SLATT UNDERGRADUATE RESEARCH FELLOWSHIP

FINAL REPORT

SCHOLAR NAME:	Omar Muñoz
FACULTY ADVISOR:	Yahya Kurama
PROJECT PERIOD:	5-26-23 to 7-27-23
PROJECT TITLE:	Animating Construction Process of Modular Lapped Reinforced Concrete Connections to Accelerate Nuclear Building Project Schedules
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	**( ) Energy Conversion and Efficiency** **(x) Sustainable and Secure Nuclear** **( ) Smart Storage and Distribution** **( ) Transformation Solar** **( ) Sustainable Bio/Fossil Fuels** **( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS

Create an animation to illustrate how modular lapped reinforced concrete connections would be connected in sequence. The final product was a finished video totaling over three minutes.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Create a video demonstration of modular blocks	Finished the video with different frame rate options	100%

RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS SUBMITTED	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount)
EXTERNAL AWARDS RECEIVED	(Sponsor, Project Title, PIs, Award Date, Award Amount)
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	(Event, Presentation Title, Presentation Date, Location)
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	(Purpose, Title, Date Received)
INTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
EXTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
WEBSITE(S) FEATURING RESEARCH PROJECT	(URL)
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)

RESEARCH EXPERIENCE

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

I was very surprised how much autonomy I had in the beginning of the research. I spent the first week doing training videos for lab and training to learn how to use SketchUp. Then I started modeling simple geometry which then led to simple animations and eventually complex animations. I was always engaged because If I felt exhausted with animating

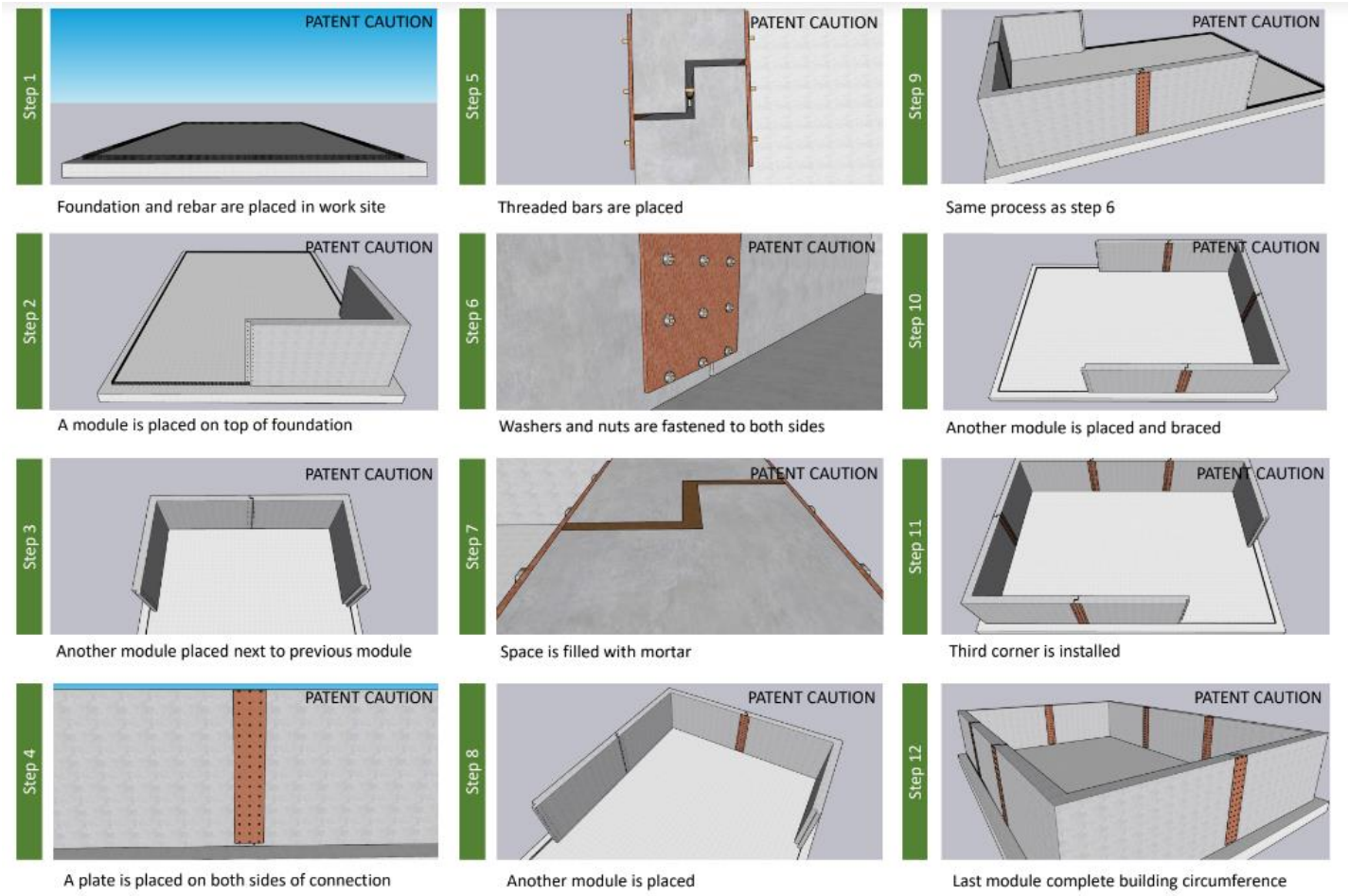
then I could help Dr. Manning in the high bay lab with concrete testing. Each day I was doing something new and when I needed a break, I could take one. All my expectations were surpassed during this program. One thing that could have improved my learning is if there were more students in the same project. I would have enjoyed working with another student and it would have helped me develop more collaboration skills. Overall, research was a great experience, and it was incredibly informative.

FINAL WRITTEN REPORT

Nuclear power plants are expensive to build with long building construction project duration. Decreasing the on-site construction time of nuclear facilities would significantly reduce the overall project costs. Construction of reinforced concrete (RC) buildings by assembling and connecting large, prefabricated modules would allow significant efficiencies in construction. However, state-of-practice connection designs typically used in non-nuclear buildings do not provide the structural strength and stiffness continuity required for nuclear applications. This project, funded by the Nuclear Regulatory Commission, is experimentally and numerically investigating the design, materials, behavior, durability, and construction of lapped connections for safety-related nuclear RC buildings. The novel lapped geometry of the connection provides “face-to-face” (rather than “end-to-end” or “butt”) joint interfaces with large surfaces to develop the required continuity of the strength and stiffness of the structure. The lack of straight-line discontinuities across the structure thickness enhances the connection performance. Work conducted as part of the Vincent P. Slatt Fellowship by the Center for Sustainable Energy at Notre Dame developed a visual animation of the proposed construction process for nuclear RC buildings with lapped connections.

The video that was created was useful because it was required for the project proposal. The video is useful to demonstrate how this process would work to the average viewer. The video shows the sequence in which blocks will be placed together like puzzle pieces and connected. The video also illustrates modules with accurate dimensions and the modules also have holes for utility purposes. The video process was also important to highlight constructability. The bracing for example will be slightly different in real life application but the video is still useful because it gives the audience a general understanding that the two connections will be braced using steel plates, threaded steel rods, washers, and nuts.

Here is a copy of my poster that illustrates the sequence in which modules will be placed.

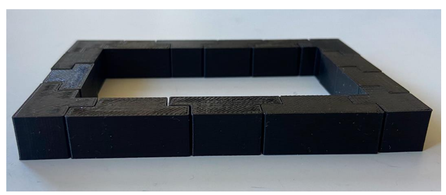


Animating Construction Process of Modular Lapped Reinforced Concrete Connections to Accelerate Nuclear Building Project Schedules

Omar Muñoz, New Mexico State University

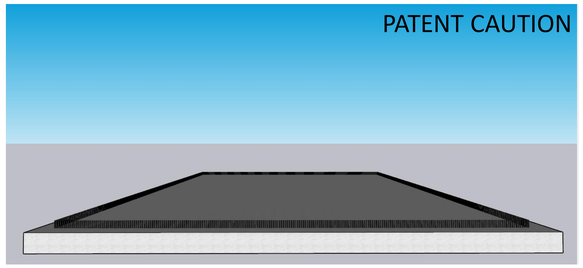
Abstract

Nuclear power plants are expensive to build with long building construction project durations. Decreasing the on-site construction time of nuclear facilities would significantly reduce the overall project costs. Construction of reinforced concrete (RC) buildings by assembling and connecting large prefabricated modules would allow significant efficiencies in construction. However, state-of-practice connection designs typically used in non-nuclear buildings do not provide the structural strength and stiffness continuity required for nuclear applications. This project, funded by the Nuclear Regulatory Commission, is experimentally and numerically investigating the design, materials, behavior, durability, and construction of lapped connections for safety-related nuclear RC buildings. The novel lapped geometry of the connection provides “face-to-face” (rather than “end-to-end” or “butt”) joint interfaces with large surfaces to develop the required continuity of the strength and stiffness of the structure. The lack of straight-line discontinuities across the structure thickness enhances the connection performance. Work conducted as part of the Vincent P. Slatt Fellowship by the Center for Sustainable Energy at Notre Dame developed a visual animation of the proposed construction process for nuclear RC buildings with lapped connections.



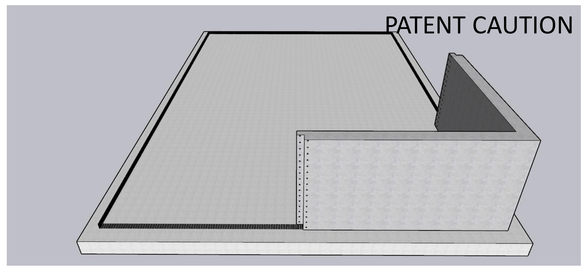
PATENT CAUTION

Step 1



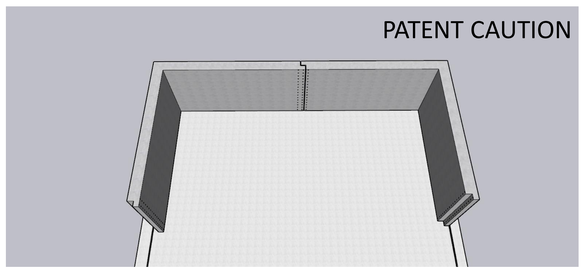
Foundation and rebar are placed in work site

Step 2



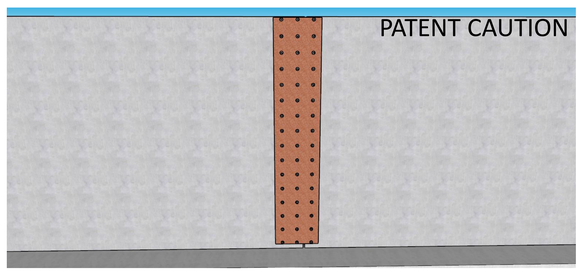
A module is placed on top of foundation

Step 3



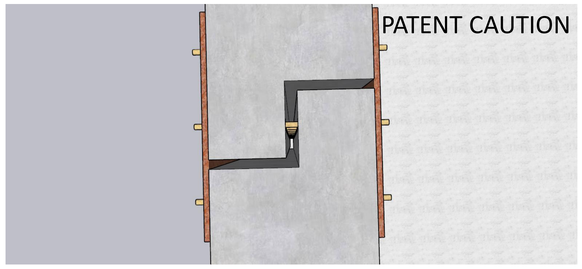
Another module placed next to previous module

Step 4



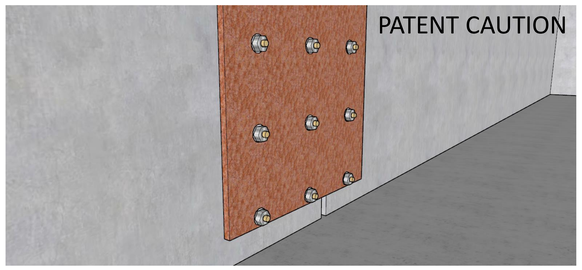
A plate is placed on both sides of connection

Step 5



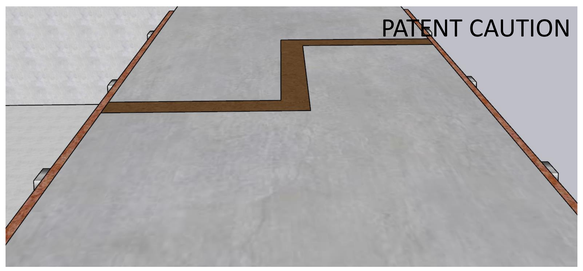
Threaded bars are placed

Step 6



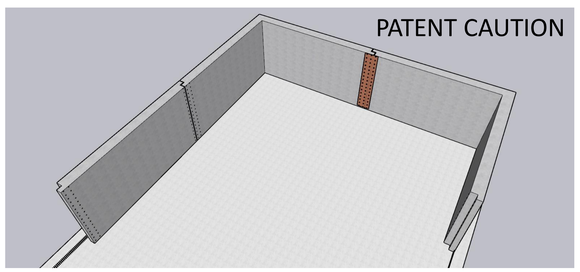
Washers and nuts are fastened to both sides

Step 7



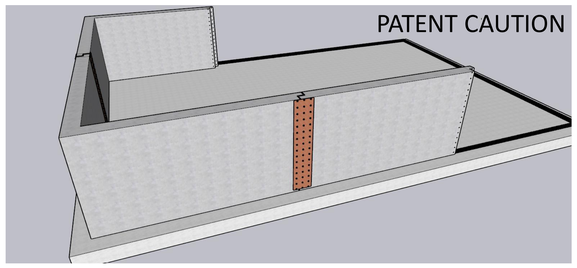
Space is filled with mortar

Step 8



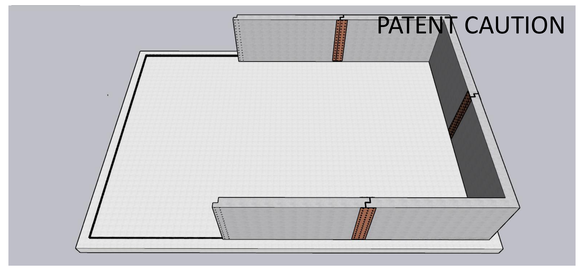
Another module is placed

Step 9



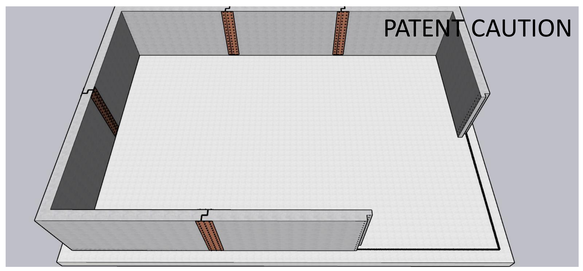
Same process as step 6

Step 10



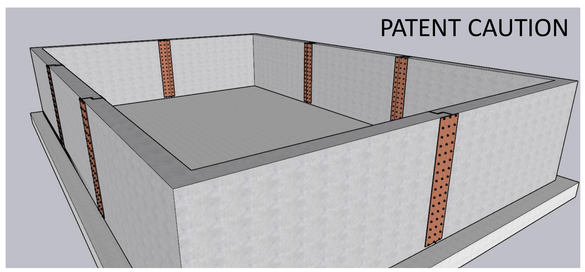
Another module is placed and braced

Step 11



Third corner is installed

Step 12



Last module complete building circumference

ND Energy

CENTER FOR SUSTAINABLE ENERGY AT NOTRE DAME

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

NM STATE

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