

# Natural Adversities: Finding Solid Ground for School Architecture

## MAGED GUERGUIS

University of Tennessee Knoxville

## KRISTIN PITTS

University of Tennessee Knoxville

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**ABSTRACT: Each year, schools damaged by natural disasters often leave hundreds of thousands of students with no access to education. Therefore, there is an urgency for design research that responds to the demand for affordable, innovative, resilient, and environmentally sustainable school buildings. Studio Mozambique is an advanced research design studio that focuses on the cultural, economic, political, and spatial history of schools in cities susceptible to natural disasters.**

**The work presented in this paper serves as a compendium of post-disaster recovery of primary educational institutions. Additionally, it can potentially help answer these fundamental questions: Which factors and parameters inform a more integrated design of a school building? Which processes can be adapted for local fabrication or rapid deployment within the limitations of a remote site? What materials and construction systems are best suited to the limited means of transportation and fabrication (i.e., light-weight, local, reused, weather-resistant, adaptability, resilient)? What strategies could be implemented for the design of school structures for functional integration of sustainable characteristics (i.e., use of local renewable or biodegradable materials and structural optimization)?**

**As a proposal for an integrated research design curriculum, this paper describes the strategy, approach, assessment, and comprehensive planning of a flood-resistant, affordable, resilient, and environmentally sustainable school campus in Chokwe, Mozambique following the 2019 cyclone Idai.**

## INTRODUCTION

Early education has a significant impact on society. It serves as a platform to gain the necessary knowledge and skills to make rational and informed decisions. It is through education that communities can achieve their goals for growth and development. Every year, natural disasters, such as floods, hurricanes, cyclones, and earthquakes, often cause property damage, including schools and educational institutions, disrupting children's education. The Mozambique design research studio seeks to examine the multiple aspects in which schools

and education as a whole struggle to find solid grounds post natural disasters. In many areas of the world, natural disasters coupled with poverty are not merely a temporal transition or a reversible state. Rather, they have detrimental long-term effects and often results in indefinite school shutdowns.

Tropical cyclones are expected to increase due to climate change, which has contributed to an increase in oceanic hurricane activity (REF). In Mozambique, over 3,400 classrooms were damaged or destroyed in cyclone-affected regions. In some cases, schools require extensive rehabilitation after being used as emergency shelters for children and families displaced by the storm<sup>1,2</sup>. This research seeks to develop methodologies for school facilities in affected regions of the world to be constructed to withstand recurring natural disasters.

Over 13 years ago, Sybil Baloyi started a children's ministry in Chokwe, Mozambique. Sybil left her home country, South Africa, and moved to Mozambique with the goal of serving small children orphaned or made vulnerable by war, famine, or natural disasters by providing them with permanent shelter and education. Due to increased needs and demands, Sybil's small preschool of only 14 children quickly grew into the private school now known as Hlauleka School which serves over 300 children through the 7th grade. In 2019 the school was hit by cyclone Idai and with limited resources the school was partially rebuilt. However, the same methods of construction used prior to the hurricane were implemented.

While meeting with Sybil, she described her vision of expanding the school to include a high school through the addition of a new campus to be developed on a recently acquired plot of land closely located to the current Primary school. This research design studio focuses on the development of a new master plan for Hlauleka high school in Chokwe, Mozambique in an effort to bring this vision to life (Fig. 1).

## STUDIO MOZAMBIQUE COURSE OUTLINE

Advanced architectural research can have a great impact on the society. Thus, to achieve novel effects in architecture, a degree of expertise in disciplinary methods is essential<sup>3</sup>. Therefore, a series of research methodologies related to contemporary practices address post-disaster recovery of educational institutions were investigated. Studio Mozambique pursues this



Figure 1. Clockwise: Tornado damaged classroom. Credit: Andrea Booher, U.S. National Archives & DVIDS; Cyclone Idai, Mozambique. Credit: Climate Centre; Hlauleka Organization, Mozambique. Credit: Sybil Baloyi; Baloyi, Guerguis, and Hllauleka graduate. Credit: Randall Lind.

hypothesis in three phases, each with a set of preconditions, tactics, and goals.

### PHASE 1 - NOVEL EFFECTS (HISTORICAL ARCHIVE)

It is imperative to recognize the impact of different cultures, heritages, and teaching methodologies on the program arrangement, building form, and function. Therefore, the first phase of the studio documents school buildings from different cities by running an in-depth analysis of vernacular and contemporary case studies. The data includes the cultural, economic, political, and spatial history of the site and its context. Here, the traditional dichotomies between public and

private, separate and communal, individual and collective, are re-examined, generating a new species of schools. The first exercise focuses on two different groups of case studies, vernacular versus contemporary, and introduces their potentials to the studio's collective imagination. Cataloging these monuments of architectural styles, including compilation, comparison, and analysis, develops an itinerary for possible future of this typology. These studies are then documented in a book format which serves as a reference for the studio, for later phases.

### **PHASE 2 - EXTRAORDINARY METHODS (TECHNIQUE)**

In the second phase, the studio investigates innovative techniques for conventional construction methods utilizing the limited resources and trained labor on the site. These methods provide quicker, safer, and more resilient options for school design and construction. The resulting design interventions could be adapted to local needs considering cost efficiency, robust-deployment, fast-recovery, passive design strategies, and sustainability. One of the major studio premises is that opportunities for design arise through the recognition and realignment of various constraints. These novel methods are used to extend the organizational principle to other aspects of the project, not merely architectural style but also embodying ecology, heritage, culture, and sustainability.

### **PHASE 3 - APPLICATION (PROJECTIVE DESIGN)**

The third phase tackles the design problem of the future school master plan as well as building prototypes manuals for local builders for easy construction (Fig. 2). The research presumes that the novel effects of educational building typology are the result of the tactful application of modern building technology. The program module of this phase serves as the generator of organizational logic and building forms. The program assembly would form the basis for the new school, which situates the project as a more identifiably public institution given the specific urban research and identity generated in the earlier exercise.

### **NATIONAL ORGANIZATION OF MINORITY ARCHITECTURE STUDENTS (NOMAS)**

Students from the National Organization of Minority Architecture Students (NOMAS) east Tennessee chapter, for which the PI serves as the faculty advisor, contributed to the development of this curriculum. This course creates new research opportunities that are offered to underrepresented and minority students, giving them a sense of identity as they contribute to a project with a pressing concern.

### **FINDING SOLID GROUND FOR HLAULEKA NEW SCHOOL**

For the first stage of the studio, case studies of vernacular and contemporary school buildings were analyzed and documented. For Mozambique, strategies from both vernacular and contemporary types could be innovatively combined to create an inspiring educational experience on the new campus. Simple strategies, such as using paint to activate spaces, vibrant textiles crafted by local artisans, and furnishings that support varied approaches to learning and discovery in ways that embody the ideas being realized in contemporary educational settings, all held unique possibilities for implementation in Mozambique.

Bordered to the east by the Indian Ocean, Mozambique is highly susceptible to hurricane and cyclone devastation. Located in Chókwe, a district of the Gaza Province in southwestern Mozambique, the site lies about 130 miles north of its capital city, Maputo. In the second stage of the studio, the students conduct site analysis distributed into five categories: 1) site plans and physical models; 2) programming and interior; 3) environmental analysis and sustainable strategies; 4) materials and construction details; 5) master planning and landscape.

An additional focus of the research was flood control including developing strategies for floodwalls, seawalls, floodgates, levees, and evacuation routes. Such novel methods would be used to extend the organizational principle to other aspects of the project, beyond architectural style to embody ecology, heritage, and culture. The students were asked to document the result of the research as a series of construction tactics simplified manual cards for local builders (Fig. 2).

### **SITE DESIGN AND MASTER PLAN FOR THE NEW CAMPUS**

Emerging from a ministry founded to aid vulnerable and orphaned children of Chokwe, Mozambique, the Hlauleka School was established as a private preschool that also provided permanent shelter and education for those it aimed to serve. This project focuses on the future expansion of the school through the development of a master site and design proposal that embraces and celebrates the unique characteristics of the region, ecosystem, and site.

Anchored by its three prominent programs, the proposal embeds openness, engagement, and longevity into the master plan. Building program acts as the generator for organizational logic and architectural form and works in tandem with prior research that informs methodologies and typologies to shape the project's identity. Phase-based planning strategies are implemented to maximize opportunities for future growth and sustainable development without compromising its spatial and adaptive qualities. Related functions are located within close proximity to each other creating zones of connection and interaction.

With a primary focus centered upon creating an elevated learning experience that promotes flexibility, health, and interaction, architecture and landscape are creatively engaged in the development of a unique and efficient campus plan. With the northwest area of the site being the closest to the existing school campus, the goal of the site design for the high school was to concentrate the majority of the school's programs as close as possible to the existing primary school to provide efficiency through proximity. The site design also promotes health beyond the aspect of construction as varying opportunities

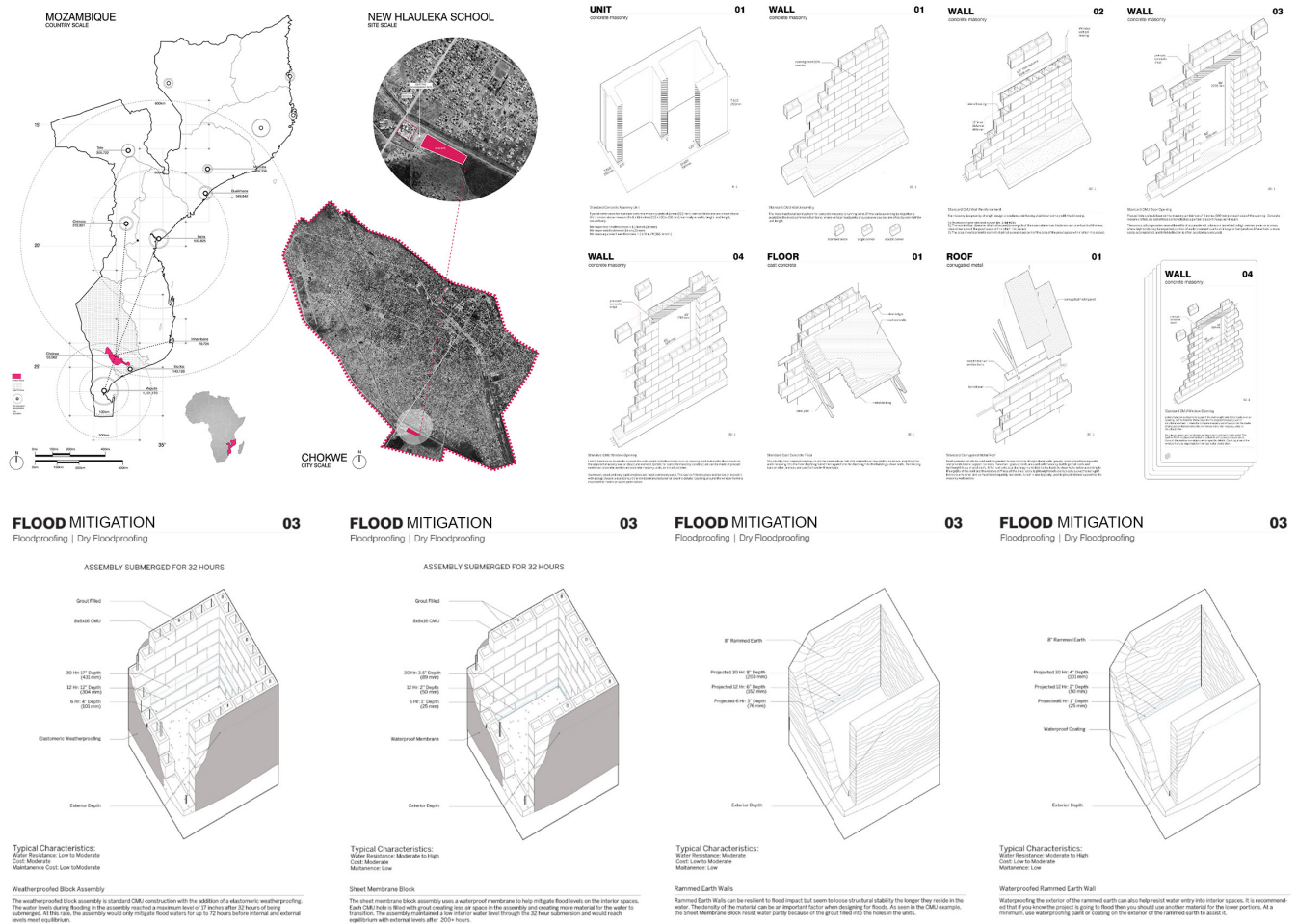


Figure 2. Clockwise: Site analysis. Credit: Kristin Pitts; Construction tactics simplified manual cards for local builders. Credit: William Nix; Flood mitigation strategies. Credit: Matthew Crow.

for healthful choices and activities are included such as raising livestock, school farm, and gardens while increasing spaces available for recreational use.

### LEARNING VILLAGE: SITE PROGRAMMING AND CIRCULATION

Upon entering the site, all administrative functions are placed directly at the entrance to allow for ease of access for visitors and staff. A health center is adjacent to administration. A large dining hall is centered within the site with kitchen, large storage, and staff dressing rooms. A community garden area and accommodations for small animals are near for direct kitchen access. Within the academic zone, a large central library containing a computer lab nested in a radial array of classroom spaces creating a “learning village”. A science laboratory and the existing classroom building completes the arrangement. Restrooms are strategically placed for ease of access to all students from both the academic and recreational wings. To

the opposite side of the dining within the central portion of the site, a maker’s space that is separated from the academic wing for noise reduction. A pool and amphitheater are located within the center of the site offering spaces for interaction and recreational activities. This also serves as a transition into the athletic zone which includes a gymnasium and sports fields. Within the gym, a stage, locker rooms with toilets, storage, and multipurpose spaces are provided. Space for farming and accommodations for larger animals are located at the most remote end of the site (Fig. 03).

### MASTER PLAN DEVELOPMENT ROAD MAP AND CONSTRUCTION PHASES

To accommodate a sustainable and gradual approach to the campus’s construction as resources become available, a series of phasing plans were developed. For phase 1, programs considered most critical were included to ensure the campus could function even at its most elementary stage.

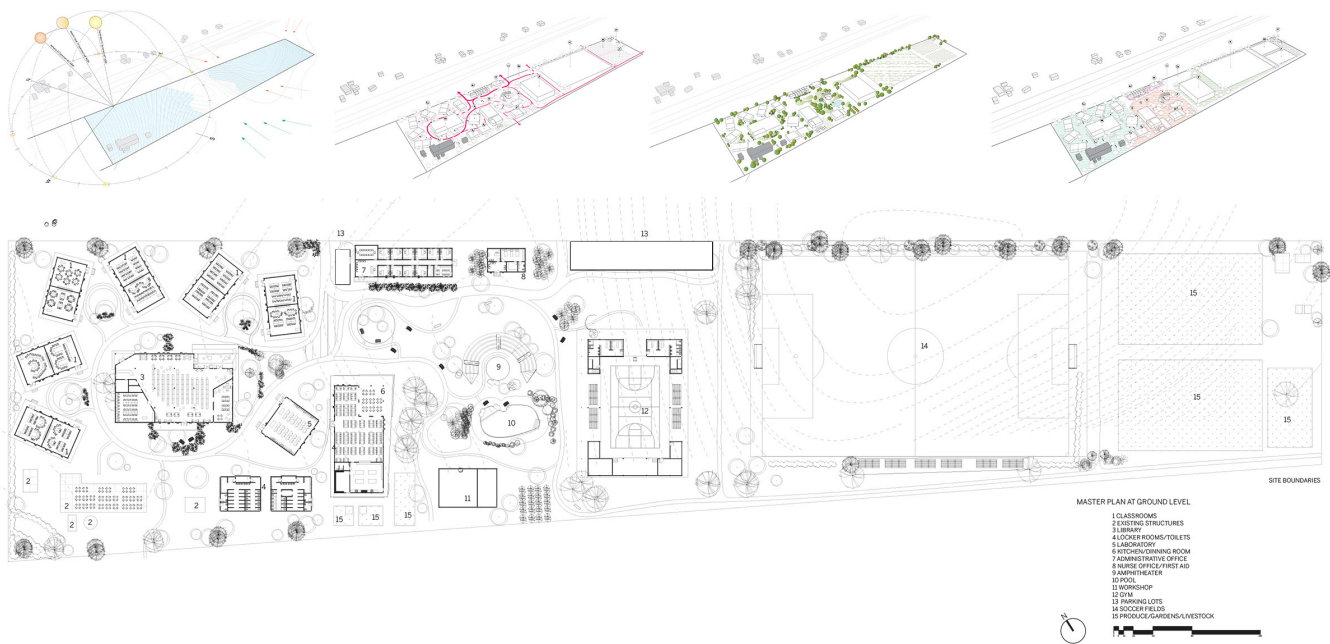


Figure 3. Top: Master plan diagrams; Bottom: New Hlauleka high school site plan. Credit: Kristin Pitts and Hollywood Conrad.

Phase 2 includes the library and the computer lab along with only one additional grouping classrooms. Phase 3 includes the remaining educational buildings, support spaces, and the pool. Phase 4 adds the large gym and health center. Due to its scale of construction, the gym receives its own phase. The health center is included within the last phase but as it is an optional program not originally requested, it is reserved for last or may be included in an additional phase (Fig. 03).

### CLASSROOMS DESIGN

While not the largest of the buildings, the classrooms in many ways are one of the most important building types. Each academic cluster has two separate classrooms which share a wall extending to structure to mitigate sound transfer. Each cluster face each other creating a small courtyard. The courtyard design was purposeful as, by decreasing the amount of hardscape and increasing the amount of vegetation, it decreases and combats the dust that is traditionally associated with this climate. Elevating the classrooms increases their usability during periods of flooding. Multiple configurations of the seating allows a fluid and dynamic environment. This provides more opportunities for growth, learning, and interactions among the students (Fig. 4).

### INTERIOR MODULARITY FOR ACTIVE - LEARNING

Inspired by the active and flexible approaches to learning environments implemented within contemporary educational contexts, custom furnishings innovatively integrate these ideas into the project's context. Through furniture design,

classrooms have the potential to be configured to support varying approaches of active learning, embedding flexibility into each classroom. By introducing a highly configurable modular desk design, teachers and students are empowered with the freedom to craft and elevate the learning experience. Both the interiors and exteriors are transformed using local resources creating a sense of refinement <sup>4</sup>.

### ENVIRONMENTAL DESIGN AND SUSTAINABLE STRATEGIES

The site experiences a range of extreme conditions due to Chokwe's warm, tropical climate and monsoons flooding from the coast. Using the previous research, resilient building design strategies are implemented for the structure, ventilation, lighting, and shading of the buildings to improve thermal comfort levels and mitigate the impact of adverse environmental conditions experienced on the site.

Using passive ventilation strategies, interior spaces are more easily cooled and ventilated. Natural lighting is maximized reducing energy needs. Lofted roofs allow heat to rise and escape through perforated clerestories while masonry walls and partitions reduce heat gain through the building envelope. Cantilevered roofs provide exterior shading for the occupants and decrease the amount of direct sunlight into the building's openings. The elevated building structures help to both address the site's propensity to flooding and impede the access of pests commonly encountered on the site.

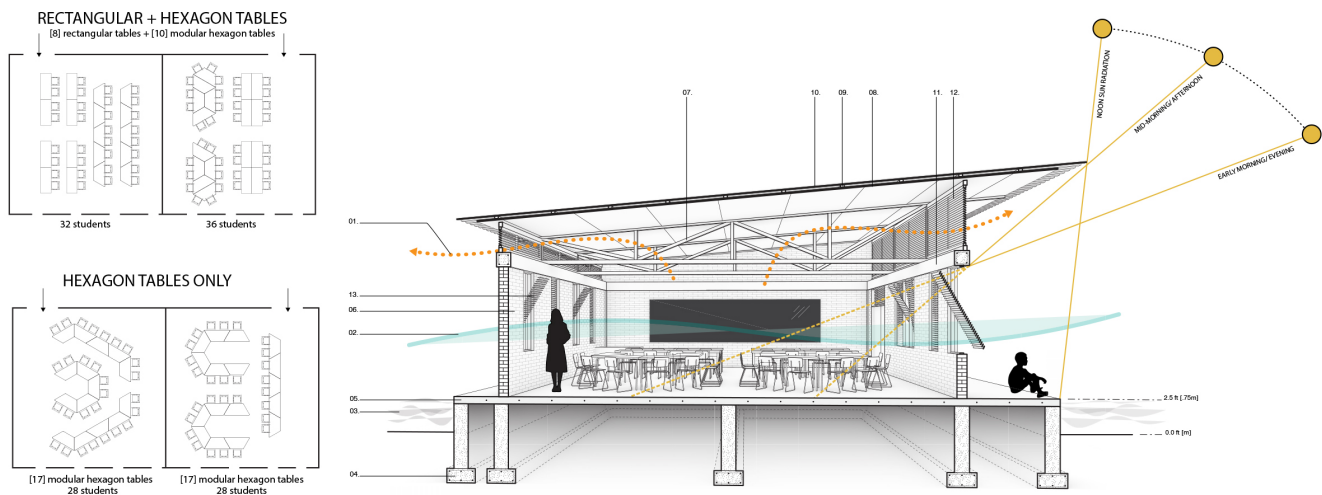


Figure 4. Clockwise: Adaptable classroom furniture arrangements; Environmental and sustainable design strategies; Classroom interior rendering. Credit: Kristin Pitts.

### BUILDING TYPOLOGIES: RESILIENT AND FLEXIBLE DESIGN METHODOLOGIES

Informed by the prevalent and reliable construction techniques of the region and relevant case studies, the proposal seeks to implement simple and resilient building designs and construction materials for optimal performance. All primary structural elements are comprised of reinforced concrete with clay bricks serving as the infill wall material. The roofs are lofted above the structure with wooden trusses and their

ceiling areas are enclosed by a slatted wood window system at the clerestory level. Operable window shutters allow controlled levels of light to filter through while simultaneously providing the passage of air<sup>5</sup>. The majority of all the campus building structures follow similar design principles establishing a cohesive architectural language throughout the site. Alternative strategies for the building envelopes that provide comparable performance were also explored offering further flexibility to the design.

Overall, the proposed buildings design utilizes design principles that are technically simple, but utilize research-based design to enhance the building tectonics. Traditional construction methods are elevated by employing innovative strategies that reinterpret familiar materials and building techniques common to the area. In all cases, the design responsibly utilizes humble resources in thoughtful ways that enable efficient site development. Though simple materials and construction methods form a basis of design, creative variations generate a cohesively unique design language (Fig. 5).

### **ECONOMY OF MATERIALS AND RESOURCES**

The materials proposed were chosen based on their availability and common construction practices in Chokwe. Supplemental research into construction practices and materials for similar buildings in comparable climates also guided the project selections. It was important to propose construction materials and building techniques that were not only applicable and successfully used in similar conditions and regions<sup>6,7</sup>, but also those that were accessible to the site and familiar to those involved in the building efforts. Informed by the prevalent and reliable construction techniques of the region and relevant case studies, the project implements simple and resilient designs and materials for optimal performance.

### **LEARNING LANDSCAPES AND ECOLOGICAL STRATEGIES**

Since learning is not limited to a classroom and can be facilitated in multiple environments, the proposed landscape design explores this idea by providing multiple areas to gather for both learning and leisure. Garden spaces, intimate courtyards, and shaded porches offer alternative learning environments while an open-air amphitheater, pool, and open spaces create places of leisure and interaction. Dense areas of vegetation create quiet areas and hinder sound travel across the site. Throughout the landscape the senses are more fully engaged as green spaces and architecture of the site are intricately layered using a variety of tones, textures, and arrangements from a grove of mango trees to small groupings of edible species. Fruit trees and onsite crops provides sustainable source of nutrition as they are incorporated into meals served for the students.

This project was designed to conserve the ecosystem by focusing on enhancing the living environment around it through an incorporation of local and native vegetation which maximizes softscape with a strategic use of hardscape. By increasing the variety of native species and increasing the abundance of the species, an ecosystem that would reach stabilizing populations quickly and efficiently is proposed. This approach would also provide habitats for the native species, and niche environments. Through the construction of courtyards and strategic

placements of plantings, the high levels of dust often experienced on site would be substantially reduced. By increasing the amount of vegetation, the amount of surface area available for runoff is decreased as well. Introducing native grasses provide further benefit to the site's natural ecosystem. Additionally, the use of trees to provide windbreaks and buffer zones, simultaneously increase carbon absorption while preventing soil erosion.

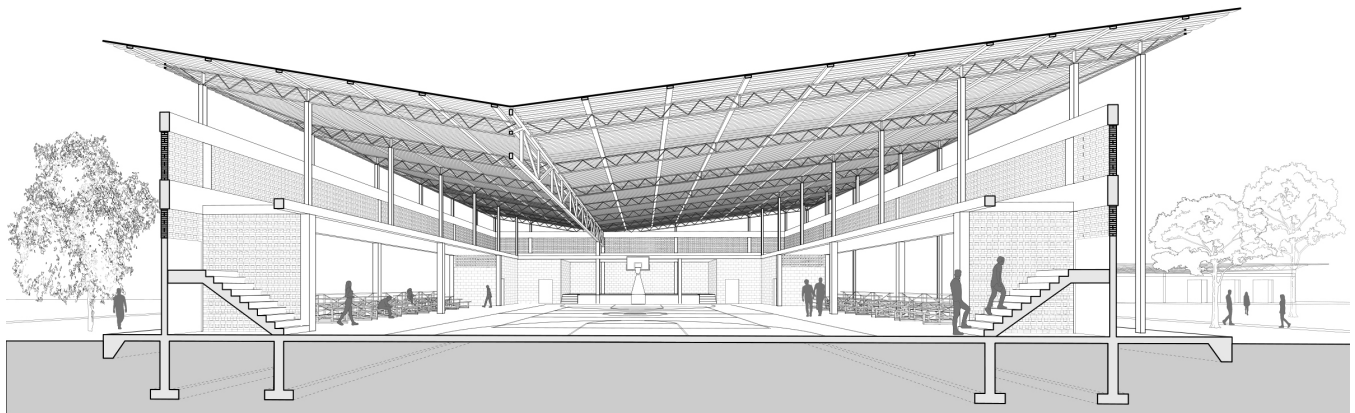
### **DESIGNING FOR WATER**

The roofs are designed to support rainwater collection as the continuity of their surface areas and pitches provide the opportunity to capitalize upon periods of significant rainfall. Water is key to the site, as it alternates between periods of scarcity and abundance. Rainwater collected during the wet season can be stored for future use in crop irrigation and water for livestock.

### **CONCLUSION**

By exploring the potential of the Hlauleka school through precedent, site context, program analysis, and projective propositions, the course challenges concepts of responsible and purposeful architecture, and advocates for sensible architecture solutions rooted in resiliency and resourcefulness which promote dignity and longevity. The course reinforces the vital linkage between interdisciplinary, investigative learning, and real-world practice while simultaneously accommodating imaginative and pragmatic expectations.

We consider this research as the first step toward a novel, fully integrated approach to construction driven by the material economy and have the potential to transform the current practices and decision making and planning of flood-resistant, affordable, resilient, and environmentally sustainable school buildings in cities susceptible to natural disasters.



MEZZANINE LEVEL PLAN

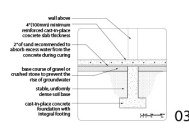
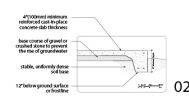
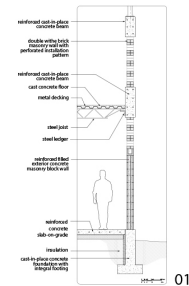
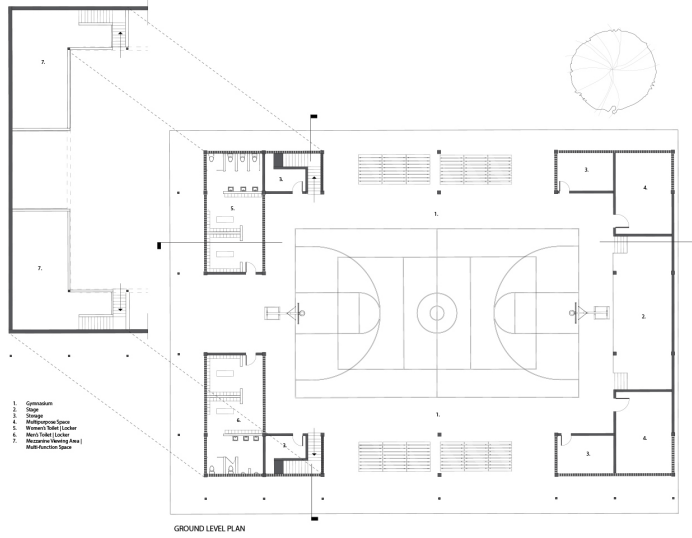


Figure 5. Top: Gymnasium construction and materials; Bottom: New Hlauleka high school campus Exterior rendering. Credit: Kristin Pitts.



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