmorga16@calpoly.edu

Meeting Notes

Discussion

1. Create a page for Zoom links. Include buttons for office hours, and explain where to find previous classes via "previous meetings" or "cloud recordings."
2. Two PowerPoints need to be ~~completed~~ animated and recorded into lectures:
   a. See Google Drive folder "PowerPoint Presentations."
   b. "Beam Deflection Lecture 1: Effective Moment of Inertia" and "Reinforced Columns."
   c. "Column Design" PowerPoint in the future.
   d. Fix slides (animations) by next meeting (Thurs. 10/08/20).
   e. JM try to do one presentation to get used to Screencast-O-Matic.
   f. Do not forget to caption your videos!
   g. Export completed lecture as a .somrec file ~~or as an .mp4 file~~ and place in "Presentations to Review" folder. Do not place as Mp4 files take longer to export.
3. "Beam Deflection" Lecture:
   a. Service loading: the crack height is due to loading at that moment in time.
   b. The modulus of rupture is about 10% of compressive strength—it's low!
   c. I_{eff} equation is empirically determined.
   d. I_n for masonry is the same as I_g for concrete (= bh^3~~^3~~/12). *NEVER use ^ if at all possible*
   e. I_{cr} = moment of inertia at greatest crack height - ultimate.
   f. M_{cr} is based on I_n NOT I_{cr} (~~see equation~~ linear and elastic, eq. in item 3.d.).
   g. The code allows us to ignore the cross section of steel in analysis.
   h. M_a is based on unfactored loads, therefore do not factor! (load factor is 1.0)
4. "Reinforced Columns" Lecture (conceptual, thus no equations):
   a. Recall that compression is positive (+) for columns ????.
   b. Columns experience combined stresses: bending and axial ($\pm My/I + P/A$).
   c. Animations on slenderness graph: crushing (blue), buckling (purple), code equations (black).
   d. Piers fail in crushing only; The term Pier is an old reference last ~~seen~~ defined in 2013 code.
   e. Animate the dimensional limits on piers on diagram (i.e. red bubbles).
   f. Try to include a 3D view of rebar in column to show longitudinal and transverse rebar.

   g. Textbook says “Vertical Rebar”, specify that it is the longitudinal (flexural) rebar.
5. “Column Design” Lecture:
   a. e = 0.1 x (lesser of b or t) for allowable stress design.
   b. h/r = 99 is not the buckling point. It is the masonry code equation transition point.

Deliverables

Item	Description	RP	Due
1	Fix “Beam Deflection” and “Reinforced Columns” PowerPoints.	DH/JM	10/12
2	Record lectures for “Beam Deflection” and “Reinforced Columns.”	DH/JM	10/12
3	Create a page for Zoom links.	DH	10/12

Deliverables Description

1. See Items 3-4 for details.
2. See Items 2-4 for details. JM reach out to DH for questions about Screencast-O-Matic.
3. See Item 1 for details.

Please notify of any revisions, clarifications, or additions within 48 hours of receipt.

Respectfully Submitted,

Dolores Herrera &

Jacob Morgan

D. ***Developed Sample Meeting Minutes***

Online Summer Course Weekly Meeting Notes

Date: November 9, 2020 **Time**: 3:00 PM – 4:00 PM

Location: Office 108-B, Building 21, Engineering West, Cal Poly San Luis Obispo

Project Name: CMACN Online Summer Masonry Course

Attendees:

Name	Position	Email
Dr. Craig Baltimore (CVB)	Advisor	cbaltimo@calpoly.edu
Dolores Herrera (DH)	Student	doherrer@calpoly.edu
Jacob Morgan (JM)	Student	jmorga16@calpoly.edu

Meeting Notes

Discussion

6. Curvature Relationships PowerPoint comments: – JM
    a. Slide 2 is an outline/procedure, not a summary.
    b. Redefine radius of curvature without using the word "curvature." Define curvature first.
    c. As ρ decreases, the curve becomes more extreme—draw a more extreme curve on the beam figure.
    d. Animate diagram on slide 4 to appear with text and move "c" on the diagram to the side of the beam (not on the beam).
    e. Take out geometric equation for chord length. Start with arc length equation, which does not assume small angles.
    f. Color coordinate equations with the pictures.
    g. Bending normal stress equation is the starting point since it uses curvature in the derivation. Still define radius of curvature for emphasis.
    h. For information on bending stress $\sigma = My/I$, see Sections 4.1-4.8 in Mechanics textbook (see Beer, Ferdinand P., et al. Mechanics of Materials. 7th ed., McGraw-Hill Education, 2015.).
    i. Engineering strain is $\varepsilon = \Delta L/L$. True strain is ½ the engineering strain. This is where the small angle approximation is made.
    j. Refer to "our" arbitrary section after defining it the first time.
    k. Make sure all equations appear as minimum 18 point font; don't rely on default font size.
    l. Make image on slide 7 larger, so that angles read more clearly.
    m. Showing radius of curvature equation for cartesian coordinates is not necessary, but okay.
    n. Better wording for slide 10 is "Describe These Relations Pictorially" rather than "graphically"

Discussion Continued

o. The notation for vertical deflection is typically Δ or y is oriented for buildings as an introduction to structural mechanics and for speaking to non-engineering professions. Deflection is written as "u" (horizontal) and "v" (vertical) for continuum mechanics notation because the defined coordinate system is to the material itself. The continuum mechanics notation is rarely seen beyond the Master's Program or Finite Element Analysis
p. Show the equations that relate moment, slope, & deflection in the summary.
q. Use left aligned column headers instead of centered as a matter of style, it helps define the column.
r. Rename presentation "Curvature's Relationship" because it does not present the moment-curvature relationship as typically used in structural engineering.
s. For the report and senior project presentation: We are introduced to curvature and its relationships in our second year of the ARCE undergraduate program, and it is not seen for a year or so. Then, it reappears in structural dynamics. This presentation is a summary of curvature relationships with slope, moment, and vertical deflection and serves as a review.

7. Discuss why these 5-minute videos are important as "the times are changing" in project write-up.
    a. There is a paradigm shift from lengthy written explanations and guidelines to fast information that is easily accessed from a smart phone.
    b. Learning how to create these videos introduced the concept of web accessibility.
8. PowerPoints are completed. DH will record 1-2 videos per week (at ~2.5 hours per video). DH will continue to work through Winter Break to complete all lectures before the start of Winter Quarter.
9. DH will work on building the course during the Winter Quarter.

Deliverables

Item	Description	RP	Due
1	Record the Curvature Relationships lecture.	JM	11/16
2	Continue to record lectures.	DH	11/16
3	Review Accessible PowerPoints.	CVB	11/16

Deliverables Description

4. See Item 1 for details.
5. See Item 3 for details.
6. Accessible PowerPoints are located in its own folder under the PowerPoint Presentations folder in Google Drive.

Please notify of any revisions, clarifications, or additions within 48 hours of receipt.

Respectfully Submitted,

Dolores Herrera &

Jacob Morgan