THE UNIVERSITY OF MEMPHIS | Department of Architecture

NCMA Education and Research Foundation Grant

FINAL REPORT

September 30, 2024

PROJECT TITLE: 2023.027 – Virtual Reality for Architectural and Structural Collaboration in CMU

Principal Investigator:

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PROJECT PARTICIPANTS:

Lead Faculty:	Dr. Marika Snider, University of Memphis
Collaborating Faculty:	Dr. Waseem Reda Ahmad Salameh, An-Najah National University
Structural Engineering Faculty:	Dr. Adel Essam Abdelnaby, University of Memphis
Graduate Research Assistant:	Aditya Chidananda
Graduate Students:	Michael Boongaling Blake Childers Forhad Hossain Matthew Krosp Dakota McMullen Alexis Rogers

Collaborating Students

UofM Civil Engineering Students:	ANNU Architecture Students:
Mohamed Aly	Aseel Abdelhafiz
Tristen Johnson	Ghaysana Sholi
Benjamin Jones	
Adila Mulugeta	
Luke Vailes	

Project Overview:
During Spring Semester 2024, graduate students in Advanced Design 3 designed a community pool in Nablus, West bank with CMU as the primary structural material. Throughout the project, the architecture students collaborated with architectural students in Nablus studying structures and with the University of Memphis structural engineering department. The goal of the grant was to experiment with using virtual reality as a tool for communication about structural design.

Design Program:

The ancient city of Nablus is one of the largest cities in the West Bank with a population of approximately 200,000. It is nestled in a valley between two holy mountains and is named in the Bible as Sechem in the land of Canaan. The modern city is a commercial center and hosts one of the largest Palestinian Universities (An-Najah National University). It lies about 40 miles northwest of Amman, Jordan and 30 miles north of Jerusalem. The mountainous area is has hot dry summers (80s) and the winters are cool with rain between October and March. The area is in a high seismic risk zone and suffers from shortages and political unrest.

The public natatorium will provide pool access to the residents of Nablus for fitness, recreation, and swim lessons. The natatorium will also serve as a community and emergency response center for the population of Nablus. It should be inclusive, especially for women, but also other marginalized groups including people with disabilities and old people. Access to swimming pools is extremely limited in the West Bank.

This project will follow the ACSA 2024 COTE (Committee on the Environment) Competition Framework for Design Excellence: https://www.acsa-arch.org/competitions/2024-cote-competition/program/. Students may elect to submit this project to the competition.

University of Memphis students developed the specific program in consultation with the architecture students from An-Najah National University (ANNU).

Agenda:

Phase 1: Pre-Design, Jan. 17-Feb. 12

- Develop Programming Document, as a class
- Analyze site, as a class
- Field Trip to St. Louis to learn how to build with CMU at Midwest Block, tours of CMU projects
- Research through precedents, individual
- Establish goals, individual

Phase 2: Schematic Design, Feb. 12 – Mar. 11

- Begin collaboration with ANNU students
- Develop and articulate concept
- Plan and organize space
- Develop massing model
- Develop integrated site strategies
- Integrate structural systems
- Develop preliminary VR models
- Develop floor plan
- Complete preliminary code compliance
- Preliminary testing of goals

Phase 3: Design Development, Mar. 11 – May 1

- Begin collaboration with UofMemphis structural engineering students
- Developed site plan, plans, sections, and exterior
- Code review and life safety
- Demonstrate integration of building envelope and structural systems
- Refine VR models
- Create integrated site strategy
- Incorporate custom materials
- Integration of structural, MEP, and sustainable strategies
- Energy modeling and other metrics to assess effectiveness of sustainable strategies
- Reflections

Phase 4: Post Project, May 2 – Sept. 30

- Assess effectiveness of teaching methods
- Finish building VR lab for subsequent studios

Collaboration:

With Architectural Students

One of the greatest challenges is that typically all participants "going into" a virtual reality model need to be on the same server and the students were on two different continents. The other challenge to this method was the need for both participants to have VR headsets or be in a VR lab. The UofMemphis students had access to VR headsets but, due to political unrest, access to campus facilities at ANNU, including the Virtual Reality Lab, was severely limited and internet connections were weak. Most of the ANNU students were participating in classes remotely for much of the semester and did not have access to any VR equipment.

The students compensated by learning ways to communicate complex three-dimensional ideas using tools that required lower bandwidth and which could be accomplished with off-the-shelf technology. The UofMemphis students tried a number of different architectural collaboration VR programs that could be used by the ANNU students but all of their models were too complex. The students made up for this by using a number of hybrid solutions. They shared models which could be downloaded asynchronously and then they could "walk through" the projects at the same time on their own machines. This did not have the same immersive quality as virtual reality but allowed them to discuss architectural structural questions in a 3D virtual space. They also used more traditional methods such as sharing drawings, sketching together, and synchronous discussions on Zoom and WhatsApp.

With Structural Engineering Students

The structural engineering faculty member began consulting with the students midway through the project to discuss design options. He continued to consult throughout the project and helped the students develop detail solutions. In the third phase of the project, structural design students met in person with the UofMemphis students to discuss the evolution of their projects. The structural engineering students used the architecture students' projects as a basis for a more in-depth structural project.

One of the challenges with collaboration in virtual reality with the structural students was that the programs required a high degree of detail and resolution to be useful for collaboration. The ideal program would allow students to collaborate on "big picture" ideas in a way that is quick to build.

Surprisingly, the 3D printer was one of the most useful tools for collaboration with the structural engineers. It allowed the structural engineering faculty and students to clearly understand what the architecture students were trying to accomplish. It also facilitated explaining to the architecture students where the challenges lie and what impact different solutions could take.

Outcomes of Project Objectives:

1. Improve architecture students' ability to develop a cohesive comprehensive project which integrates clear design concepts, effective building envelope, and a well- executed structural system
    a. Student projects were approximately 30% improved from previous years in terms of clear structural design and level of structural details, and approximately 10% in the integration of clear design concepts. The integration of effective building envelope remained similar to previous years.
2. Increase students' knowledge of design possibilities, sustainable strategies, structural properties, and detailing CMU structures
    a. Student work showed a significant improvement in structural sophistication and students were much more willing to try new and different methods of approaching structural systems. This is attributed to the collaboration with other students which gave them more confidence.
3. Connect small scale learning about materials through hands-on activities to whole building design through virtual modeling
    a. The project began with hands-on training in the Midwest Block production facility in Bridgeton, MO. This led to a student increase in understanding of how to work with and detail CMU. The most surprising takeaway was that many of the students embraced the oversized blocks and incorporated them into their projects. Because they better understood the construction process and physical characteristics of the material, their renderings and walk-thrus better reflected the realities and potential of CMU.
4. Increase collaboration between architecture and structural engineering students
    a. Collaboration between architectural and engineering students was one of the most important outcomes of this project. The students learned about the importance of working together as a design team and the benefits of working together. The use of Virtual Reality as a collaboration tool was an engaging element that got both disciplines excited to collaborate.
5. Demonstrate how virtual reality tools can be used to more effectively create dialog and understanding about structural systems
    a. This project showed that the abilities of the collaboration tool are less important than a person's comfort with and ability to use a tool. In collaborations with both architectural and structural students, the architecture students were most effective when they used a variety of communication tools which include virtual reality, 3D models, static drawings, sketches, and talking.
6. To more effectively communicate technical aspects of architectural design of CMU structures
    a. This semester's projects showed significantly more sophistication in their structural design, particularly with respect to connections between CMU and horizontal spanning elements. Students also demonstrated better understanding of lateral forces on CMU walls because of the collaboration.

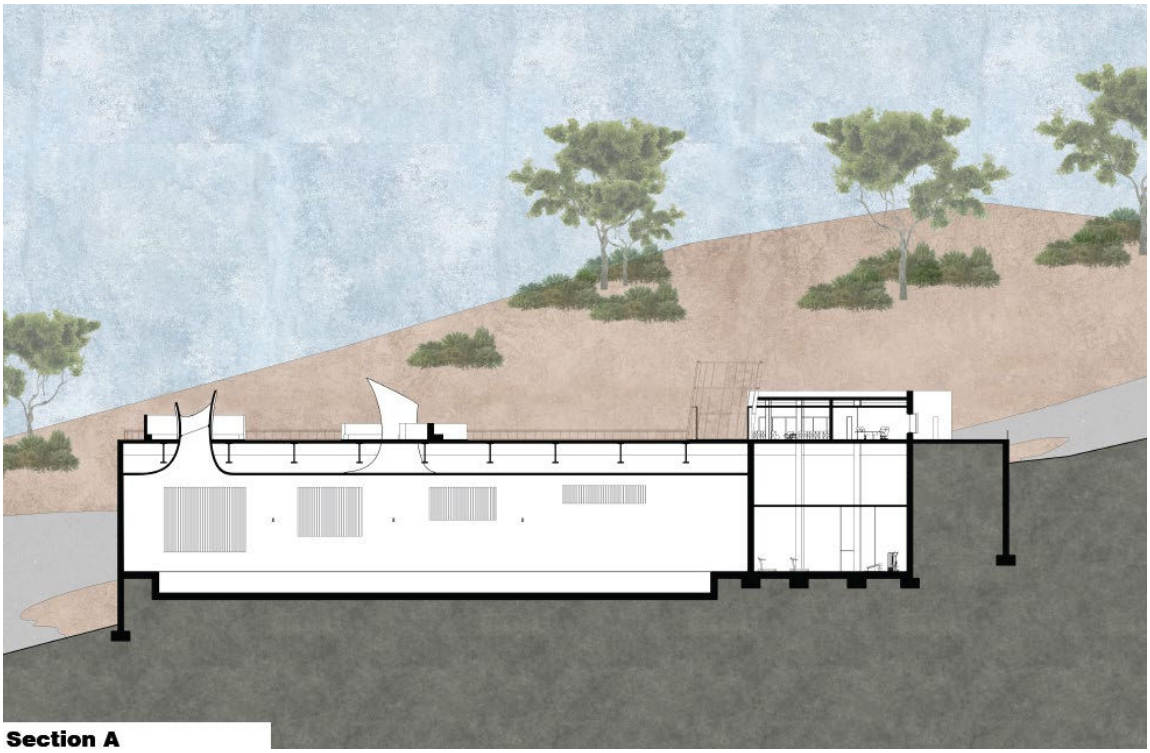
PROJECTS:

The following are samples from each of the student projects. See OneDrive folder UofM Final Boards for NCMA for complete boards from all of the students.

Alexis Rogers: *A Light Within*. This building is entered from a large plaza that corresponds to the highest level of elevation on the site.

Exterior View

The use of CMU, a common local building element allows the building to act as a retaining wall from the upper slope and be a durable enough material to withstand the harsh environment of a pool.



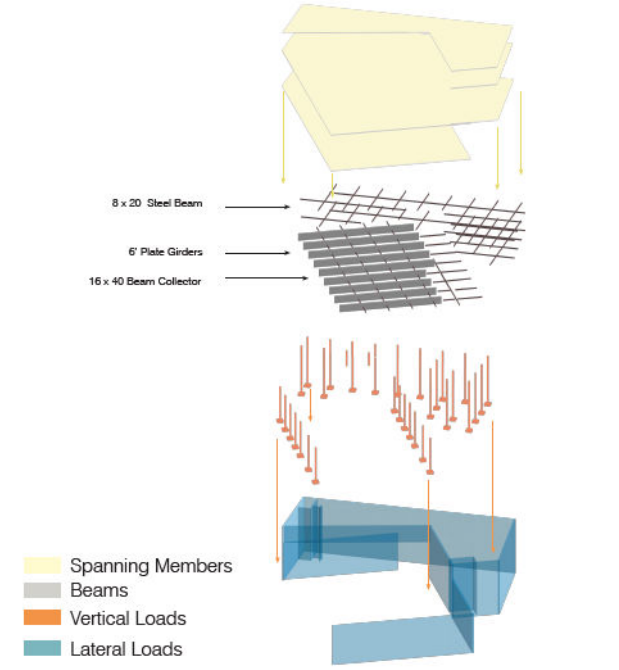
Section A

Large light wells puncuate the roof structure to allow light into the pool while providing privacy from outside viewers. The exterior is clad in stone panels while CMU is exposed on the interior.

7 AM

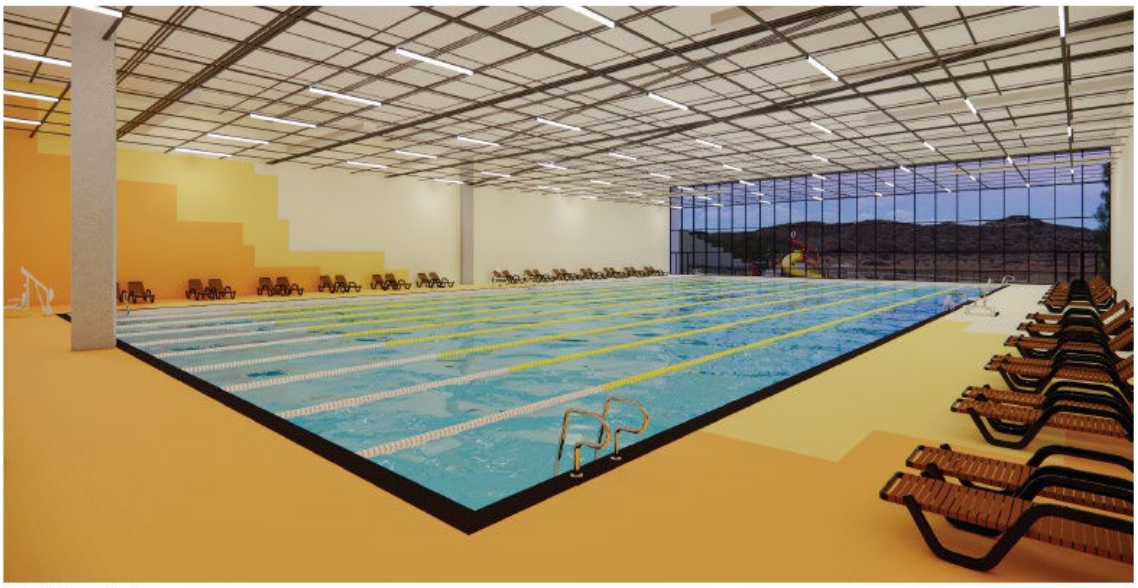
2 PM

The structural challenges were how to laterally reinforce the building, how to deal with two competing structural grids, and how to work around the large (up to 40') skylight penetrations in the roof structure.



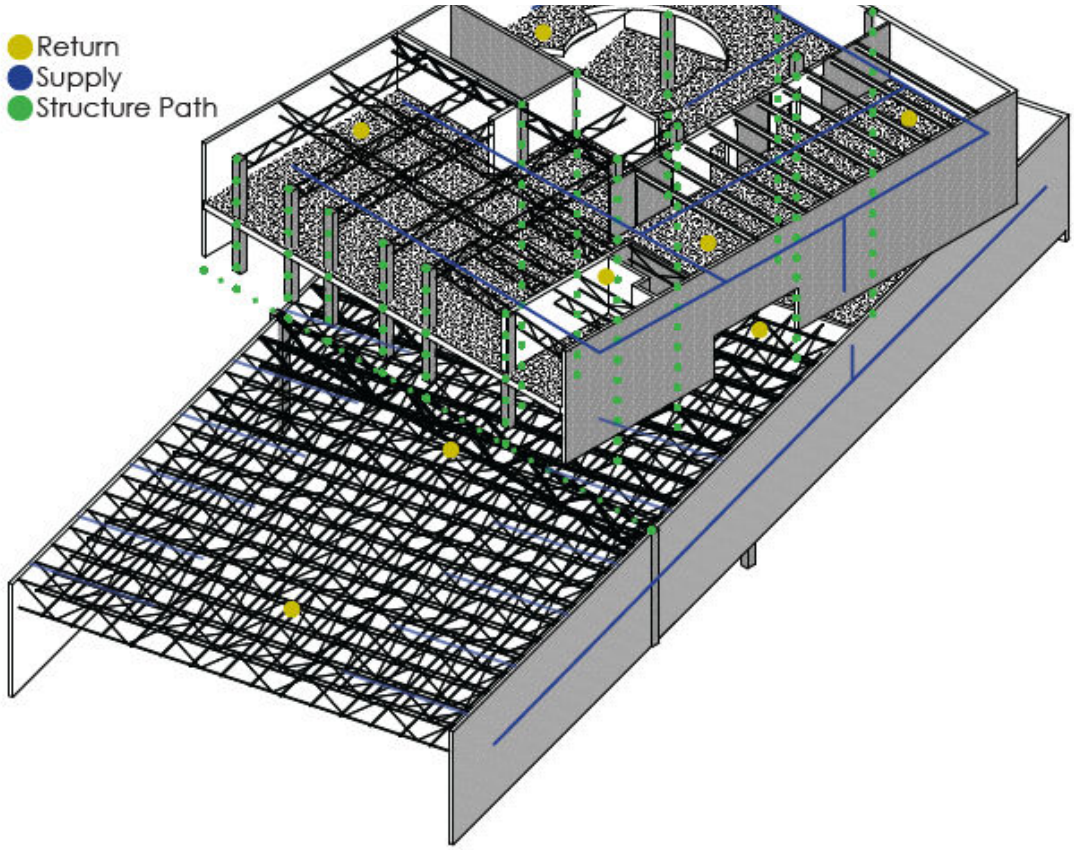
Structural Diagram

Blake Childers:



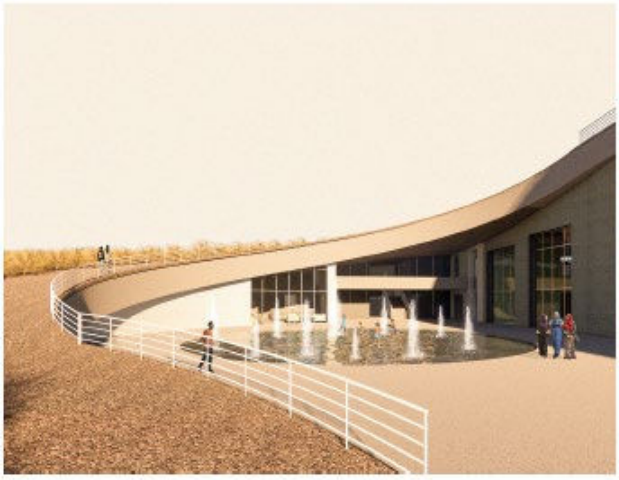
Pool Rendering

Color in the pool brightens the space and highlights the modularity of the CMU.



The complex structural design of this project required multiple iterations and negotiations with engineering.

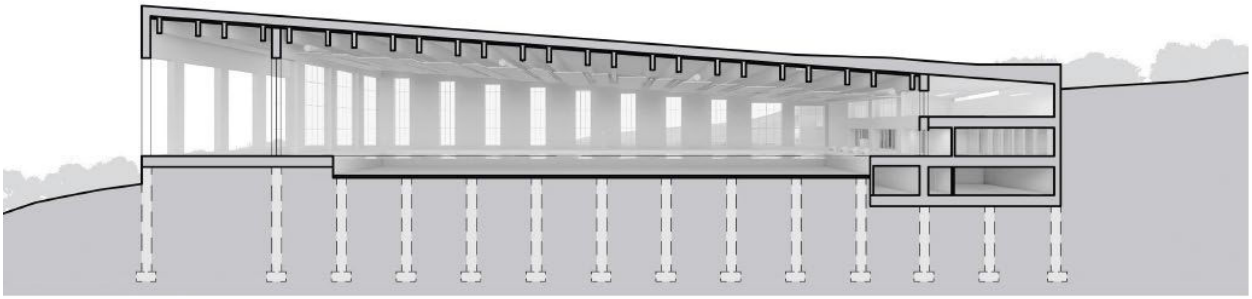
Dakota McMullen



The building wraps splash pad

An evening at the Cafe

The building burrows into the hillside to create a private court with splash pad to help women feel comfortable and out of the public gaze.

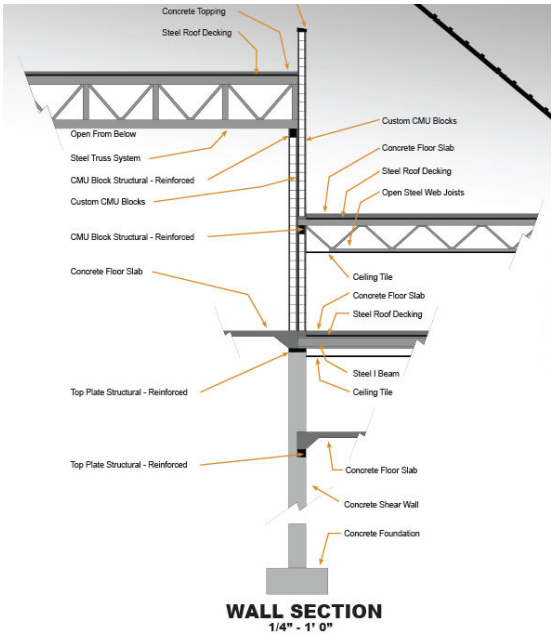


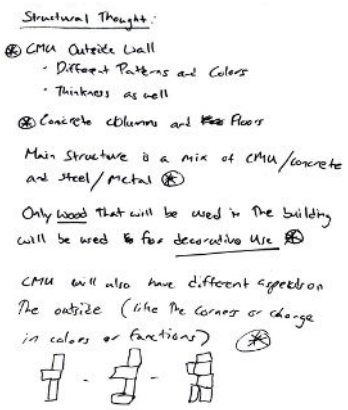
Section through Pool

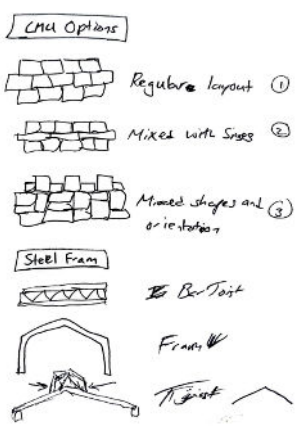
Forhad Hossain

This building boldly uses exposed concrete block throughout as a modernizing element. A monumental stair connects the lower street to the upper and the oversized landing in the center acts as a courtyard for the two halves of the building.

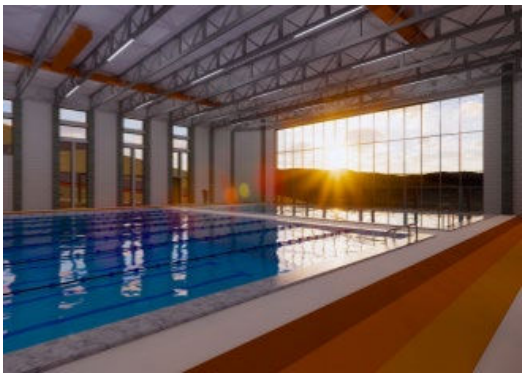
Matthew Krosp



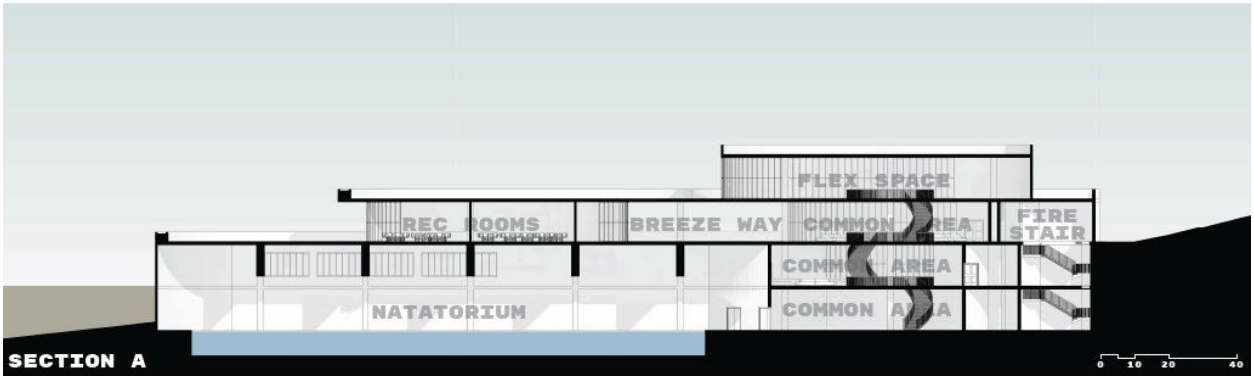




This building is wrapped by protected walking/jogging path which encircles and penetrates the building.



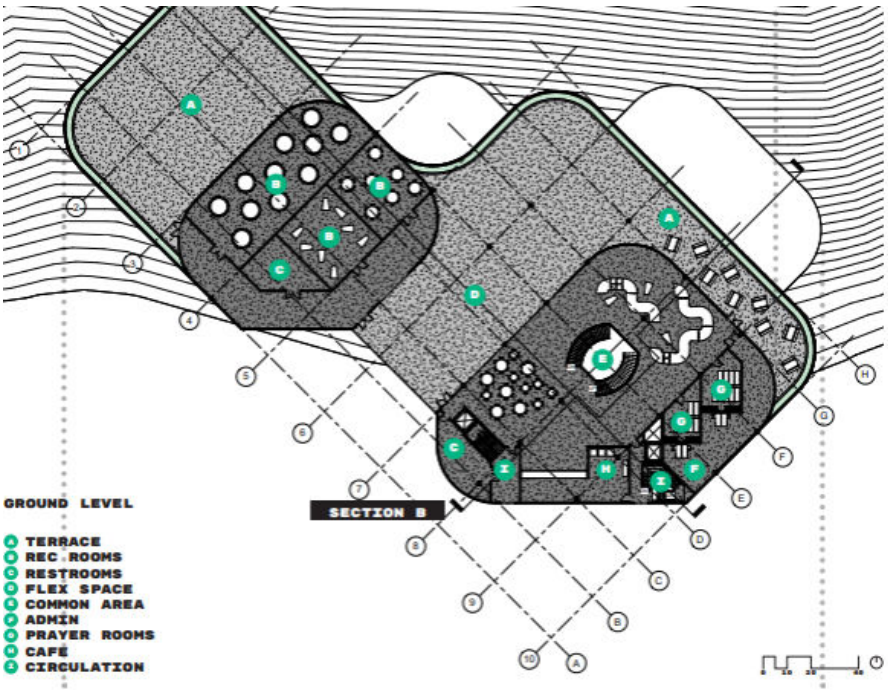
Michael Boongaling



This project investigates how to manipulate rectilinear masonry to form massive curved forms.

CMU Integration

Concrete Masonry Units (CMU) were utilized within the project as 1 of 3 masonry courses found within the wall makeup of the natatorium. While being initially imposed to utilize CMU for the project, the material offered the discovery on how materials on the exterior and interior could inform one another and find parallels and similarities without being the exact same material. Large CMU blocks on the exterior first implied the fact that the interior space should have a much smaller module and ultimately led to the inclusion of bricks to have a much smaller pattern compared to that of the CMU. While this pushed the CMU onto the exterior, it was understood that an exterior material being both structural and available to the elements were not ideal; it is because of this that the exterior is faced with large format CMU tiles that imply and event larger scale module on the exterior to allow for the form of the overall project to be broken down into smaller parts. With this, it allowed for a 3 tiered masonry wall that scaled from larger modules to smaller ones as a person moved from the exterior into the interior.



OUTCOMES:

Institute of International Education Virtual Exchange Competition

Matthew Krosp, Blake Childers, Ghaysana Sholi (ANNU), and Aseel Abdelhafiz (ANNU) were selected as finalists in the HIVER (Harnessing Innovation through Virtual Exchange for Enhanced Results) Competition. The four students were funded to travel to Washington, DC where they will met their partners for the first time in person. They competed and won first place in the international competition.

HIVER Staff and competition winners. Winning students are located in the center of the picture. Matthew Krosp (turquoise checked shirt), Ghaysana Sholi (red and white dress with black and white shawl) Aseel Abdelhafiz (red and white dress with black headscarf), Blake Childers (white shirt).

Graduate Student Computer Lab Upgrade

The eight computers in the graduate student computer lab were upgraded with new graphics card that can sustain the demands of virtual reality production.

Maker-space Upgrade

Two new 3D printers were purchased. This allows students to complement the virtual tools with physical models and was a more effective collaboration tool than expected.

Virtual Reality Lab

The department will use the final installment to build an immersive Virtual Reality laboratory (VR cave) to assist student collaboration and experimentation with virtual reality. Two new virtual reality headsets were also purchased which allowed multiple students to connect to virtual worlds at the same time.

APPENDIX A

For Student Complete Work See UofM Final Boards for NCMA

APPENDIX B

Photos of students (below)

Hands-on Training at Midwest Block


ALUMNI

Collaboration