

# SCHOOL CONSTRUCTION IN SIERRA LEONE

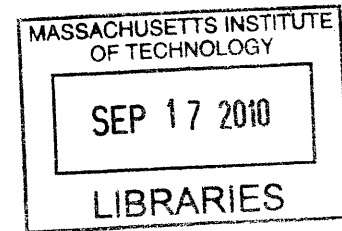
by  
Joanna Rodriguez-Noyola

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE IN PARTIAL FULFILLMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE IN ART AND DESIGN  
AT THE  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE, 2009

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Department of Architecture  
May 26, 2009

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# SCHOOL CONSTRUCTION IN SIERRA LEONE

by  
Joanna Rodriguez-Noyola

Submitted to the Department of Architecture  
May 26, 2008

in partial fulfillment of the requirements for the  
Degree of Bachelor of Science in Art and Design

## ABSTRACT

After years of British rule and a decade of civil unrest, rural communities in Sierra Leone were left with the residues of a colonial mentality and the psychological, physical and economic ravages of war. As a result, people are trapped in a mindset that discards vernacular architecture as obsolete and unpractical, and that associates modernity with the “concrete and zinc” model. Thriving to overcome extreme poverty, these villages plan to develop stronger economies and encourage education by building permanent school structures.

The aim of this thesis is not to just provide villages with an economical school design, but to inspire a new mentality towards architecture and a construction system that can adapt to a diverse range of situations and be applied in Sierra Leone and beyond. In order for them to propose a new architecture; I suggest they look back to their roots.

The only way to produce sustainable and practically cost-free buildings is by making the most of locally abundant and renewable resources, such as earth to their full potential, thus giving an effective and interesting twist to traditional architecture. The new system breaks up the school into subunits that serve as a “kit of parts” that may be arranged to suit any condition. Furthermore, these individual units must take into consideration function, daylighting, waterproofing, and ventilation.

When an entire community comes together to create exciting and innovative architecture, a new window of opportunity will be opened and a better standard of living can be reached.

Thesis Advisor: Jan Wampler  
Title: Professor of Architecture



# SCHOOL CONSTRUCTION IN SIERRA LEONE

Reinventing Vernacular Architecture: A New Approach to Sustainable Design



## ACKNOWLEDGEMENTS

I would like to thank the following people for their support, time, and cooperation on this thesis:

To John Ochsendorf, who made it all possible, for bringing this project to my attention. Thank you for all your advice and motivation. I can only hope that the product was everything that you expected.

To Jan Wampler, who is so much more than a thesis advisor. Thank you for your guidance and constant commitment, you were truly the best person I could go to for advise on this project. You will always be an inspiration, a mentor, and a friend.

To Jonathan Bart, for your endless support. I hope this thesis can be useful to your organization, Village Hope, now and in the future.

To Paul Koroma. Thank you for giving us your knowledge and friendship, and for showing us the many beautiful aspects of Sierra Leone.

To the Sierra Leone D-Lab team, for letting me join them in exploring and learning about that amazing country, and for sharing with me all their valuable findings.

To Les Norford and Alejandra Menchaca. Thank you for sharing all your knowledge on ventilation, daylighting, and thermal comfort, it made all the difference in my design process.

To Luis Ernesto Guarneros, Aliya Popatia, Tylor Hess, and Ryan Doone, for being the best thesis helpers/ model builders one could ask for and for being there in my times of need.

To my undergrad architecture friends. Thank you for motivating me, for keeping me focused, and for providing distractions.

To my family. Thank you for your unwavering support and for always believing in me.



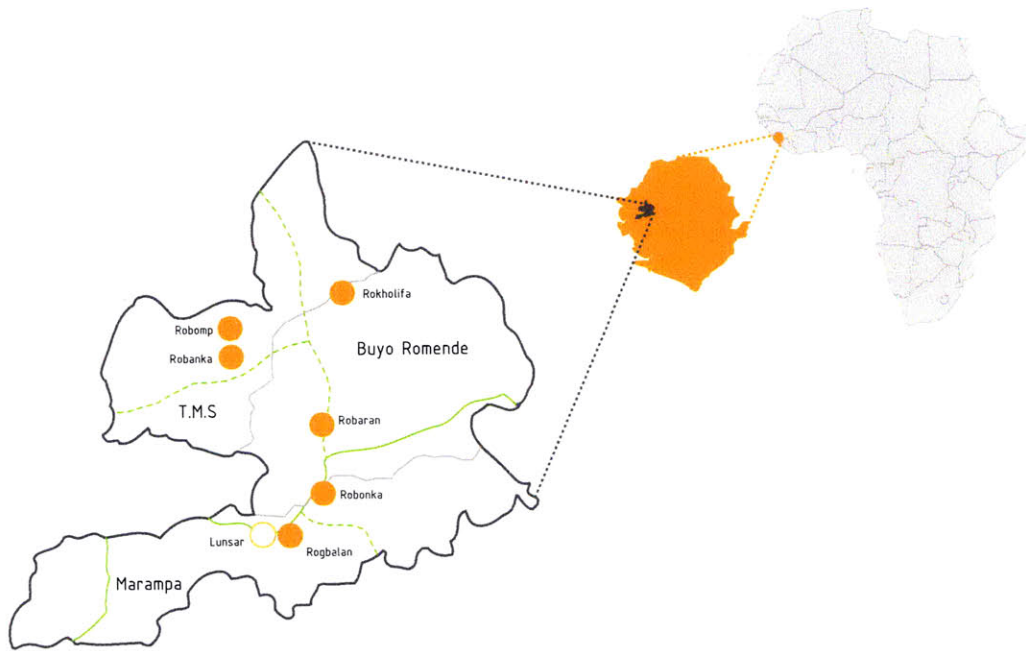
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INTRODUCTION

1



14 africa > sierra leone > northern province > lunsar

statistics>

8° 41' N / 12° 32' W

06:50 SLT sunrise

18:29 SLT sunset

November–April dry season

May–October wet season

31 in max precipitation (August)

9mph South West wind avg

~70mph max storm wind gust

temp:

91°F high

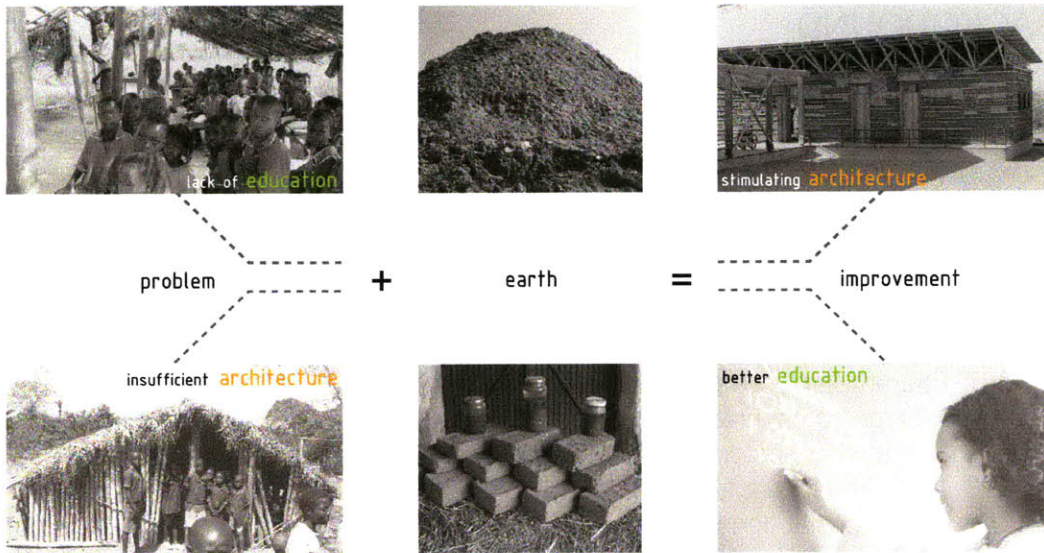
81°F mean

68°F low

## BACKGROUND

Sierra Leone Key Historic Moments:

- Has been continuously inhabited for 2,500 years
- AD 1000: First examples of agriculture
- 1462: Portuguese explorer Pedro da Cintra maps the region around Freetown, naming it Serra de Leão (Lion Mountains)
- 1495: Fort/ Trading point was built. Main trade: slavery.
- 1787: London's "Black Poor" (emancipated slaves) moved to Province of Freedom
- 1792: Freetown settlement established: population mostly formerly enslaved Africans.
- 1827: Fourah Bay College founded, it is the only European style university in Sub-Saharan Africa. Freetown becomes the educational center of western Africa.
- British rule strongly established in Sierra Leone by the early 20th century
- 1898-1956: Multiple riots and attempts to overthrow British rule.
- 1951: New Constitution established, provides more liberties
- 27th April 1961: Sierra Leone is independent
- 19th April 1971: Sierra Leone declared a republic
- 1978: A new constitution declares it a one-party state
- 1991: In response to growing unrest a multi-party system is approved
- 1991: Civil war breaks out due to corruption in the government and mismanagement of the diamond resources (Blood diamond war).
- 1991: Revolutionary United Front (RUF) created, become leaders of rebellion against government.
- 1991-2001: Over 50,000 people killed in the war, many others relocated, the country was left in a state of devastation.
- January 2002: War declared over.
- May 2002: First post-civil war elections held



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## PROBLEM

After many years of civil war and economic instability, communities in rural Sierra Leone are struggling to overcome poverty and improve their education, health, and economic security. To accomplish these goals, six communities around the northwestern city of Lunsar they have teamed up with the American-based non-governmental organization Village Hope, Inc. to come up with community development plans. Loans are then provided to the community to carry out community development or personal, income-generating projects.<sup>1</sup> Only 35% of their population is literate and the high number of dropouts as age increases is a problem. Also, most villages don't have permanent school structures because the current school construction methods adopted in other parts of the country are costly and do not provide suitable learning conditions. Another issue is that as a result of a colonial mentality, people are trapped in a mindset that discards vernacular architecture as obsolete and unpractical, and that associates modernity with the "concrete and zinc" model.

1. Bart, Jonathan "Our Hope" Village Hope, Inc. 2009  
<http://villagehopeinc.org/>

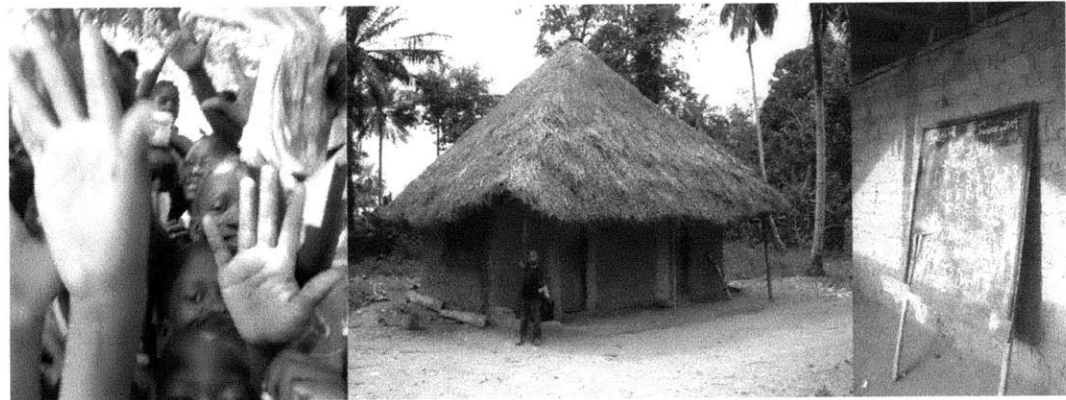
## GOALS

This thesis sets out to solve some of the problems in education through school prototype designs. I want to create a space of special value to the children and villagers. I believe that good design does not have to be expensive, that it can be 'hand-made' and still have excellent architectural qualities and spaces. This project will help prove that low-cost does not mean unsightly, inefficient, or uncomfortable. I will research into traditional construction methods, and see how some informed design thinking could alter the vernacular to create something new and exiting that responds efficiently to the site. The proposed design will take ventilation, daylighting, and thermal comfort into consideration to create living conditions. It structural qualities will also be planned to endure even the harshest weather. I hope that by making the most of the site and the natural resources, I will shine a new light on traditional architecture; thus revolutionizing construction methods in the region and beyond.

4500 people > 33 villages > 6 communities > 6 schools

each school

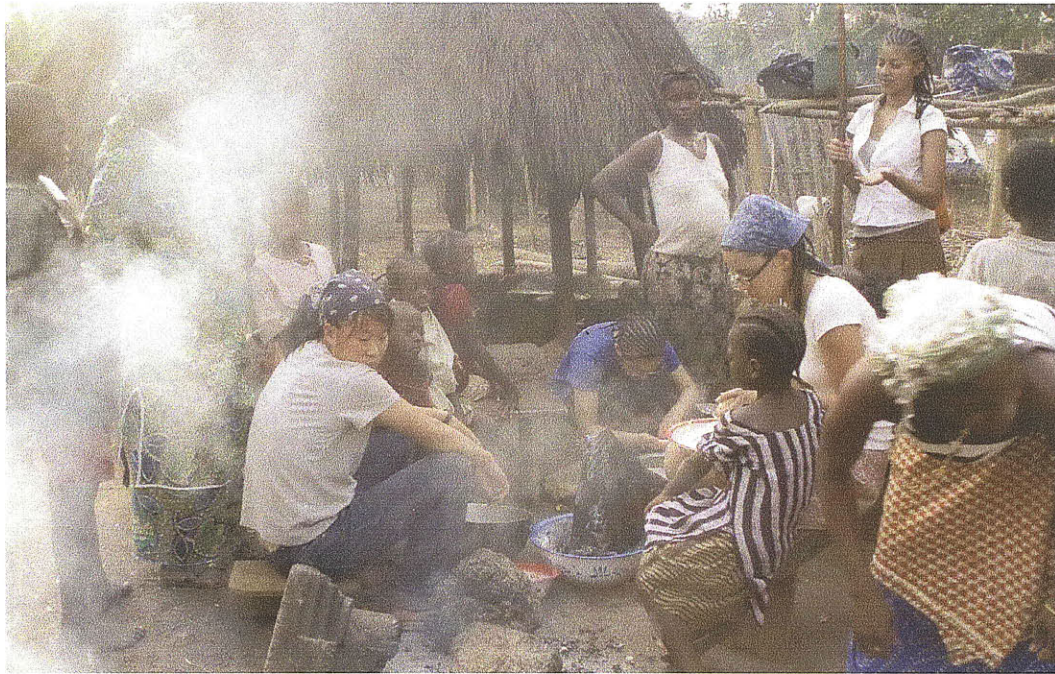
- > classrooms for 300 students
- spaces for contemporary and traditional methods of elementary education
- > open public gathering space
- courtyards, playgrounds, gardens and green areas for human interaction
- > bathrooms
- latrines and handwashing stations separated from main building
- > headmaster's residence
- > office
- > storage and equipment room





SITE

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## SITE ANALYSIS AND RESEARCH

### VISIT TO SIERRA LEONE

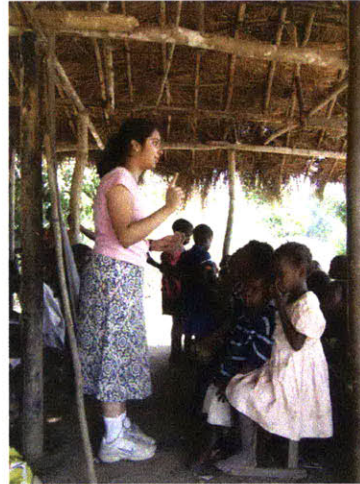
In the dates of January 16th to the 28th of 2009 I visited the villages Sierra Leone to get a better understanding of the sites and the people. I stayed in the catholic mission located in the heart of the city of Lunsar. This location was ideal because it was in a central location to all the six villages. It also provided a protected place to keep equipment and supplies. I went there with 2 University of Illinois students and 7 other MIT students who were part of the Development Lab (D-Lab) and were working on several development projects in cooperation with Village Hope, Inc. We visited several schools, vocational centers, hospitals, churches, rivers, and participated in social activities in the Lunsar region in order to learn and immerse ourselves in the local culture. In addition to visiting and documenting these places and the 6 villages, we went to Freetown to meet with local university students and discuss education and see the difference between urban and rural settings in the Sierra Leonean context.

## EDUCATION RESEARCH

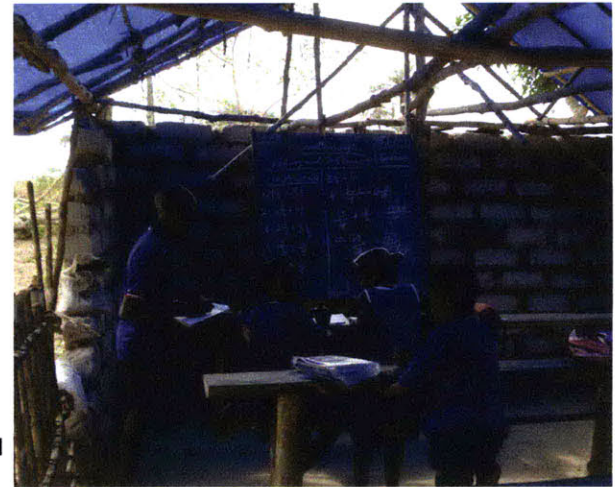
I visited the six villages, interviewing the school headmasters, teachers, and students about their current educational conditions and their goals for the future, asking them specific questions about the school buildings. The D-Lab students also developed an education report; they visited each village's school during class time and interviewed the teachers. They held a teacher workshop to teach skills and solve problems, bringing representatives from all 6 villages together. We found out the following from our research:

School Structure in Sierra Leone:

- 6-3-3-4 (years of primary, junior secondary (JSS), senior secondary (SSS), university)
- Exam from primary school to JSS: NPSE
- Exam from JSS to SSS: BECE
- Exam from SSS to University: WASE (West African Secondary Exam)



yalu

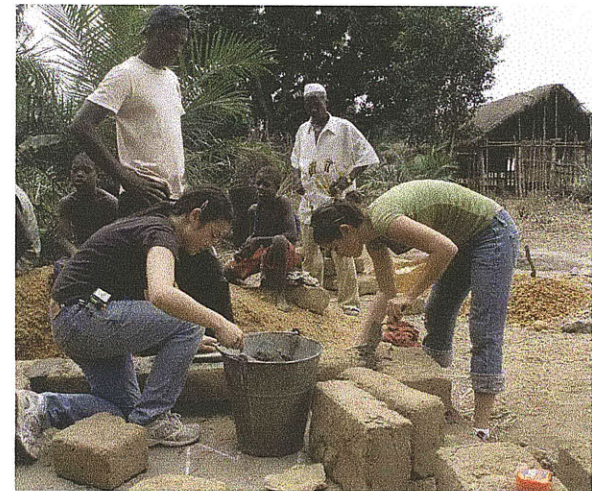


## CONSTRUCTION METHODS RESEARCH

Another focus of my research when I visited the six villages was the local construction methods. I interviewed the local builders about their resources and current building systems and materials.

As part of this research I participated in the construction of a latrine for the Rogballan school with some members of the D-Lab. This hands-on learning experience was probably the best way to study construction. Also, our project leader, a skilled local builder named Paul Koroma was very helpful in explaining traditional and common building methods used in the villages. He was raised in the Lunsar region and later went on to work as a builder in Freetown. After inheriting some land in Rogballan, he moved there and now works as an employee for Village Hope, Inc. Working with him also gave us an insight on local perspectives on traditional construction methods vs. “modern” ones.

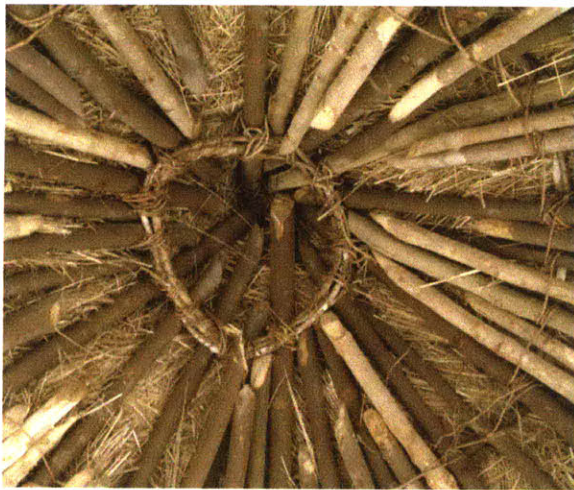
The latrine was built by Paul, a local carpenter, and three students, villagers of all ages also helped with small tasks throughout the process. The work took about two weeks (the pit was previously dug) and the total cost of the latrine (materials only) was \$425 (USD). The latrine was a pit latrine (unlined 12’ deep pit) with three . The base and lintel above the doors was made of steel reinforced concrete, the walls were made out of molded soil blocks with mud mortar and plastered with cement on the interior and a termite hill and mud mix on the outside, the structure for the roof was made out of tree branches and the roof itself out of zinc, the roof was tied down to the walls with thick steel wire, and the doors were made out of solid wooden boards.



## RESOURCES AND BUILDING MATERIALS

### Water

- Plentiful even in dry season
- Sources: streams, rivers, and wells
- Most well waters in villages are potable (water testing performed by D-Lab)



### Timber

- Sticks: used for roof structures, framing houses, temporary structures, furniture, tools, etc. Very abundant at no cost.
- Boards: used for roof trusses, doors and windows (frames included), formwork, furniture. Available by purchasing in Lunsar (~\$3.33 for a 12" x 1" x 14' board) or cost free if villagers saw their own (electric saw must be provided)
- Plywood: not very common in villages, boards are more available and cheaper.
- Bamboo: very common in villages but not farmed or produced in a large scale. Mostly used in furniture and smaller objects and tools.
- Thatch: used for roof and fences. Must be re-thatched regularly. Very abundant at no cost.

## Earth

- Two types of earth found: Red (higher sand and gravel content) and Grey (found in riverbeds, very high clay content).
- Termite hill soil: grey earth obtained by breaking the hard earth several feet under a large termite hill. This is mixed with sand to make a plaster for walls that repels water better than mud.
- Wattle and daub: most common traditional building system. Uses a branch grid frame for walls, the gaps are filled with balls of mud. Can be sturdy and long-lasting if build carefully and protected from exposure (wood frame must remain concealed)
- Soil block: second most common method of construction, sturdy structure as long as it is protected from rain. Mud is used for mortar and plaster.
- Rammed earth: we built a test wall to show them the technique but villagers did not like it, the wall was too thick and required too much work and mud to build. Also the formwork was hard to make without an electric screwdriver and plywood.

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#### Concrete

- Very desirable for its durability and strength
- Unaffordable in large amounts: \$11.33 per bag
- Usually found in lintels, plasters for walls, or floor slabs.

#### Steel and Metal

- Also desirable but unaffordable.
- Used for reinforcement in concrete, roof ties, thin columns, roof trusses (rare)
- Cost: \$15.00 for 12mm x 40' of rebar.

#### Zinc (corrugated sheets)

- Very common, often used (and reused) for roofs.
- Not affordable, especially in large scale projects: \$148 for 20 sheets of 8' x 2' zinc.

#### Cow Dung

- Available if the village has cows
- Used for exterior floor and surface plastering





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#### Building Problems and Issues

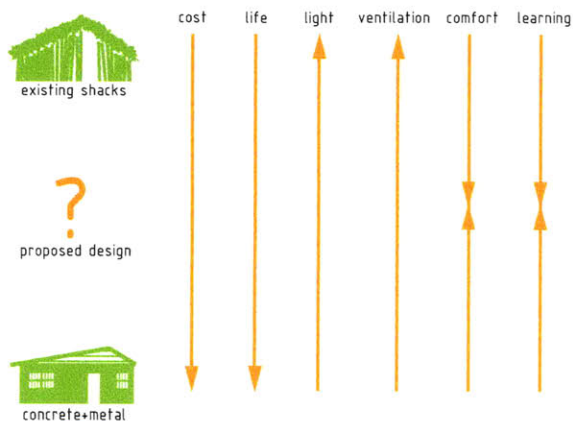
- Weather: The rainy season is very strong and brings a lot of powerful storms. The wind comes in gusts from all directions and there is heavy daily rainfall. This is a problem because roofs and fragile structures are torn apart and earthen walls are washed away.
- Termites: Any exposed wood is in risk of getting termites. Sometimes entire roofs collapse within 3 years due to this.
- Lack of tools and skilled labor: Locals do most of the construction work themselves, but most of them are not trained or experienced builders. This leads to ineffectiveness or mistakes in construction. Also, the construction sites are often unregulated and disorganized.

## LOCAL MENTALITY TOWARDS ARCHITECTURE

After working with the villagers and interviewing them I discovered that many of them believe the local vernacular architecture is outdated and ineffective. To a certain extent this is understandable; when compared to a cinder block wall, a soil block one seems very weak and not durable against rain. Also, steel structure and zinc roofs last longer and are less permeable than a thatch timber structure roof. Also, they have a problem with the dustiness of earthen floors and walls.

A mentality that associates concrete and zinc boxes with the modern ideal was the result of a colonial mentality and the remnants of British-imposed architecture. Most villagers strive to build their structures with those materials for this reason and because of their proven durability. However, they cannot afford these construction methods. Also, buildings made in this manner are very poorly lit and ventilated: they provide very poor lighting for classrooms and overheat to uncomfortable levels.

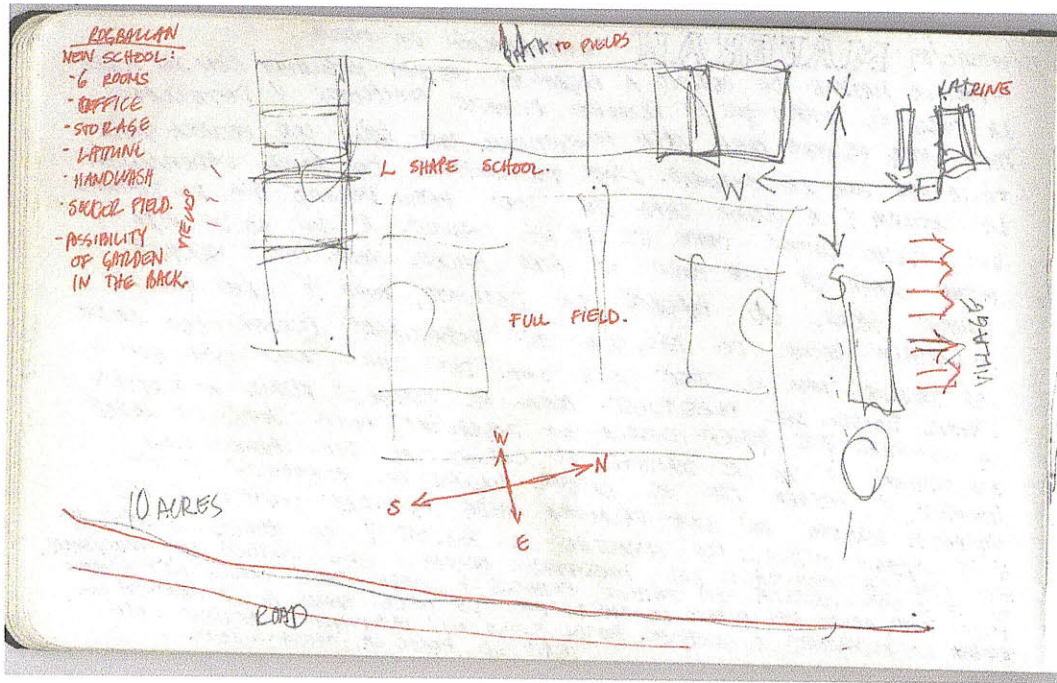
After learning about their local methods and available resources, I concluded that the best approach for a building system would be to look back at the vernacular architecture and alter it slightly with educated architectural ideas. This would maintain buildings low-cost and sustainable and provide greater comfort and durability than the traditional and British models. This could be achieved by taking the site into consideration when orienting buildings to take advantage of sunlight and wind direction. However, in the proposed model, I will still use some materials that are costly, such as steel ties and metal plates, but I will keep their usage to a minimum: only the necessary amounts needed to strengthen the structure and make it last.



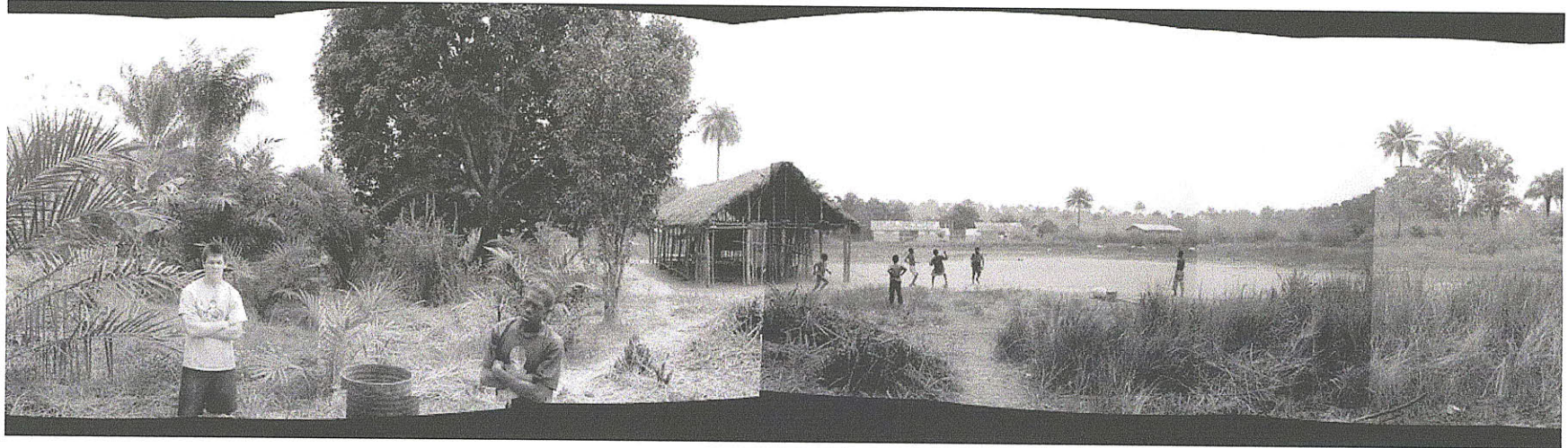


6 VILLAGES

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2. Wu, Yalu and Kambhampati, Swetha. "Education Report" D-Lab Sierra Leone Trip Reports. 2009 <<https://wikis.mit.edu/confluence/display/DLABFA06/Sierra+Leone+Trip+Reports>>

## ROGBALLAN

### School Specs<sup>2</sup>

- Number of teachers: 4; 1 community teacher and 3 government teachers
- Villages served by school: 6
- Population: 180
- Students don't come because: children are often not well, or help parents sell vegetables
- Subjects Taught: Home Economics, Agriculture, Science, Maths, English Language, Creative Art, Environmental Studies, Social Studies, taught with a weekly periodical schedule
- Language of Instruction: English, with a mix of Temne and Krio
- Supplies: Blackboards, exercise books from UNICEF, chalk, not enough tables or benches, need a better floor, building too small and children get distracted, some students don't have pencils so they just watch
- School Latrines: Yes, that D-Lab built
- School Meal Program: No: there was a possibility of one but the organization removed Rogballan from the list because the village did not have school latrines
- School Garden: No
- Class split up by: Class 1 and 2, Class 3 and 4, Class 5 and 6



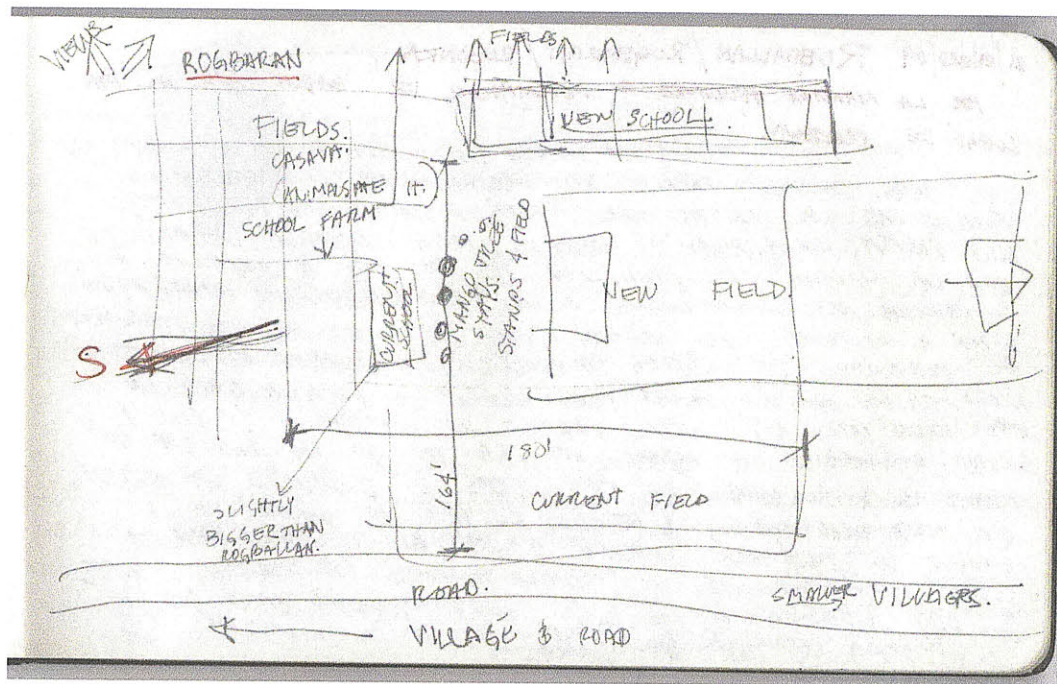


## ROBONKA

### School Specs<sup>3</sup>

- Number of teachers: 4, Alfred Msankoh is the head teacher
- 3 community teachers and the head teacher is a government teacher
- Villages served by school: multiple
- Population: 170, 65 girls and 105 boys
- Students don't come because: children are often not well, or help parents sell vegetables
- Subjects Taught: Relatively same, since they follow a government issued curriculum
- Lunch: Children go home to the village for lunch and water or do without
- School hours: 8:30-2:10
- Language of Instruction: English, with a mix of Temne and Krio
- Supplies: Blackboards, books, chalk, not enough tables, need a better floor, building too small and children get distracted, some students don't have pencils so they just watch
- School Latrines: No
- School Meal Program: No
- School Garden: Yes
- Class split up by: Class 1 and 2, Class 3, Class 4, 5, 6





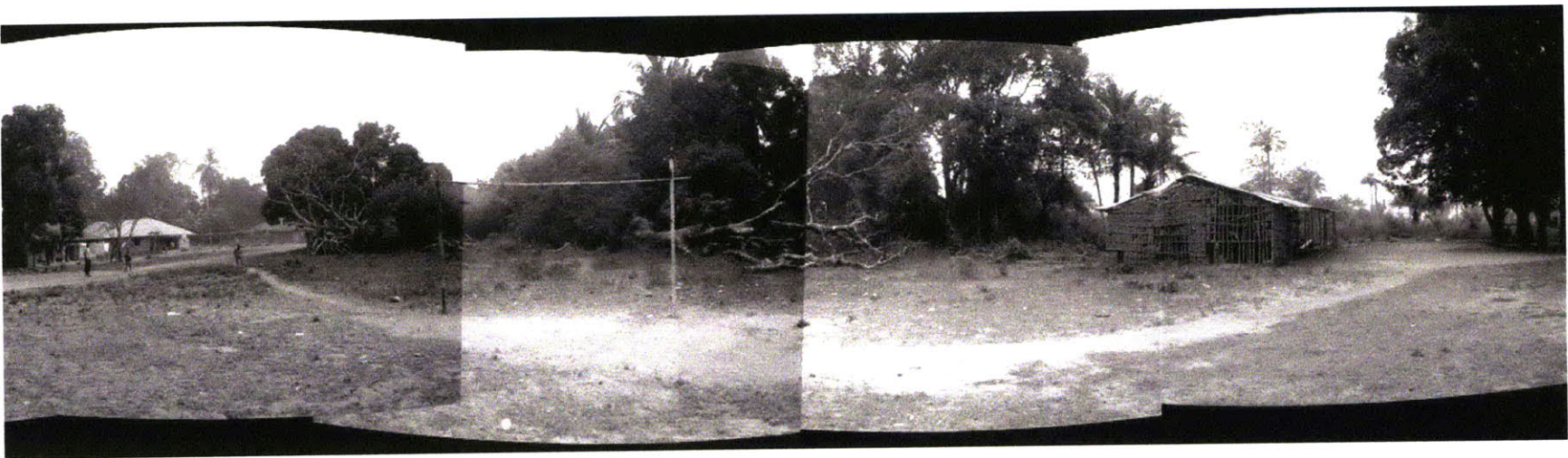
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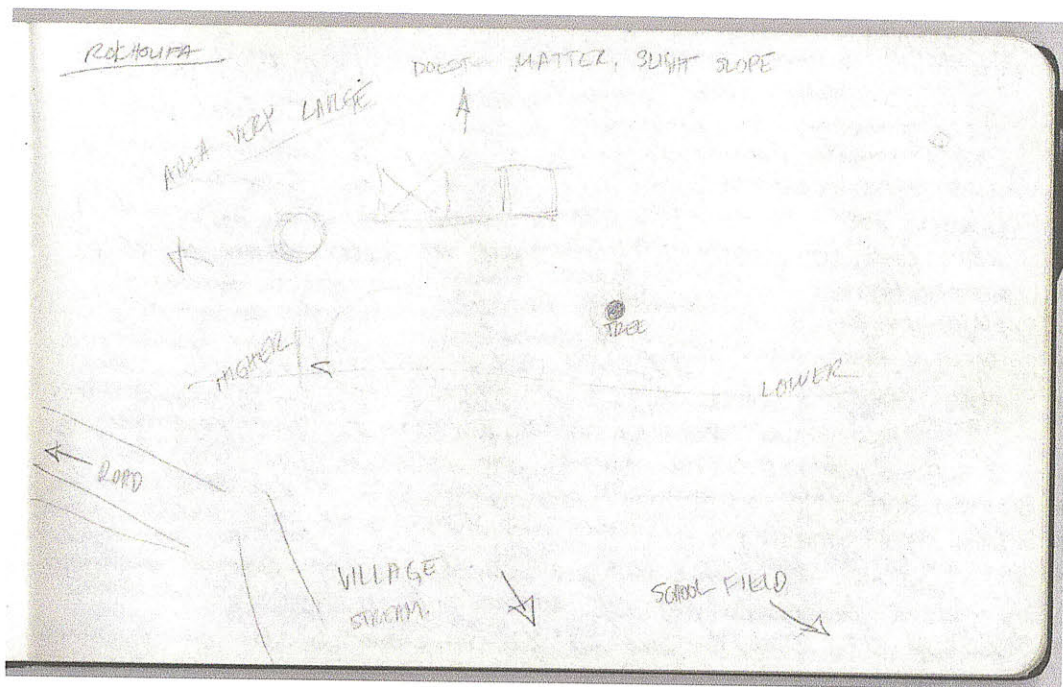


## ROGBARAN

### School Specs<sup>4</sup>

- Number of teachers: 3
- Villages served by school: 5
- Population: 259
- Students don't come because: often not well, or help parents sell vegetables
- Lunch: go home
- School hours: roughly 9-2pm
- Language of Instruction: English, with a mix of Temne and Krio
- Supplies: need more blackboards, exercise books, chalk, not enough tables or benches, need a better floor, building too small and children get distracted, some students don't have pencils so they just watch
- School Latrines: No, though they started to dig a pit
- School Meal Program: No
- School Garden: Yes; grows cassava and pepper; teacher + children tend to the garden; problems with insects, termites, and grasshoppers
- Class split up by: Class 1 and 2, Class 3 and 4, Class 5 and 6





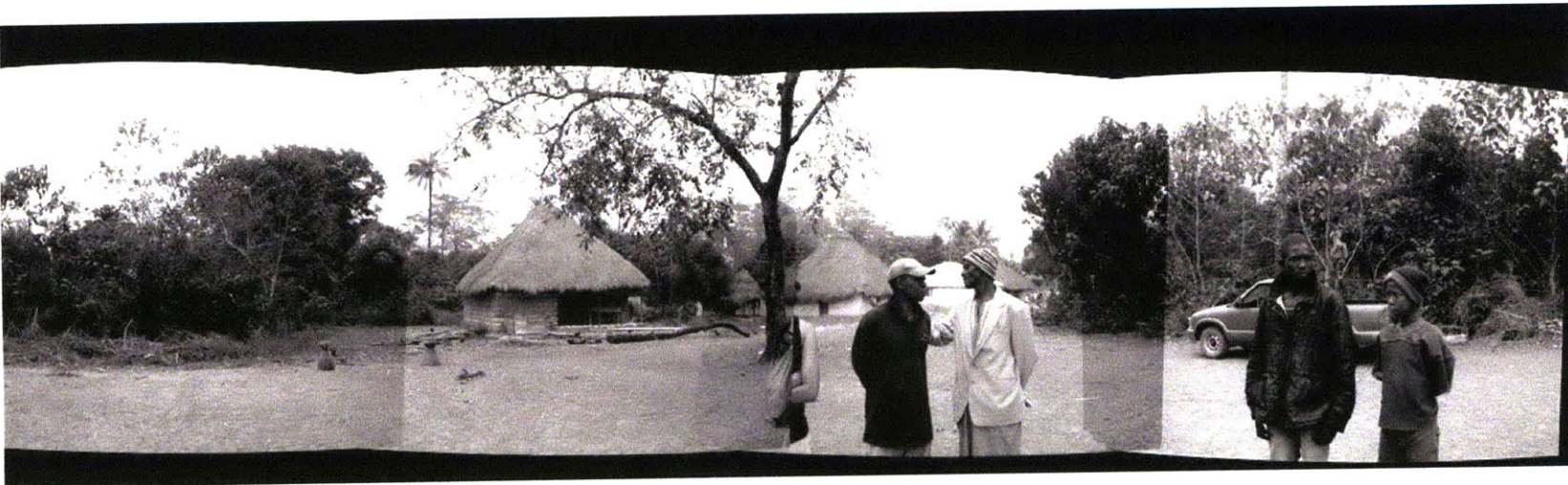
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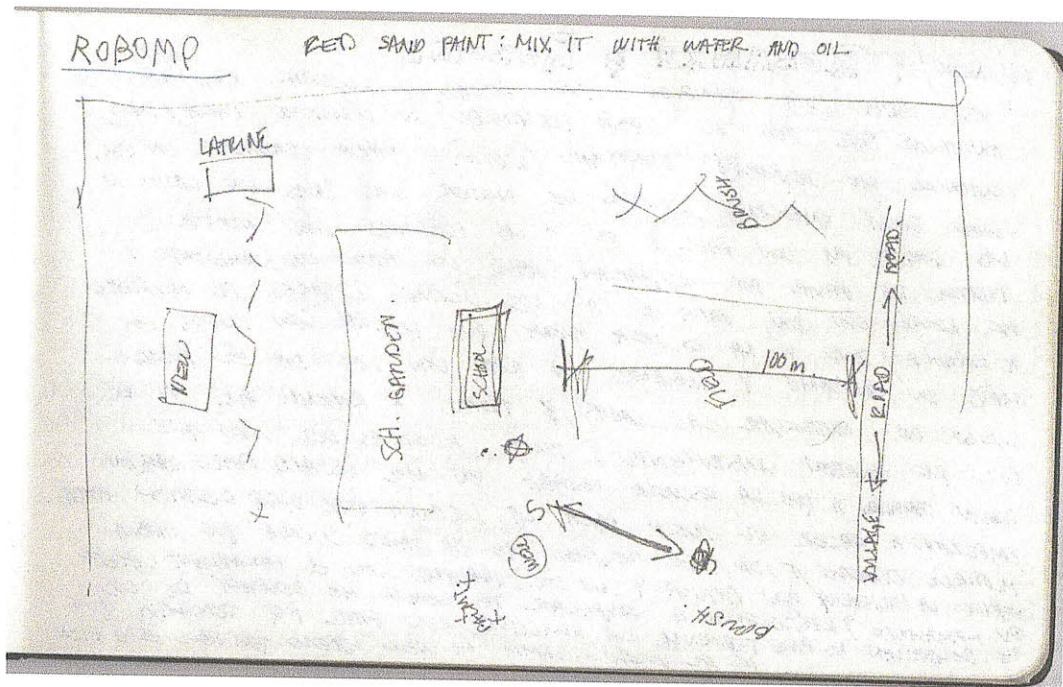


## ROKHOLIFA

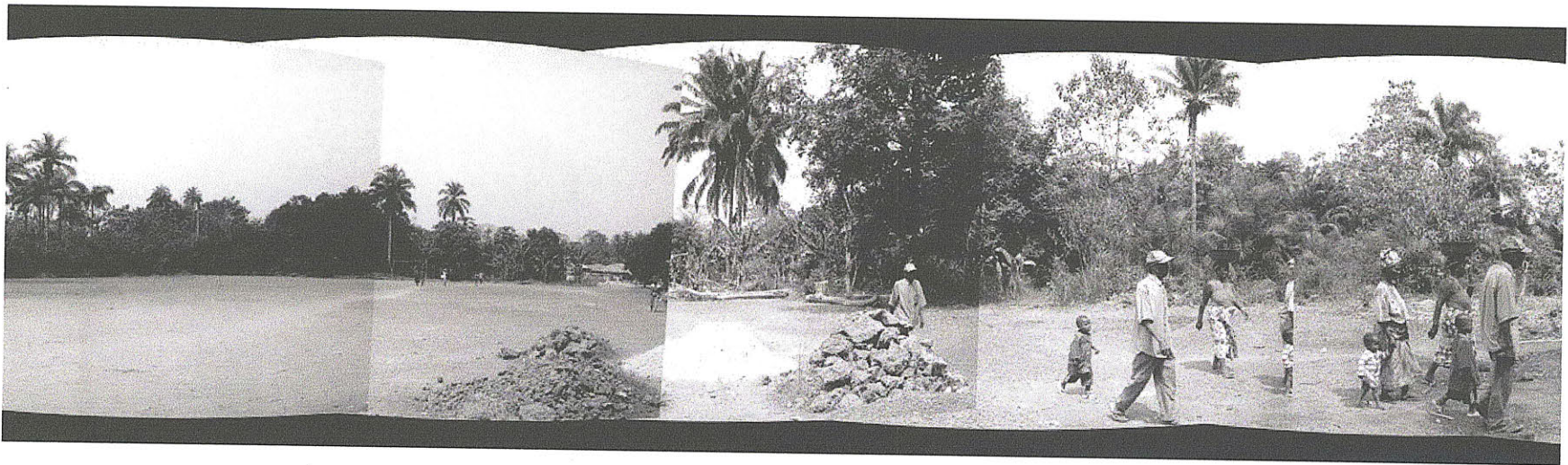
### School Specs<sup>5</sup>

- Number of teachers: 3, 2 government, all live in Rokholifa
- Villages served by school: 6
- Population: 160 students, 8 students this year class 6, 7 boys and 1 girl
- Students don't come because: help is needed at home
- Lunch: go home
- School hours: roughly 9-2pm
- Language of Instruction: English, with a mix of Temne and Krio
- Supplies: need more blackboards, exercise books, chalk, not enough tables or benches, need a better floor, building too small and children get distracted, some students don't have pencils so they just watch, students should wear uniforms but the teachers still teach them without uniforms, school lends supplies such as books but there are not enough
- School Latrines: No
- School Meal Program: No
- School Garden: Yes, at a farther away location we did not observe
- Class split up by: On the day we observed, one classroom was not being used because it was too dusty and they had put water on the floor, so there was a classroom with class 1-6





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## ROBOMP

### School Specs<sup>6</sup>

- Number of teachers: 3 who live in the village
- Villages served by school: 8
- Population: 154
- Students don't come because: children are often not well, or help parents sell vegetables
- Language of Instruction: English, with a mix of Temne and Krio
- Supplies: Blackboards are adequate, need more exercise books from UNICEF, chalk, not enough tables or benches, need a better floor, building too small and children get distracted, some students don't have pencils so they just watch
- School Latrines: No
- School Meal Program: No
- School Garden: Yes
- VClass split up by: Class 1 and 2, Class 3 and 4, Class 5 and 6





## ROBANKA

### School Specs<sup>7</sup>

- Number of teachers: 6, all government
- Villages served by school: 9
- Population: class 1-50, class 2-45, class 3-40, class 4-45, class 5-28, class 6-15
- Students don't come because: funerals, illnesses, transfer schools because parents move, cannot pay for school supplies
- Lunch: go home
- School hours: roughly 9-2pm
- Language of Instruction: English, with a mix of Temne and Krio
- Supplies: need more blackboards, exercise books, chalk, not enough tables or benches, need a better floor, building too small and children get distracted, some students don't have pencils so they just watch, students must come to school with ur them (community teachers) just so they will keep on teaching. Some younger students come to Class 1 and 2 simply to get exposure.
- School Latrines: No
- School Meal Program: No
- School Garden: Yes; students eat food from there and grow cassava, but there are problems with termites and oftentimes, grasshoppers eat/devastate the cassava leaves
- Class split up by: Class 1, Class 2, Class 3, Class 4, Class 5 and 6





DESIGN

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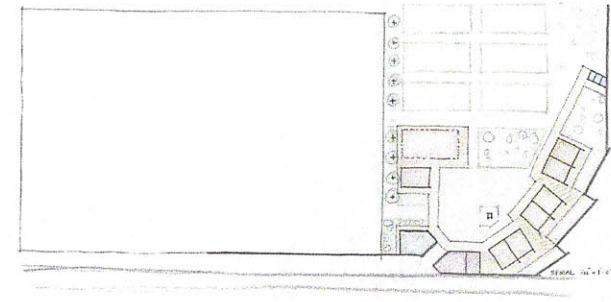
## DEVELOPING A SITE PLAN

The design process began with a study of each village's school site and its natural features. After noting the orientation of the sun, wind, village, main road, water features, etc., I began to list the guidelines for my site layout:

### PROGRAM

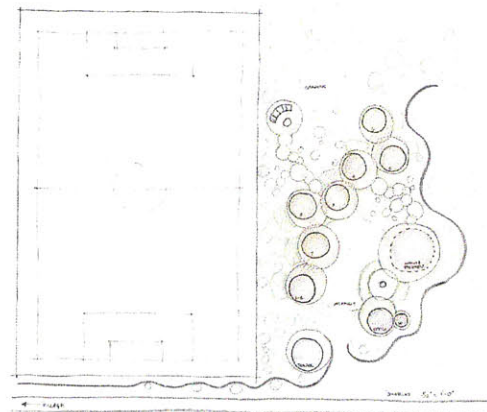
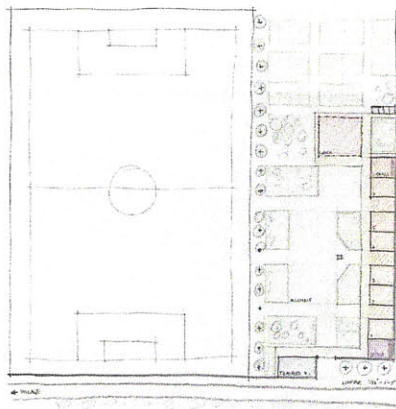
The program for the school complex was influenced by the interviews with the headmasters of the schools and the information obtained from the D-Lab report. For my master plan, I will include all of the buildings listed below. However, I realize that all of the schools might not be able to (or might not require to) build all of them. This is expected and the final design should accommodate this and flexible to allow for several arrangements.

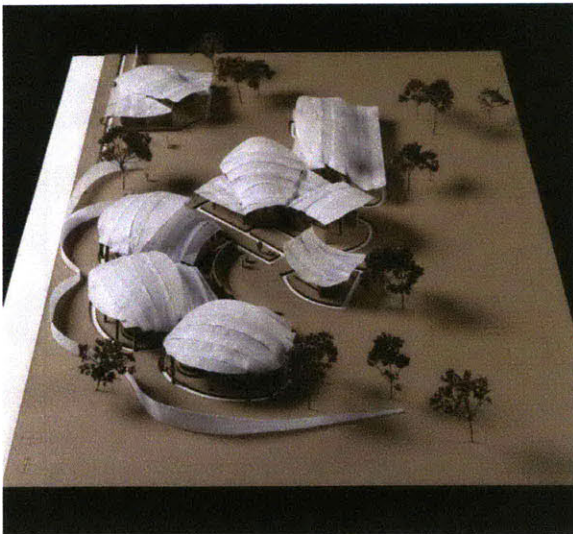
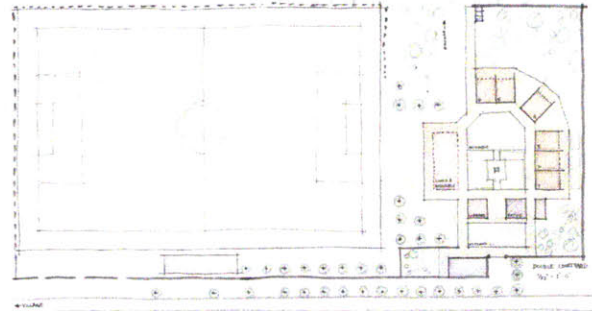
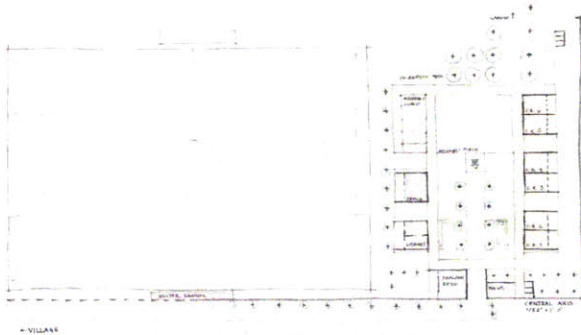
- 6 classrooms
- office with storage space
- latrines (at least 3 stalls)
- well and hand washing station
- outdoor gathering space
- soccer fields and other sports fields
- gathering hall/ lunch hall (sheltered multi-purpose activity space)
- headmaster's (head teacher's) residence
- library (might also include storage)
- gardens/ agricultural fields



Early site designs

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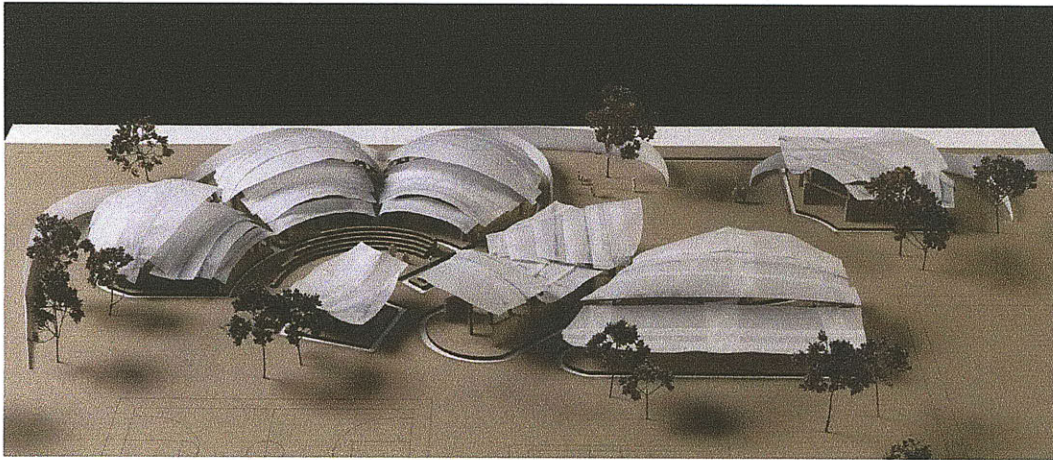




## KEY FEATURES

The following list describes a few of the ideas that guided my design process, they are the things that I wanted to make sure happened in the design. 45

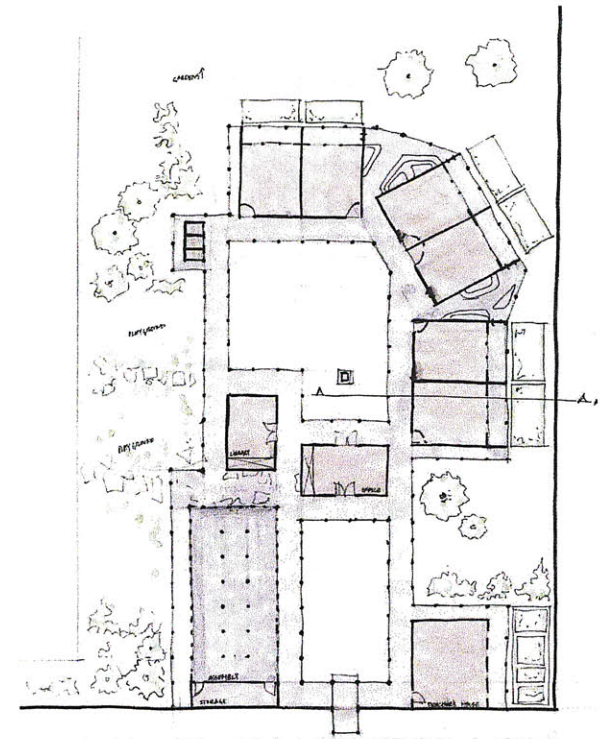
- Keep the school separated from the village. This will promote the sense that the school is a special place that exists outside of the “home” setting of the village, this helps decrease the amount of students that miss class or stray away in the middle of a school day. This could be accomplished by placing the sports fields between the school and the village.
- Create a sense of entry. This emphasizes the difference between the village and the school as separate entities. It also creates a sense of suspense as a person gets closer to the entrance and of surprise once he arrives.
- Create a gathering space that can be used for school activities as well as community activities (without distracting the students if it takes place during class time).
- Keep children focused on classes and not the outside.

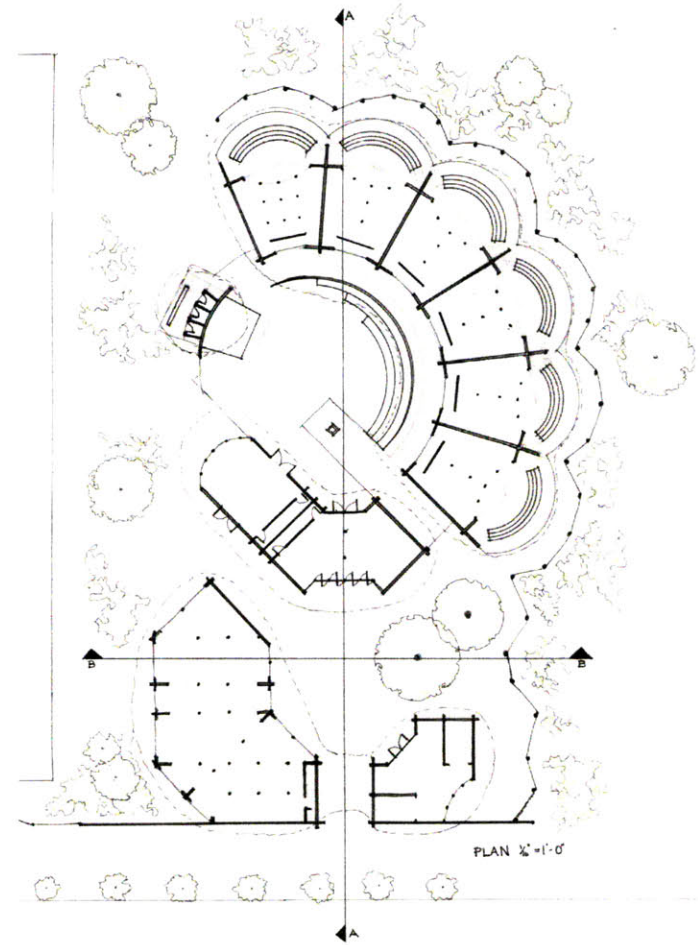
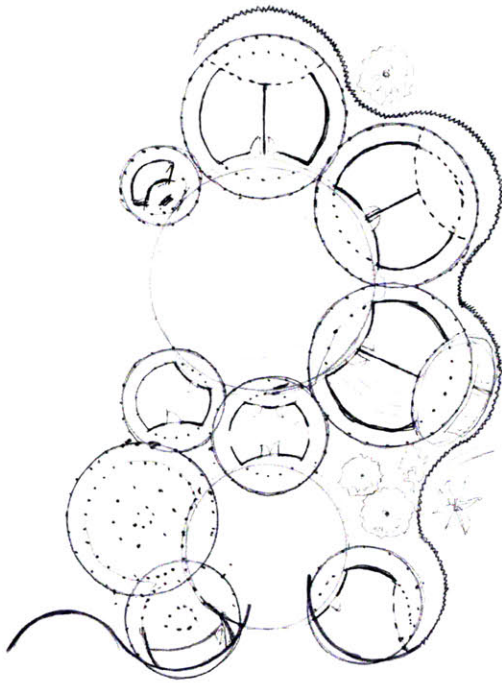
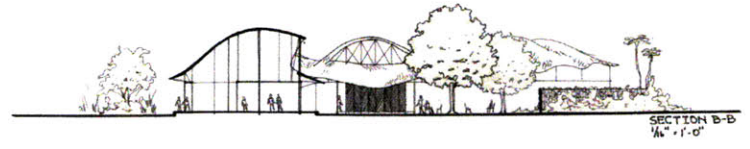
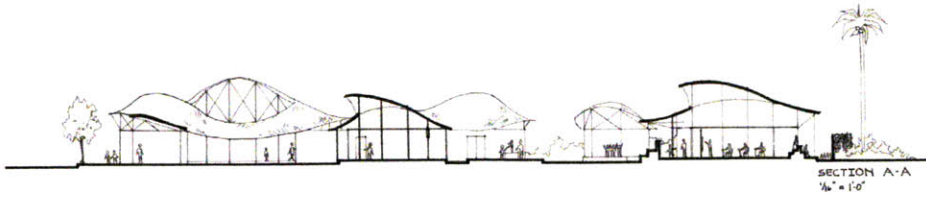


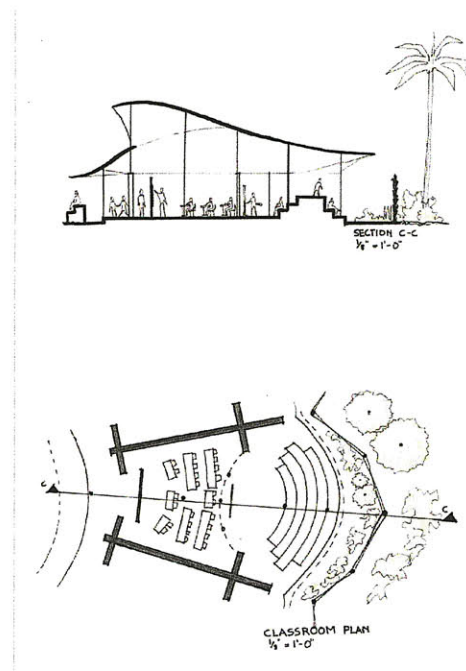
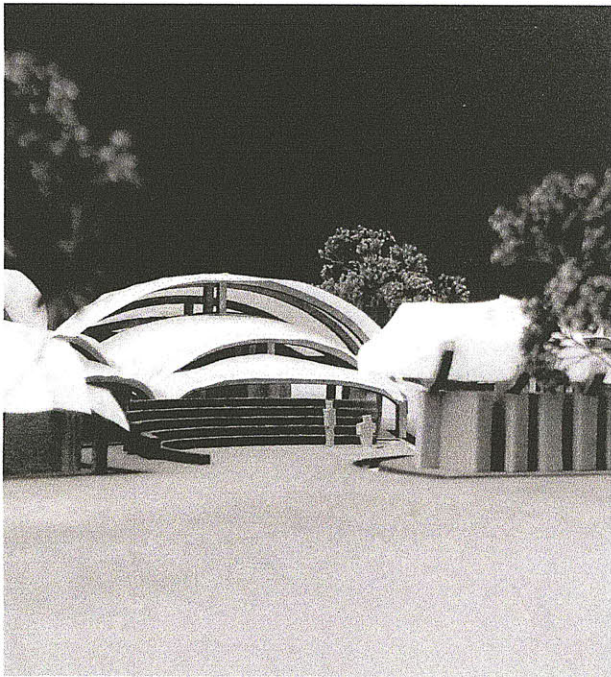
Early site designs

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At this point of the design process I was not thinking about the building systems yet, I was focusing on the master plan layout: how it affected the way people inhabited the spaces and how it could be arranged to improve education. Thought about solar or wind orientation was not taken into consideration at this point. My initial designs all had a centric courtyard with the well in a somewhat centric place. The design with the most desirable qualities was the one with a double courtyard design. This allowed the first one to be an “entry space”, one that was public and very open to the villagers and acted as yet another buffer between the students and the village. In these original designs, the headmaster’s residence is at the entrance, keeping him closer to the villagers and also at a “gatekeeper’s” position. The classrooms are at the back courtyard with all their entrances facing the “plaza”, which is larger because it also acts as a playground. This back courtyard can also become a large amphitheater space because the curved side of it that faces the classrooms is lined the stadium seating and the back walls of the latrine building is reused to create a small stage for performances. The gathering hall takes a spot that is close to both the private student courtyard and the community one. The office takes on the role of the divider, acting as the ‘face’ of the school to visitors while maintaining a close supervision on the classrooms. The library and the office, being the two places that require storage, could be placed next to each other with a shared storage closet wall. As this plan developed, the building shapes I explored with varied from the typical orthogonal shapes that are “easy to build” to circular shapes that give a freeform impression.

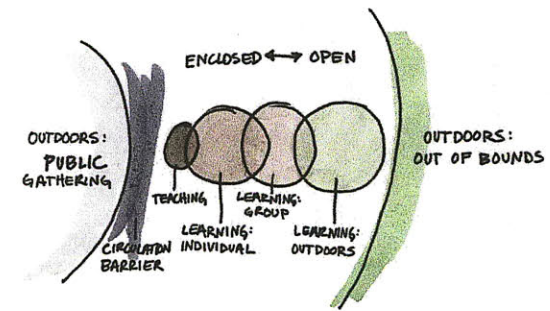






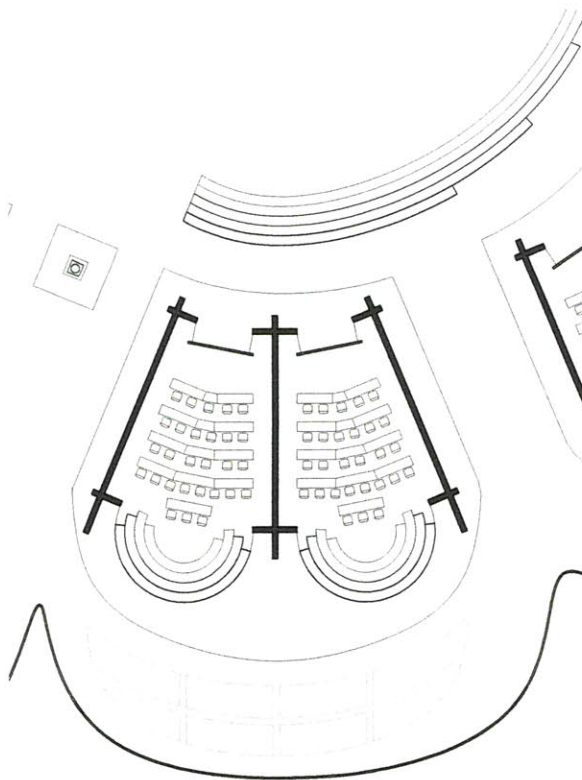
## 48 CLASSROOM UNIT

The classroom design is centered around the notion of smooth transitions: transitions from outdoors to indoors and outdoors again, transitions from public to private, and transitions from large group to single person to individuals to small groups. I want to change the way these communities think of a classroom by opening up the possibilities for different learning experiences, not just the type where a teacher stands in front of a blackboard facing rows of children seated individually. The classroom design incorporates areas for circulation and transition from the exterior public spaces, for traditional "individual" learning, for group learning such as readings or plays, and for outdoor group learning. The spaces listed above flow into each other along a longitudinal axis that strings them all together.



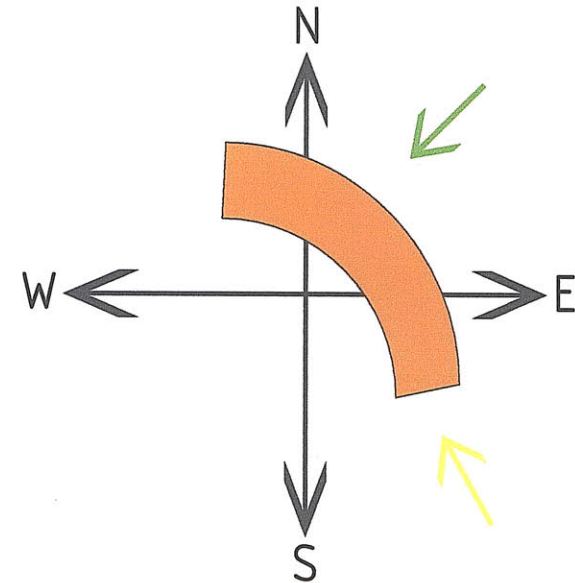
The roof of the building is lower at the front of the classroom, and the side walls were brought together at an angle, being closer towards the front of the main classroom space to give it a sense of privacy, enclosure, and to focus the attention of the students towards the teacher (much like a lecture room or a theater). The division between this space and the walkway that connects the classrooms is a timber branch screen that lets air and some light go through and serves the double purpose of separator and blackboard holder. As this space transitions onto the back, the roof pitch and height increase, letting more indirect light come in through the back and giving an increasing sense of openness. At this point there are no more tables and the floor rises to form semicircular stadium seating. This small amphitheater space is for group learning activities where students can present plays or participate in group discussions. There is an extra ledge that runs along the back of the seating, this contemplation seating space that faces away from the classroom facilitates the change from indoors to outdoors. The roof only covers as far as the seating, and the ground beyond that point gives way to a garden space. These small private gardens are used for teaching purposes and classroom activities. The back boundaries for the classroom are delimited by a thatch fence that separates the school from the surrounding land.

Final classroom designs



### COMFORT: DAYLIGHTING AND VENTILATION

The main challenge in increasing the comfort of the spaces created is to get enough ventilation and light inside of the buildings while keeping the rain from coming inside or coming in contact with the walls. Ideal lighting conditions for a classroom environment require diffused or indirect lighting from the back of the classroom and a minimal amount of light coming from the front. To accomplish this and to bring more light into the rest of the spaces in the classroom building, the roof was broken up into three sections. Having the largest and tallest opening at the back is ideal for bringing the main portion of daylight from the back. If this opening is also oriented to receive the main wind loads, cross-ventilation could easily occur throughout the building. The orientation of the buildings thus becomes a key factor in the design. The semicircular classroom clusters must be arranged so that the arc curves towards the northeast. At this point in the design process the classrooms were clustered into groups of two because it makes it more economical. The amount of brick walls exposed to rain decreases and now there is only one large roof that needs to be made to cover two classrooms. Since the dividing wall between the classrooms now acts as a central support for the structure, the roof can be taller, increasing the pitch, which is better for heat stratification, ventilation, and repelling rain. A two-classroom unit is also ideal because it is small enough to multiply and adjust the site plan easily if a school's population is larger or increases. It also allows for simple arranging according to each community's preference or to accommodate the specific features of a site.



Ventilation and Daylighting analysis:

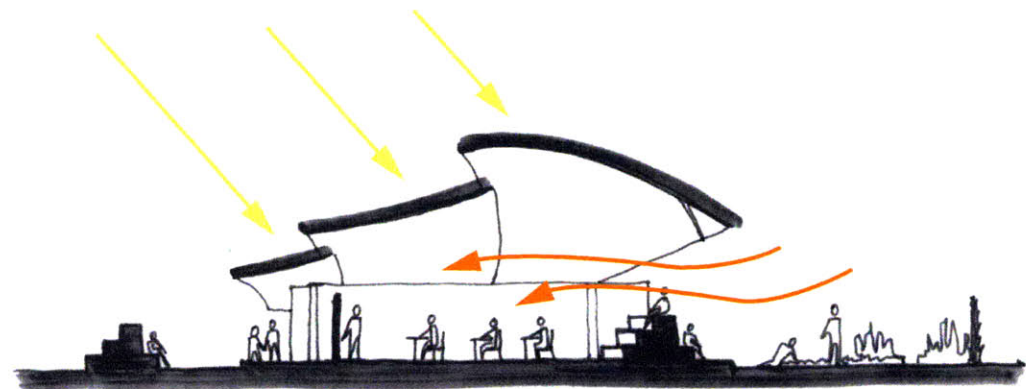
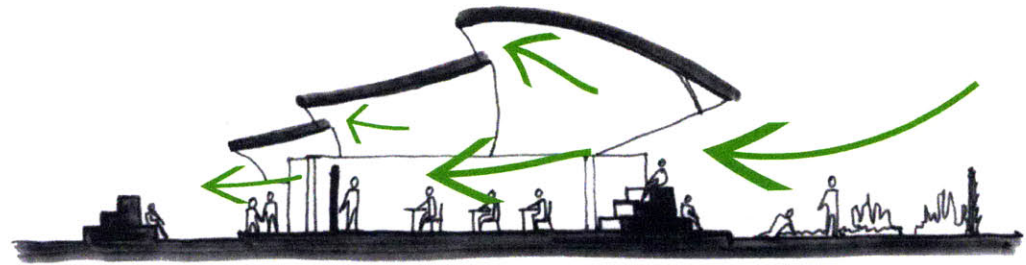
Yellow: Direct Sunlight  
Green: Prevalent wind

Ventilation and Daylighting analysis in sections:

Yellow: Direct Sunlight

Green: Prevalent wind

Orange: Indirect sunlight



## CONSTRUCTION SYSTEMS

### Walls

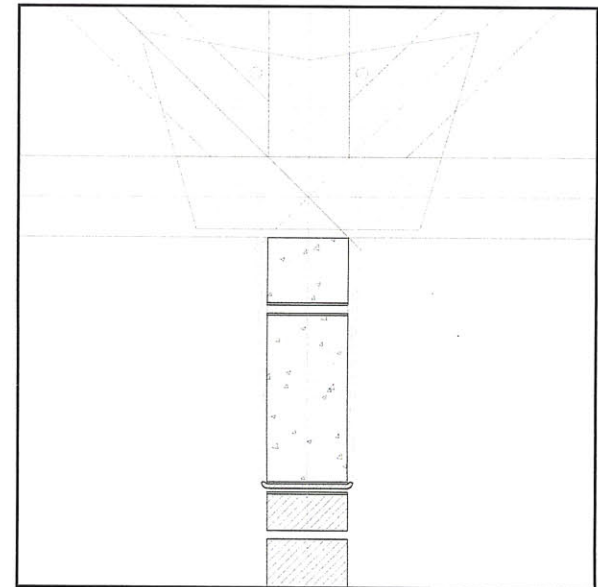
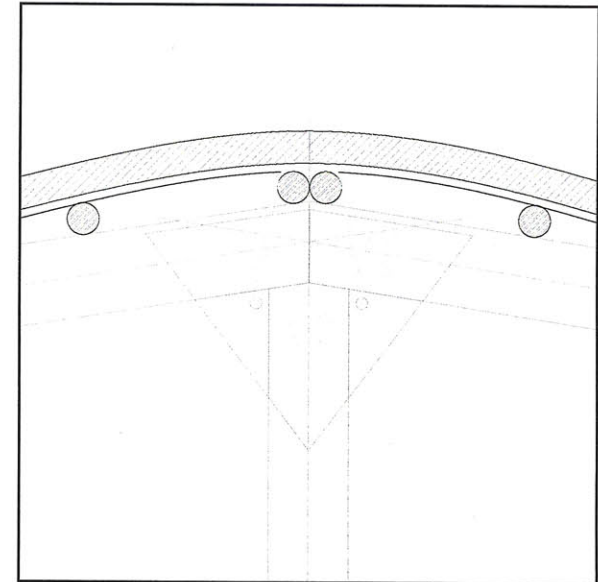
The walls of the classrooms and other buildings in the school complex are built out of compressed soil block with a small content of cement. This material was chosen because in the January of 2009 site visit, Village Hope brought an Auroville Auram Press 3000 to the village of Rogballan. Promoting buildings that use bricks produced in this village will help support the budding economy of Rogballan. Another important aspect of the walls is that they do not have openings, this design choice was made for several reasons: This eliminates outside distractions for the students, provides a physical and sound barrier between classrooms, and strengthens the structure of the load bearing wall. The ends of the long side walls were crossed with shorter wall sections that intersect at 90° in order to make it sturdier against lateral wind loads and help it sustain roof loads effectively. As an added bonus, these intersecting sections help divide the spaces within the building, providing enclosures.

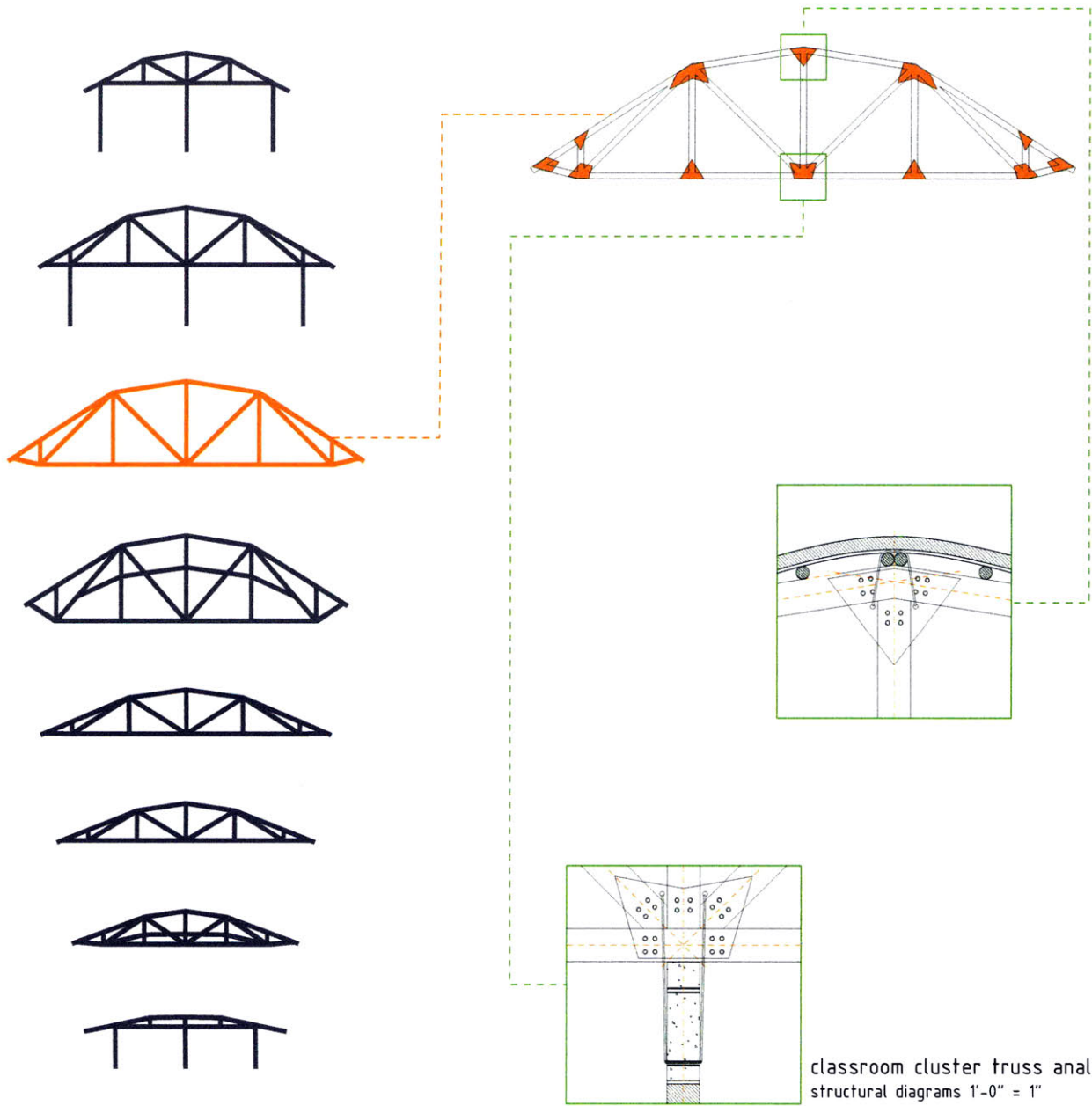
The wall section directly under the places where the roof structure comes into contact need to be stronger to receive and spread the loads and hold the roof ties in place. To accomplish this, the 3' deep sections of the wall in these places need to be made of a stronger material such as concrete or fired soil brick.

To protect the walls from usual wear as well as harsh weather, a series of possible inexpensive plastering techniques were studied. The most effective traditional technique is to mix termite hill soil with sand and water to produce a mud-like plaster that lasts fairly well against rain. The other method studied and being tested in small scale during the 2009 rainy season is a highly effective traditional Aztec method for protecting walls from rain: it is a white paint prepared with lime, water, and the viscous juice extracted from the prickly pear cactus plant (commonly found in the wild in the Lunsar region). If the results from the cactus paint tests are positive, I propose the walls of the school buildings are plastered with a layer of termite hill plaster and covered with a topcoat of the white cactus-lime paint to give it a finished whitewash look.

### Roof

Thatch was chosen for the roof of the buildings because it is an inexpensive (cost-free) traditional roof system that has the flexibility to be easily adapted to form a wide range of surface shapes, including curved ones. The experience of the villagers with thatch and the maintenance that it requires creates an opportunity for special





classroom cluster truss analysis  
structural diagrams 1'-0" = 1"

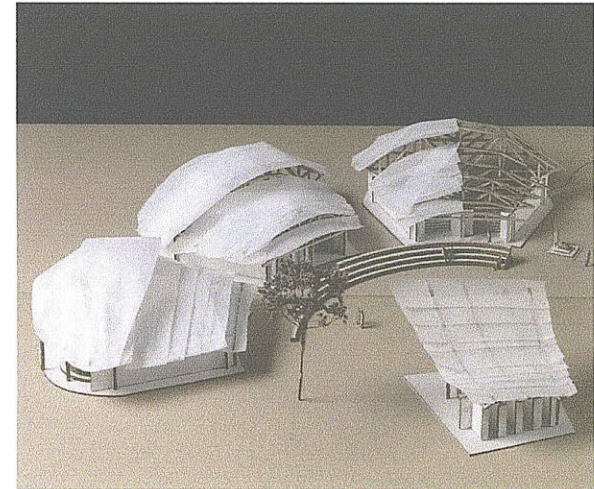
interactions within the community. The re-thatching of the roofs in the school every two or three years can become a community bonding activity that brings its members closer together and makes them more attached to the school, making it truly their own.

The structure to hold up the thatch could be built out of several materials depending on the budget each community has for the school. For an expensive but longer lasting roof, the structure would be made out of steel or metal trusses. The cheaper alternative would be to build the trusses out of dimensional lumber with branches for lateral bracing. This is the method explored in depth in this text. To support the necessary weight and wind loads, the boards used for each truss member should be a stack of two 2" x 10" boards. Even though the overall shape of the roof is curved, the truss segments need to be straight to maximize the effectiveness of the truss shape. The joints between these segments are connected by sandwiching the timber members in between two flat sheets of metal and tying all the pieces with threaded bolts and washers. The lateral bracing and the branches that are laid on top of the trusses to give the roof shape are nailed and tied to the trusses. As mentioned before, the entire roof is connected to the walls using steel wire ties that connect the bottom metal joint plates to the stronger wall material. However convenient and inexpensive these trusses might be, there is one inconvenient: the termites might ruin them in a few years. In the villages, one cannot really estimate how fast the termites will reach a timber structure, but it is definitely not a permanent solution. This could be solved by considering the timber trusses as a temporary structure used until it begins to deteriorate, by which point the village might be able to afford metal trusses as a replacement. If the community still can't afford this, it can monitor carefully all the truss members and replace sections of roof at a time according to the rate of decay.

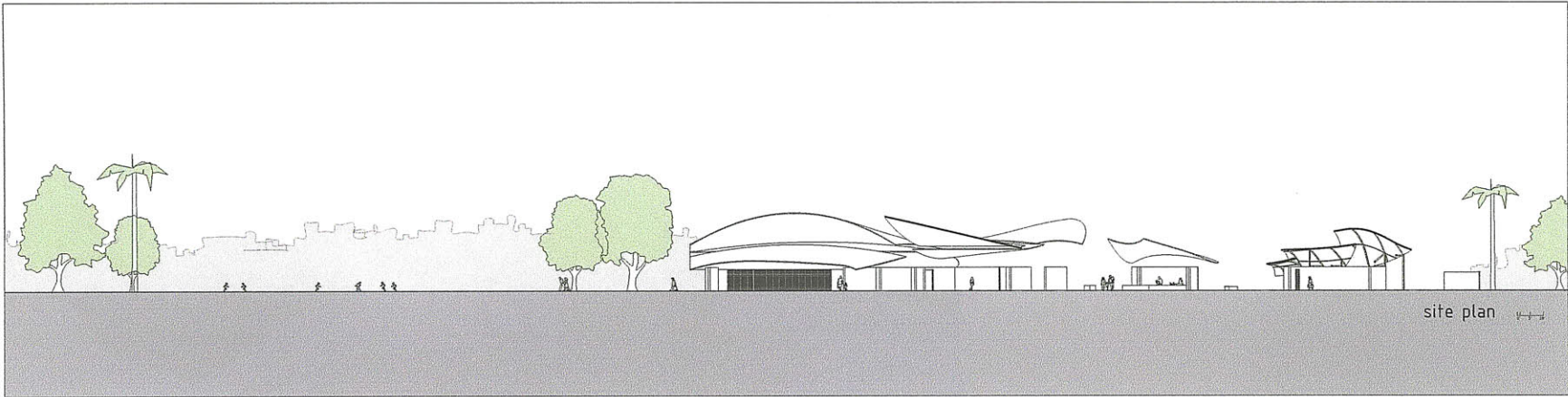
54

### Floors and Benches

The floor slab for the buildings will begin as a rammed earth floor while the walls are being raised and the construction carried out. After everything is in place a fired soil-brick floor could be laid out to make the floor resist the wear and tear of multiple children as well as rain. Fired bricks are a good choice of material since some of the villages are considering building a brick-firing oven, making them less expensive. The benches or "stadium" seating in the design could be built out of rammed earth, compressed soil brick or fired soil brick if it is a more exposed bench.





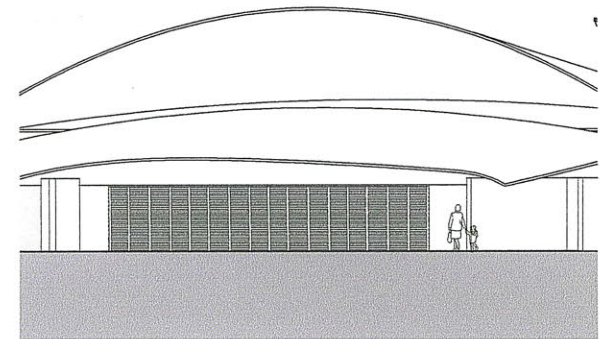


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## FINALIZING THE SITE PLAN

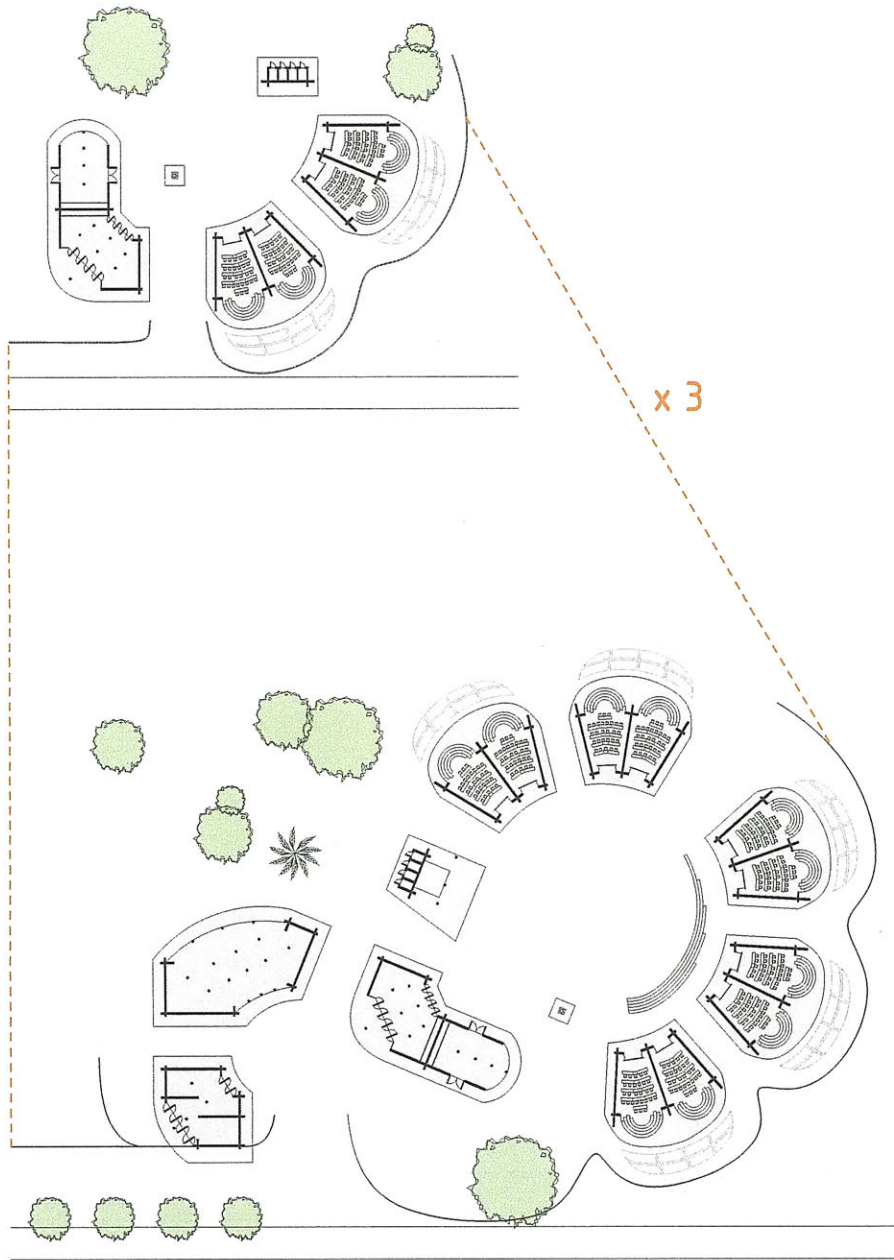
After all these specific issues about building construction and classroom planning were solved, I was able to revisit the master plan and change it to accommodate ventilation and lighting requirements. I also took into consideration the actual orientation of the school sites in Robonka and Rogbaran as a guide for this finalized site plan example. The roofs of all the buildings were divided into segments to allow light and ventilation come in from the appropriate directions.

This site arrangement strategy can also be followed to create schools of different scales. All you need to know is where north is located so you can orient your buildings.





site plan



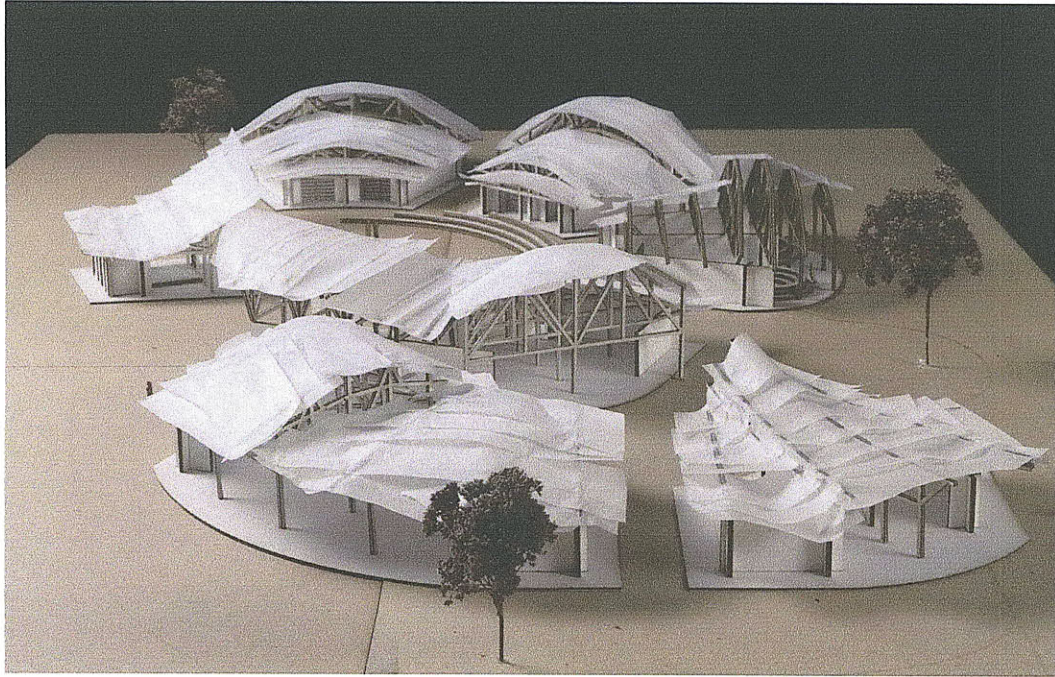
Variation in site plan scales:  
showing different arrangements

Wind flow analysis through entire site >58

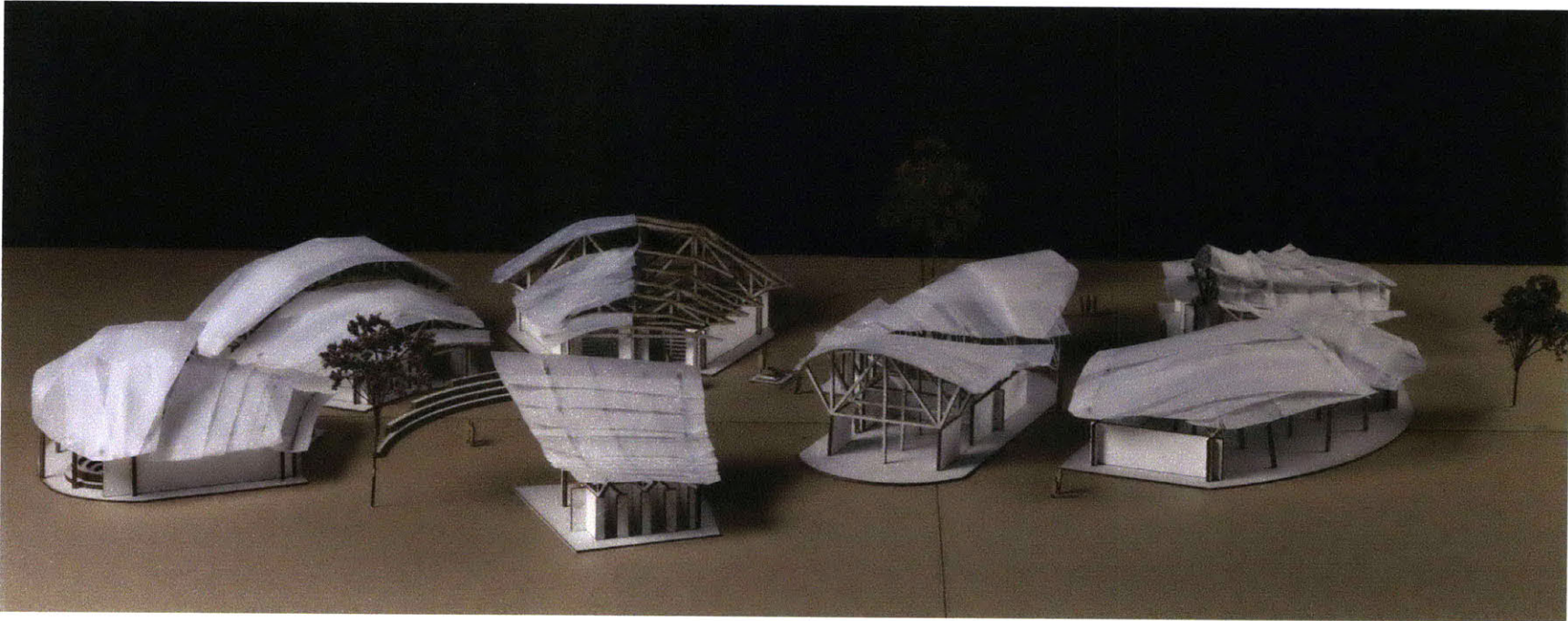


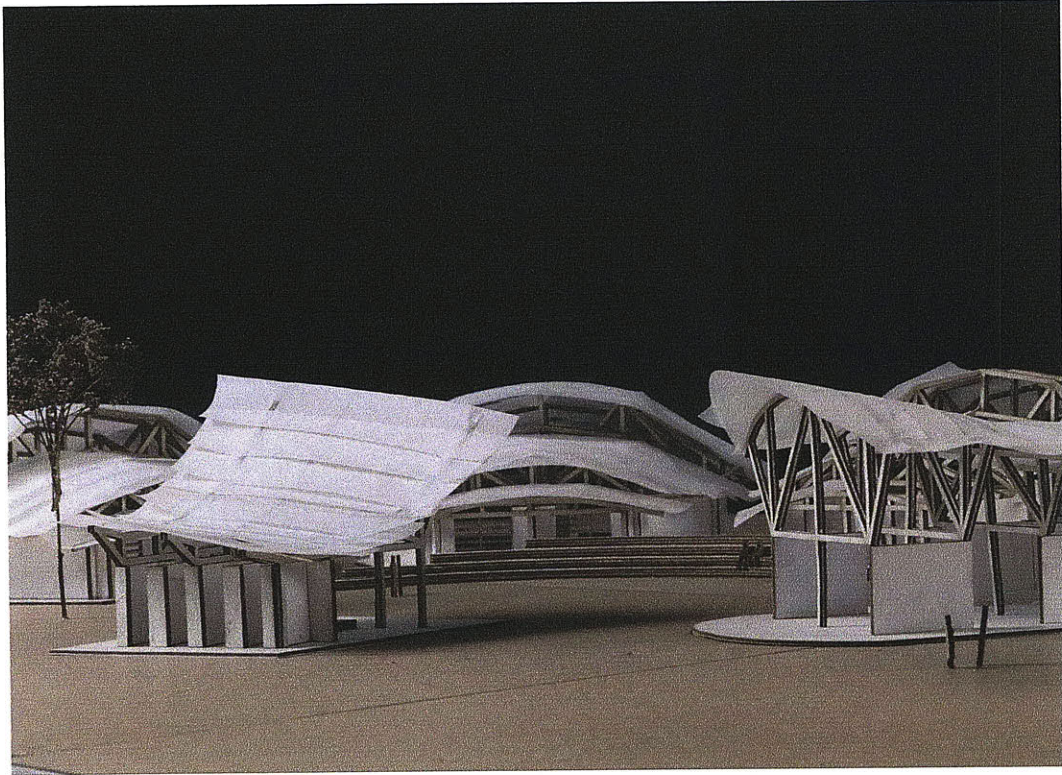
site plan





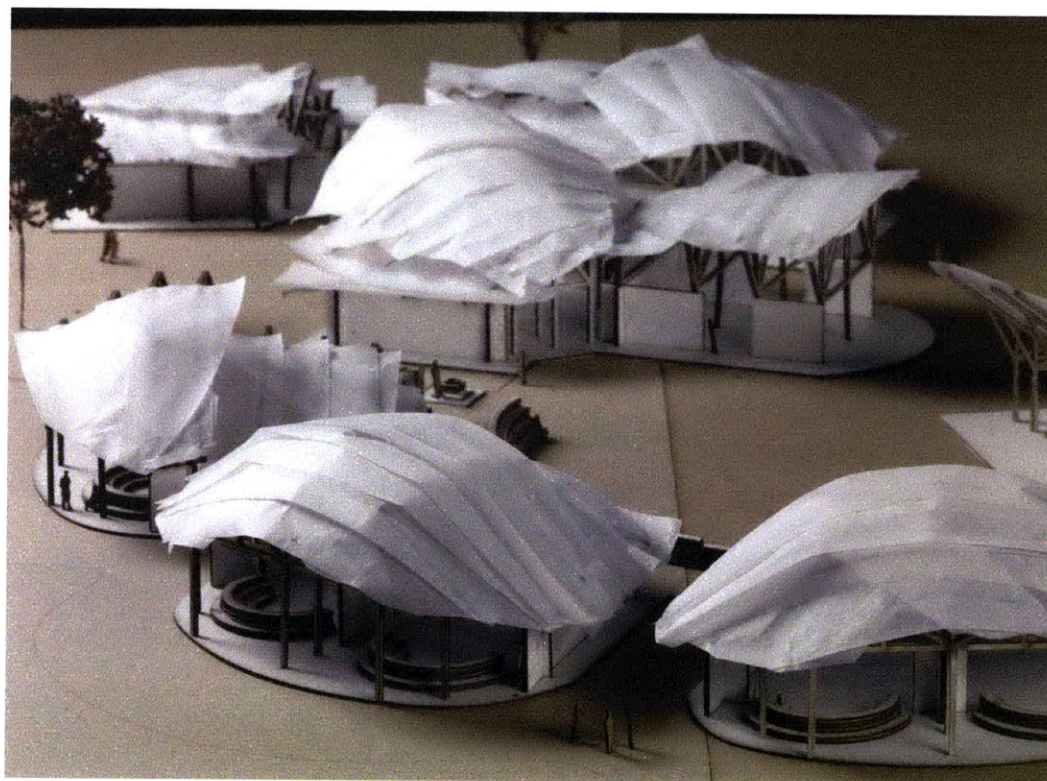
60 MODEL IMAGES





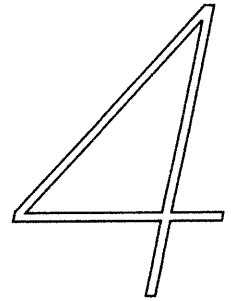
62

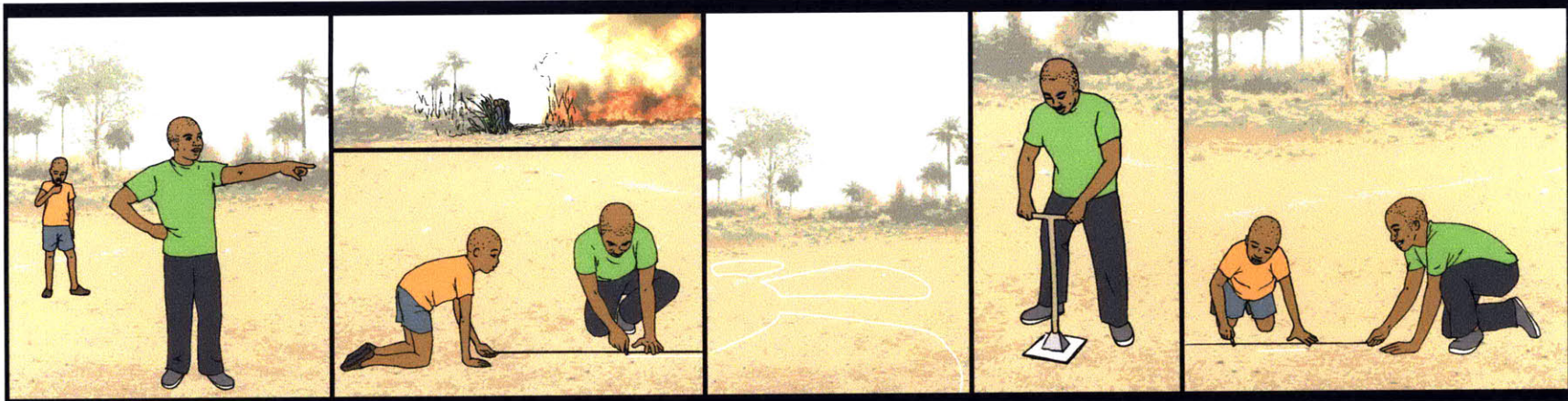






CONCLUSION

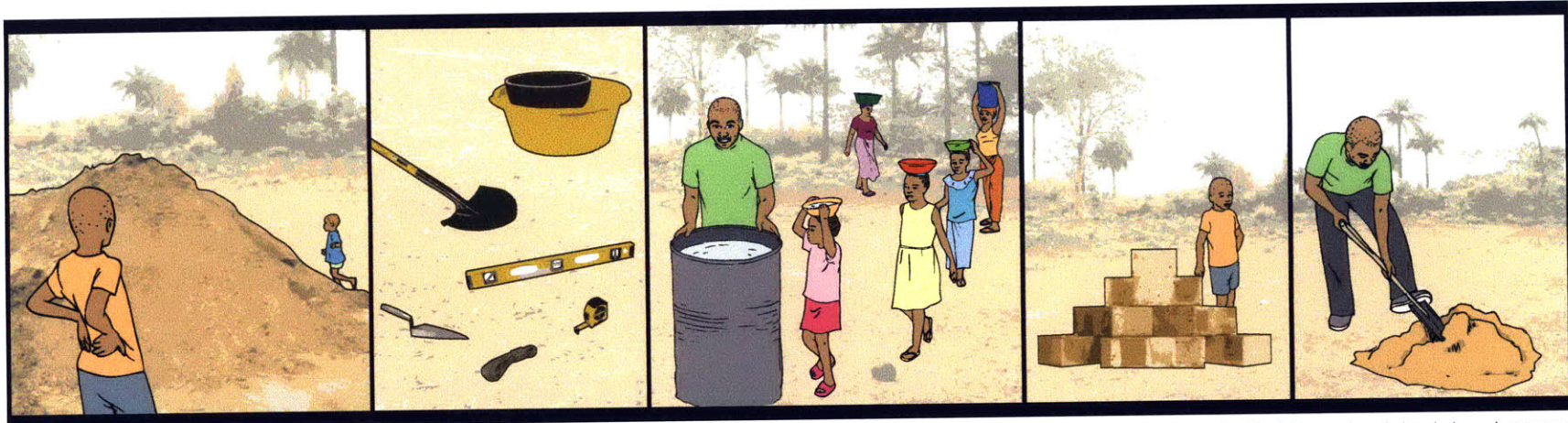




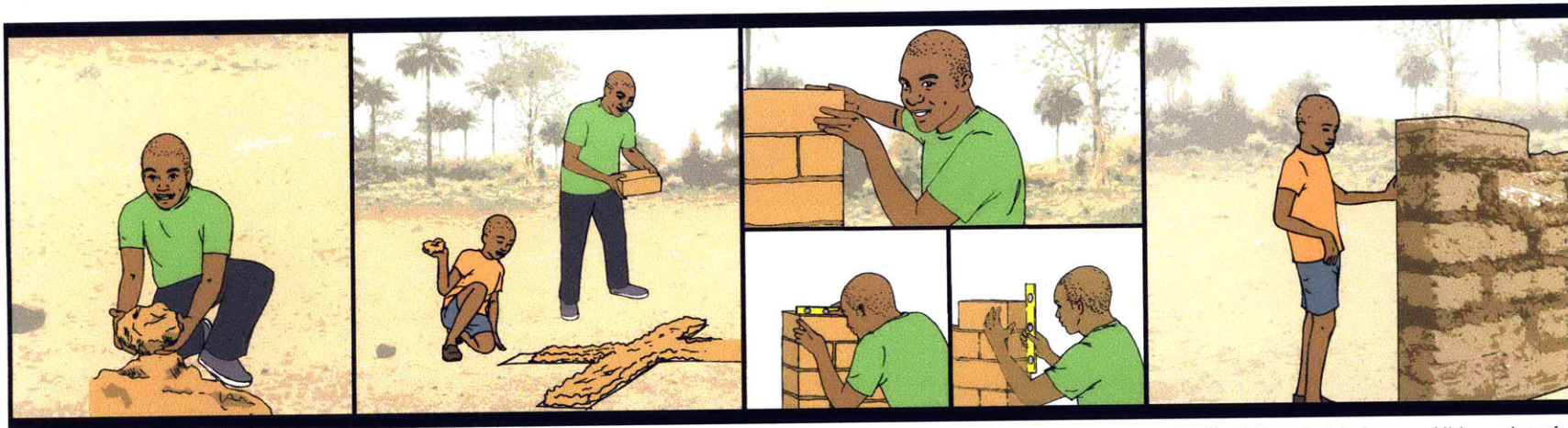
To begin the construction on the school, you first need to pick a site, a large piece of flat land is good. Make sure that you know where north and south are, this is important! Then flatten out the landscape and burn the excess vegetation to clean it up. Ram the earth where the buildings will be, make sure the earth is level. Then draw with chalk the locations of the brick walls.

## FINAL PRODUCT

The final aim of this text was to convey the product of the research and the ideas about the construction systems and the site layout strategies to the communities. To facilitate the communication of this information to the 6 villages and possibly others in the region, an illustrated construction manual will be produced. In the manual, comic-strips portray instructions on the way each building element is put together: walls, roof and floor. In between each segment of the book, there will be indications on how to put all the elements together and adapt them to different building needs and shapes. The idea is that it will not be a manual for building a school, but a construction reference book that presents systems that could be easily applied to different situations. The following images are examples of what the construction manual illustrations and instructions might look like.



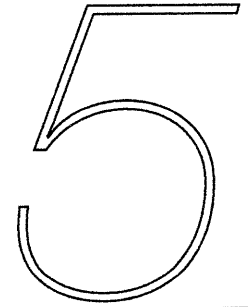
Now you are ready to build the brick walls! Here is what you need: -A large pile of earth (from at least 12' under the surface) with the rocks sifted out. -Containers, shovel, level, trowel, measuring tape, string. -Lots of water... -And of course, compressed earth bricks! After this, you can begin mixing water and the soil in a spot nearby the site for the wall.



Mix until the soil is soft and moldable. Then begin "chucking" or throwing mud at the place where the wall will stand. Be careful to stay within the lines! Now start laying your bricks on top of that. Remember to level out bricks on the edges of the wall first, and use the string to mark where the other bricks should be placed. Keep building layers until you reach 9' height.



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