

Mbesese Build 2023
8 June 2023

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The Mbesese Initiative for Sustainable Developments (MISD) is a non-profit organization that aims to uplift the area of Northern Tanzania from extreme poverty through education. The MISD aims to develop a technical school called the Same Polytechnic outside of Same, Tanzania. For the last 10 years, the non-profit has been constructing structures for the school and local community.

Students in the Architectural Engineering, Architecture, and other departments at California Polytechnic State University of San Luis Obispo have been working with the non-profit for the past couple of years. In 2017, the purchase and ownership of the future polytechnic site was finalized, and a sign was built. This symbolized the beginning of construction and a commitment to the local community. The following year, a test structure was designed and built. The main goal of this structure was to experiment with different structural, construction, and architectural designs and techniques, ultimately helping visualize how permanent structures on the site may look and function. In 2019, a local footbridge used by children to travel to school was replaced with a new, steel bridge. This project not only directly benefited the local schoolchildren, but also built invaluable, lasting relationships with the local community. In 2022, students designed and began construction of the first school building for the site in Same. Building off of knowledge gained through the construction of the test structure, the roof and building skeleton was completed in the summer of 2022.



Figure 1: First School Building in Summer 2022

The 2023 phase of the Same Polytechnic Build aimed primarily to finish what was started in 2022 and produce a fully functional communal/educational space. Doors and a facade for the “box” underneath the roof were designed to create a secure storage area and to give the building a more finished appearance. Additionally, a water collection system was designed, along with an accompanying shade structure and gathering area. This system would primarily serve the local community by providing safe, free rainwater - a resource in high demand - while also furthering the relationship between the MISD and the community.

According to the “Tanzania Mainland Poverty Assessment” report, Tanzania has some of the highest poverty rates and lowest tertiary education enrollment rates in East Africa. Opportunities for higher education are limited in the country’s rural regions. This report also describes how increasing the availability of education has allowed those in poverty to be able to work in more productive industries, increasing their economic standing. This demand for higher education in rural regions led to the creation of the idea of the Same Polytechnic.

Due to the high heat that is typical in Tanzania, the buildings will be partially open, allowing for airflow and natural ventilation utilizing large shade structures serving as cover against the harsh equatorial sun. A mix of indoor and outdoor spaces will serve as the primary motif in the design of the school. The build site is located in the town of Same, Tanzania, which is in the northern region of Tanzania, near the Kenyan border and Mount Kilimanjaro. The site itself is located about 3 miles east of the town center.

The integration of indoor and outdoor spaces for the building manifests in our chosen design. As it stands, there are four open spaces for doors, approximately six feet wide and seven feet tall. Each opening will feature a set of double-revolving doors, which rotate around one-third of their length. These doors will allow simultaneous learning in a combined indoor/outdoor space when opened and will preserve the open program and flow of the space by having a shorter span of the door stick out when it is open. When necessary, the doors will be able to be locked together, to store supplies or other items inside the room when not in use.

Another aspect of the needed additions to the existing building skeleton is the facade. The facade will feature a simple plywood and batten design, continuously wrapped around the building. The Doors will not have the batten pattern, and remain flat instead, as the intention is to work with local artists to create a mural on the door to enhance the beauty of the project and solidify the connection to the surrounding community.



Figure 2: Permanent Structure Roof Truss

Looking at the structural system of the main building, the roof is supported by a series of wooden trusses. Looking at Figure 2 the truss is sloped with the roof, with a height of about three feet at the low end and five feet at the high end. It spans about 24 feet between the wood columns. All of the webs of the truss are 2x4 wood members, with chords being made up of double 2x6 members. 12mm bolts are used in connections. Due to wood member size limitations existing in Same, the truss members are limited to about 12' in length. This means that splices are needed in the top and bottom chords in order for the truss to span the building. These chord splices are proposed at the mid-spans of the chords and are composed of a 2x6 wooden member slotted in between the double chord that is bolted through.

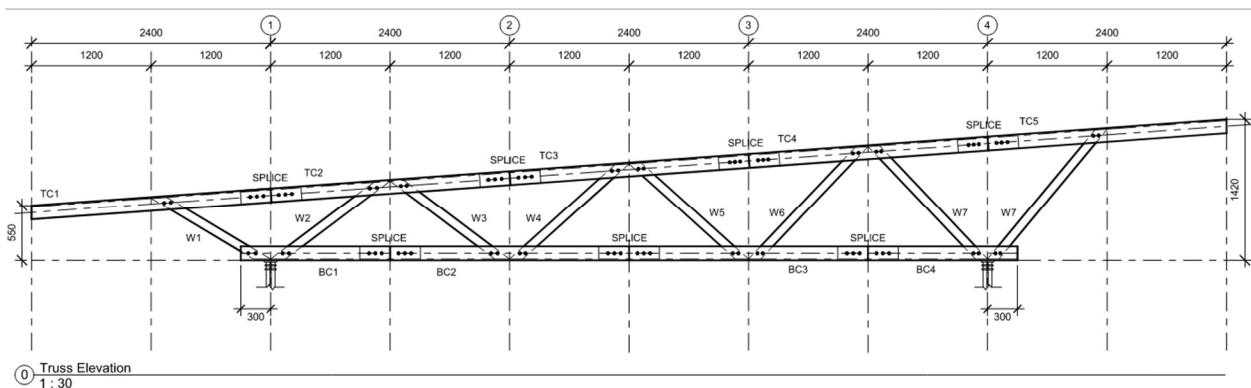


Figure 3: Roof Truss Elevation

Construction drawings such as Figure 3 were made for the wood roof truss, with the objective of simplifying the fabrication and construction process of the truss'

members while simultaneously maintaining the high level of detail required for the structural system to function as designed. To this end, individual construction drawings were made for the components of the truss: the bottom chords, the top chords, and the webs. These drawings document all the relative construction information about their respective members, such as member locations, lengths, cut angles, and bolt hole locations.

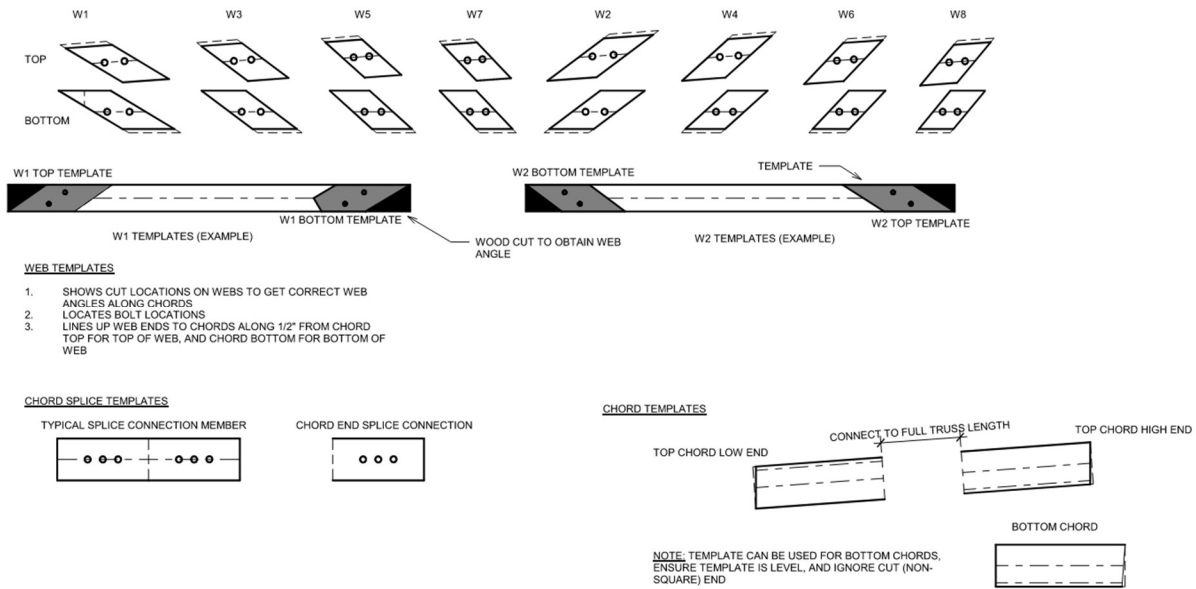


Figure 4: Truss Templates

In addition to these drawings, connection templates were made for the purpose of assisting in constructing these trusses further. In order to ensure that the templates are able to be transported easily and resist damage, a thin but durable tarp material was chosen. These tarps will be placed over members, such as a steel plate or a 2x4, allowing the user to make perfectly accurate cuts and holes without needing to measure. This lessens the likelihood of construction error, while also greatly streamlining the fabrication process of more complex members. An example of how these templates would be used can be seen in Figure 4, and Figure 5 shows a physical template for one of the gusset plates.



Figure 5: Physical Gusset Template

Similar to the truss, construction drawings were created for the braces to update and verify the previous year's design and produce a consistent set of drawings. Then, they were reconstructed by hand at $\frac{1}{2}$ scale to troubleshoot construction issues that may occur and verify the tolerance and centerline dimensions. One issue that occurred during the construction of these braces was that the wood member dimensions in the drawings used nominal sizes, as is done in Tanzania, but the members were cut to represent the "actual" dressed sizes typical of American lumber. This generated noticeably larger gaps than was planned for, especially at the center of the brace where the two members converge. Another issue that occurred was the inconsistency of getting the proper angle on the ends of the braces--as one initial construction method involved cutting the first piece and using that piece as a guide, generating slight errors that would accumulate into larger errors.

Due to these issues and potential confusion while building, construction templates were also deemed to be necessary to aid in the accuracy of the construction of the braces. These templates are at a 1:1 scale, and have locations cut out for the bolt holes to be drilled. Like the truss, the templates also convey the exact size and angles of the cuts needed for the angled edges of the braces and the gusset plates.

In Tanzania, access to clean water for drinking, bathing, and cleaning remains a critical issue. Much of the groundwater contains high levels of fluoride, affecting bone health through a condition known as fluorosis in much of the population. Additionally, the country has faced a severe drought in recent years. However, in a typical year, there are two short rainy seasons, where rain is expected and can be quite heavy. As such, we aimed to collect the rainwater on the roof of the existing structure and store it in water tanks for use by the local community. The approximate area to harvest rain is around 7000 square feet, which would produce over 7000L of water with only 1 inch of rainfall. The design of the catchment system is quite simple, as the roof already has a slope to one side. Gutters will be added along the lower side of the sloped roof, to guide flow of water onto a secondary roof, where it then flows down into one of two barrels. The barrels are surrounded by seating and covered in a shade structure, providing an area for community engagement and relaxation while also serving as a water distribution center. The water tanks are supported by locally produced bricks that elevate them approximately 9" off the ground, allowing for gravity to provide the distribution mechanism for the rainwater.

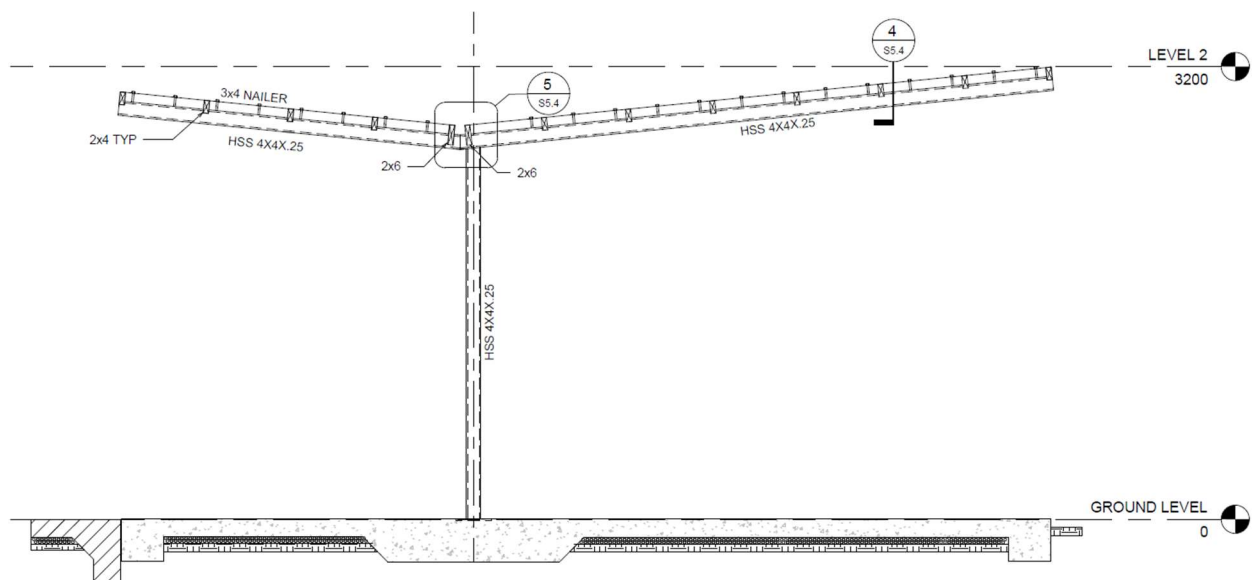


Figure 6: Section Cut of Shade Structure

While designing the water collection system, the space evolved to also include a gathering area. To accomplish this goal and facilitate communal interaction, a smaller shade structure was designed, to provide comfort and relaxation around the water collection area. Through several iterations, both architecturally and structurally, the final design resulted in a rectangular butterfly roof as seen in figure 6. The intention of this design was that the butterfly roof would partially lay under the overhang of the main building's roof, allowing water to flow from the gutters onto the shade structure.

Structurally, the shade structure consists of three 4x4 HSS columns offset from the trough of the roof, with two 4x4 HSS members cantilevering off to each side, matching the slope of the roof of the existing structure. These steel members are welded together, with the columns being supported by a pier foundation. Spanning between these are 2x4 wooden joists supporting the roof. The joists are connected through a wooden member over the HSS cantilevers with nailers.

Overall, the main focus of the 2023 build was the water collection system and accompanying shade structure, the existing building's facade and openings, and the templates and construction drawings for the trusses and braces. These will foster a developing community and allow for greater ease of construction when the site is expanded with more school buildings in the future.

Matthew Chung's Project Reflection

Throughout this project, I was able to gain a lot of valuable insight and firsthand experience on the transition between design and construction. From a design standpoint, things went very smoothly. The team was able to come to decisions quickly, work through issues with ease, and decide upon a final plan that satisfied everyone's desires. However, transitioning these ideas, even into scale mockups proved challenging. The part I worked most closely with was the door. After realizing that a sliding door concept was not feasible, we went ahead with a revolving door concept, where I produced a materials list and preliminary drawing, and began construction. I quickly learned the importance of understanding the materials I was working with, as naming conventions often differ. For example, a #4 (4/8") rebar has a 1/2" diameter, but a 1/2 inch PVC pipe has a 1/2" radius, and the initial mechanism I imaged did not work due to this discrepancy. Furthermore, the necessity of clear, concise drawings was emphasized, as while I could understand my design intent, it was difficult to communicate my ideas with others if I did not have accurate, clear drawings on hand. On a more general note, this project helped me look at construction techniques on a more global scale. Common materials here such as S4S Lumber and readily available steel are not as easy to come by in other parts of the world, affecting how the design fits together. Furthermore, typical construction practices differ from place to place, and therefore must be considered when producing construction documents.

Matthew Chung's Trip Reflection

Throughout the trip, we encountered construction and design challenges that were both anticipated and unanticipated. While we knew beforehand that the wood members, we were working with would not be of comparable quality to local material, I underestimated how difficult this would prove to work with in practice. It would sometimes take 2 or 3 people using their full body weight on a member in order to bend it into place to counteract a bow. This, paired with wet wood, as well as hardened old wood that was rescued, led to a very difficult and lengthy construction process. Furthermore, due to the limitations of the materials and tools we had, small mistakes or inaccuracies were more punishing than I was used to. A stud cut 1/4" too long could end up causing the entire wall to be unlevel at the top. If I did it all over again, I would be as accurate as possible with every cut, and ensure drawings were shared with every member of the construction teams, as often times we were not working on the same page, leading to some parts being constructed incorrectly at first.

Ian McConnell's Project Reflection

For me, this project was very fascinating in a lot of ways. Due to the project's current stage of construction, there was much less engineering design that needed to be done than I anticipated. It became more of a construction project than engineering with a focus on the ease of constructability with things like the templates. Working with architecture students was also interesting as we had different thought processes and really helped display the interdisciplinary nature of the building design. Throughout the project though, there were times when neither group had a clear understanding of how to design an element as the element fell outside the scope of architecture and engineering. This was most relevant in the design of the door which had an initial idea to be a sliding door. We went through many possible methods for how we could cheaply and easily create such a door in Same, but after a few weeks of work, no viable design was conceived, and we eventually switched to the door rotating about its third point. For me personally, the greatest point of learning was drafting construction documents that are easily understood and give all the information necessary. As I developed my part of the construction drawings, I came up with many iterations of drawings that failed to effectively communicate all the information necessary. These iterations allowed me to improve the drawings so that they can be easily understood by just about anyone while considering what information is necessary for each step. I would say the most valuable thing I learned was the importance of coordination, which we honestly did not do enough of in the early stages. The communication between everyone regarding our drawings allowed us to help resolve the problems in our drawings faster and allow for consistent standards.

Ian McConnell's Tanzania Trip Reflection

The trip was wildly different than what I had anticipated, especially arriving on site to see that the box structure had been torn down and we were to rebuild the entire thing. While the design stage of the project taught me a fair chunk about construction and thinking architecturally, the construction in Tanzania taught me so much more, and how much of the process can easily get oversimplified early on. The doors were modified at the site to have a more standard design, but due to constructing the doors and aligning them and the jambs as perfectly as possible, the process was significantly more complicated than just hammering some hinges in. The walls were even more complicated than the doors as we checked for their alignment multiple times in separate phases of construction, and each time required measuring the diagonals then pushing the walls to be more right. When it comes to the engineering side, this trip showed me the high value of having details and for the construction process as so much is easily overlooked, especially by someone who has not spent the time in the field to discover these issues that will occur.

Ben Stewart's Project Reflection

Being a part of the 2023 Tanzania Build Project for my Architectural Engineering senior project was unlike any other academic experience I have had in my four years at Cal Poly. Going through the design phases of research, to design, to building prototypes, then to building the full-scale structures has been able to provide a much more complete understanding and familiarity to this project. I feel I gained valuable real-world structural design experience in producing construction documents or cut sheets for wood trusses. Another source of valuable experience I gained was through the trial and error in designing the structure over the water collectors. There were many instances where a design idea would be presented by one of the Architecture Major students, and myself or another Architecturally Engineering student would evaluate it structurally and from a constructability perspective to determine its feasibility or if another, similar design might be able to achieve their goals. For example, we were approached with the idea of making a curved butterfly roof. While we determined that a butterfly roof itself is doable structurally and had benefits of aiding water collection while providing more vertical space, we also found that a curved roof would impact constructability negatively. Due to this, it was decided by everyone to go with a rectangular butterfly roof. More on this process, it was exciting to work directly with architecture majors, and be able to see their perspectives on the design side of a project. I feel like I was able to learn a lot about their design methods and goals in contrast to a structural engineer's. More so on the project as a whole, it was also interesting to go outside of my comfort zone and research construction in Tanzania and try to adjust my vision for potential designs to be more in line with what is more realistic and possible while keeping the architect's vision and goals in mind. I feel like I was able to achieve this during the project and looking towards this summer, I feel more confident that we will be able to accurately build what we designed, and I hope that Same, Tanzania will be able to benefit through the templates and construction drawings of the college structure.

Ben Stewart's Tanzania Trip Reflection

As much as I tried to picture what the trip to Tanzania would be like in my head, the experiences I had there were nothing like I was expecting. Despite all of our research into the material quality and the difficulty using it, I still struggled to carry out some seemingly basic tasks like nailing blocking in between two studs. This showed me how much a different environment can affect the quality of construction, as well as the ability to actually apply a structural design. I also learned a lot from just building three shelves, in that when doing something new for the first time, it can be very helpful to go through the whole process at once. That way you can find out what worked, what did not work, and how the next iteration can be improved. This is what I applied to building the

shelves, with the final shelf ending up being the most stable and level. Beyond that the exposure to the different cultures and nature was unlike anything I had ever experienced, and it has left me wanting to experience something like this again sometime in my future.

References

1. *National Bureau of Statistics - Home*, www.nbs.go.tz/nbs/takwimu/hbs/Tanzania_Mainland_Poverty_Assessment_Report.pdf. Accessed 9 May 2023.