COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA

KUAKATA, BANGLADESH

AALBORG UNIVERSITET

MASTER THESIS THEME:
COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA
KUAKATA, BANGLADESH

MAIN SUPERVISOR:
MICHAEL LAURING

CO-SUPERVISOR:
CLAUS TOPP

GROUP 29 [QAS]
QUAZI WAFIQ ALAM
ARK'ALUK ALEXANDER KLEEMANN GOUL
SIMONA SKINKYTE

A&D (MSc04 ARC)
MAY 2017

EXTERNAL PARTNER:
COMMUNITY DEVELOPMENT CENTER IN BANGLADESH

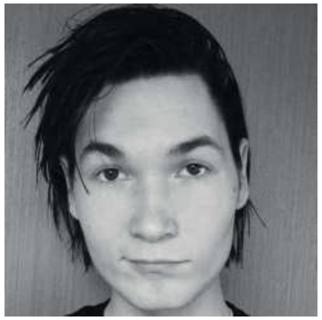
CODEC

DEDICATION

QUAZI WAFIQ ALAM

First of all I want to dedicate this project to all of those people who are living in the exposed coastal areas o Bangladesh. Their sheer struggle for survival and extreme sense of adaptability always motivates me to do research and projects which will be focused on the disadvantaged coastal people of Bangladesh. I want to sincerely thank our supervisors for their kind support and guidance though out the semester and. I really enjoyed working with our group so thanks to all of them. Lastly, I want to thank my parents for always having faith on me and to my wife for being patient.

We are very thankful to our external partner in this project CODEC helped us a lot with providing information and assistance.



ARK'ALUK ALEXANDER KLEEMANN GOUL

I would like to dedicate this project to the helpful people at CODEC and in the local community. I would also like to dedicate the project to our supervisors, for their guidance during this semester. Finally, I would like to thank my family for the support they've provided, not only during the master thesis but also during the whole master's degree.

SIMONA SKINKYTE

It was interesting two years of Master education at Aalborg University, which I could not have achieved without support from my family and boyfriend Arvydas. I have learned a lot about group work, because of the professional group mates and integration between architecture and engineering, because of the right guidelines from professors. Also, I strongly believe that this project can help for people in Kuakata, who are facing so many disasters, because of the climate change.

LIST OF CONTENT

1. Introduction 8
2. Thematic description 9
3. Problem formulation 10
4. Methodology 11
5. Why community center? 12
6. Contextual analysis 14
    6.1 Bangladesh 15
    6.2 Coastal areas 16
    6.3 Site area: Kuakata 19
7. Site analyses 20
    7.1 Regional overview 21
    7.2 Site and surroundings 22
    7.3 Climate 23
    7.4 Calendar 25
8. User comfort 26
    8.1 Ventilation principles and daylight 27
    8.2 Thermal comfort modeling 28
    8.3 Thermal comfort criteria 29
9. Functional requirements 30
10. Framework/Background Review 32
    10.1 Local Culture/ Traditional Building Practices 33
    10.2 Rural Learning Environment 36
    10.3 Regional Modernism 37
    10.4 Building in disaster prone areas 38
    10.5 Case studies 40
    10.6 Inspirations 44
    10.7 Local materials 45
11. Design Process 46
    11.1 Design Criteria 47
    11.2 DGNB Criteria 48
    11.3 Users and functions 49
    11.4 Protected areas during storm surges 50
    11.5 Conceptual framework 51
    11.6 Initial sketching phase 53
    11.7 Initial technical studies 54
    11.8 Development of the initial idea 55
    11.9 Initial study of perforated facades 56
    11.10 Initial plan development 57
    11.11 Volume studies 58
    11.12 Solar energy harvesting 59
    11.13 Structure and joints 60
    11.14 Structural optimization 61
    11.15 Modular approach and double facade 62
    11.16 Thermal and daylight optimization 63
    11.17 The concrete structure 64
    11.18 The tower 65
12.Presentation 67
    12.1 Master plan 69
    12.2 Plans 71
    12.3 Gathering places 72
    12.4 Meeting spaces 74
    12.5 Educational spaces 75
    12.6 The tower 76
    12.7 Elevations 78
    12.8 Disaster scenario 80
    12.9 Feedback to the community 84
13. Epilogue 86
    13.1 Reflection 87
    13.2 Conclusion 88
    13.3 References 90
    13.4 Illustration list 92
14. Appendix 94
    14.1 Final technical results 95
    14.2 Rain water harvesting 96
    14.3 Solar energy storage 97
    14.4 Analyses of the relation 98
    14.5 Initial daylight testing and opening 99
    14.6 Daylight control of the tower 100
    14.7 Structural analyses 101
    14.8 Bamboo thermal shape testing 102
    14.9 Calculations 103

1

INTRODUCTION

The presented material contains the architectural proposal for the design of a community center complex located in the coastal region of Kuakata in Bangladesh. In addition to the architectural and aesthetic focus, the proposal also brings focus into sustainability in a holistic manner that seeks to unify the local cultural identity with the difficulties in a developing country.

This aspect also include the environmental issues in a disaster-prone area, which is subjected to the effects of climate change, through constructive and functional means.

The proposal is designed for the local non-profit organization “Community Development Center (CODEC)” which have been working for the development of coastal communities in Bangladesh for the last 35 years, with the premise for the project to pragmatically create a community center that provides a platform for the local communities to interact through various activities and offers adaptable solutions, to ever increasing natural calamities occurring due to the climate change effects.

FIG. 1: BANGLADESH FOREST AND RIVER

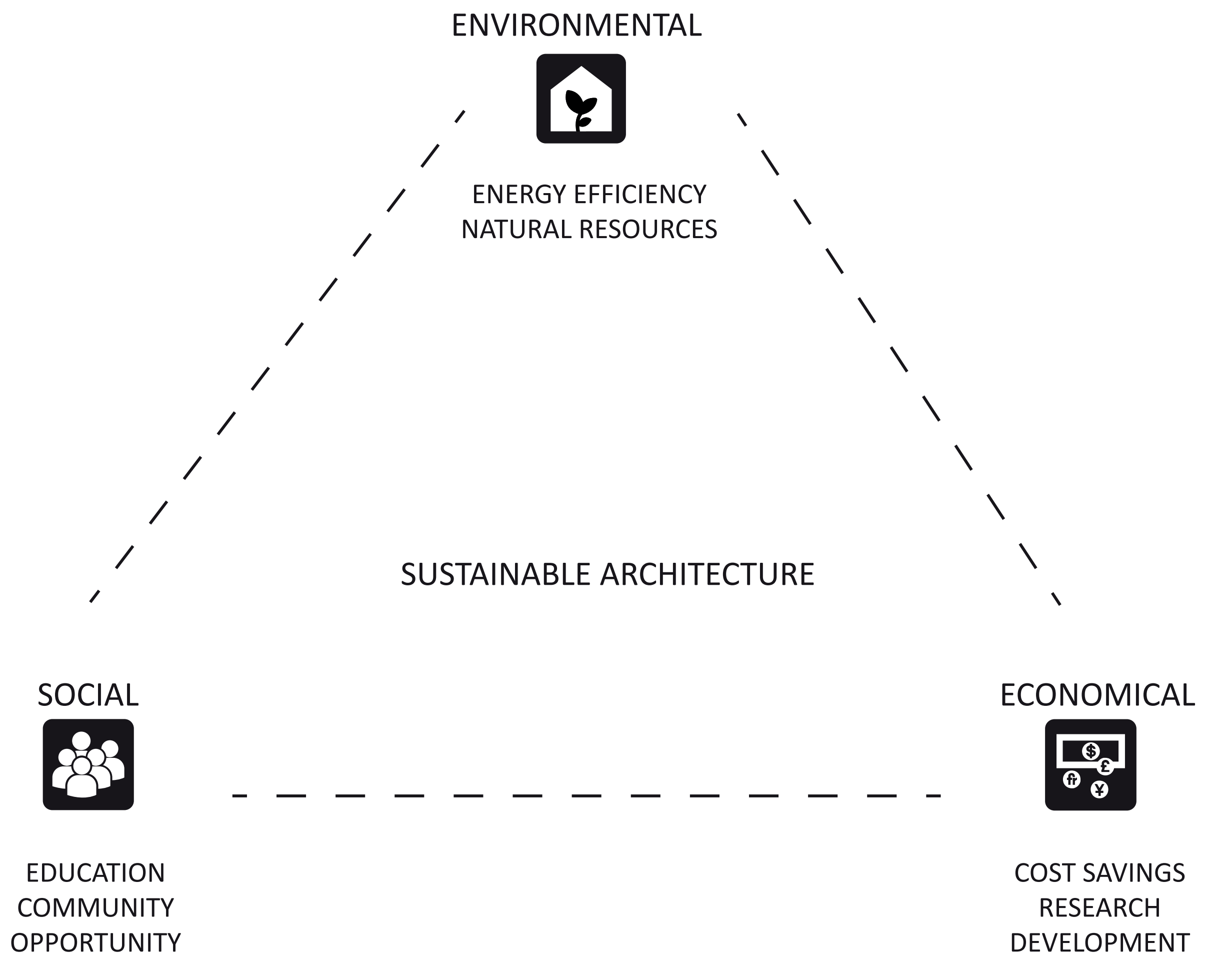


FIG. 2: SUSTAINABLE ARCHITECTURE TRIANGLE

2

THEMATIC DESCRIPTION

Thematically, the proposal revolves around the contemporary problems posed by the effects of climate change in the disasterprone coastal areas. The project proposal is based in Bangladesh - a country bordered by the Bay of Bengal to the south, where the larger part of the country is comprised of low-lying lands, which are especially vulnerable to the frequent natural disasters occurring in the region. This is not only due to the tropical cyclones originating in the Indian ocean, but also the feeble preconditions that includes inadequate infrastructural capacity and overpopulation.

These devastations often result in the complete or partial destruction of the built forms in the local region, while the following reconstructions often leads to a sub-par constructional condition, resulting in an increased future vulnerability for the increasing effects of climate change.

Because of this, sustainability is set as an essential element in the design proposal. The environmental sustainability is something that is an integral constituent of the project, by showing awareness of the changing climatic situation, while taking into consideration that the area is in an economically developing country, thus the economically disadvantaged condition gives an incentive to focus on locally available materials and technologies. Another aspect is social sustainability which concerns and analyze the working, living and socializing patterns of the inhabitants of the local community.

3

PROBLEM FORMULATION

How can a community center be designed in the disaster-prone coastal area of Bangladesh in a way that will create a platform for the local communities to involve themselves and participate in different activities while also holistically incorporating the principles of sustainability?

FIG. 3: FOGGY FIELDS

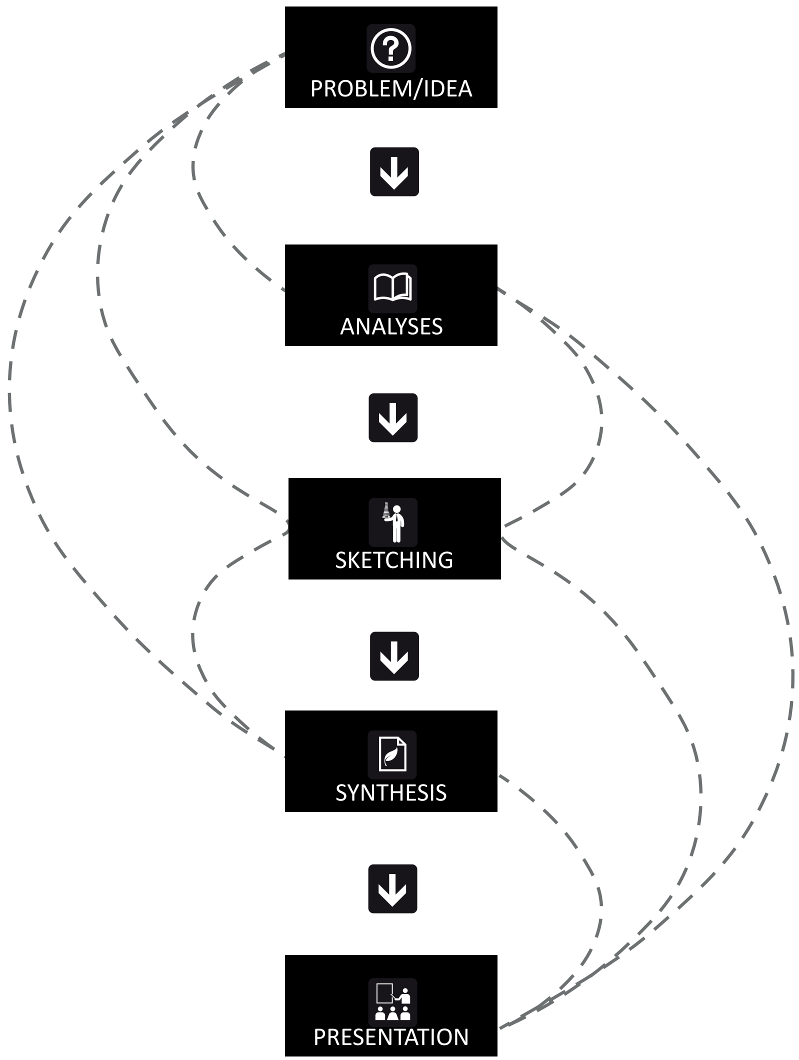


FIG. 4: INTEGRATED DESIGN PROCESS

4

METHODOLOGY

During the design process of a project proposal, it is important to have a well-organized design phase structure, that can drive the project in an efficient way, which is why the Integrated Design Process (IDP) has been designated as the primary methodological driver for the project. The Integrated Design Process provides the ability to combine architecture and engineering to solve the design of holistically sustainable buildings, as it touches within the most relevant fields such as design, function, energy, indoor climate and construction. The Integrated Design Process model integrates itself as a model of the Problem-based Learning model (PBL), where the team project work revolves around a problem to ensure both architectural and engineering disciplines. [Knudstrup 2003, 2004]

The first phase is the problem phase, where the main problem is found and defined in order to gain an understanding of imposed challenge. This phase provides the framework for the rest of the project by giving the initial idea of the project. The analysis phase begins to with informational gathering. In this phase, all relevant information is procured and analyzed before the next sketching phase can begin. The information found during this phase includes theme analysis, contextual- and climate analysis, case studies, functional requirements and program detailing. In the sketching phase, the analyzed data is processed into concepts which merge the architectural and the engineering disciplines to design sketches that are later evaluated regarding requirements, demands and aesthetics. The synthesis phase focuses on the optimization and refinement of a conceptual proposal in terms of the relationship between form and space, as well as the technical optimizations to indoor climate and structure. The presentational phase provides the finalized presentation of the design proposal, where the communication of the building as a unified concept is presented through visualizations, plans, sections and elevations.

5

WHY COMMUNITY CENTER?

The coastal areas of Bangladesh have historically been disaster prone areas. Natural disasters like cyclones and flooding is a common phenomenon in these coastal zones. Moreover, due to the devastating effects of climate change, the frequency and intensity of these natural calamities are always increasing. The coastal areas of Bangladesh are the most vulnerable for this increasing numbers of natural calamities. The site of our project is located in the exposed south-eastern coastal area of Bangladesh known as Kuakata which has been subjected to many natural disasters in the last decade. There were four major cyclones which occurred in the last ten years which affected the rural communities in the Kuakata region. Many homes and infrastructural elements were destroyed and people were in most of the cases forced to take refuge in the cyclone shelters. Our external partner "Community development center (CODEC)" is a local non-government organization in Bangladesh who has been working for the development of the impoverished coastal communities for the last thirty years is planning to design and build a "Community Center" in the Kuakata region.

The project is conceived as a Community Centre in a disaster-prone coastal area which will incorporate the surrounding communities for different types of activities. These activities include community meetings, group discussions, training programs, community school, cultural events, etc. The purpose of this community center is to help the inhabitants of the area to develop adaptive strategies and decrease their vulnerability to the increasing number of natural calamities through different kinds of activities initiated by the NGO and the local community. Therefore functional zones which support these activities will be a part of this project. The major functional zones for the community aspect of this project are: meeting areas (both indoor and outdoor), amphitheater, community school, workshop and training facilities.

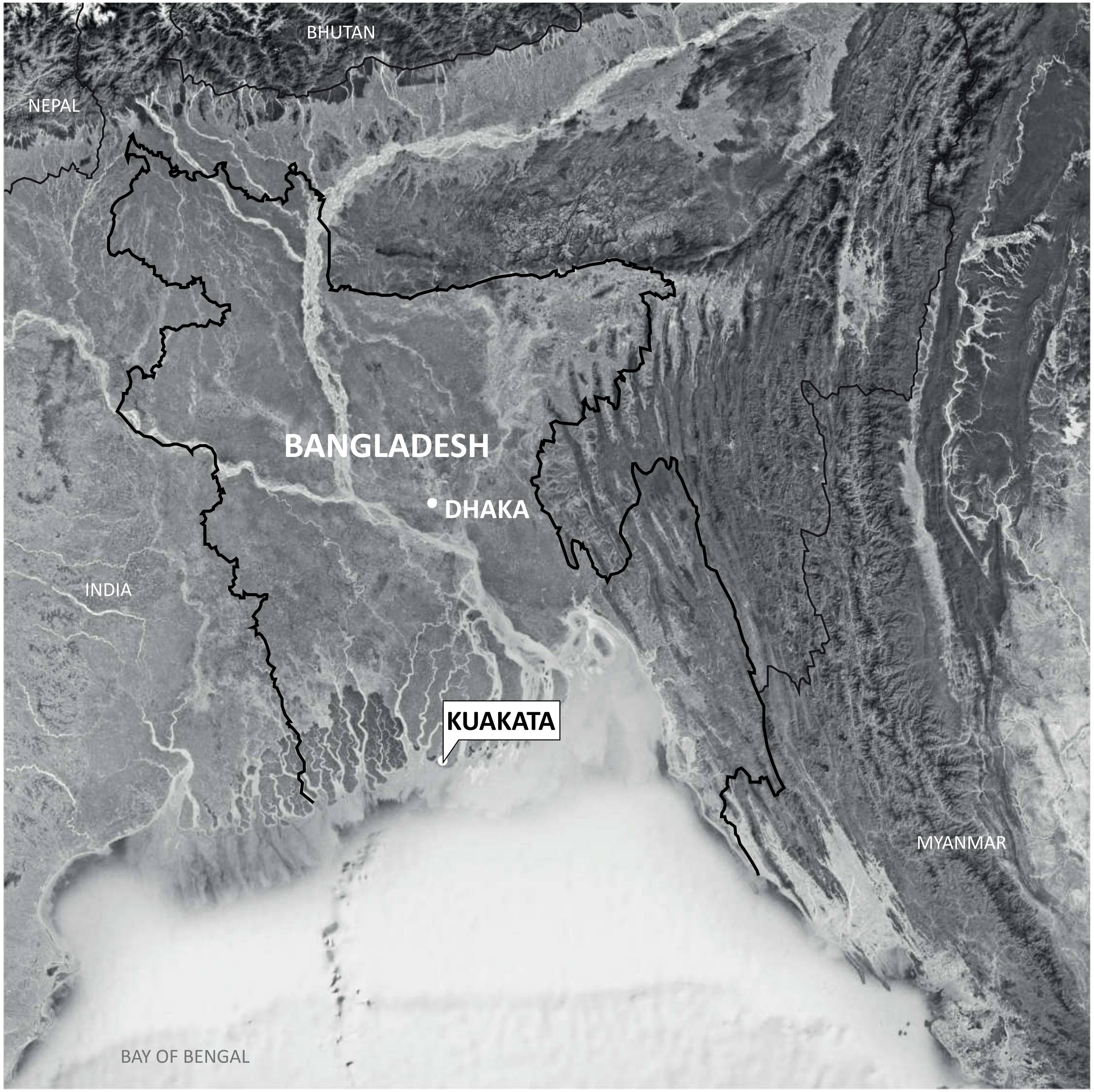
FIG. 5: KUAKATA SEASIDE DURING THE TOURIST SEASON

Kuakata is the number two tourist destination in the country which is well-known for its panoramic sea beach. It is also the place of pilgrimage for both Hindu and Buddhist communities. Innumerable devotees arrive here for different festivals throughout the year. As this area is one of the major tourist destinations in Bangladesh, there is also a commercial aspect to this project which will help to generate income and sustain itself commercially. A small community-based display shops which will represent the local culture and way of life will be the main focus of the commercial zone. Other supporting functions like conference facilities, dining area and dormitories will also be included in this project.

6

CONTEXTUAL ANALYSIS

FIG. 6: KUAKATA BEACH



MAP 1: MAP OF BANGLADESH

BANGLADESH

Bangladesh part of the largest delta in the world, formed mainly by three major (Ganges-Brahmaputra-Meghna) river systems, except for the hilly regions in the northeast and southeast and terrace land in the northwest and central zones. The country is located between 20°34’ to 26°38’ north latitude and 88°01’ to 92°42’ east longitude. Bangladesh has an area of 147,570 square kilometers and a population of about 163.7 million (United Nations estimates 2016); making it a densely populated country (1252 person per Km2).

The official language of Bangladesh is Bangla (or, Bengali). Dated even before the common era (BCE), Bangla was widely spoken in this region, and now spoken by almost a quarter billion people all over the world. It has a various dialects with different accents, pronunciations and minor grammatical changes in different regions in Bangladesh. [visitbangladesh.gov.bd]

After the dissolution of British Empire in 1947, Bengal was partitioned as a province of West Pakistan with being renamed as East Pakistan. Dhaka was declared as its capital. In 1971 after nine months of war against Pakistan, Bangladesh was liberated. [visitbangladesh.gov.bd]

A network of 230 rivers with their tributaries and distributaries crisscross the country and, therefore, the country is virtually a conglomerate of islands. Floodplains occupy 80% of the country. Mean elevations range from less than 1 meter on tidal floodplains, 1 to 3 meters on the main river and estuarine floodplains, and up to 6 meters in the Sylhet basin in the north-east [Rashid 1991]. Only in the extreme northwest are elevations greater than 30 meters above the mean sea level. The northeast and southeast portions of the country are hilly, with some tertiary hills over 1000 meters above mean sea level [Huq and Asaduzzaman 1999].

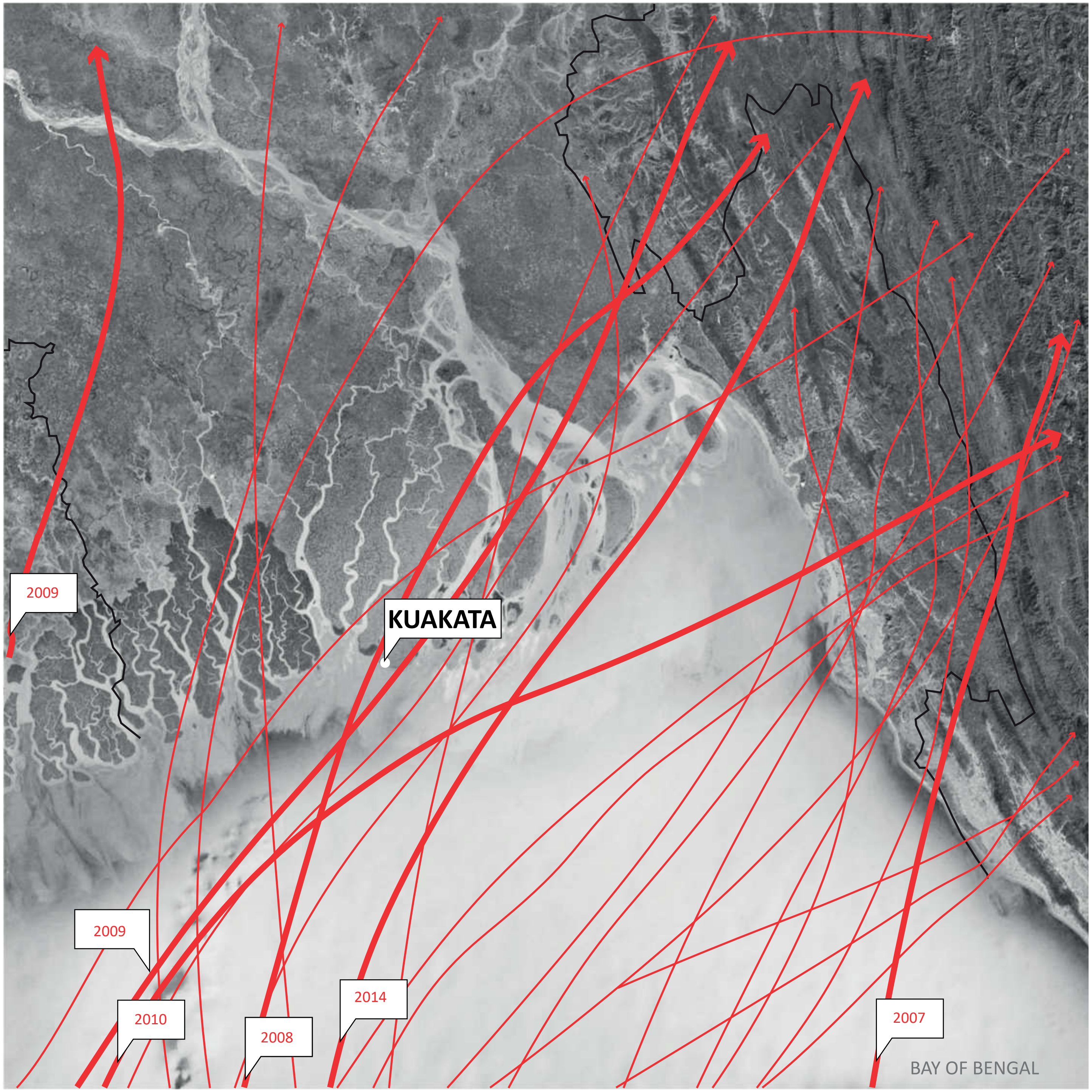
COASTAL AREAS

Bangladesh has a coastline of 710 kilometers. There are different views on the demarcation of the coastal areas. The conventional view is that the land that is inundated by the high and low tides is called the coastal belt. Coastal zones refer to areas where land and sea meet. Three indicators have been considered for determining the landward boundaries of the coastal zone of Bangladesh. These are: influence of tidal waters, salinity intrusion and cyclones/storm surges. The coastal areas in Bangladesh are the most vulnerable to the different kinds of natural disasters especially Cyclones, Storm surges and the effects of climate change [Alam 2016].

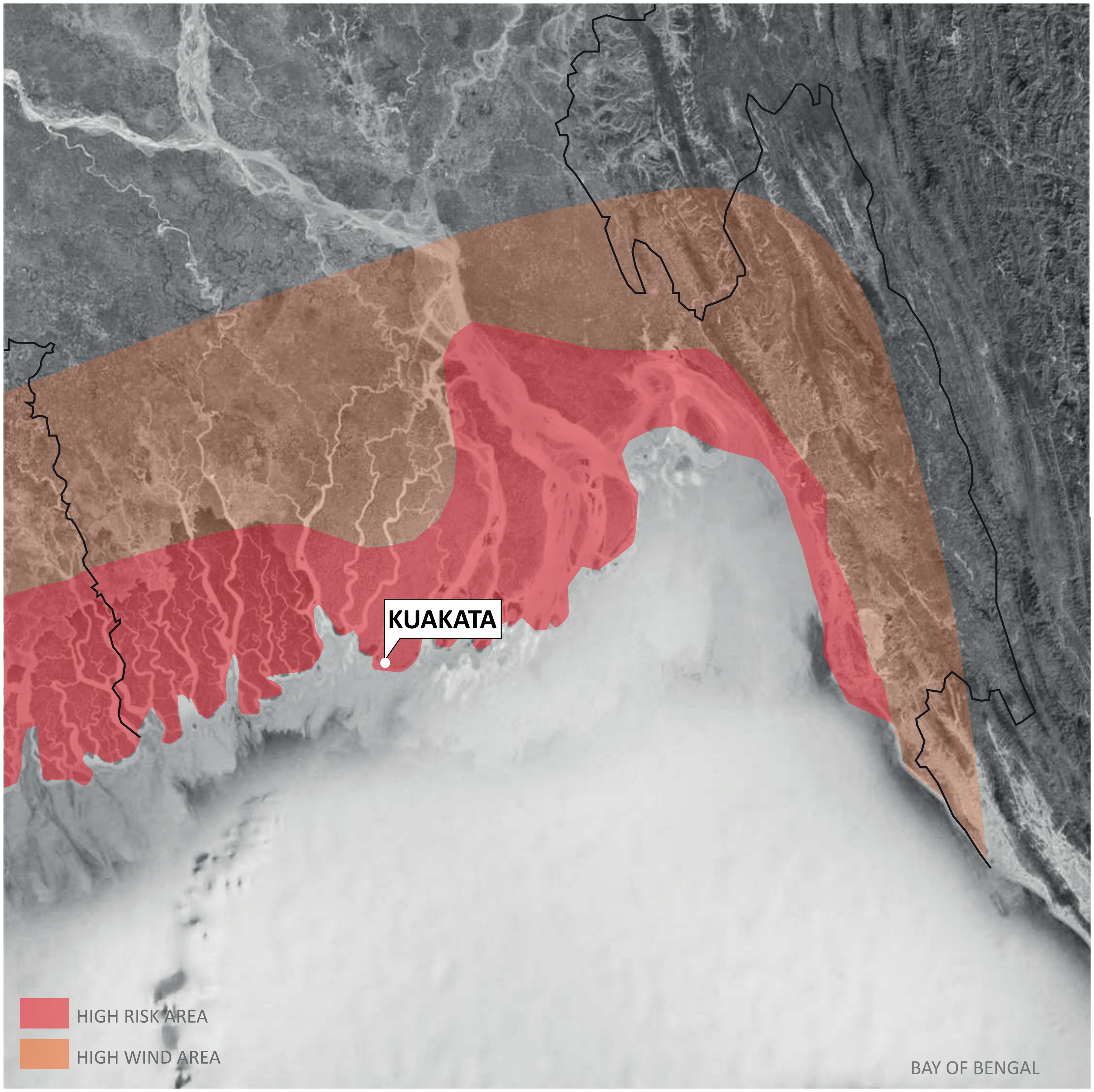
Natural disasters are one of the main hindrances to development Bangladesh. Especially the coastal regions suffer the worst effects of these natural calamities. Bangladesh has been identified as one of the countries which are most vulnerable to climate change and rising sea-level. This is because it is located at the northern end of the funnel-shaped Bay of Bengal, and as a consequence it experienced a number of severe cyclonic storms and surges [Alam 2016].

The effects of Climate change are making the situations in the coastal areas of Bangladesh even worse. Projections indicate that the average annual temperatures has a possibility to rise more than 2°C in most parts of South Asia by the mid-21st century compared to the average in the 20th century (IPCC 2014). In some studies relating Bangladesh it is projected that the mean annual temperatures will increase by 1.8°C by the 2060s and 2.7°C by the 2090s (compared to 2010), although some project increases up to 4.1°C by 2090s [Karmalkar et al. 2012].

Bangladesh is expected to be 4% wetter by the 2050s [World Bank 2010a]. It is projected that by 2090s the mean annual rainfall will increase by on average 7% compared to the 1970-2000 mean climate. This increase is expected to be higher in the North, North



MAP 2: TRACKS OF MAJOR CYCLONES IN THE COASTAL AREAS OF BANGLADESH [Source: Banglapedia]



MAP 3: CYCLONES AFFECTED AREAS IN BANGLADESH [Source: Banglapedia]

West and the Coastal areas of Bangladesh. The highest increases (on average 14% by the 2090s) will take place in the monsoon season [Karmalkar et al. 2012].

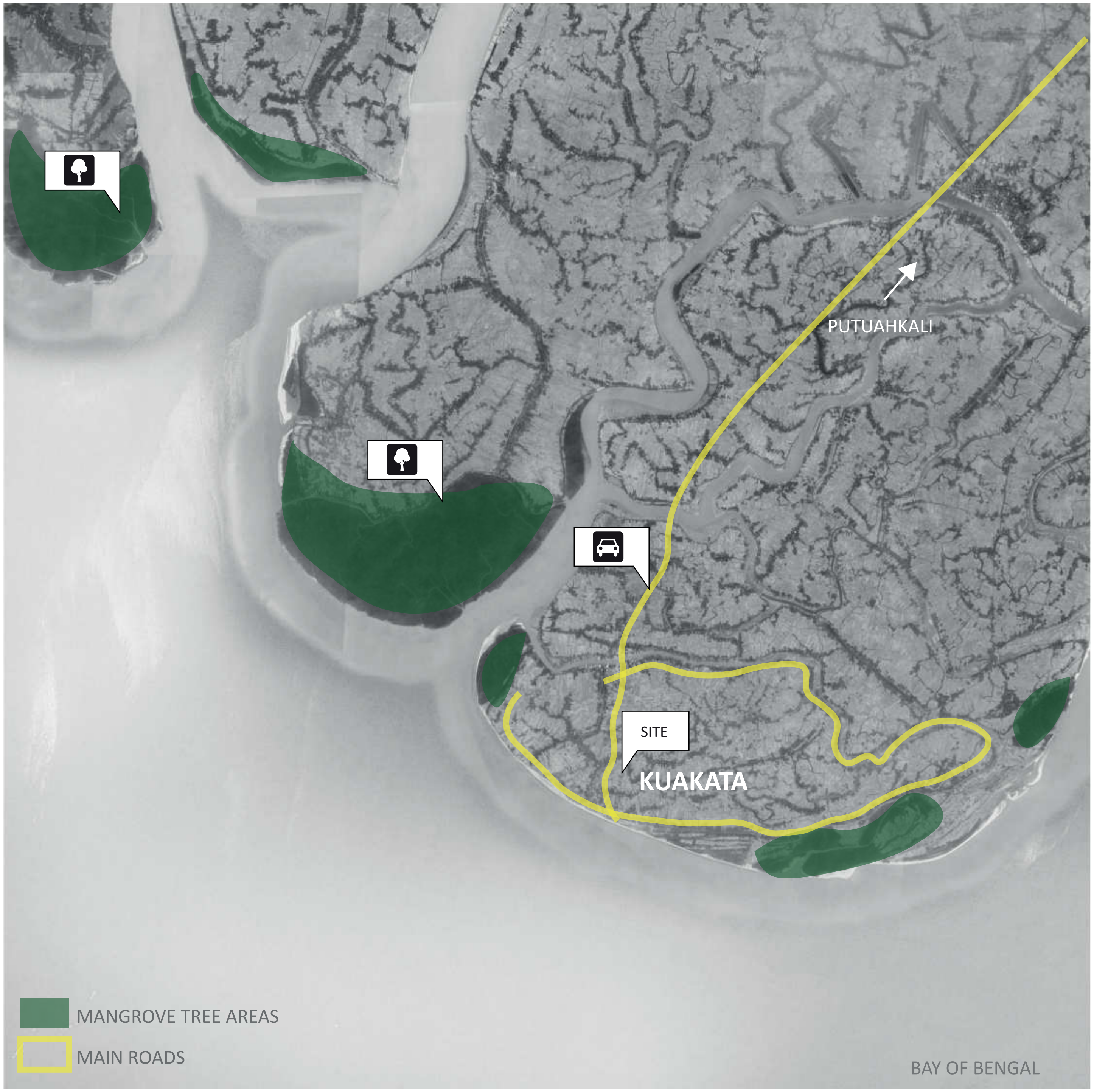
The magnitude of sea level rise by the end of the century will significantly increase the vulnerability of the coastal settlements of Bangladesh. Due to the simultaneous submergence of low coastal areas, relative sea level rise in Bangladesh is greater than in many other countries. A large number of people will be affected by this. By 2050 it is assumed that about 27 million people of the coastal areas of Bangladesh will be at risk due to the effects of sea level rise. 18 % of the country's land will inundate if the sea level rises by 1 meter [World Bank 2010b]. Moreover, the combined effects of sea level rise and cyclones can inundate 15% of Bangladesh's coastal zones [World Bank 2010a].

It is also projected that extreme events like cyclone and flood will be both heavier and more frequent. Floods will not just be more frequent but it will also cover more areas of the land and the inundation depth will increase in most parts of Bangladesh [Thomas et al. 2013]. Table 1 shows the number of all severe cyclones in every ten years that made landfall in the coastal zone of Bangladesh from 1966 till 2016. It can be clearly observed that the number of severe cyclones has almost doubled in the last decade compared with the previous four decades. This is a clear indication of climate change affecting the frequency of severe cyclones and surges [Alam 2016].

Year	Number of Severe Cyclones
1966 - 1976	4
1976 - 1986	5
1986 - 1996	5
1996 - 2006	4
2006 - 2016	**8**

Table 1: Number of severe cyclones 1966 to 2016.Source: Bangladesh bureau of statistics, Banglapedia, Alam 2016.

FIG. 7: SITUATION AFTER THE CYCLONE



MAP 4: MAP OF AREA

SITE AREA: KUAKATA

Kuakata is popularly known as “Sagor Konnya” (The daughter of sea) is located at the southern tip of Bangladesh in Patuakhali district. It is about 320 kilometers south of the capital Dhaka. It has the second largest sea beach in Bangladesh and is visited by considerable amount of tourists. It is becoming a major tourist attraction for both local and foreign tourists. The beach stretches for about 18 kilometers.

Kuakata offers a full view of the sunrise and sunset from the same white sandy beach in the water of Bay of Bengal. It is also the place of pilgrimage for both Hindu and Buddhist communities. Innumerable devotees arrive here every year for religious festivities.

According to 2011 Bangladesh census Kuakata has 2065 households and a population of 9077. Like the others exposed coastal areas of Bangladesh Kuakata is also extreme vulnerable to natural calamities especially Cyclones and storm surges. In the last decade more than seven severe cyclonic storms made landfall in this area. Moreover the intensity and frequency of cyclones and storm surges are always increasing due to the effects of climate change. In November 2007, the cyclone “Sidr” swept off the coastal region of Bangladesh and completely devastated the small seaside community of Kuakata. The retreating tidal waves took thousands of souls into the vastness of the ocean and left most of the people homeless. Most of the families lost their close ones who were involved in deep sea fishing at that time. The frighteningly fierce waves rose so high and entered so deep into the habitable lands.

Ernest Hemingway said “A man can be destroyed, but cannot be defeated.” While one think of evidences for such extraordinary claims, take a look at Kuakata, with all its relentless and courageous inhabitants proudly survives there, as the epitome of human resilience.

7

SITE ANALYSES

FIG. 8: KUAKATA BEACH

REGIONAL OVERVIEW

MAP 5: REGIONAL OVERVIEW

FIG. 9: LOCAL BUILDING

FIG. 10: STREET MARKET

FIG. 11: EMBANKMENT NEAR THE SEASIDE

FIG. 12: SEASIDE

SITE AND SURROUNDINGS

FIG. 13: SITE

Site area: 4365 m^2

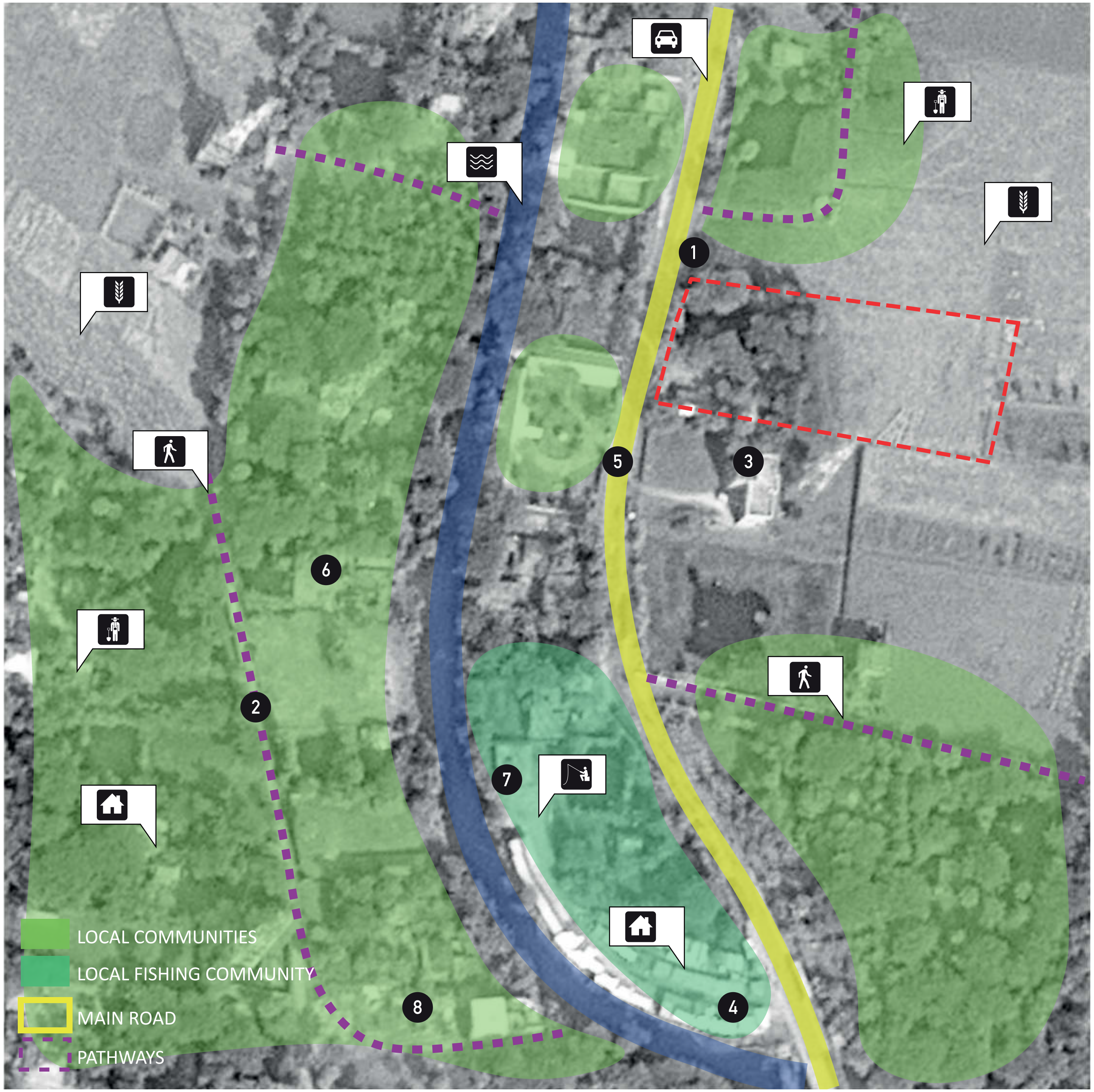
Site area is surrounded with residential areas and farming lands. Main access to the site is from the main road in west. The major occupations in this area is fishing and farming. There is a small river near the site.

FIG. 14: PATHWAYS

- Site from South and West parts are surrounded with local people housings, while East and North part is facing to the agricultural fields.

- Small pathways [violet color in the map] connect with the main road

- Near the seaside in the main road is street market



MAP 6: SITE AND SURROUNDINGS

FIG. 15 a-f: SURROUNDINGS

CLIMATE

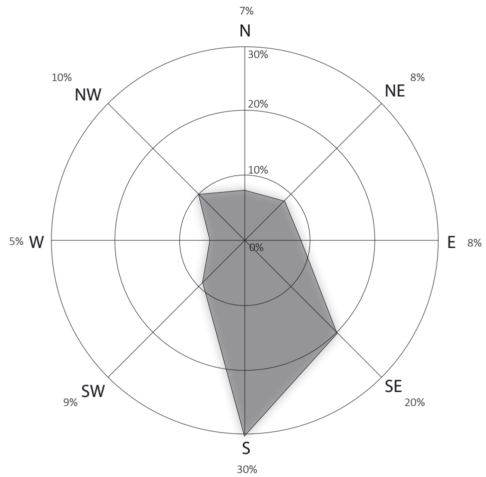


FIG. 16: WIND DIRECTION AS PERCENTAGE OF TIME [Source NCDC]

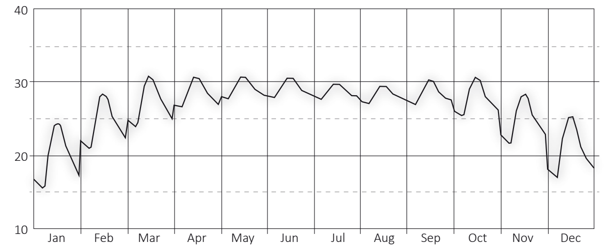
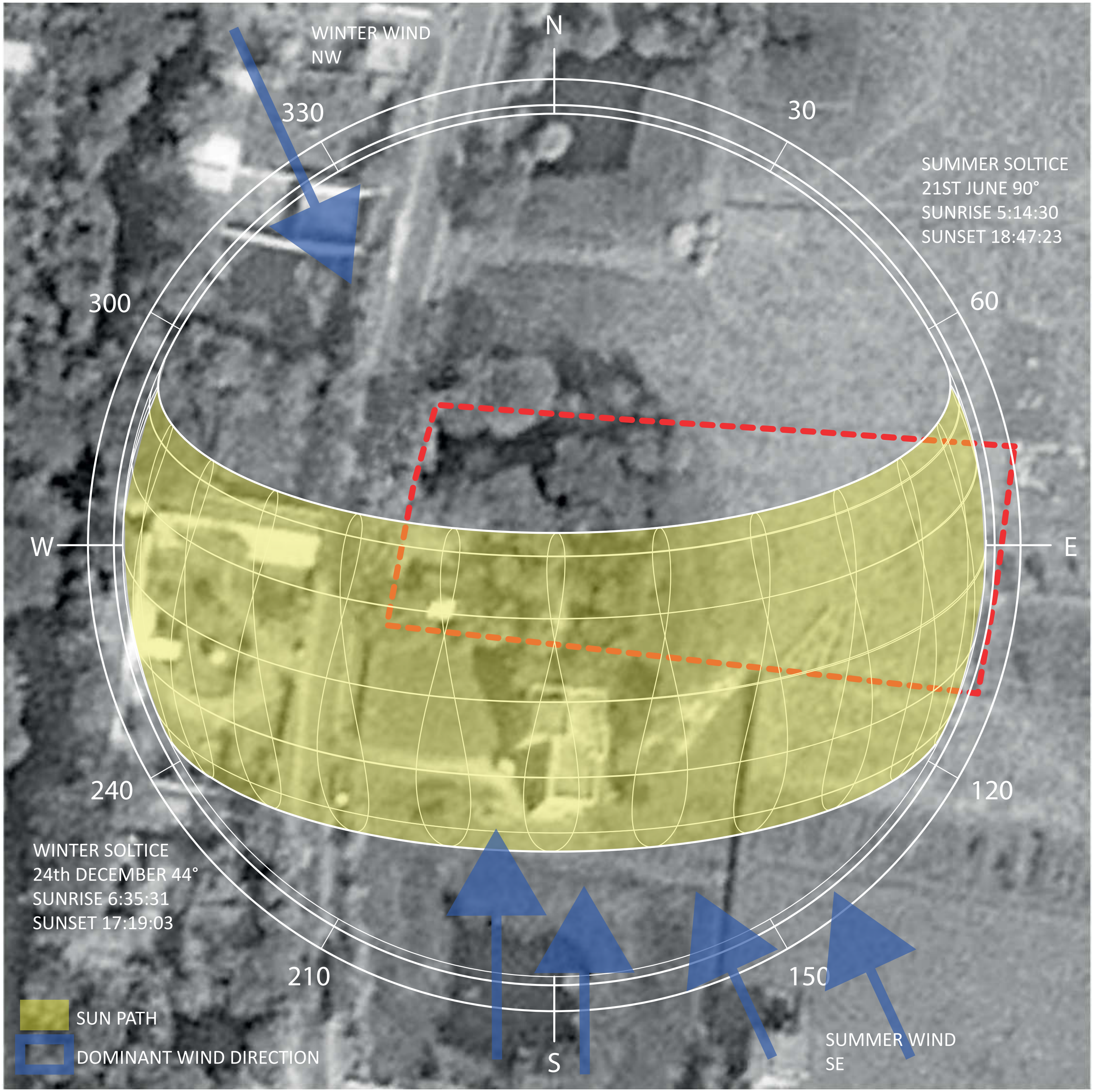


FIG. 17: ANNUAL DAILY TEMPERATURE [Source NCDC]

- Predominant wind direction during summer time is from the South.

- During summer solstice sun angle is 90 degree and winter solstice is 44 degree.

- Cyclonic storms always approach from the direction of the sea towards the coast, the wind velocity and direction relative to a building remain random due to the rotating motion of the high velocity winds.



MAP 7: SOLAR PATH

CALENDAR

FIG. 18: CALENDAR OF THE YEAR [Source Banglapedia]

FIG. 19: FLOOD

FIG. 20: AFTER CYCLONE

FIG. 21: WINTER TIME

FIG. 22: RAINY SEASON

FIG. 23: SUMMER TIME

8

USER COMFORT

FIG. 24: RURAL VILLAGE HUT IN BANGLADESH

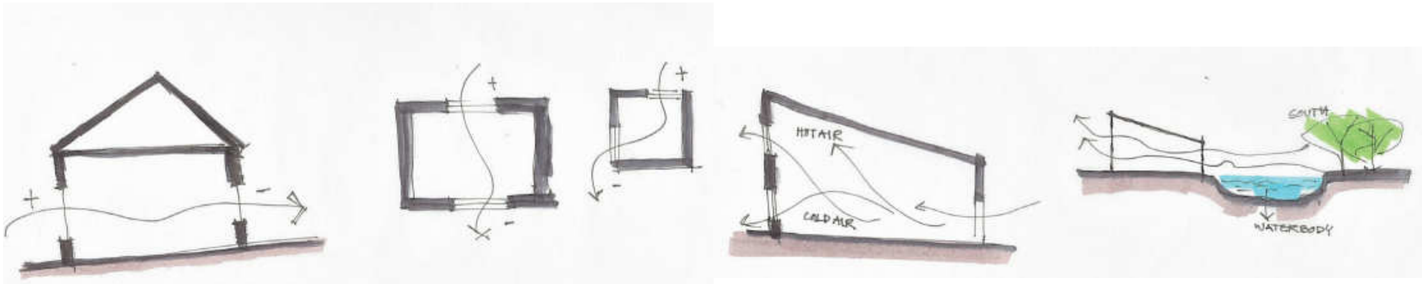


FIG. 25: VENTILATION PRINCIPLES

FIG. 26 a-d: INTERIOR OF RURAL VILLAGE HUT

VENTILATION PRINCIPLES AND DAYLIGHT

For the project, an important aspect of creating a comfortable thermal environment is the proper usage of passive cooling strategies, as the main driver for bringing down the thermal heat towards the outside air temperature. Cross-ventilation is a wind-ventilation strategy where the key is to maximize the pressure difference between the windward and the leeward sides, which in the case of the project would primarily be the south-to-north orientation. (See wind-rose page 24) [Sustainability Workshop] Stack ventilation is an air-pressure based ventilation strategy, where the difference between temperatures in a building causes different air pressures. Hot rising air (due to thermal buoyancy) causes lower pressure higher in the building, which simultaneously causes cold air to enter from below. [Sustainability Workshop] Passive evaporative cooling is a water and wind-based strategy, where the presence of a cold-water body allows for the wind to catch the colder evaporated water, which again makes the air cooler and less buoyant. As such, the air temperature can be cooler, but also slightly more humid before it enters the building. [Kwok, Allison G; 2006]

There are no enforced national building regulations in Bangladesh concerning daylighting requirements, so international standards have been adapted to the project. The Danish building regulations [BR10] states that a room is well lit if there is a minimum of 2% daylight factor. Meanwhile, the British CIBSE [CIBSE 1997] states that a daylight factor of 5% ensures that a room is substantially lit so it doesn't look dull or gloomy. [BR10; 2010, CIBSE; 1997] In the functional requirements, the daylight requirements have been set based on the evaluated importance and general activity conducted in the functional space. The calculations will be done according to the DGNB guidelines [as stated by the CEN / TC 169 WG 11], where the daylight factor is calculated for a grid of points and percentage for the space. [prEN 17037]

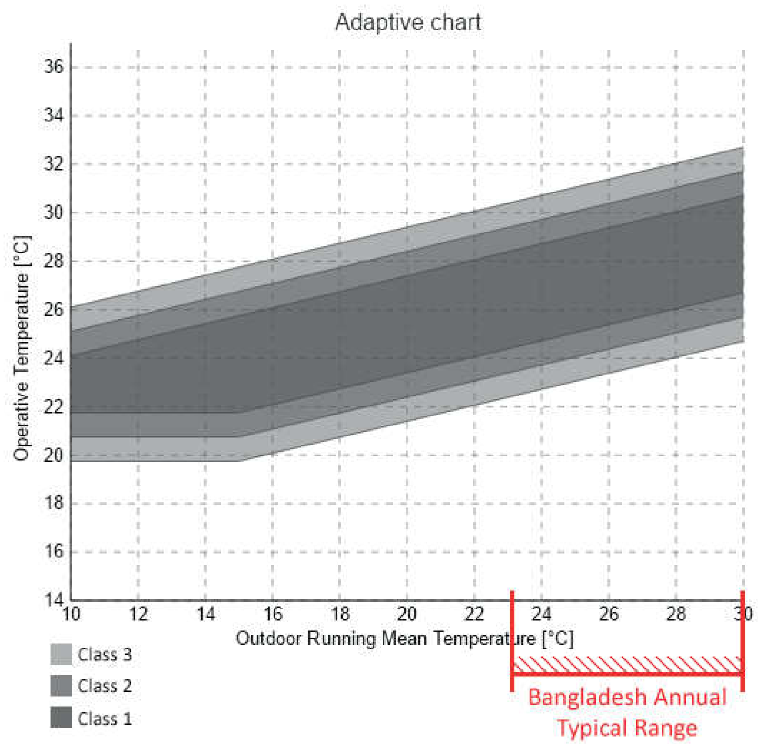
THERMAL COMFORT MODELING

Thermal comfort is a subjective response and is a method of representing the individual occupant's thermal satisfaction with an environment. The thermal comfort in buildings is traditionally evaluated using the PMV-method (Predicted Mean Votes), which is based on empirical surveys of thermal comfort votes from a database of people in diverse environments. The factors playing a role consists of environmental and personal factors, and are listed to fig.27 [Fanger, 1970; ASHRAE-55, 2004].

The problem with this method is that it's inflexible regarding occupant adaptivity (clothing change) and it's not initially conceived to take non-mechanically cooled buildings into account. As such, this leads to the PMV method often over-estimating the discomfort for naturally ventilated buildings in warmer climates. Due to this, a newer model was developed that allows for more adaptivity. The Adaptive Comfort Model is similarly developed on an empirical database, but of users in naturally ventilated environments, and allows for a wider band of comfort. [Brager, Gail; 2003]

An investigation conducted in Bangladesh for traditional rural houses had an annual thermal discomfort percentage of 42,5% where 35,8% of these was due to overheating. Occupants were better able to adapt to cold, either by arbitrary heating methods or a change in clothing, whereas this wasn't a possibility with hot temperatures. The conclusion was that emphasis should be put on designing adaptive controls and mechanisms for preventing high indoor temperatures occurring during the summer. [Shajahan & Ahmed; 2013] For the project, the Adaptive Comfort Chart with the European calculation norms (EN15251) for a new building (class 2) have been designated as the thermal framework for the project.

FIG. 27 THERMAL COMFORT FACTORS



The Adaptive Comfort Chart, edited to show the average annual temperature range, as well as the designated classes and comfort ranges.

Categories of building in EN15251

Category	Applicability/level of expectancy	Temperature range in NV buildings
I	High: Buildings with high expectancy for sensitive occupants	± 2ºK
II	Normal: New buildings	± 3ºK
III	Acceptable: Existing buildings	± 4ºK
IV	Low expectancy only for short periods	> 4ºK

The categories according to the EN15251 version of the adaptive chart. For the project class 2 have been chosen. (Source EN15251)

FIG. 28: ADAPTIVE CHART AND BUILDING CATEGORIES

THERMAL COMFORT CRITERIA

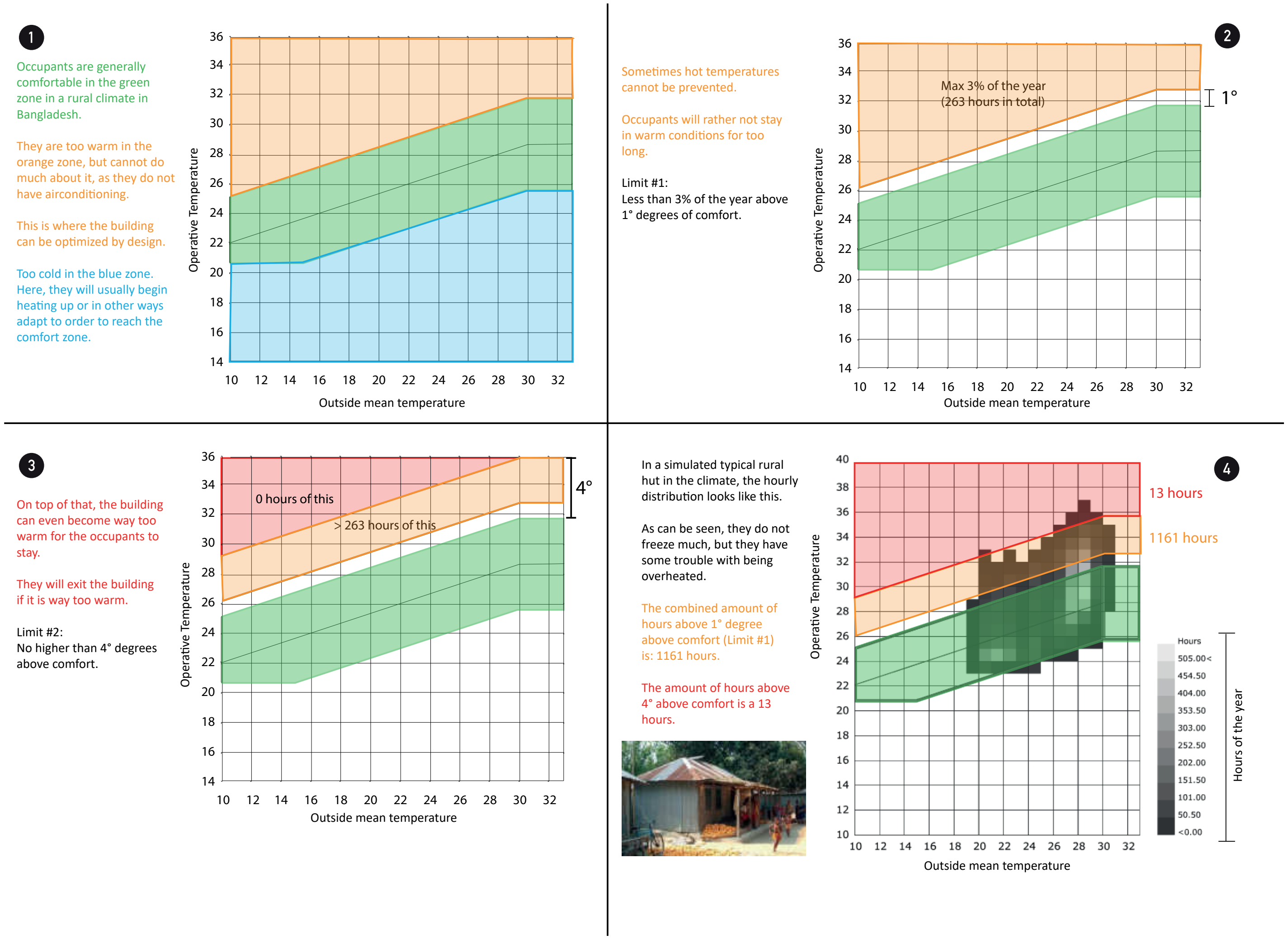


FIG. 29: SETTING THE THERMAL CRITERIA FOR THE PROJECT AND ANALYSES OF A RURAL HUT

As Bangladesh have no thermal building code requirements, there's no recommended guidelines for the thermal over temperature hours. Furthermore, climatic differences deny the usage of established commonly used guidelines. To adapt existing models into usable guidelines, the BS/EN 15251-2007 includes some recent additions for measuring the over comfort exceedance (orange-zone) in naturally ventilated buildings. These additions include:

Criterion 1 states a max. 3% of 1°C degree threshold exceedance (orange zone) of the occupied time. In our case, the buildings are permanently occupied (8760 hours).

Criterion 3 states a hard limit of 4°C exceedance, to which there cannot be any hours in the designated zone (red). [BS/EN 15251-2007, TM52]

Furthermore, to provide comparative limits, simulations have been made for buildings of low (a traditional rural hut of wood/metal-sheet) thermal mass buildings, based on degree hours for these criteria.

For the future design iterations of models, these will in the report be compared to these data, where requirements will be set to achieve degree hours below these models. The adapted criteria will act as a guideline, where these will act as comparative numbers.

COMMUNITY ZONE	AREA (m^2)	NUMBER OF PEOPLE	DAYLIGHT (%)	LEVEL OF PROTECTION DURING STORM SURGES
1. MEETING AREA				
2 MEETING SPACES [INDOOR]	200	70	≥ 3%	Moderate
TOILETS [M/F]	15			
PRIVATE MEETING ROOM	30	12	≥ 3%	Moderate
LOUNGE	45		≥ 3%	Moderate
MEETING SPACES [OUTDOOR]		80		None
AMPHITHEATER		50		None
TOTAL:	**290**			
2. EDUCATIONAL AREA				
2 CLASSROOMS	200	60	≥ 4%	Moderate
WORKSHOP SPACE	70	20	≥ 3%	Moderate
IT/MULTIMEDIA ROOM	50	10	≥ 2%	Adequate
TEACHERS’ ROOM	20	2	≥ 3%	Moderate
TOILETS [M/F]	10			
TOTAL:	**350**			
3. ADMINISTRATIVE AREA				
COMMON OFFICE SPACE	70	8	≥ 4%	Moderate
MANAGER ROOM	15	1	≥ 3%	Moderate
ACCOUNTING SECTION	10	1	≥ 2%	Moderate
LOUNGE SPACE/TEA CORNER	121		≥ 3%	
STORAGE	10			
TOTAL:	**226**			
4. COMMERCIAL ZONE				
CONFERENCE ROOM	100	60	≥ 3%	Adequate
2 DISPLAY SHOPS	20		≥3%	Adequate
DINNING AREA	100	60	≥ 3%	Moderate
KITCHEN	37	2	≥ 3%	Adequate
FOOD STORAGE	10			Adequate
TOTAL:	**267**			
5. RESIDENTIAL AREA				
8 DOUBLE ROOMS	168	16	≥ 3%	Adequate
4 DORMITORIES	114	18	≥ 3%	Adequate
COMMON TOILETS/SHOWERS	36			
LOBBY/RECEPTION	204		≥ 2%	Adequate
TOTAL:	**522**			
6. UTILITIES				
TOILETS	27			
PARKING	3 CARS			None
TECHNICAL ROOM	10			Adequate
GUARD ROOM	10			None
TOTAL AREA:	**1702**			

FIG. 30: RURAL COMMUNITY MEETING

9

FUNCTIONAL REQUIREMENTS

As previously stated, the NGO (CODEC) provides a set of preliminary functional requirements for the project, which in terms would also serve as the proper foundational basis to build the functional requirements upon. During the process, it was decided to divide the requirements for the community center into a community part and a commercial part.

These are then further subdivided into meeting spaces, educational spaces and administrative spaces for the community part, and rentable accommodation and shops for the commercial part.

Each of these areas are then imposed to have a specific set of areas which is comparative to the estimated number of people who will be using the particular function. Furthermore, this also includes the daylighting conditions (Estimations based on functional activity, as Bangladesh has no national codes concerning this) for the rooms.

Finally, the security level of that particular function is serving as an indication of the required protection level it needs to have in terms of structure and elevation (See page 30.)

10

FRAMEWORK/ BACKGROUND REVIEW

FIG. 31: AFTER A DISASTER IN THE AREA

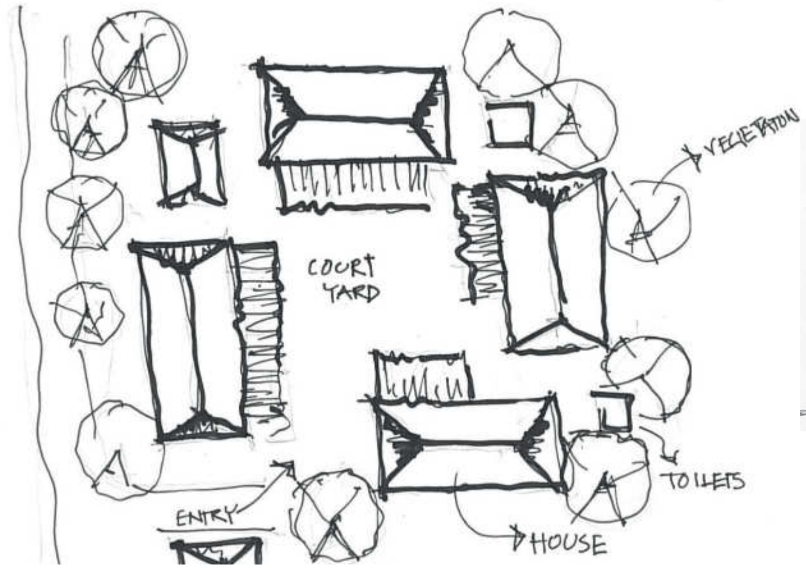


FIG. 32: COURT YARD BASED ARRANGEMENT

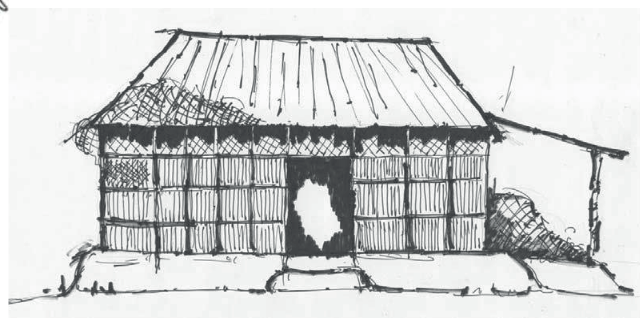


FIG. 33: ELEVATION OF A TRADITIONAL HOUSE

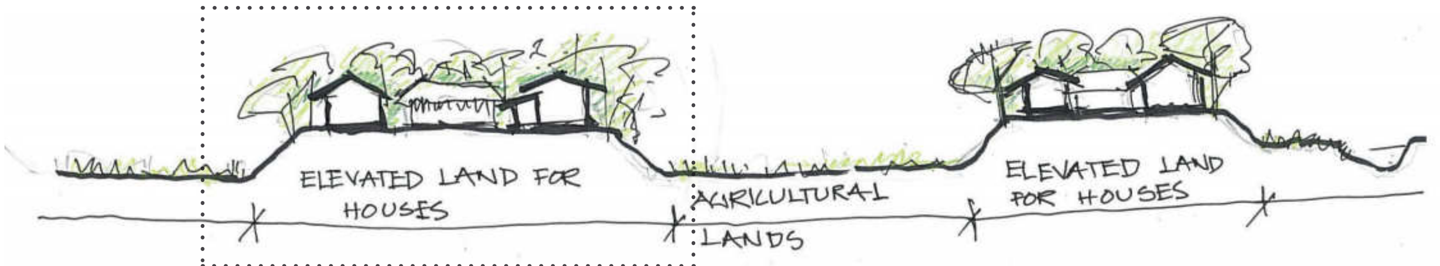


FIG. 34: ELEVATED LAND FOR BUILDING HOUSES

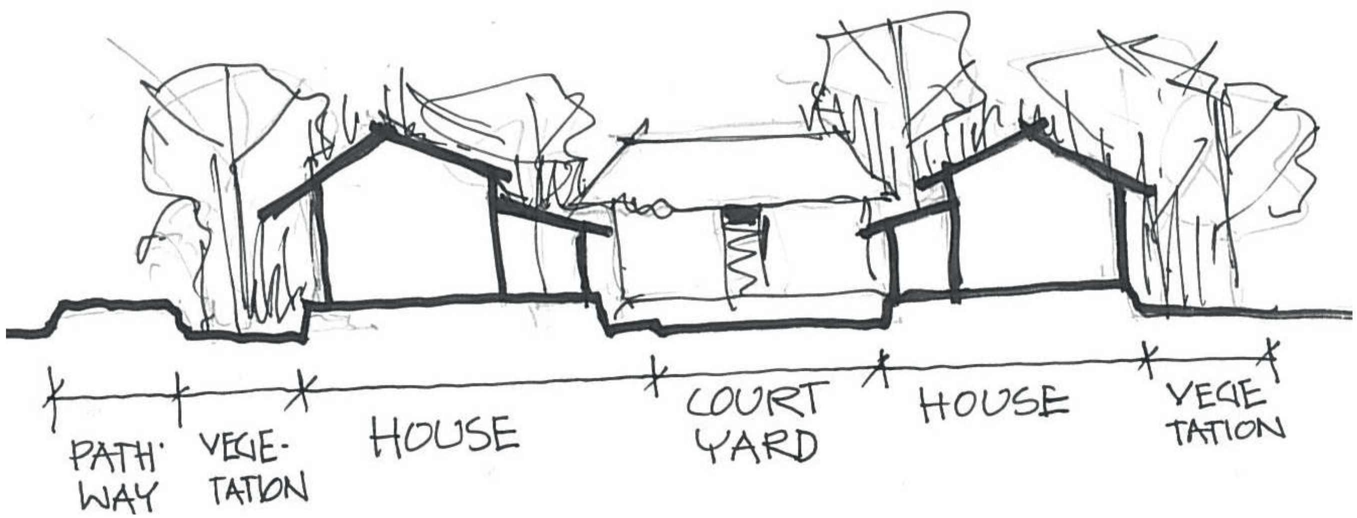


FIG. 35 SECTION OF A TYPICAL CLUSTER OF HOUSES

LOCAL CULTURE AND BUILDING TRADITIONS

Across human civilization factors like climate, economy, society has motivated people in shaping their settlement strategies. From the very beginning of people's settlement practice, housing practice became a symbol of safety and protection for human existence. Whenever people think of housing construction, ecological factors have been given the principal contemplation to cope with the hostile natural calamities and unusual environmental behavior. People around the world still maintain and practice this trend historical, pragmatic and situational in housing construction. Indigenous people across the world have hereditarily been exercising this sort of housing technology for years that includes ecological and environmental reflection [Nasir 2007]. Traditional knowledge is highly significant and experimented paradigm that exists over years from generation to generation [Alam 2016].

The village is an important cultural and spatial concept for the inhabitants of Bangladesh even for the inhabitant in the major cities as Bangladesh is still primarily a rural culture. In rural Bangladesh, the housing process is more vernacular in nature and is developed in relation with the physical environment and to the development of socio-economic and cultural setup. Bangladesh is predominantly a flood plain/delta terrain. For this reason, houses are preferred to be built on high lands and in the case where high lands are not available or scarce houses are built on artificially raised grounds [Hasan, Ullah and Gomes 2000].

Paul Rudolph while talking about the spatial aspects of Bangladeshi villages said "*Maybe this is a romantic thing, but I am fascinated, as everyone is, by the rural villages of Bangladesh. There is a spatial aspect of individual units being very close together, and built on higher land with the surroundings covered with fields under cultivation and sometimes with water. This islands in space give a unity and a meaning to the land which I find truly poetic.*"

In the disaster-prone villages of Bangladesh, the main factors which influence the settlement pattern and housing practice are poor economic condition of the inhabitants and their constant struggle with the natural calamities like cyclones and floods [Alam 2016].

Hasan (1985) mentioned the traditional house in its basic form is a cluster of small 'shelters' or 'huts' around a central courtyard called the uthan. The huts are usually single roomed, detached and loosely spaced around the central court. An extensive landscaping is done to define the house in the surrounding environment. The latrine and bath are never considered as parts of the main structures and are always kept at a distance. The combination of all the huts is called the bari. In the traditional system, bari represents the nuclear, joint or extended family while the huts represent individual households. The courtyard or uthan serves to maintain both unity and individual identity of the families in the house [Hasan,1985, p 29-31].

The courtyard has multi-purpose functions in the rural settlement pattern. It has the functional utility for husking of cereals, drying of jute fibers and clothes etc. [Hasan, Ullah and Gomes 2000]. The courtyard is also used as meeting and discussion place for the rural people. In many cases, the meetings of the NGO workers with the rural inhabitants are also executed in the courtyards. Sometimes folk musicians play music in the courtyards.

The dwellings in the villages are constructed mainly by people who are living in those houses. The services of architects or engineers are not available in the rural areas. So people use their traditional knowledge to build their houses. So these dwellings in the coastal villages can also be termed as non-engineered houses. The design and internal planning of the houses are very much dependent on the inhabitant's economic conditions and family requirements [Alam 2016]. However, the houses are different from each other but they still have some common characteristics in their construction. Each house has three distinct parts. These parts are the plinth, the enclosure and the roof [Muktadir and Hassan 2001].

FIG. 36: A HOUSE IN THE COASTAL VILLAGE WITH HIPPED PITCHED ROOF MADE OF CI SHEETS

FIG. 37: RURAL MEETING WITH AN NGO EMPLOYEE IN THE COURTYARD

FIG. 38: OUTDOOR FOLK MUSIC PERFORMANCE UNDER THE TREE

The plinth is normally raised from the ground level. The height of the plinth is generally between 0.5 meters to 1 meter. Almost all of the dwellings in the rural areas use local mud for the construction of the plinth and floor. The enclosures of the houses are made with bamboo and CI sheets as they are easily available in those areas. The structural frame is generally made with bamboo posts and beams in some cases concrete posts with bamboo beams are also used. The walls are then attached to the frame with nails, bolts or metal wires. Cross bracing is generally not used in the structural frame. The roofs are generally built with CI sheets or straw.

Traditionally the use of straw or leaves for roofing material was very common. But in the recent times, the use of CI sheet for roofing material became really popular as they have a comparatively longer life span and they have also become easily available and affordable for the inhabitants of the rural communities. There are mainly two variations of the pitched roofs. They are the hipped or the gable pitch roof. The roofs are usually projected from the walls to protect them from rainwater. The dimension of this overhang generally ranges between 0.2 meters to 0.4 meters [Alam 2016].

The people in both the rural and the urban areas of Bangladesh prefer open fields for large-scale gatherings especially for cultural festivities. Gathering of people for different activities under the shade of a tree in an open field is a very common practice in the rural Bangladesh.

FIG. 39: GATHERING UNDER THE SHADE OF A TREE

RURAL LEARNING ENVIRONMENT

Louis Kahn often spoke of his notion that the first school *"Began with a man under a tree who did not know he was a teacher, sharing his realization with a few others who did not know they were students."* The traditional learning environment in Bangladesh also incorporated this informal nature of knowledge sharing. This kind of traditional schools or learning platforms were known as "Pathshala". The pathshala was usually set up by an instructor called guru, who ran the center as his private concern. There were also pathshalas established at the initiative of the community. The pathshala system in Bengal was in existence from very early times and it continued until the system began to erode under the pressure of the new education policy of the British colonial government in the nineteenth century [Banglapedia 2015].

The pathshala was an open air institution having no paraphernalia like permanent structures, furniture and staff. A pathshala carried no name. It was usually known to people by the name of the guru (teacher) who ran it. The pupils sat on the ground. They were, however, free to bring from home their own gears to sit on, such as small-sized mats made of cane, bamboo reeds, barks, leaves etc. The guru maintained his honor and difference with the rest by sitting on a wooden stool, which was again brought from home. As the guru maintained the pathshala all alone as an enterprise, he admitted students to the limit he could well manage [Banglapedia 2015].

Even though the pathshala system has been replaced by the more modern formal educational system still many elements remain from the traditional system. The classrooms in rural Bangladesh still have the openness in nature. In many schools, students still sit on the ground in the classrooms to study and use a really small amount of furniture like chairs and tables. Outdoor classrooms under the shade of a tree are also very common in rural Bangladesh.

FIG. 40: VILLAGE CLASSROOM

FIG. 41: OUTDOOR CLASSROOM IN RURAL BANGLADESH

FIG. 42 a-b: AZUMA HOUSE. ARCHITECT: TADAO ANDO 1976

FIG. 43: SÄYNÄTSALO TOWN HALL. ARCHITECT: ALVAR ALTO 1952

FIG. 44: KANDALAMA HOTEL, SRILANKA. ARCHITECT: JEOFFREY BAWA

CRITICAL REGIONALISM

Regionalism in architecture typically denotes an architecture which is derived directly from its local settings. An architecture derived from a regionalism concept becomes inherently site specific, responding to the local climate and culture.

In regards to modernity and the language of modernism, regionalism have often fallen in opposition. Where regionalism at times becomes conservative and resorts to blind use of vernacular architecture, critical regionalism on the other hand tries to focus on architectural traditions that are rooted locally. As such, critical regionalism is more of a form of architecture which that embraces modern architecture in a critical way, and unifying it with the local traditions that responds better to the social, cultural and climatic conditions of the region. As such, critical regionalism is "*a style, which counters lack of identity and placelessness in modern architecture by relating to the building's geographical context*". [Agrawal, 2013]

The term "Critical Regionalism" itself was first coined by theorists Tzonis and Lefaivre, but later on advocated more famously by historian-theorist Kenneth Frampton in his essay "Towards a Critical Regionalism: Six points of architecture of resistance". In the essay, Frampton argues that it is vital to adopt the universal values of modernism, while at the same time considering the local contextual elements, which includes the climate, light, topography and the "local tectonic form". As such, critical regionalism becomes more than just regionalism, by also portraying how the different cultural elements and concerns of the world can be integrated. [Palmer, 2008]

BUILDING IN A DISASTER PRONE AREAS

The vulnerability of a settlement to a cyclone is determined by its siting, the chances that a cyclone will occur, and the degree to which its structural stability can be damaged by it. Buildings are considered vulnerable if they cannot withstand the forces of high winds. [Agarwal, 2007]

Therefore, it is true that a well-built and properly-engineered masonry house gives more safety than other building typologies, but on the other hand, safe housing can be and has been made by a variety of other materials such as wood and many others.

The buildings in cyclone-prone areas need to be built on solid ground. Furthermore, partial construction on solid ground and partial construction on made-up ground must be avoided. Even though the wind direction during cyclones is random, effort should be taken to have a natural shielding from the wind either in the form of a hillock or a group of trees. It is possible that the tree can damage the house, so it is important to keep at least the distance from the house 1.5 times the tree height. As cyclones are followed by floods, construction on low lying areas should be avoided. [Patnaik, 2015]

In regards to planning solutions in disasterprone areas for houses. All houses should be built in a group. Houses in a group should also be unequally arranged in the plan in a way that can reduce the effects of cyclones and storms. [Cao Duy, 2007]

Simple, compact, symmetrical shapes are best. The square plan is better than the rectangle since it allows high winds to go around them. [Agarwal, 2007]In addition to this, houses which has L, T or U shapes also need to be avoided, as that can easily create wind suction locations during the cyclones.

RECOMMENDED NOT RECOMMENDED

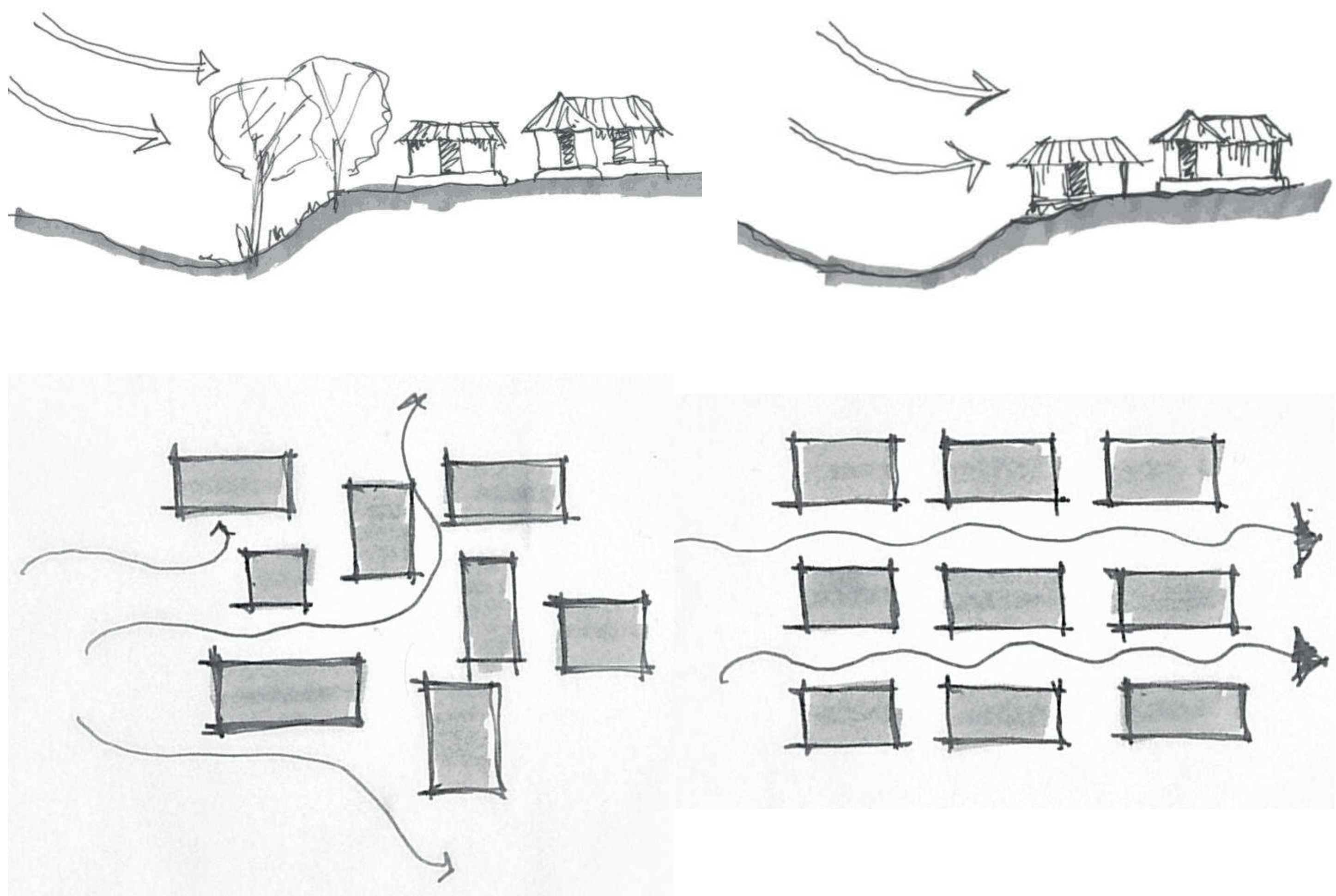


FIG. 46 a-b: RECOMMENDATIONS FOR THE BUILDINGS

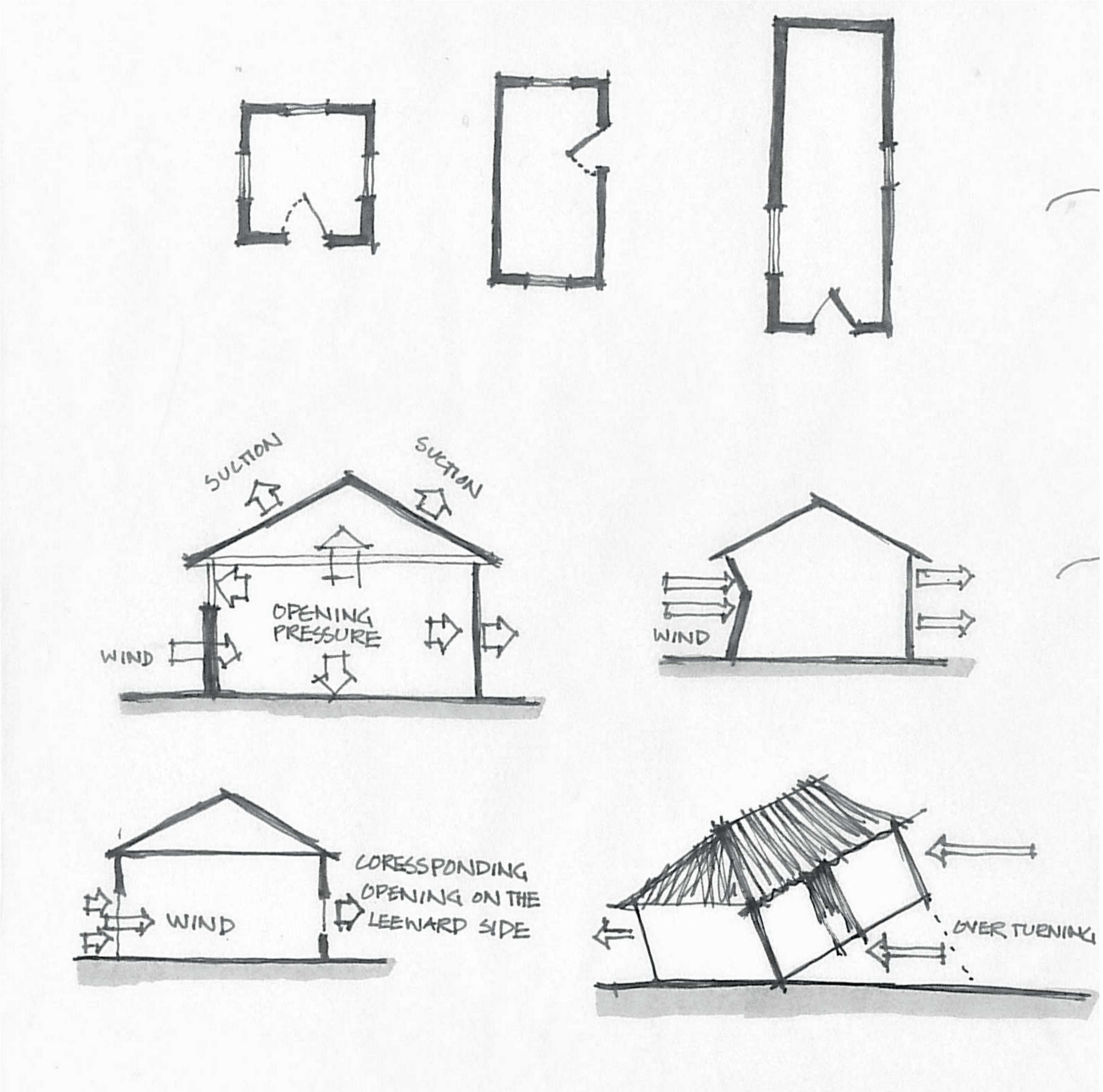


FIG. 47 a-e: PLAN RECOMMENDATIONS AND WIND EFFECT

Therefore, double perforated facade helps not only for ventilation purposes, where the air can flow in the intermediate cavity, but also, closed facades reduces the wind forces. In case it is decided to create other shapes, efforts should be made to strengthen the corners. If longer shapes are used, they must be designed to withstand the forces of the wind. For the rectangular houses, a length of no more than 3 times the width results in preferable layout .

Reinforce concrete roof are preferable to lightweight flat roofs, as they are not easily blown off in strong winds. In order to lessen the effect of the uplifting forces on the roof, the roof pitch should not be less than 22º. Hip roofs are better, as they have been found to be more cyclone resistant than gable roofs, because the suction pressure pulling the roof apart from the building is about 80% less in the case of hip roofs than gabled roofs. Besides the very high-velocity winds, the coastal areas suffer from the onslaught of seawater over the coast due to storm surges generated by cyclones. A storm surge is the sudden abnormal rise in sea level caused by cyclones. The surge is generated due to interaction of air, sea and land. The seawater flows across the coast as well as inland and then recedes back to the sea. Huge loss of life and property takes place in the process. The height of the storm surge is even higher during the period of high tides [Mishra, 2001]

Wind pressure through openings on the windward side increases the pressure on internal surfaces. In combination with the external suction, thus could potentially cause the roof to blow off and the walls to explode. A second mode of failure occurs during windward wall collapse. Finally, there's the problem of overturning for light structures, which occurs during insufficient house weight. [Agarwal, 2007]

Finally, it is recommended that cyclone-affected people should follow construction procedures of structurally strong and stable houses during the construction/reconstruction of their houses. They should also take some preventive measures to resist their houses from strong wind forces. [Alam, 2016]

CASE STUDY 1
PANI COMMUNITY CENTER

Architects: SchilderScholte architects
Location: Rajarhat, Bangladesh
Area: 910.0 sqm
Project Year: 2014

The Pani Community Center is a center meant for the local population in the region. The focus during the design process have been to utilize available materials and climatic conditions found locally. This includes elements such as, hand-shaped brick, Mango wood, reused steel, local mortar and wafer-thin recycled corrugated panels are the main materials used in the building.

One of the key aspects upon the development, was to provide a center that would be able to encourage the local people to learn the principles of sustainability and structurally durable building concepts with local building materials. An example of this is the usage of bamboo for the roof construction, despite the general local view of it being a weak material. In terms of thermal comfort, the buildings orientation ensures that natural cross-ventilation is used as a mean of passive cooling, thus rendering electric ceiling fans unnecessary. The suspended roof provides with shading and protects the primary openings against rainwater, whilst still allowing for the collection of rainwater in the courtyard.

The overall scale and dimension is optimized in order to emphasize optimal daylight conditions whilst minimizing direct sunlight into the classrooms. The usage of evaporative cooling where the draft from the local ponds is also applied. Finally, the utilization of cheap local bricks also reduces the amount of construction wood, where lightweight concrete floors is combined with bamboo. [Archdaily, 2015]

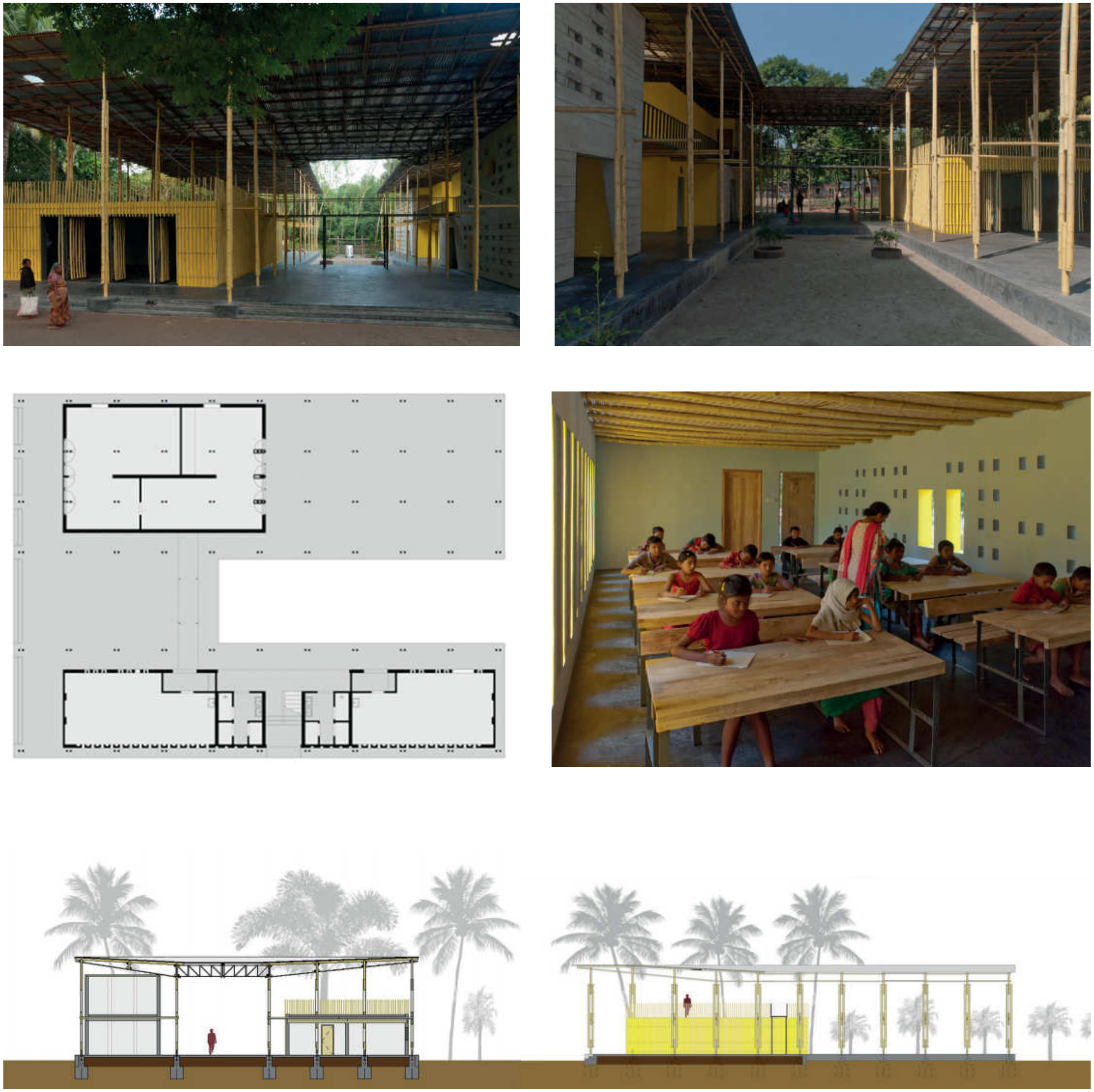


FIG. 48 a-f: PANI COMMUNITY CENTER DRAWINGS, INTERIOR AND EXTERIOR

FIG. 49 a-e: FRIENDSHIP CENTER DRAWINGS AND EXTERIOR

CASE STUDY 2
FRIENDSHIP CENTER

Architects: Kashef Mahboob Chowdhury/URBANA
Location: Gaibandha, Bangladesh
Area: 2897.0 sqm
Project Year: 2011

The friendship center in Gaibandha, Bangladesh is run by an NGO and targeted towards the local community from in the mainly riverine islands (chars), as a place for cultural events and socialization. The center serves and brings together some of the poorest people in Bangladesh, described as a place that:

"*search for the luxury of light and shadows of the economy and generosity of small spaces; of the joy of movement and discovery in the bare and the essential*." - Archdaily

The local region in which Gaibandha is situated, is protected by an embankment that protects the agricultural low-lying lands from flooding. The design relies on this surrounding embankment for protection against flooding, it's structurally built directly against the existing soil with load bearing masonry.

In the project, the rainwater is collected in internal pools, while the excess water is pumped off to another pond, which is to be used for fishing. Major important principles of the project are passive cooling through natural ventilation, which is emphasized by the organization of courtyards and the roofs being covered with earth. In order to make sure that flood water does not mix with sewage water, an extensive network of septic tanks and soak wells have been made. [Archdaily, 2013]

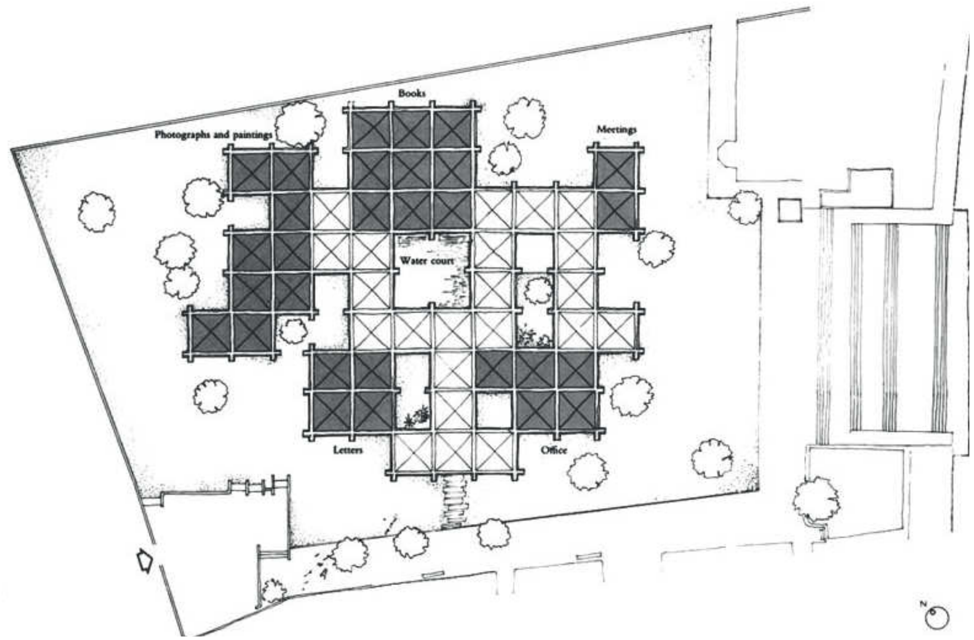
CASE STUDY 3
GANDHI MEMORIAL MUSEUM

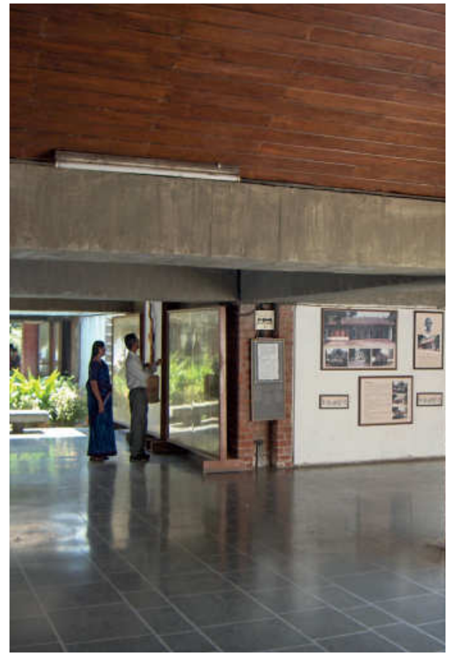
Architects: Charles Correa
Location: Sabarmati Ashram, India
Area: 1836.0 sqm
Project year: 1963

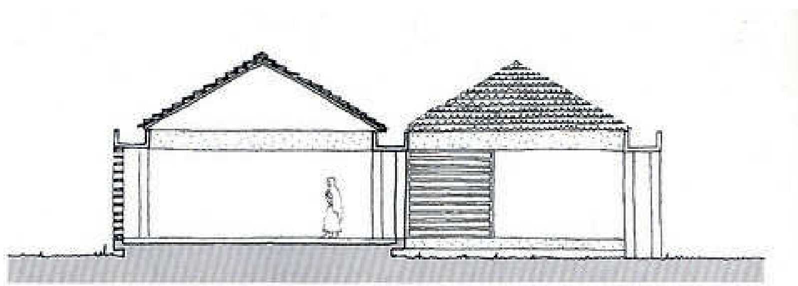
The memorial museum built in 1963 and dedicated to Mahatma Gandhi is located in the same ashram, where Gandhi lived from 1917 to 1930. [Architexturez, 2013]

The building is located on the Sabarmati River Bank, where it part of yet another ashram complex, where the museum is integrated into its gardens. The building, designed by the architect Charles Correa, made it in modular reinforced concrete units (both open and covered) of 6x6 meters to *reflect on the simplicity of Gandhi's life and the incremental nature of a living institution.*

Furthermore, the modularity provides for the possibility of expansion, as well as Correa's subtle changes to the enclosure, which would give a variety of lighting, temperature and visual permeability. The simplicity of the modular approach is continuous through the use of materials such as stone floors, brick walls, wooden doors, riled roofs and glass-less louver windows. These modular units are grouped asymmetrically as an analogy of the traditional Indian village, with meeting points, seemingly randomly placed buildings and connecting pathways. [Gutschow; 2014]







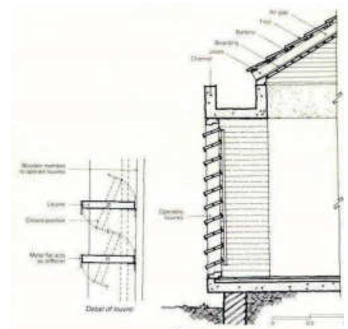
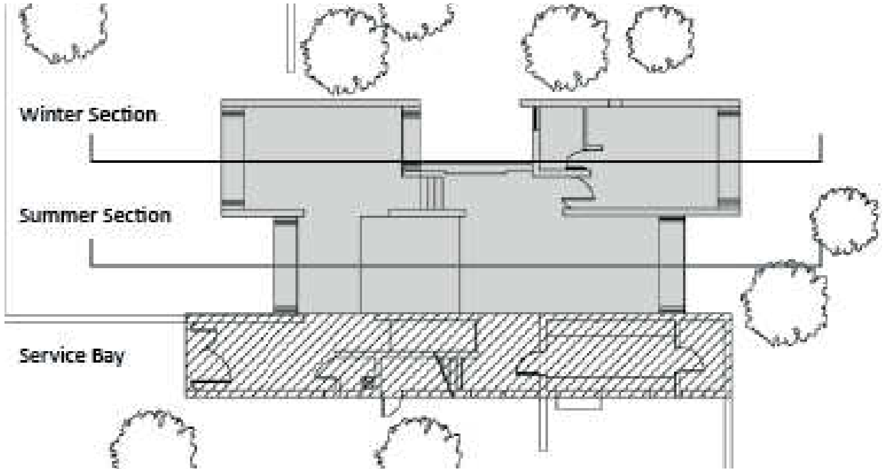
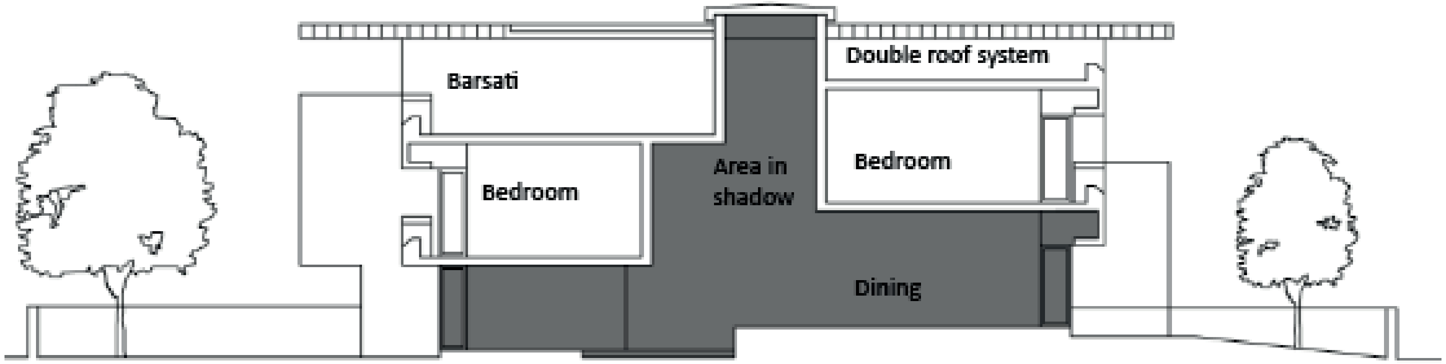


FIG. 50: GANDHI MUSEUM DRAWINGS, EXTERIOR AND INTERIOR



Summer Section



Winter Section

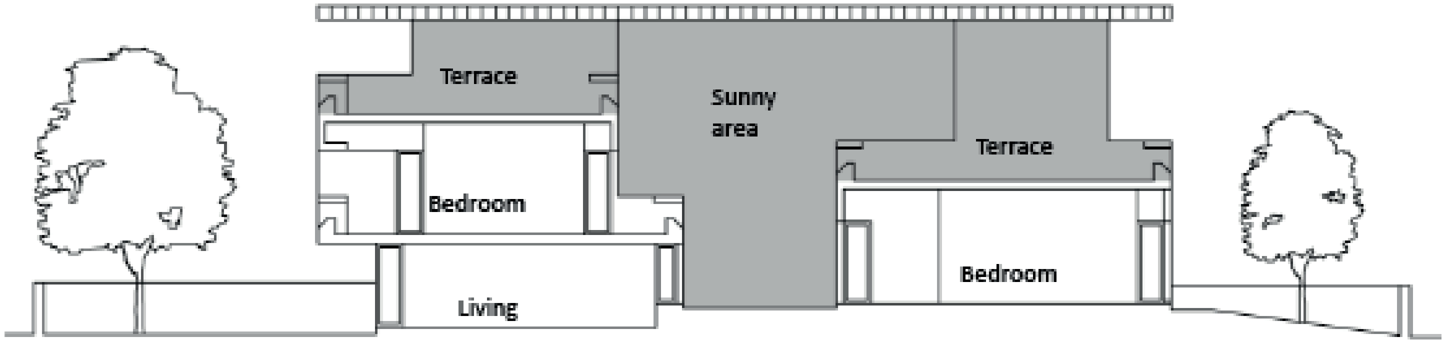


FIG. 51: PAREKH HOUSE DRAWINGS, EXTERIOR AND INTERIOR

CASE STUDY 4
PAREKH HOUSE

Architects: Charles Correa
Location: Ahmedabad, India
Area: 215.0 sqm
Project year: 1968

This house is important for its two sections. One termed the Summer Section (to be used in a daytime), protects the interior from heat, the other, termed Winter Section (to be used in the early mornings and the evenings), opens up the terraces to the sky.

Since this site faced east - west, this house consist of three bays, with the Summer Section sandwiched in between the Winter Section and Service Bay (for circulation, kitchen and toilets) on the other side. The bearing walls are made from bricks, which express directly the climatic concepts.

INSPIRATIONS

These inspirations show even deeper project focus to the local culture, local materials, simplicity in the constructions and aesthetics in architecture. It is important to mention that most of all these projects were made not only in the low budget, but also the local community built it together with a project architect.

It is also inspiring that it has nice architectural qualities, such as sustainability, good indoor comfort, enough daylight and atmosphere, which creates inside different perceptions of the spaces.

FIG. 52: DESI CENTRE, BANGLADESH, ARCH: A. HERINGER

FIG. 53: HOMEMADE - FAMILY HOUSES IN BANGLADESH, ARCH: A. HERINGER

FIG. 54: METI SCHOOL INTERIOR, BANGLADESH, ARCH: A. HERINGER

FIG. 55: BAIT UR ROUF MOSQUE INTERIOR, ARCH: M. TABASSUM

FIG. 56: METI SCHOOL, BANGLADESH, ARCH: A. HERINGER

FIG. 57: BAIT UR ROUF MOSQUE IN BANGLADESH, ARCH: M. TABASSUM

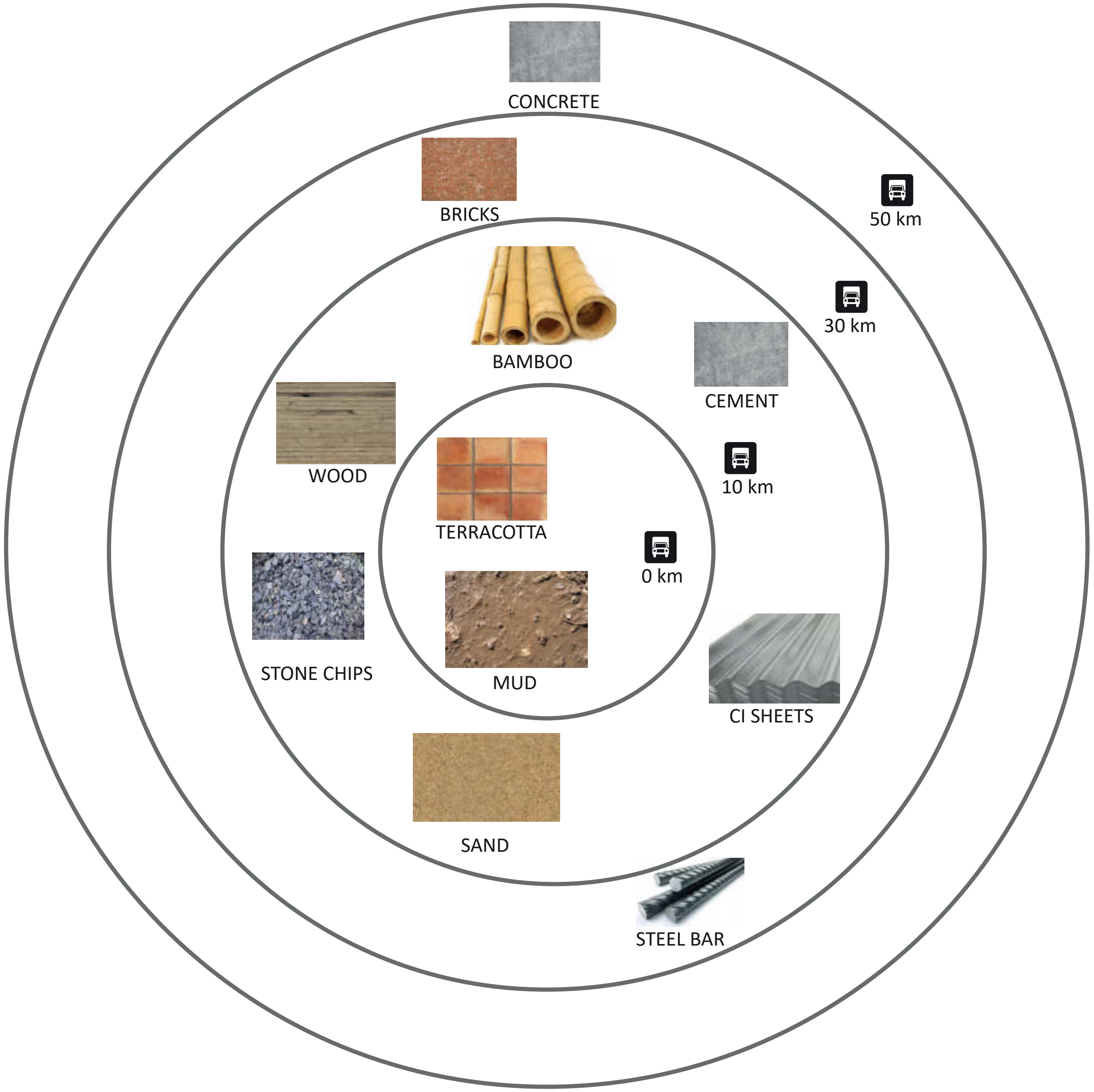


FIG. 58: LOCALLY AVAILABLE MATERIALS

LOCAL MATERIALS

As a general rule, natural materials tend to have a lower embodied energy (energy required to produce the goods) and toxicity than artificially created materials. As such, naturally occurring materials also require less processing and are less damaging to the environment. Furthermore, many of these are theoretically renewable. As a result, when the materials are incorporated into building products, these products themselves become more sustainable.

Another bonus of local materials is that it shortens the transport distance, thus also reducing pollution by vehicles. Often, local materials are not only better suited to the weather conditions found in the region, but also supports the local economy by purchases going directly to local manufacturers. If external materials are the only options, these materials should be selectively chosen and imported in small volumes. [Kim, 1998]

All these materials, such as cement, bricks, bamboo, wood, stone chips, sand, CI sheets and steel bars are easily achievable in 50 km distance from the site area.

Bamboo is the cheapest, most easily transported building material. Houses made of bamboo can be extended easily when more money is available later and it is the choice of those on the lowest incomes. [Seroj, 1999] Probably it is one of the reasons why it is going to be used bamboo in the project design.

Another popular and easy to get material is bricks. It is strong and resistance, these qualities are important to have in the project, in according to the keep building save during the storms and floods.

Worth to mention also concrete, because previously mentioned qualities about resistance in the dangerous situations are vital. It is hard to avoid concrete buildings, where are so many disasters.

11

DESIGN PROCESS

FIG. 59: FIELDS

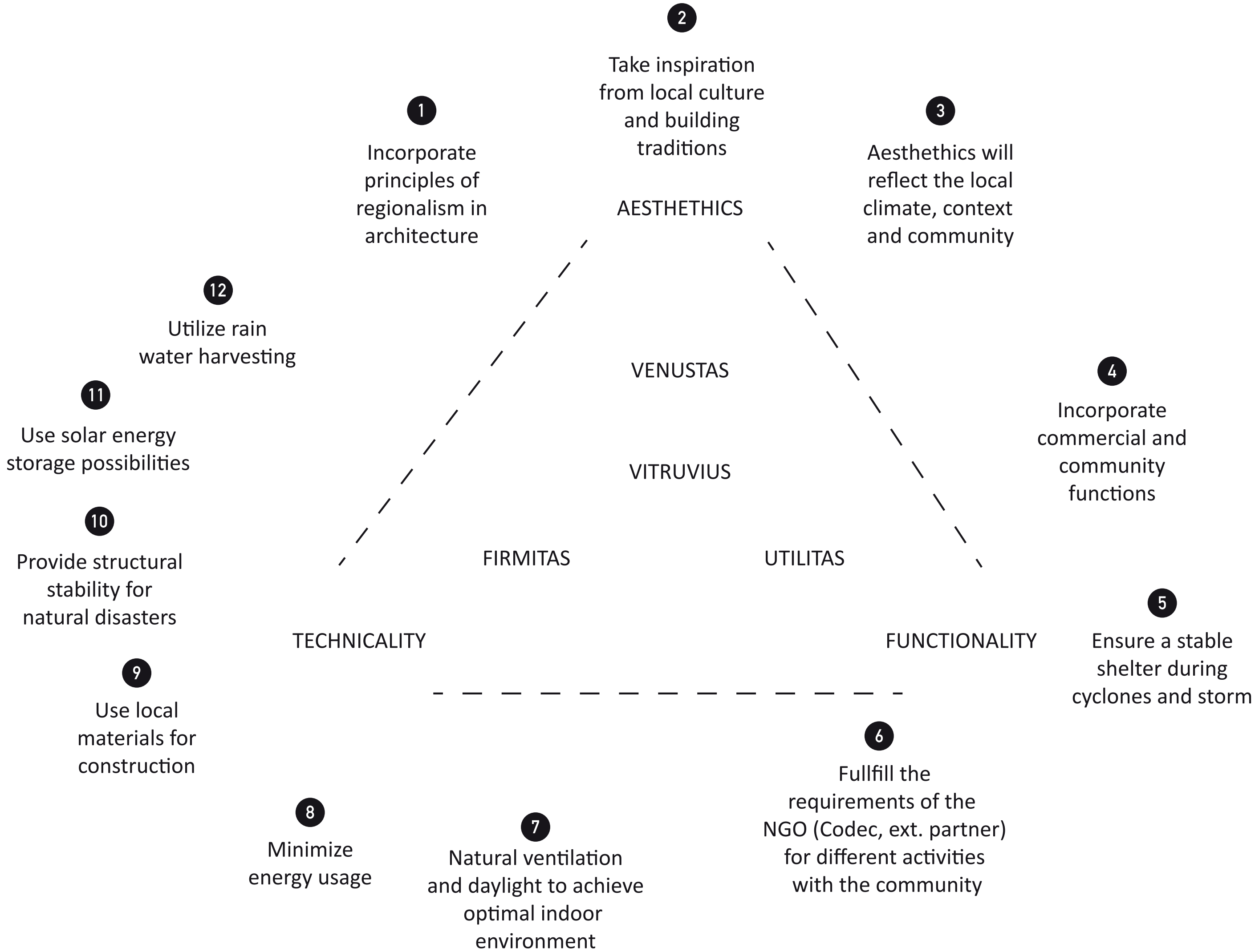


FIG. 60: DESIGN CRITERIA DIAGRAM

DESIGN CRITERIA

The development of our design criteria was inspired by the Vitruvius triangle (Firmitas, Utilitas, Venustas). Our interpretation was to develop our design criteria in relation to three main focused areas; Aesthetics, Technicality and Functionality.

The design criteria for the aesthetic expression of the project were developed by prioritizing the concepts of critical regionalism. The focus was given in taking inspirations from local culture and building traditions. The reflection of local climate, context and the community was an integral part of our aesthetic expressions.

The criteria regarding the functionality of the project was conceived keeping in mind the functional requirement of our external partner. The incorporation of community and commercial functions in a single project was one of the major concerns. As the project is located in an extremely disaster-prone area, an important criteria was to create safe zones during natural disasters like cyclones and flooding.

For the technicality of the project it was determined to make use of rainwater harvesting, solar energy storage, ensuring resilient structure during the disasters and using local materials , which is easy to transport and readily available. Also, it was considered to minimize energy usage by providing opportunities for utilizing natural ventilation, ensuring good daylight conditions and maintaining optimal indoor environment.

As it was described from the beginning that this project has special conditions and needs to sustain during the disasters so all the criteria are considered to support the sustainability of the project.

DGNB CRITERIA

The DGNB criteria have been set out and adapted as criteria foundation for the design proposal, where these will have a supplementary role for the main design criteria (see page 47). The DGNB criteria are divided into 4 overall categories of subjects.

Sociocultural and functional qualities are highly prioritized in the project and align well with the defined design criteria, which concerns general comfort quality (where especially the thermal is prioritized) as well as the ability for having user controlled elements.

The site quality not only includes the general space quality in terms of function, aesthetics and handicap accessibility but also access in terms of public access in terms of inviting aesthetics.

Finally, environmental quality and economic quality includes some overarching sub-criteria, such as environmentally friendly and sustainable construction and material usage of the building, but also the functional usage of on-site resources, cheap local resources and the overall flexibility and adaptability of the functions within the community center.

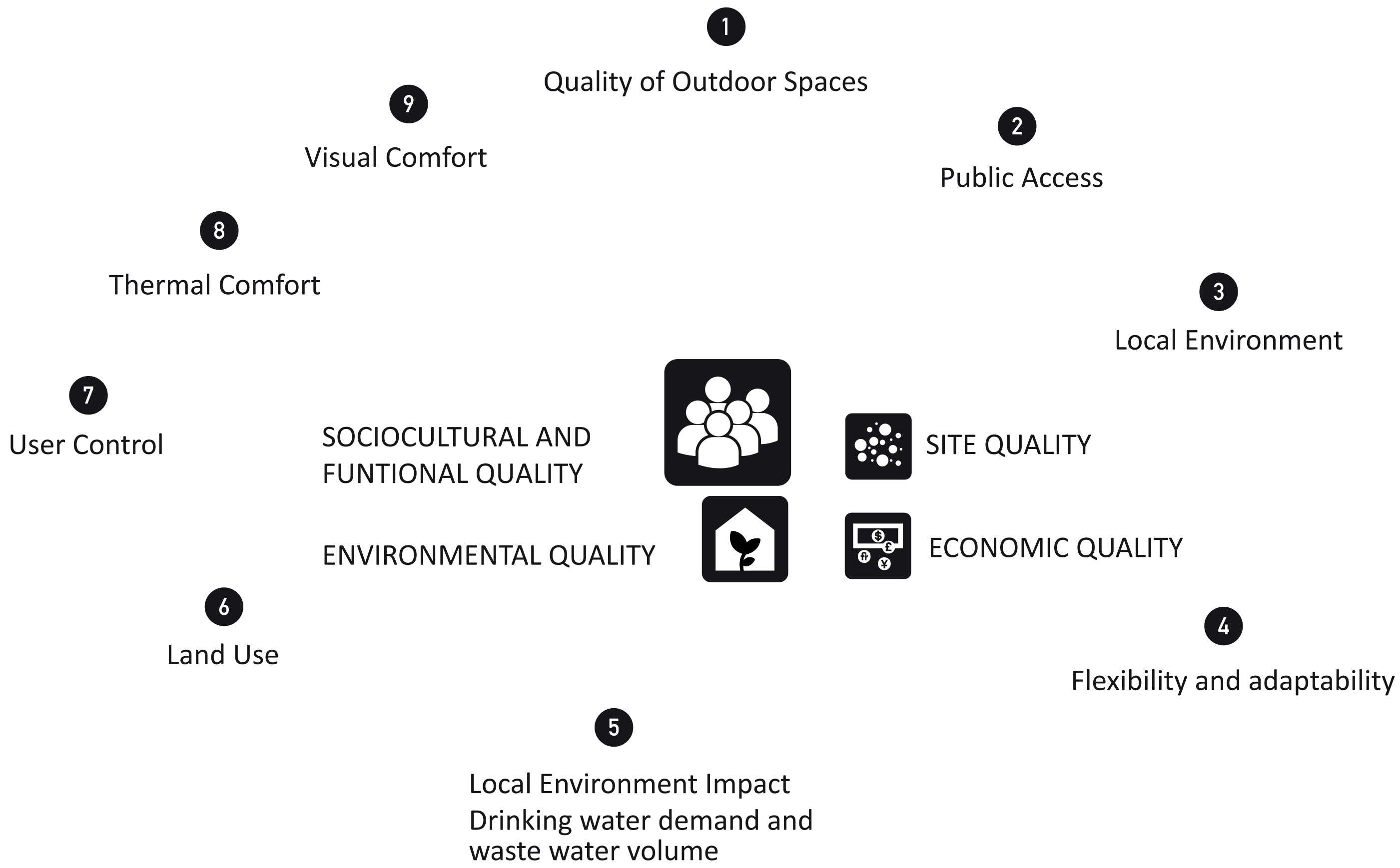


FIG. 61: DGNB CRITERIA DIAGRAM

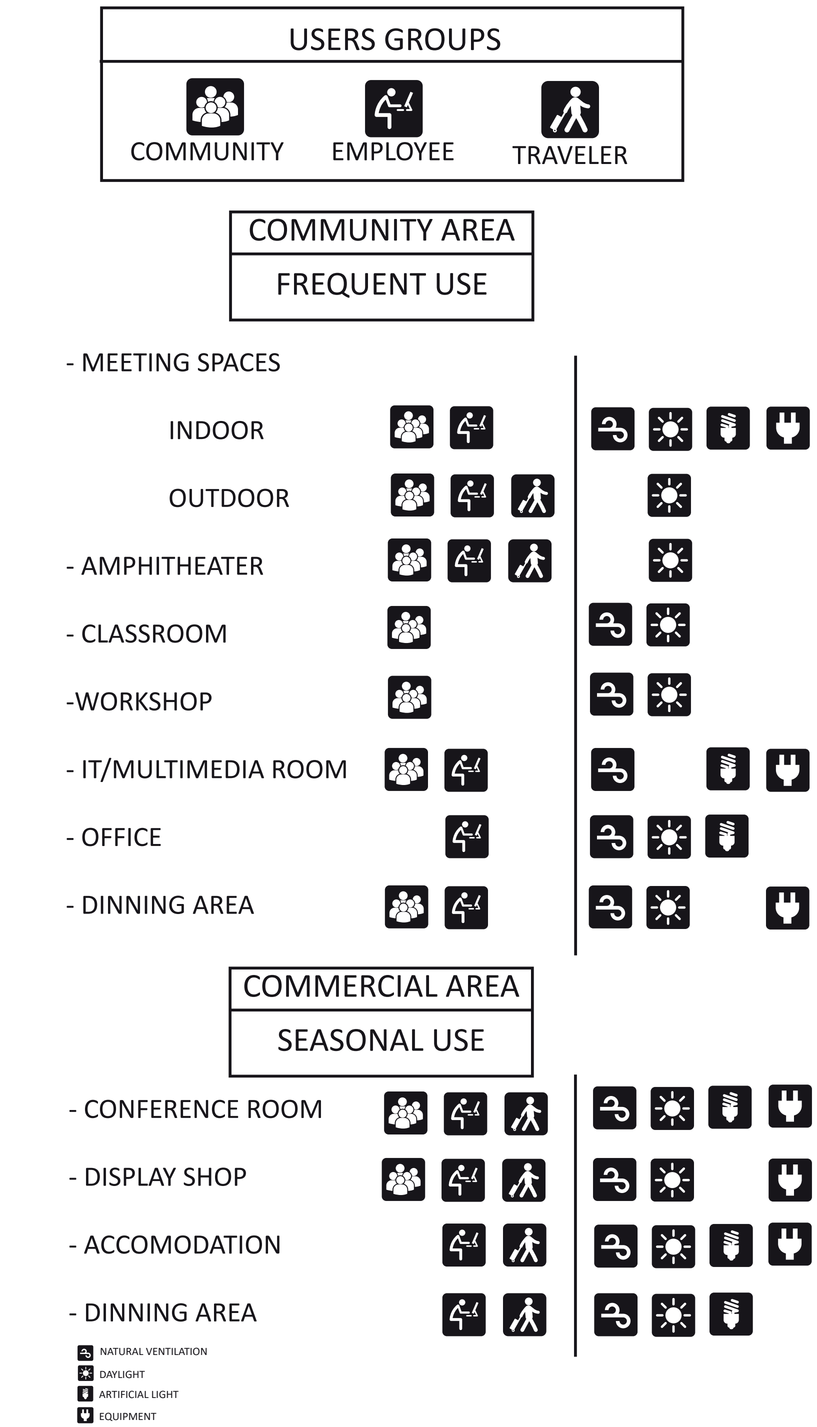


FIG. 62: USERS DIAGRAM

FIG. 63: COMMUNITY MEMBERS

FIG. 64: EMPLOYEES

FIG. 65: TOURISTS

USERS AND FUNCTIONS

As the project is a community center, the major functional criteria are to provide spaces where the community can meet and participate in a range of activities.

Our external partner is an organization who also has their diverse programs with the local community for their development and awareness building. So the functional areas for the community space include meeting spaces, classrooms, workshops, amphitheater, IT room, Dining area and office space.

The location of the project is also a tourist attraction. Many people travel in Kuakata especially in December to February period as the climate is cooler then. So for the economic sustainability of the project, functional areas focusing on the tourists were also developed. Accommodation area, Display shops, and a conference room were provided for this purpose.

In this scheme, it is also shown what areas are going to be used by which user group and what in different places are prioritized to have, for example natural ventilation, good daylight conditions, artificial lights and electrical fixtures.

PROTECTED AREAS DURING STORM SURGES

One of the conceptual considerations for the project was to ensure the functionality of the community center during natural calamities. For this purpose a protective strategy was developed to prioritize most important functions which can ensure the viability of the project.

Areas which are less important or do not have electronic devices can be flooded during the extreme situations. Most of these areas are outdoor spaces, and no great damage will be inflicted even those areas are flooded.

When the water rises less than one meter [average flood level] it is ensured that all necessary functions will be usable. Finally, when the flooding reaches maximum flood level [2m] meeting areas, classrooms and workshop areas will be flooded.

In the mostly protected areas, it was decided to put the rooms with technical equipment, where people can also have shelter during the disasters. The residential facility is also in this area. Dining and kitchen are also kept in the most protected area as it can help the residents during the flooding period.

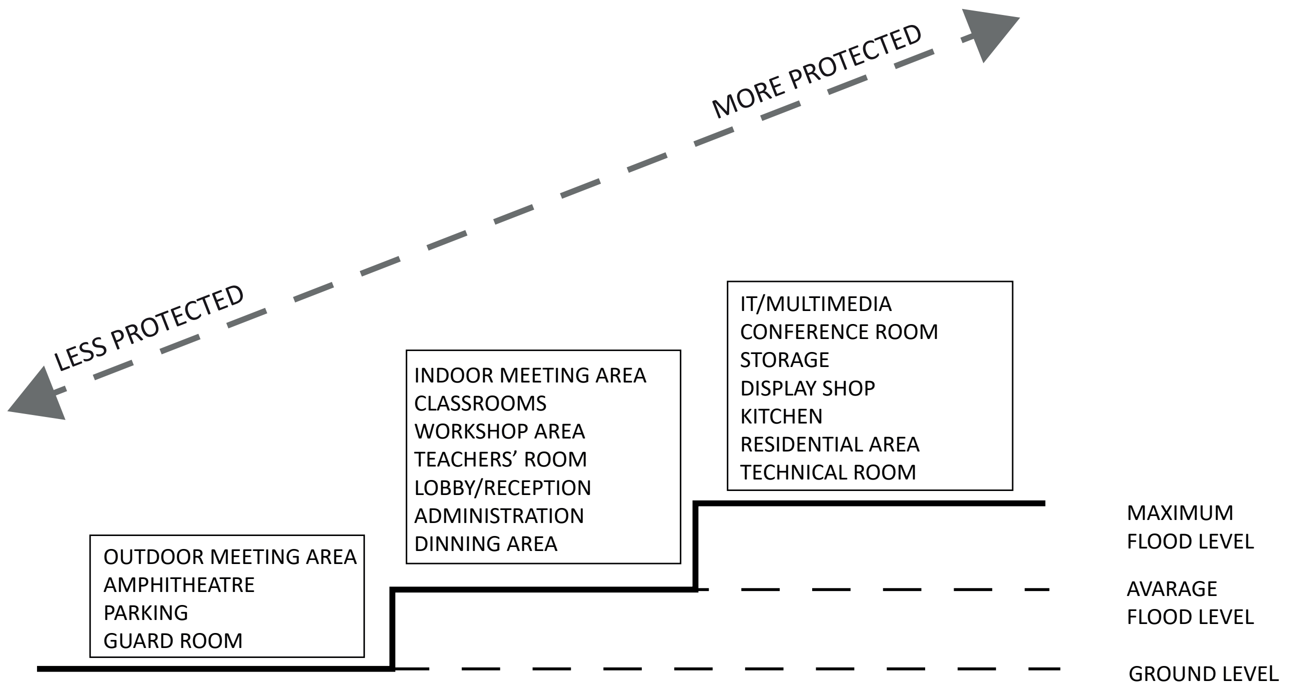


FIG. 66: PROTECTED AREAS BY THE LEVELS DIAGRAM

FIG. 67-68: CONSEQUENCES OF THE CYCLONES

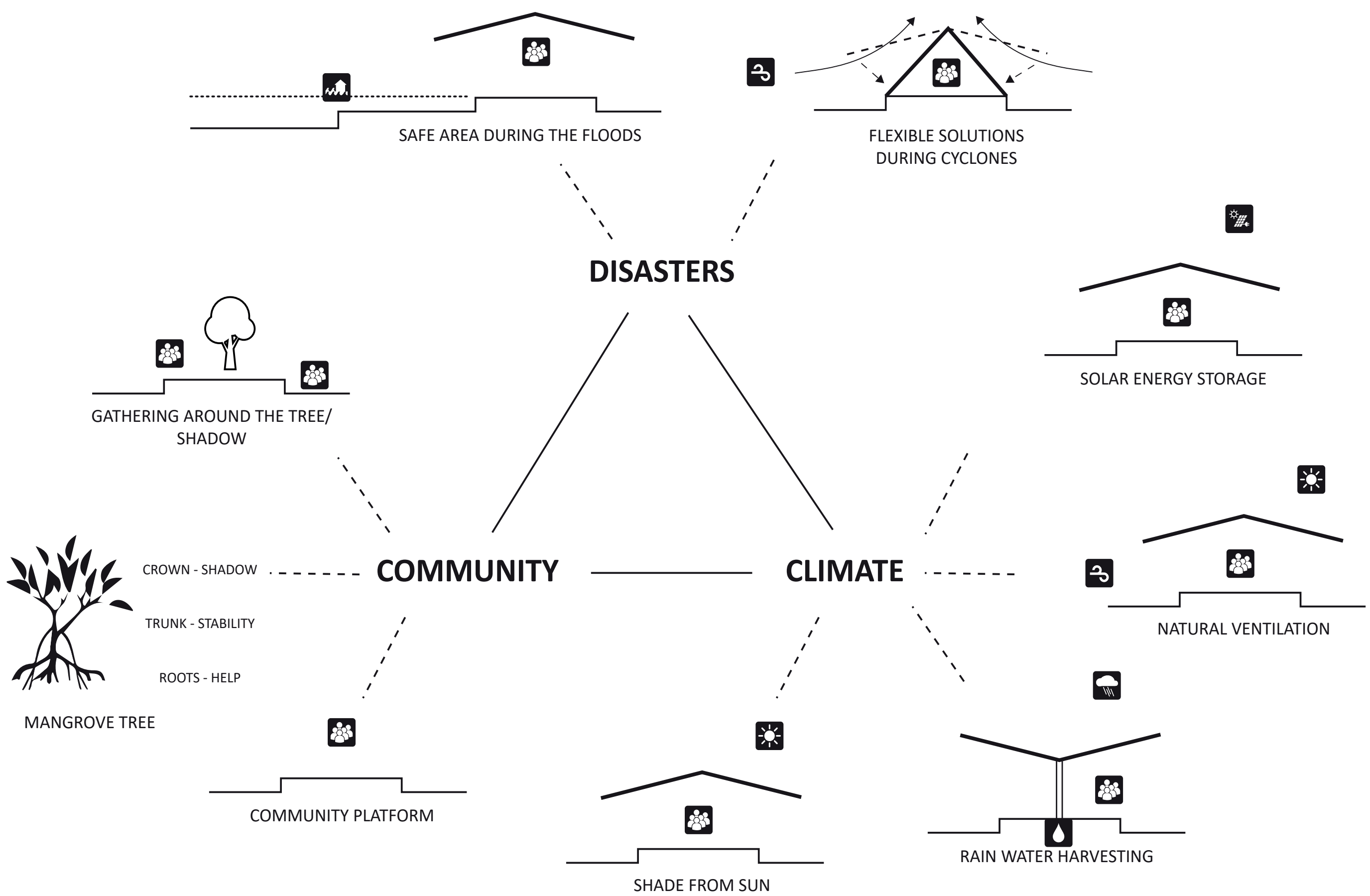


FIG. 69: CONCEPTUAL FRAMEWORK DIAGRAM

CONCEPTUAL FRAMEWORK

The conceptual framework of the project was based on three components; Community, Climate and Disasters. The development of ideas on each of these components was also integrated with our design criteria.

The community is one of the most important components in our project as the project is a community center. The main notion of this project is to create spaces where the inhabitants of an extremely disaster prone area can gather and involve in different kind of activities. So by our design, we wanted to create a platform for the community. Outdoor spaces like courtyards and shade of the tree are used by the local community to meet or gather. We also want to create spaces which reflects the local culture.

Natural disasters are an integral part of the project. The frequency and intensity of the natural disasters like cyclone and flooding will only increase due to climate change. So we conceptualized that our design should incorporate flexible and adaptive solutions to be resilient during natural calamities. We also focused on creating safe places in our project where people of the local community can also take refuge during cyclones and flooding.

Climate is also an important component in our project. Bangladesh has a hot climate. For this reason, the design should incorporate ventilated shaded areas. Our focus is using passive control in our design. So daylight and natural ventilation are considered. In the project, the integration of rainwater harvesting and solar energy storage in our design.

FIG. 70: GREEN BAMBOO

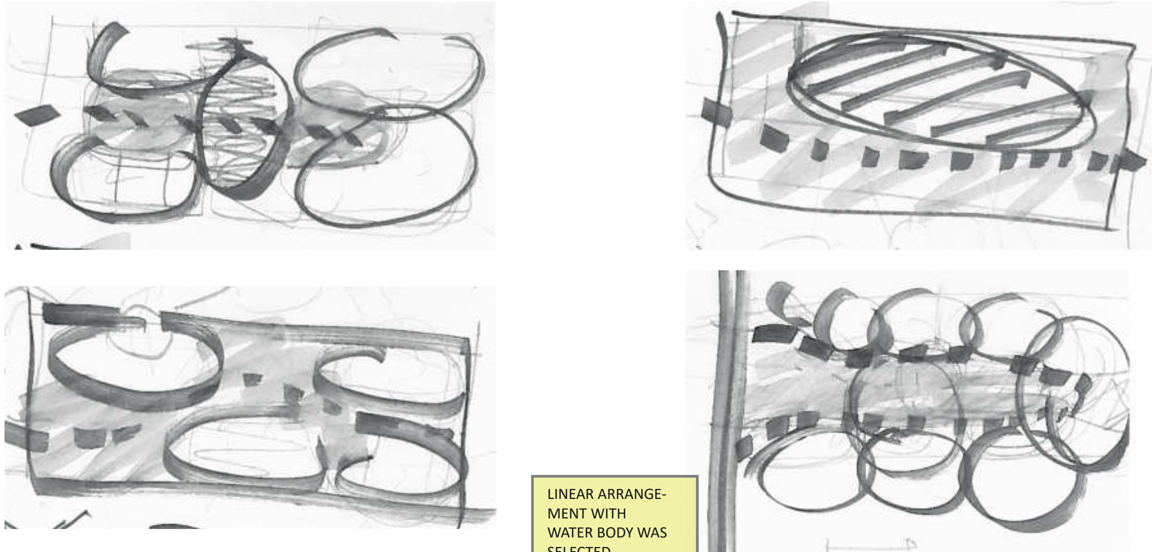


FIG. 71: FIRST SKETCHING OPTIONS

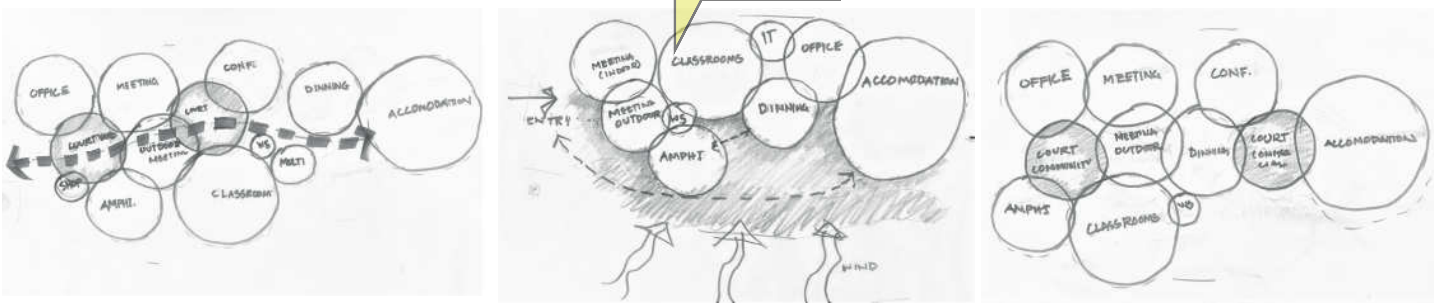


FIG. 72: FIRST FUNCTIONAL DESIGN APPROACHES

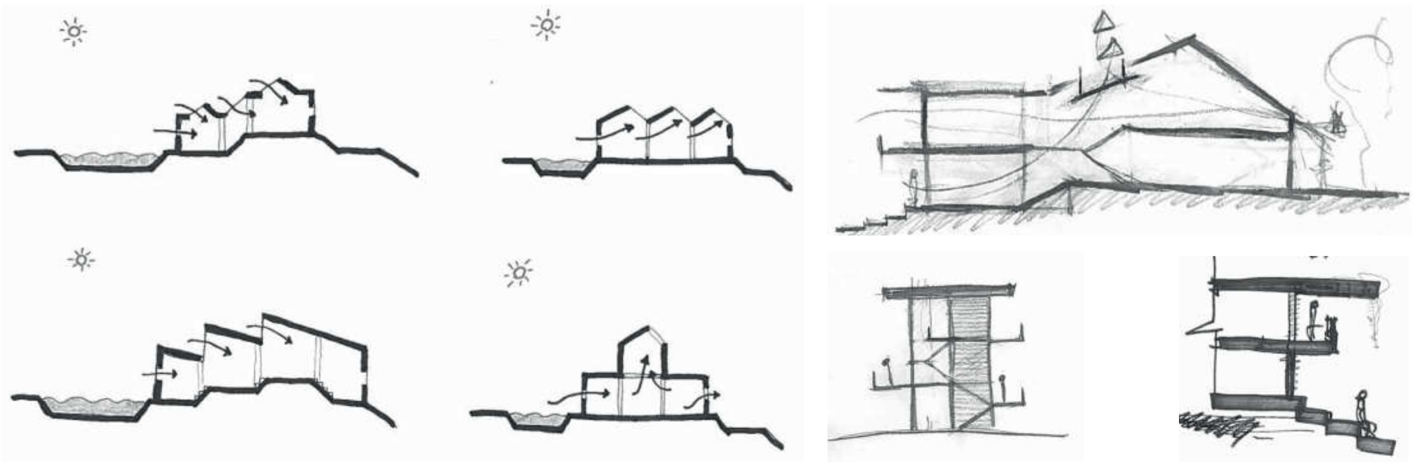


FIG. 73 CROSS SECTION STUDIES

INITIAL SKETCHING PHASE

Initial sketching phase was initiated with the primary organization of spaces in the site area, where different possibilities in building layout were studied. The organization of spaces was also integrated with wind flow analyses which lead towards the primary layout of spaces in the site area.

This sketching period evolved with three different approaches with bubble diagrams. In the first bubble diagram, we tried to create a pathway, and all functions were linked with it.

The second bubble diagram evolved around the idea of creating a water body on the site which can help with natural ventilation. Here all of the functions were arranged in a linear way so that all spaces have maximum natural ventilation.

In the third bubble diagram, the idea of courtyards was incorporated to arrange functions. Here two courtyards were introduced, a community courtyard and a commercial courtyard to arrange the functions.

Later we also developed primary cross sections in this phase. Different kinds of cross sections were developed and checked to understand and study shading and natural ventilation principles. The connection of built form with outdoor spaces was also studied in the cross sections. These initial studies gave us ideas about different options in design which can be evolved further in our sketching phase.

INITIAL TECHNICAL STUDIES

Wind flow studies were carried out with different initial master plan layouts, in order to study and understand which kind of building layout is efficient for the optimum amount of wind flow. In our conceptual framework, we have also mentioned about the importance of providing natural ventilation as we are concerned with utilizing passive means for ventilation in our project. As the analyses show the predominant wind direction is from South and our idea was to keep the southern facade longer to utilize the windward side.

Moreover, wind flow studies showed that huge overhangs would not be efficient during the cyclones as strong wind pressure is created underneath the overhangs and can push it off from the main structural system. So we tried to develop the idea of flexible solutions in order to that the facade can be easily closed down during cyclones.

In further studies with wind flow, we also tried to study different layouts of forms and tried to understand how the distribution of wind can be optimized within the site area.

Also, it was tried to simulate the wind flow conditions during cyclones. As discussed earlier the direction of wind flow during the cyclones is random. So we simulated wind flow from a different direction and studied the effects.

During the analyses it was observed that if narrow channels are created in the design the wind flow is compressed while passing through these channels and the velocity of the wind is also increased but if the channels are wider the velocity of wind does not increase as much.

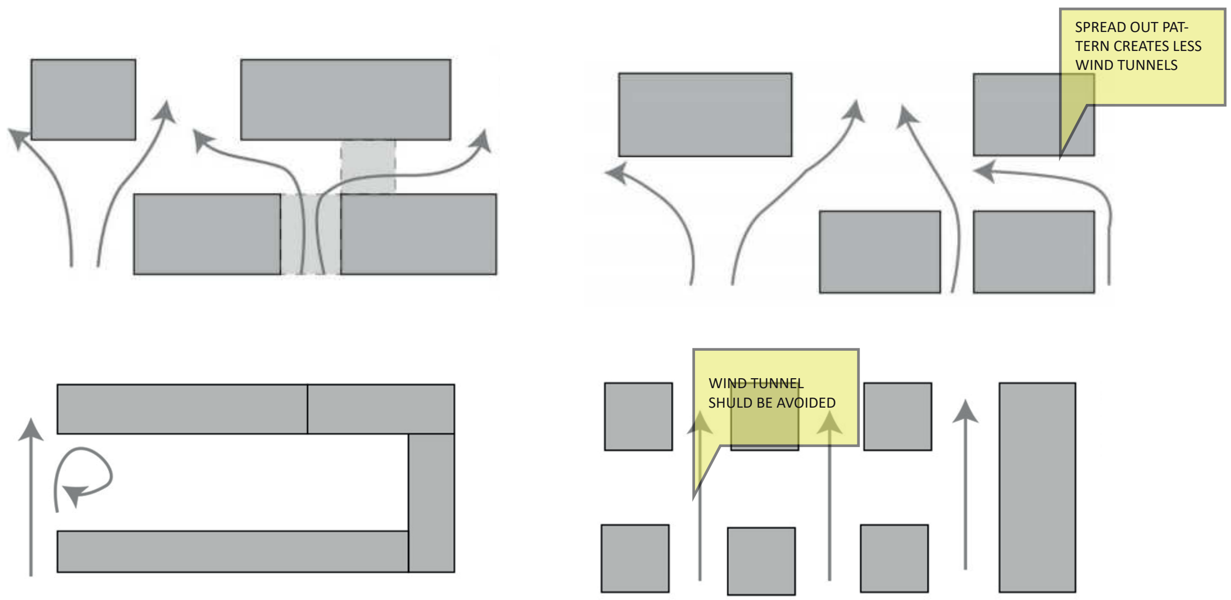


FIG. 74: INITIAL WIND FLOW STUDIES AND PROBLEMS

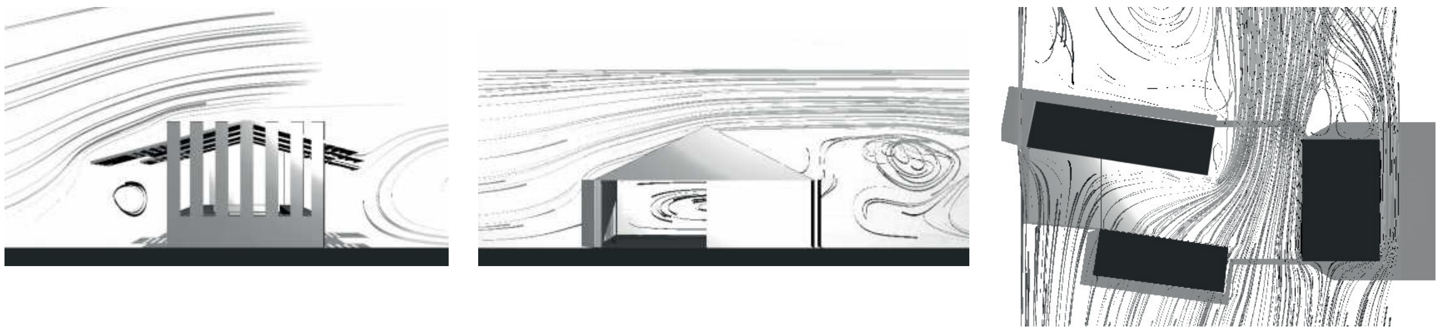


FIG. 75: WIND FLOW STUDIES

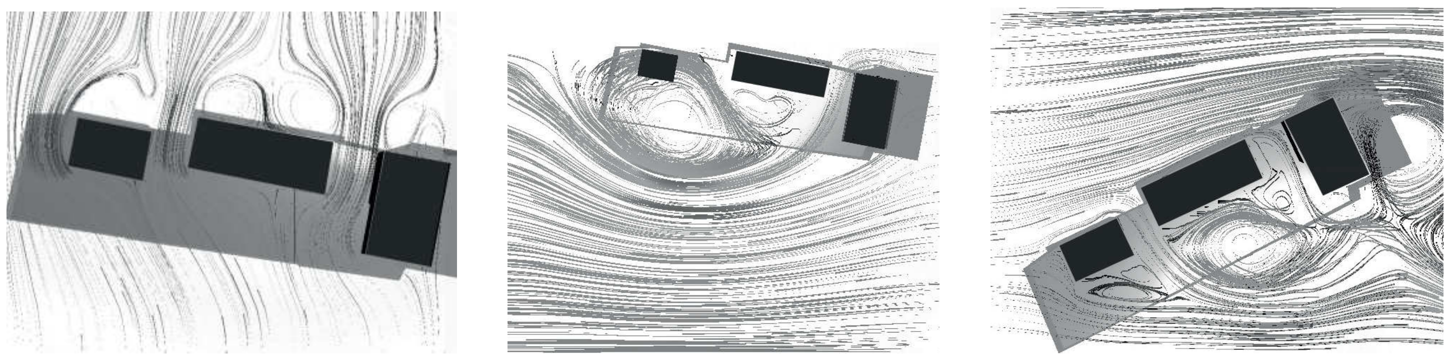
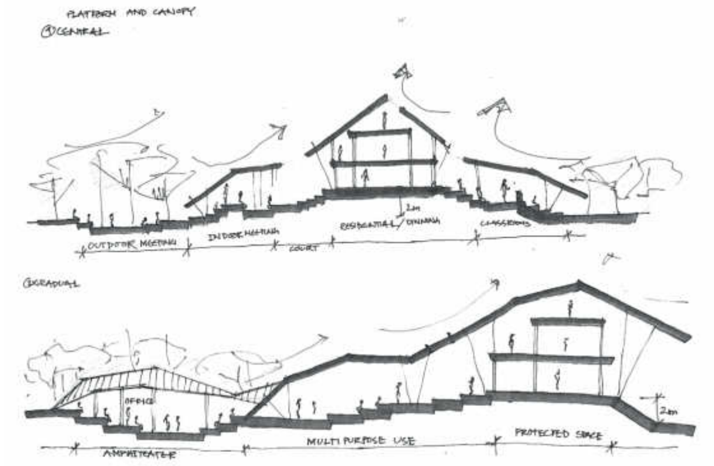


FIG. 76: WIND FLOW STUDIES DURING CYCLONE



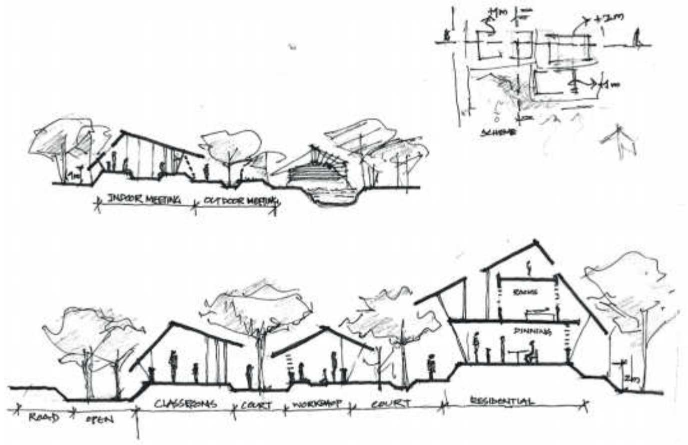


FIG. 77: INITIAL CROSS SECTION STUDIES OF THE SITE

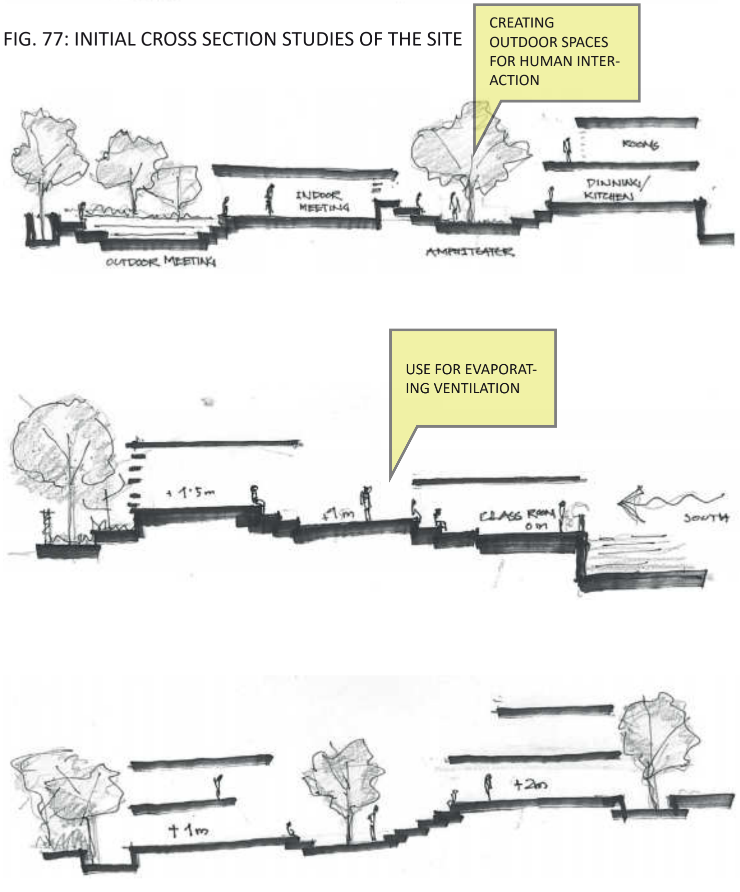


FIG. 78: CROSS SECTION STUDIES FOR DIFFERENT MASTER PLANS APPROACHES

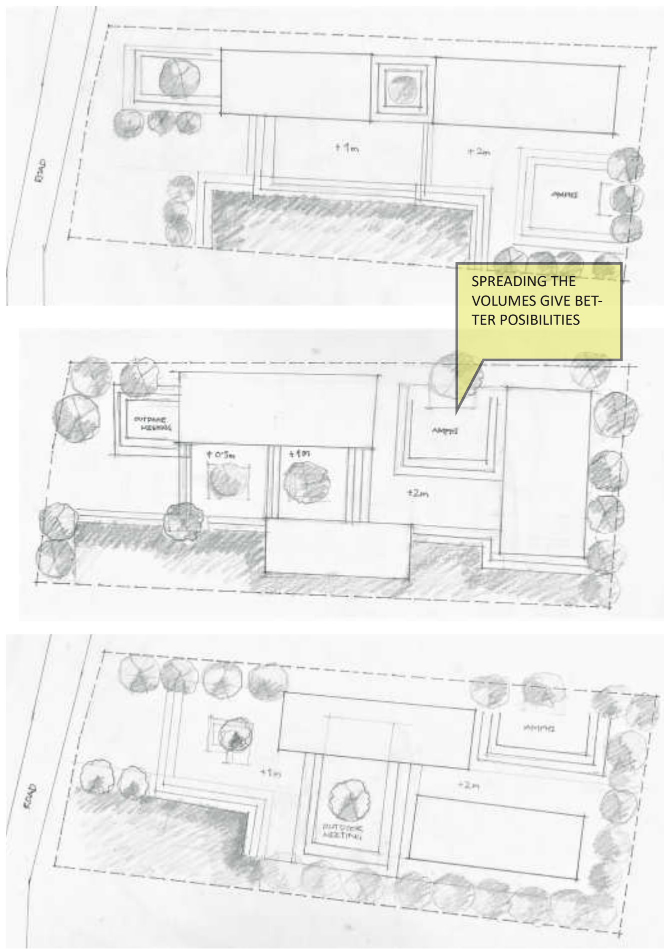


FIG. 79: INITIAL MASTER PLAN STUDIES

DEVELOPMENT OF THE INITIAL IDEA

Our development of initial ideas revolved around our conceptual considerations of creating a platform for the community which will not only provide both in-door and outdoor spaces for them to involve in different range of activities but also will create safe places during natural calamities where they can take refuge.

We developed different kinds of more precise cross sections in this phase to study the placement of our protected area on the site. Through these cross sections we also analyzed the idea of developing the platform in such a way that it can also incorporate outdoor spaces like courtyards and outdoor meeting spaces. In regards to the transition from indoor to outdoor spaces it was attempted to keep as simultaneous as possible to develop enhanced infiltration of daylight and natural ventilation as well as multipurpose uses of space.

We developed three different approaches towards our master plan and tested out for optimum wind flow and daylight. We found out that if we arrange our buildings in a linear way where the longest facade is towards the south is very effective for natural ventilation. But to accommodate all functions in this arrangement we will have to create higher structures which can be out of scale in the rural context of Bangladesh.

So we also tried to spread out the functions in the site to make it more in scale with the rural settings. The spreading out of functions can also enhance possibilities for both natural ventilation and daylight in all areas.

Our idea was to create raised areas for safety during flooding in our site. For this we wanted to utilize the mud of the site where we take mud of one part and use it to raise the other part. For this approach we also saw the possibilities of creating a water body in the site which can further enhance the possibilities of natural ventilation and passive cooling.

INITIAL STUDY OF PERFORATED FACADES

The analysis of the opening ratio and the overhang sizes shows that there is a clear correlation between the amount of daylight and sunlight received and the relative sizes of the overhang and the opening sizes. As expected, the maximum temperature seems to decrease with the lower amount of sunlight hours received, especially in the period of the day where the sun is at its highest. The natural ventilation also sees a gradual reduction with the opening ratios, although in this case, the relevance is more to be seen as a measure of the potential airflow rather than a contributor to the passive cooling system. The ventilation neither takes the inlet speed into account nor the relationship between heat, slow air and humidity. Furthermore, the studies also show that due to the height of the sun on the sky, shading against the sun is equally, if not more, efficient on the west and east directions due to the large inclination, provided the subject is not shaded by adjacent buildings.

Later the impact from the perforated bamboo walls gradually increases the daylight in an expected manner, while the wall is quite efficient at keeping out direct sunlight while still allowing a flow of natural ventilation. The parametric studies were conducted in a series of 16 turns with the output variables being the same as the previous studies.

In this study, the temperature impact was chosen to be the average biannual temperature, as it seemed to better reflect the changes in terms of daily temperatures rather than the highest peak temperature. Despite having the actual openings fully closed, even the smallest tested amount of perforation of 1/8th of the screen showed that there still was a sufficient amount of daylight present. When compared to the opening ratios of the wall, it shows that the same pattern appears from the previous studies, but that the sunlight hours are prominent from the south direct as the test subject this time contains no overhang.

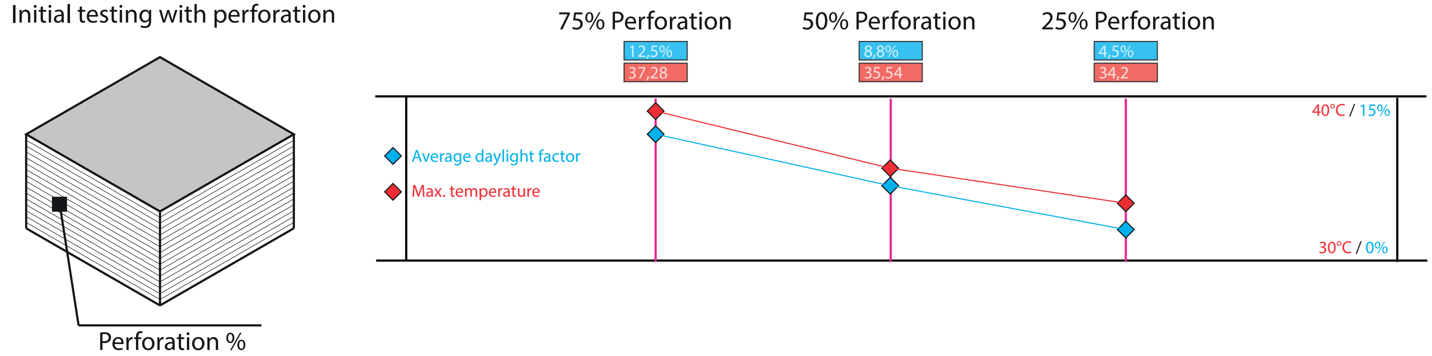


FIG. 80: INITIAL TESTING DIAGRAM

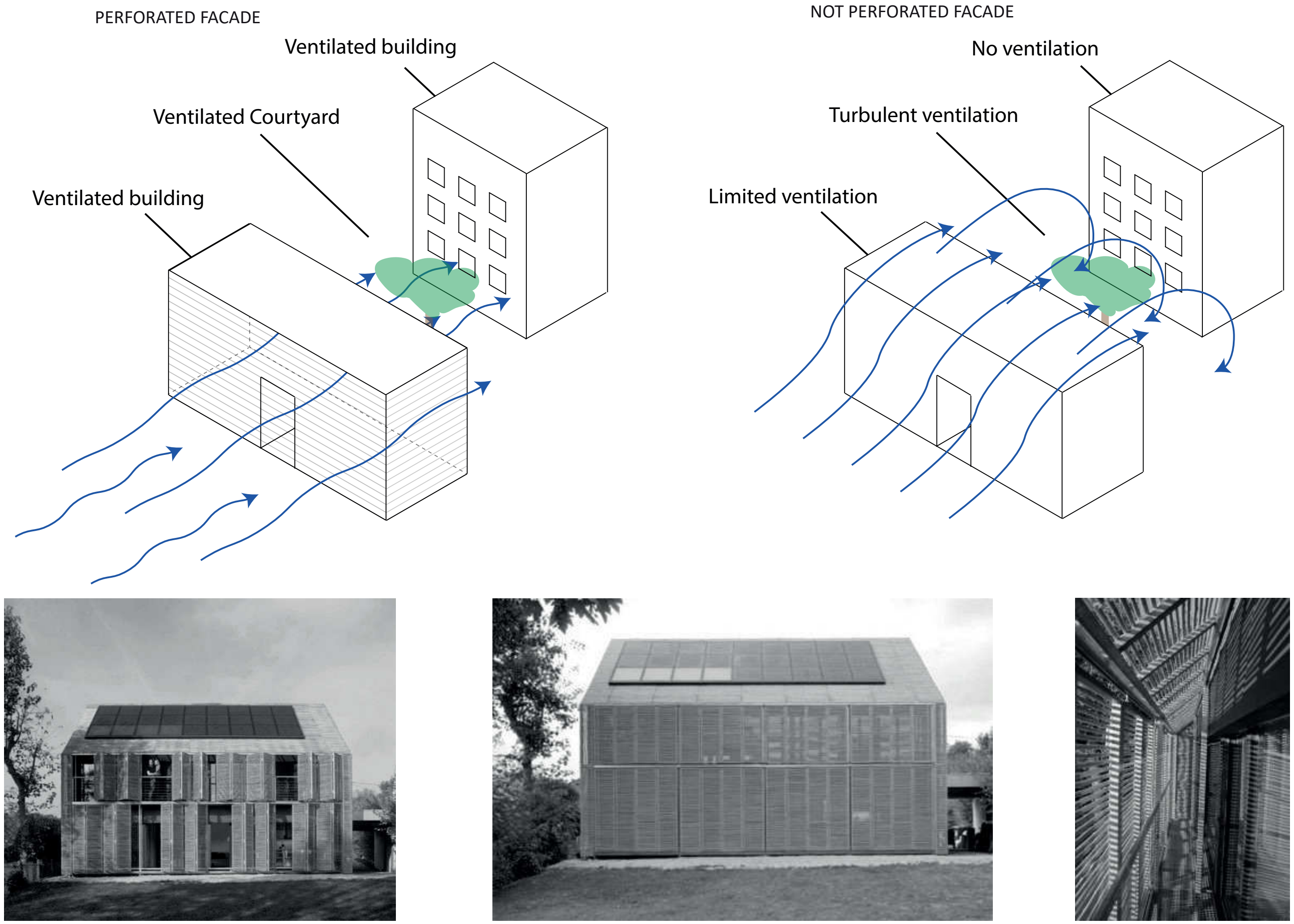


FIG. 81: STUDIES OF PERFORATED BAMBOO AND OPENINGS

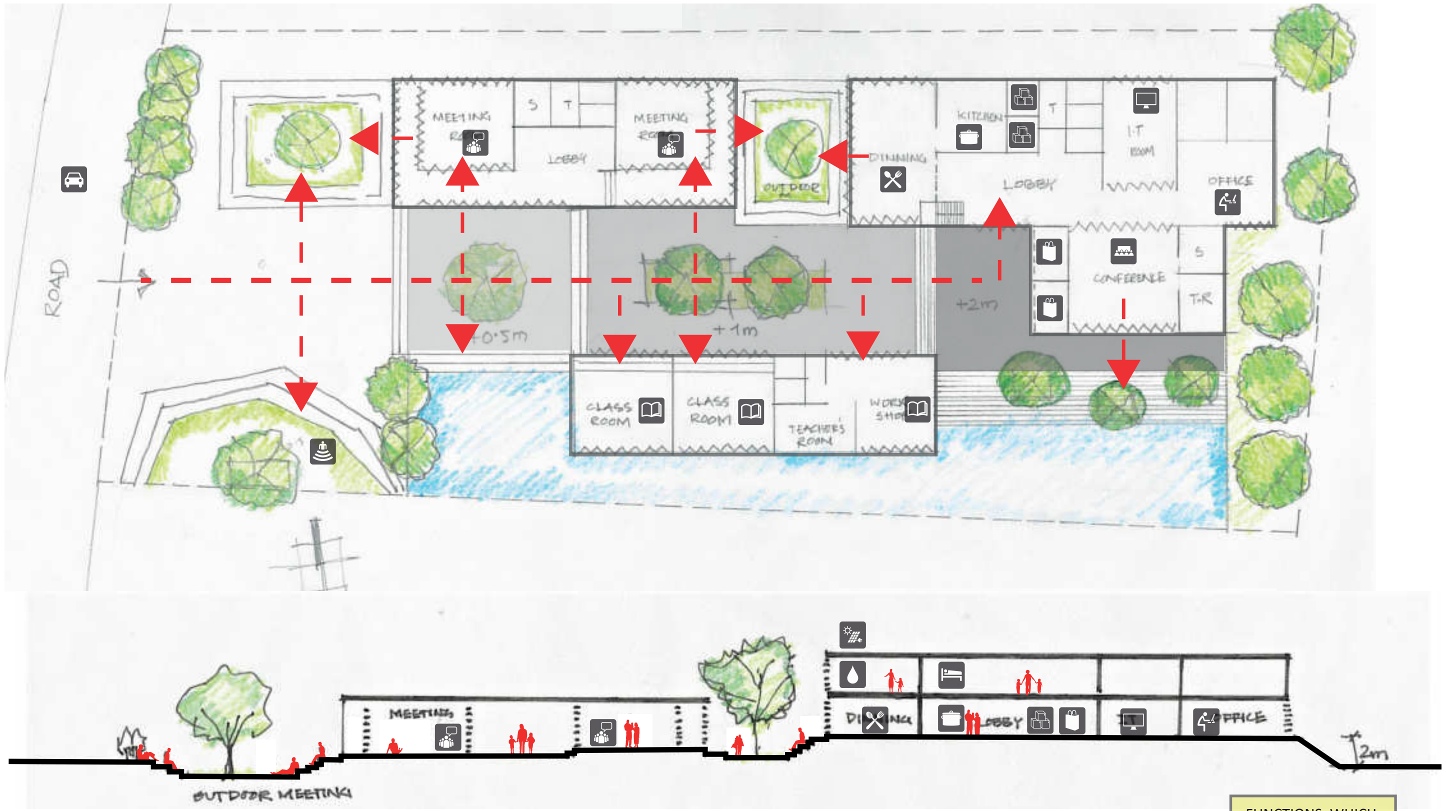


FIG. 82: FUNCTION DISTRIBUTION IN THE PLAN AND SECTION

FIG. 83: WATER AFFECTED AREAS IN THE PLANS AND SECTION

INITIAL PLAN DEVELOPMENT

***midterm**

After the preceding studies, the initial plans were developed and based on the functions and cross-section studies, starting with a southern water body for the natural ventilation, and the classrooms placed towards the south. Towards the north of the site, two blocks have been placed, with the commercial meeting rooms being near the entrance to the site and the external amphitheater placed at the very front by the road.

The north-eastern block consists of two stories placed on the highest grounds and includes prioritized functions such as kitchen, and dining area towards the outdoor meeting areas. The multimedia room is placed, so it gets only northern daylight, while the conference room and offices are placed so they get a view of the southern pond.

One the second floor, the accommodation features have been placed along with potential space for water-harvesting and a potential space for solar energy storage space. On the roof, the space there can be used for the PV cells.

The overall plan is developed in a way, that the lowest water-prioritized zones get flooded first, primarily being the outside areas to the west. The medium prioritized zones are leveled in a way that they do allow for partial flooding, where the non-water resistant items can be kept at elevated levels towards the ceiling.

The gradual incline towards ensures that during the maximum flood level, the most life and vital functions and electrical equipment is above and free, with the base of the 2 story building starting at 2 meters.

VOLUME STUDIES

In this phase, we went through different layouts of forms in our site area. And consequently, we analyzed the different layout of form with wind simulations. In several arrangements of forms we found out that those arrangements can create tunnel effects during the cyclones which are not desired.

So we decided to develop the layout of forms in such a way, so it does not create a tunnel effect during cyclones but still ensuring that the arrangement can ensure natural ventilation and daylight conditions throughout the design. In this phase, we also developed and modular approach towards our design. A 100 square meter module was developed to analyze and accommodate different types of functions. Then we also worked with different arrangements of this module to develop the overall master plan.

We also wanted to take the inspiration of the rural pathways and reflect the scale and the intimacy in our overall scheme. We wanted to work with the pitch or angle of the roofs which is also inspired by the local dwellings practice of the region. The pitch of the roof gives us additional advantages both in natural ventilation and rainwater harvesting.

The design and placement of outdoor spaces were as important as indoor spaces for us. Outdoor meeting areas and amphitheater were an integrated part of our overall design scheme. Trees are planted carefully to provide shade and also to create a sense of scale and intimacy. Trees were also used to work as a windbreaker during the cyclones.

FIG. 84: FIRST VOLUME STUDIES

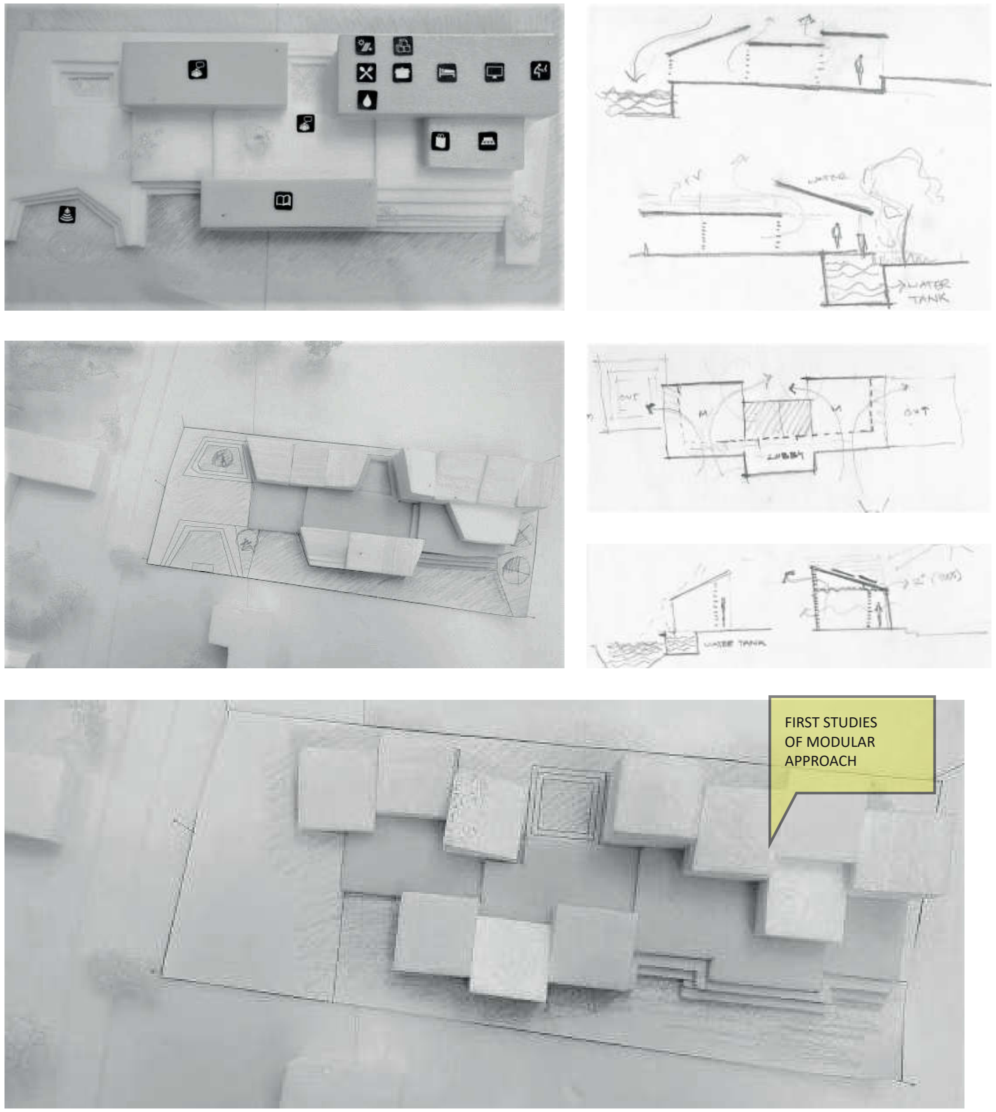


FIG. 85: MODULAR APPROACH MODELS AND SECTION

FIG. 86: WIND FLOW STUDIES DURING CYCLONE

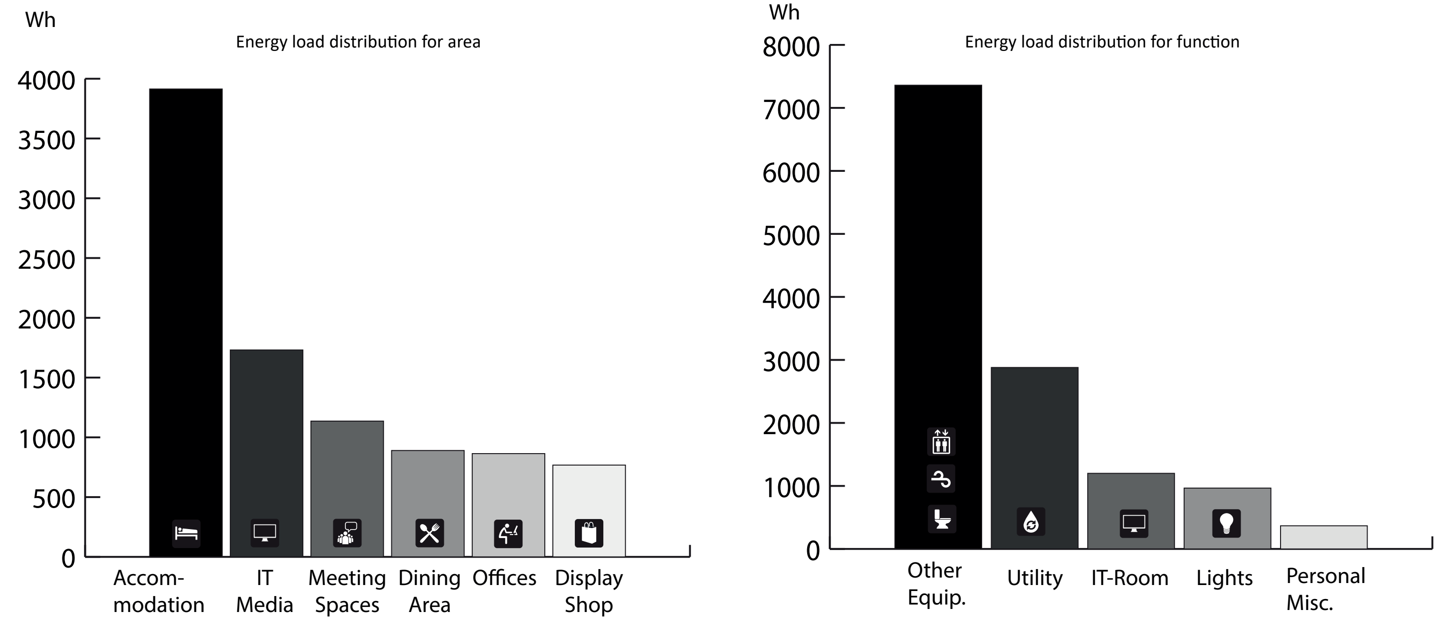


FIG. 87: ENERGY LOAD DISTRIBUTION

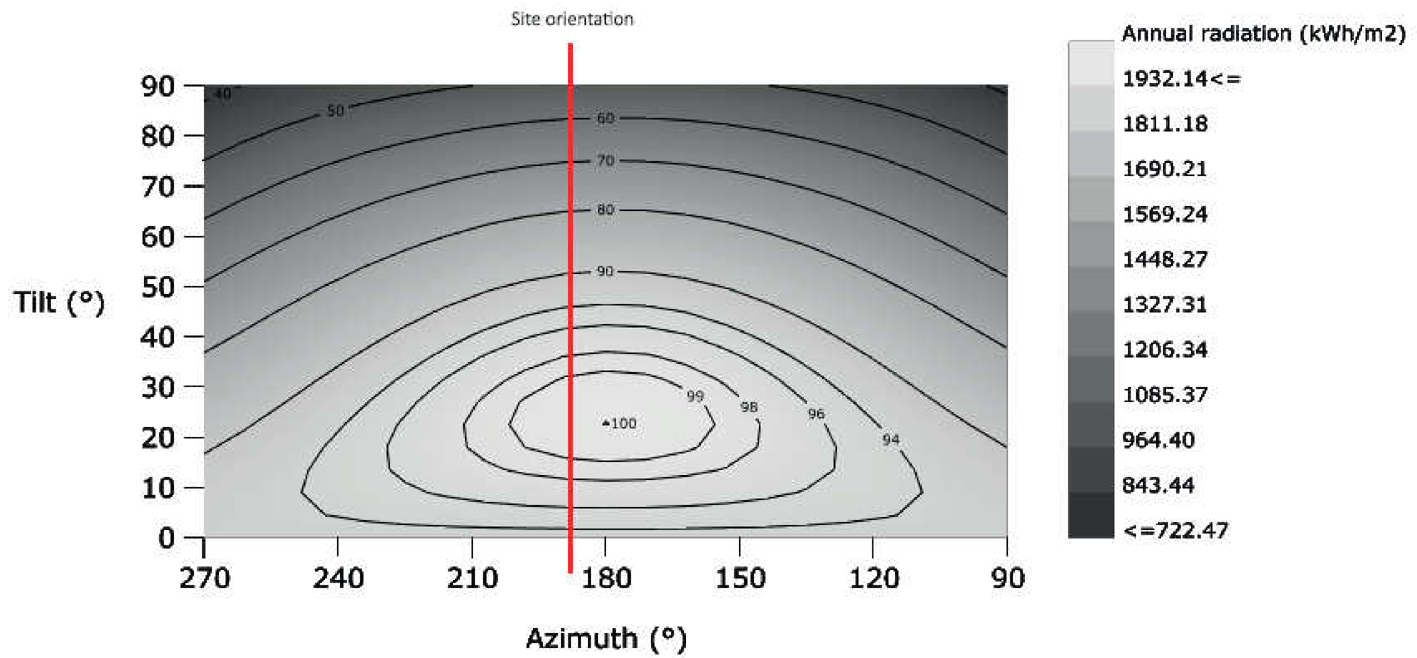


FIG. 88: ROOF ANGLE PARAMETERS

SOLAR ENERGY HARVESTING

In order to ensure that the community center is capable of running off-grid due to the local difficulties with the electrical grid, the center will be running on solar-power. The total need for the center including utilities is estimated to be approximately 12 kWh daily.

The damaging cyclones of Bangladesh result in the need to have fixed solar panels. To provide the maximum efficiency for fixed panels, a TOF (Tilt-Orientation Graph) was made for the location, which would show the optimal tilt and orientation for the location, and how much of a decrease in tilt would result in. The architectural decision to have a flat roof (0-5°) showed to not have a significant impact (7% decrease) on the efficiency due to the country's relative proximity to the equator. For 50 watt solar panels, the resulting area is calculated to be approximately 160 (m2), which includes the separate solar cells (about 40-50 m2 required to operate the solar-powered lift (power requirements included from manufacturer).

Polycrystalline solar panels have been chosen, as their production process is less polluting than monocrystalline, and although they have less efficiency, space efficiency isn't a project requirement due to plenty of roof space on the tower. The overall, coverage of the roof is provided for more aesthetic reasons together with the distinct visuals of the solar panel type. [EnergyInformative]

STRUCTURE AND JOINTS

It is known that bamboo is extremely strong fiber with as twice as high compressive strength of concrete and roughly the same strength to weight ratio of steel in tension. Bamboo has a lot of structural advantages like strength and light weight whereby properly constructed bamboo buildings are inherently resistant to wind and earthquake. [Vaghela, 2013]

The materiality of the project is going to be based primarily on bamboo and concrete. The meeting-, education-, dining- and conference-spaces are designed as bamboo structures with perforations. The prioritized protected areas are based on concrete to add high structural stability and sheltering from the weather during cyclones. In the project, the bamboo as the weakest structural compartments (compared to concrete) was analyzed to create a structural framework that would be able to survive the climatic loads.

A wide array of initial models was made to explore not only the structural possibilities but also architectural expression. These are ranging from organic, prismatic and squared structures, which were each evaluated. It was decided that a pitched roof square building would be suited best for the bamboo project, with a rectangular roof grid.

A workshop of possible connections of the bamboo joints was also explored in terms of scalability, strength and minimal complexity. Initial experiments with the actual joints consisted of metal clamps, concrete-fillings, and rope fixture. Along with the decision that a 3x3 bamboo configuration was optimal for both the possibilities of structure and weight, it was decided that the optimal structure would be an assembly consisting of 9 bamboo sticks bounded together with rope, in order to make it both easy to maintain, assemble and scalable.

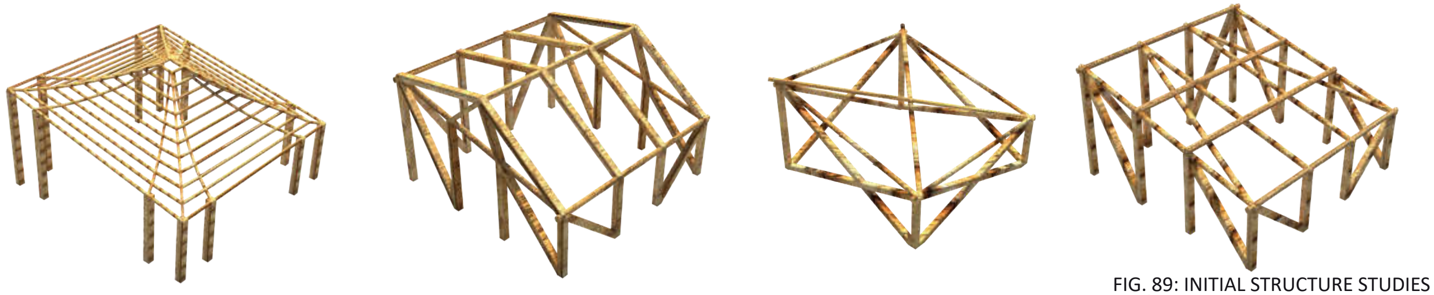


FIG. 89: INITIAL STRUCTURE STUDIES

FIG. 90: DEVELOPED STRUCTURE STUDIES

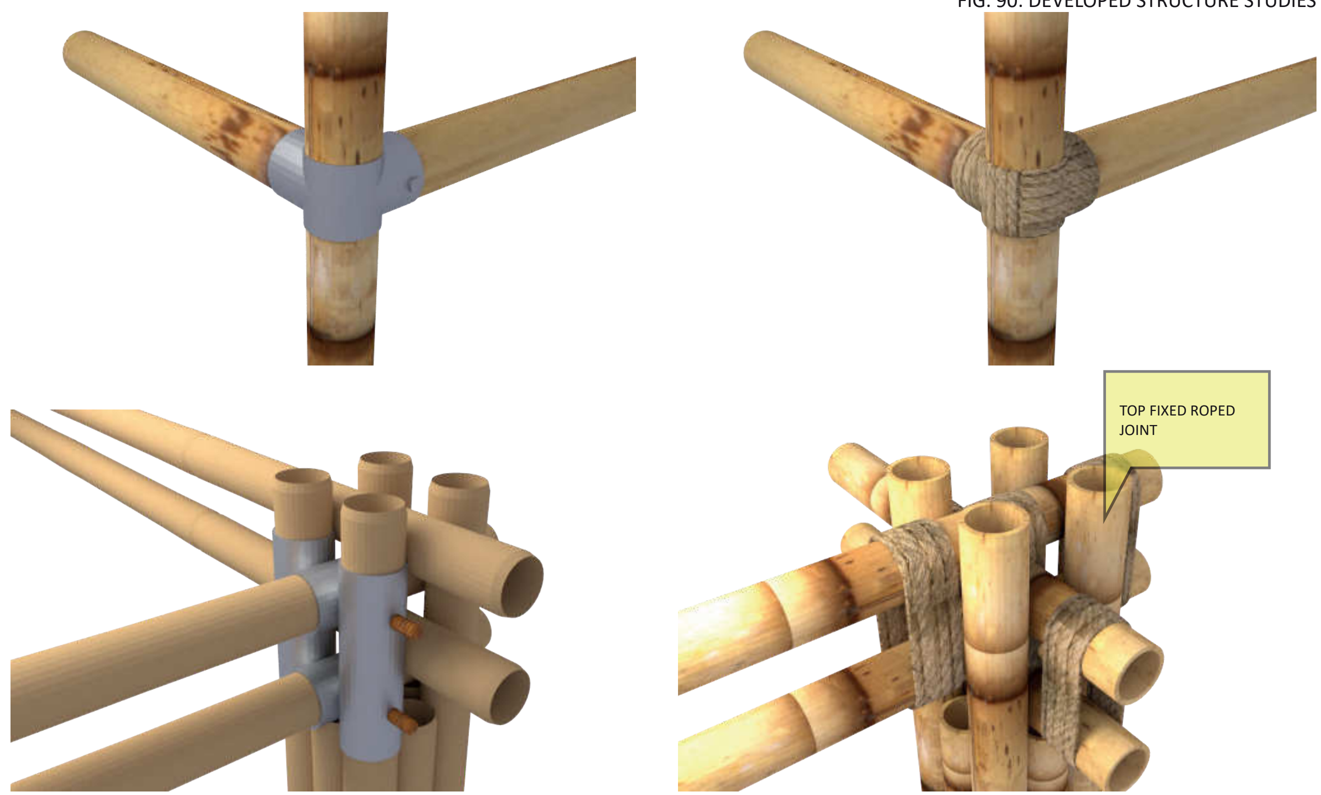
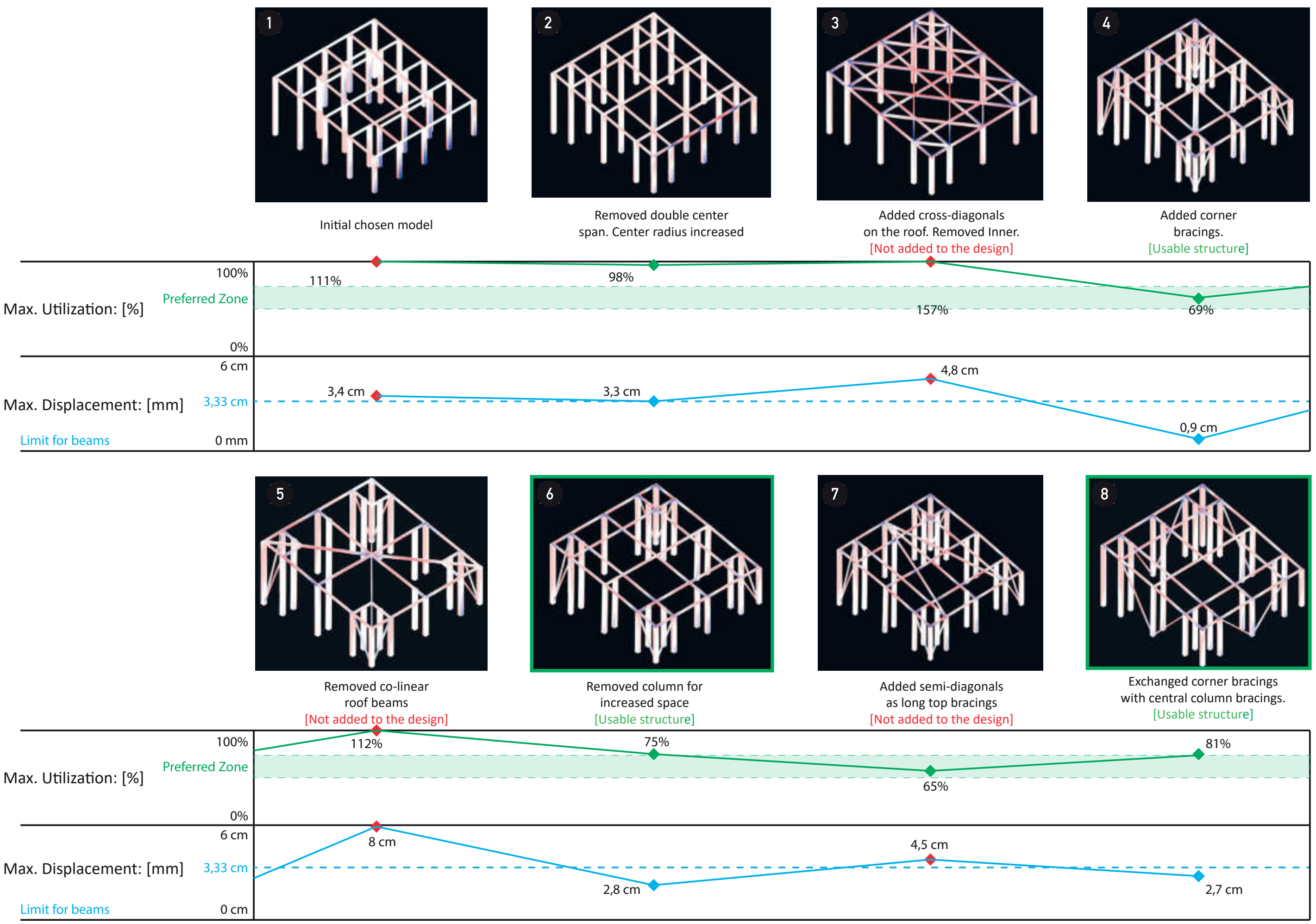


FIG. 91: JOINTS STUDIES

STRUCTURAL OPTIMIZATION



For the structural optimization, the initially chosen model has been used as a foundation. The preliminary structural experimentation consists of the highest utilized beam before breaking point (ultimate state). Furthermore, the structure was also tested against the highest recommended displacement of the 10m top beams, where the deflection is counted against the limit Length/300 (Generalized Eurocode), which is a general set provided to have deflection go unnoticeable (marked with dotted blue). [EN 1995-1-5]

Apart from the deflection, the general goal for the structural strength is to have a model that is capable of sustaining the structural loads with a little capacity for reserve (about 10-20%) for potentially higher future wind loads, as the result of global warming. Even though utilizations below 100% would have been acceptable, it was estimated that a utilization ratio in the last 3/4rd (marked as the preferred green zone) of the strength would provide with a decent reserve (25%) as well as provide a structural limit for unnecessary structural over-dimensioning.

The result would be provided in two editions, where the corner bracings could be either centrally positioned or from the two central facade columns, which in terms was provided for functional flexibility.

FIG. 92: STRUCTURAL OPTIMIZATION

MODULAR APPROACH AND DOUBLE FACADE

Going into a deeper modular approach in the study phase, we have recognized that in the plan level double facade on all sides of the designed spaces creates some difficulties as it increases the circulation space around 40% of the overall space. So we decided to create the double facade in such a way which that the efficiency of the circulation spaces are also maintained. Mostly the double facades were designed on the west and south sides as these facades need more shading from the sun.

Therefore, the structure of the highest building in the site was also wrongly incorporated as a module so in the next level it will be changed and analyzed in some various ways in order to get the most appropriate building as possible.

Master plan still stays with different levels and water body, just now the ramps are joined with greenery boxes in order to avoid only paved site and keep the spirit of the surrounded forest in the west part of the area.

The parametric testing shows that both the increase in perforation and height of the structure gradually results in the increase of the annual operative temperature. This is especially visible during the periods where both temperature and the humidity is at its highest. The daylight factor sees a similar increase, with the lowest being registered to 9,6% not taking the internal facade into consideration.

With this in mind, it allows for further testing for the shaping of the interior corridors and facade. Overall, the average operative temperature is within the criteria set on page 30 (function program). It should be noted that the numbers are comparative only, as the wind speed and user- controlled ventilation equipment is not taken into consideration, as provided by the adaptive comfort model.

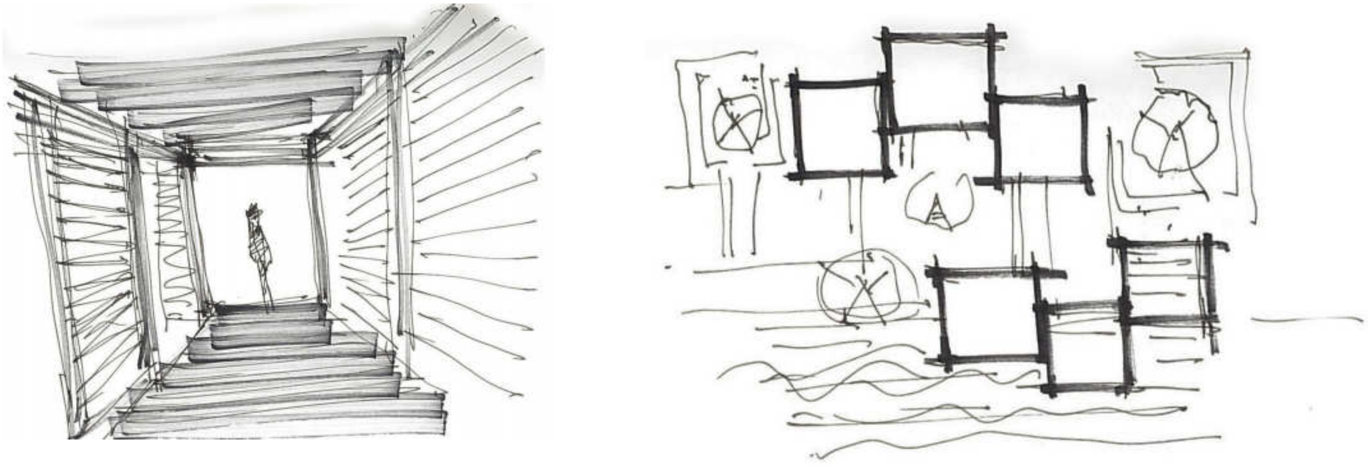


FIG. 93: CONCEPTUAL SKETCHES

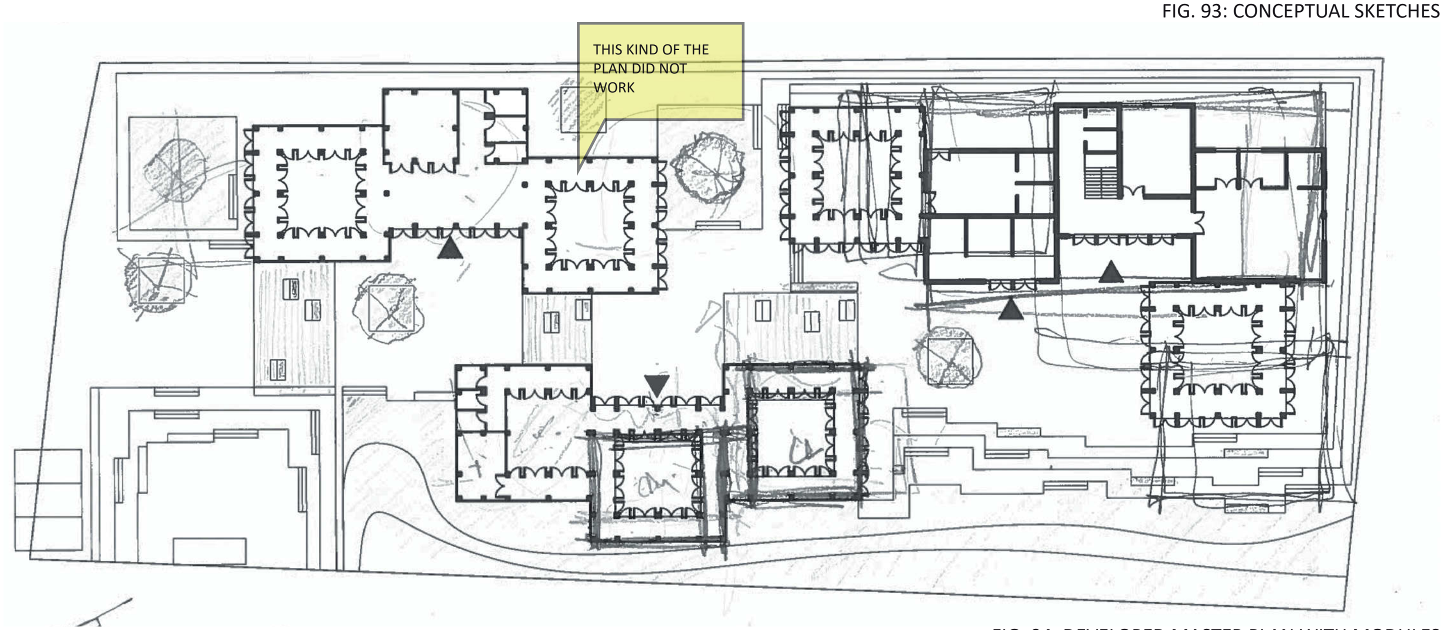


FIG. 94: DEVELOPED MASTER PLAN WITH MODULES

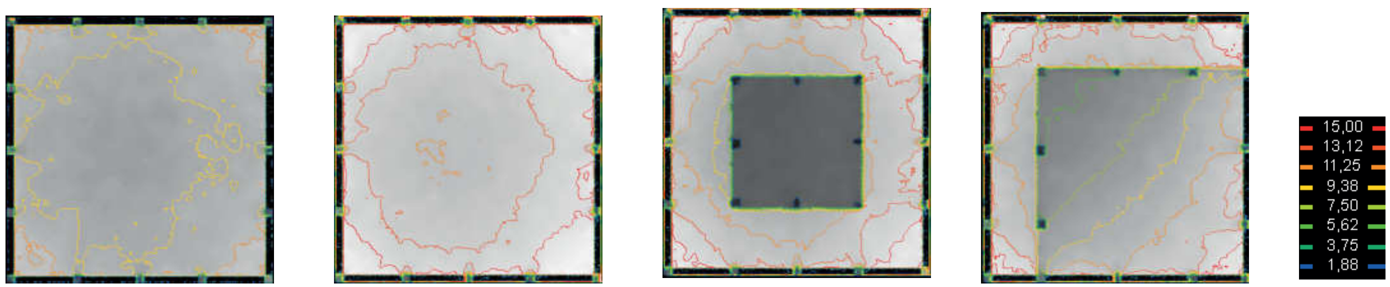


FIG. 95: DAYLIGHT STUDIES OF DIFFERENT FACADE VARIATIONS

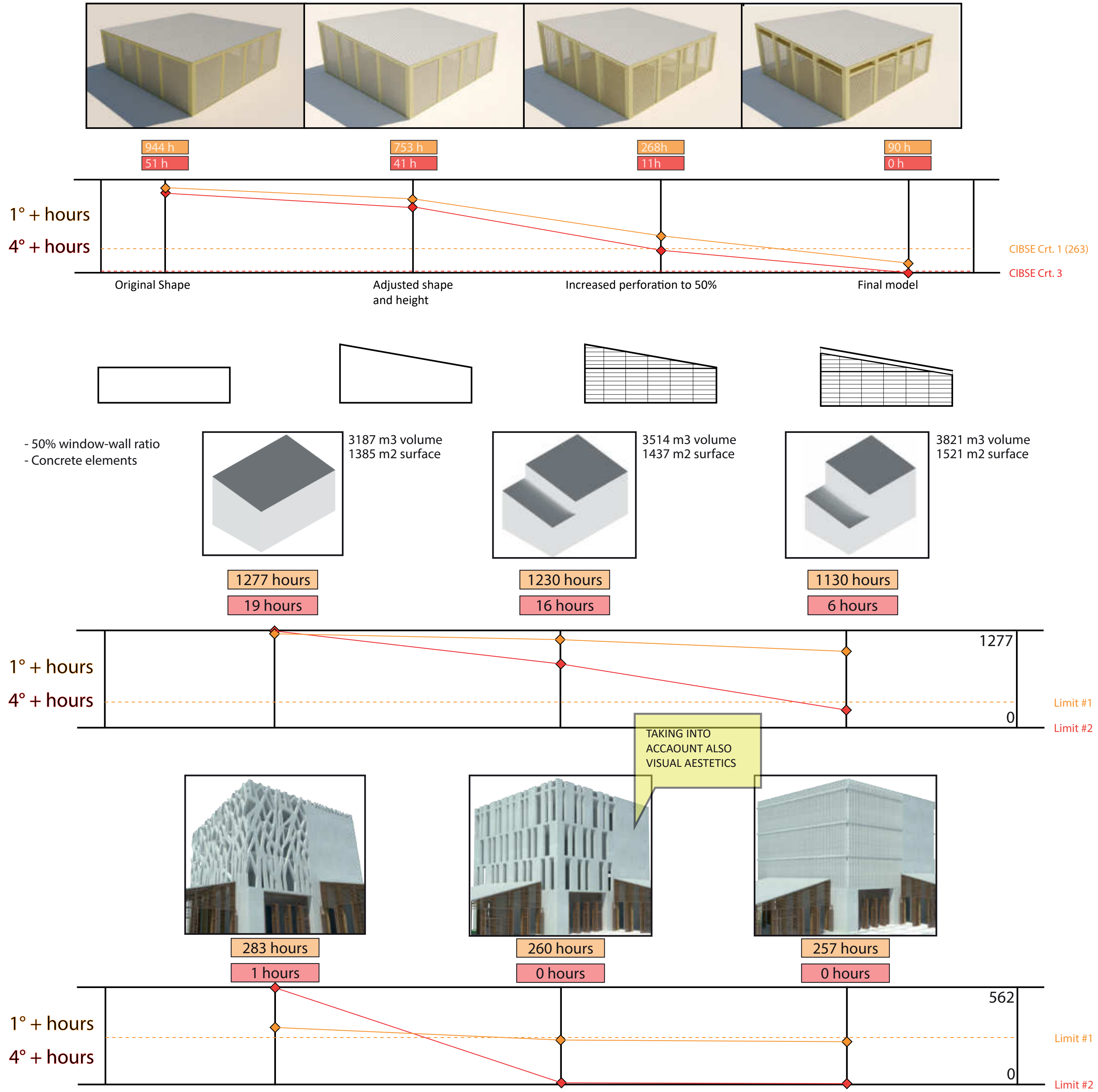


FIG. 96: THERMAL OPTIMIZATION

THERMAL AND DAYLIGHT OPTIMIZATION

The bamboo structure has been tested continuously to provide optimal conditions for visual and thermal comfort. The initial experiments were made as a combination of the relationship of ventilation, daylight and operative temperature, with an array of different shapes and sizes. The finalizing thermal experiments for the selected shape was conducted against the thermal criteria (page 29), to make the over-comfort hours as limited as possible. The measures taken during this step included changes to slope and volume, as well as the perforation ratio of the facades. Finally, the ventilated roof gap (mentioned on page 84) was implemented to achieve the designated own comfort limits. Regarding visual comfort, after the initial testing with daylight factors and opening sizes (Initial daylight testing), the daylight was first tested for the basic shapes in terms of the open area ratios as well as the perforation ratio (similarly seen on page 56)

The tower structure was facing different thermal challenges than the bamboo structure, due to its vastly higher thermal mass. During the initial tests, it was shown that the increase of surface area would provide for a vastly warmer structure, unless provided with an equivalent ratio of cross-ventilated window surfaces. The last shape was regulated so the bottom part was removed and where the window-distribution towards the 4-world axis' was tested in terms of percentage. Later, the 3 final iterations of the possible facades were tested and considered to the proposed limits. The second model (seen with 260 over-comfort hours) was chosen not only for thermal reasons but also for its visual aesthetics. Concurrent with the thermal simulations, the daylight simulations were also made to achieve a good visual comfort level. First with the variations of window distributions (as can be seen on appendix 100), then as the development progressed, the shaping of the finalized facade proposals was also simulated, and showed a decent amount of daylight for the crucial functions of the tower.

THE CONCRETE STRUCTURE

According to the difficult weather conditions on the site, it is vital to have the safest place, where during the urgent situations people can have shelter. During this phase, it was developed some different solutions of the safe concrete structure. From the early process, it was an idea of having a strong concrete building at the highest elevated level on the site, which is predicted not to be flooded during the cyclones and also can be utilized as a shelter for the local inhabitants during the disasters.

The first idea of the tower expresses one rectangular volume with conference, dining and office bamboo structures attached next to the building. White concrete was used as the concrete material, but wooden lamellas were also used in the windows.

In the second iteration of the concrete building, we decided to work with the volumes of the concrete structure. Instead of creating one rectangular volume, we divided the structure into two parts where one part was lower than the other. It gave an expression of a gradual increase in the height.

In the third iteration, we tried to see the effects when we increase the height of the concrete building. As we want the concrete building to be a shelter space for the local inhabitants during the disaster situations, we thought that increasing the height of the concrete building will make it visible in the existing rural landscape. This gave us the idea to treat our concrete building as a tower or landmark.

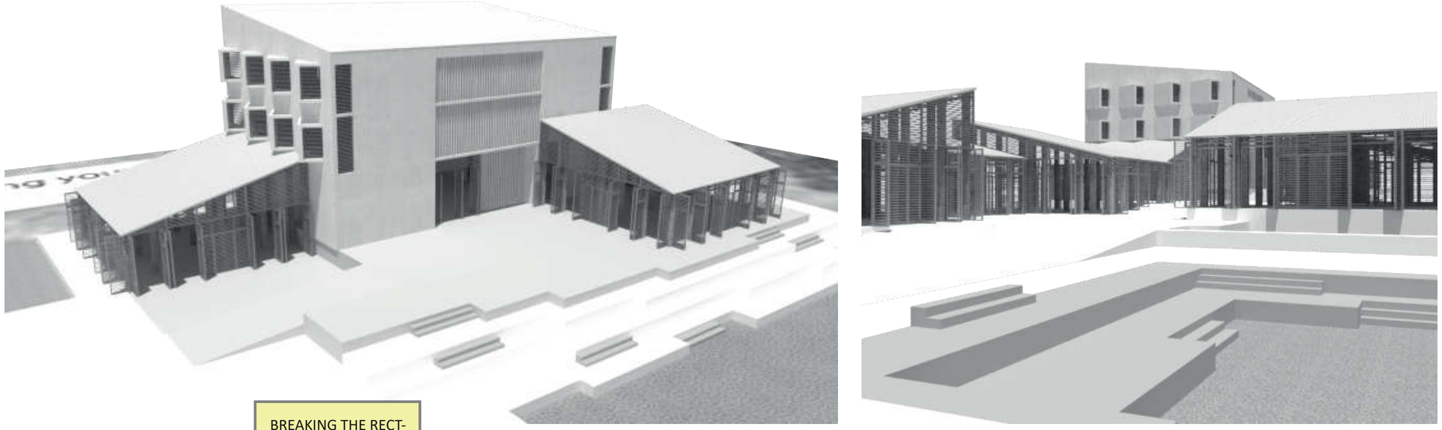


FIG. 97: FIRST SAFE TOWER IDEA

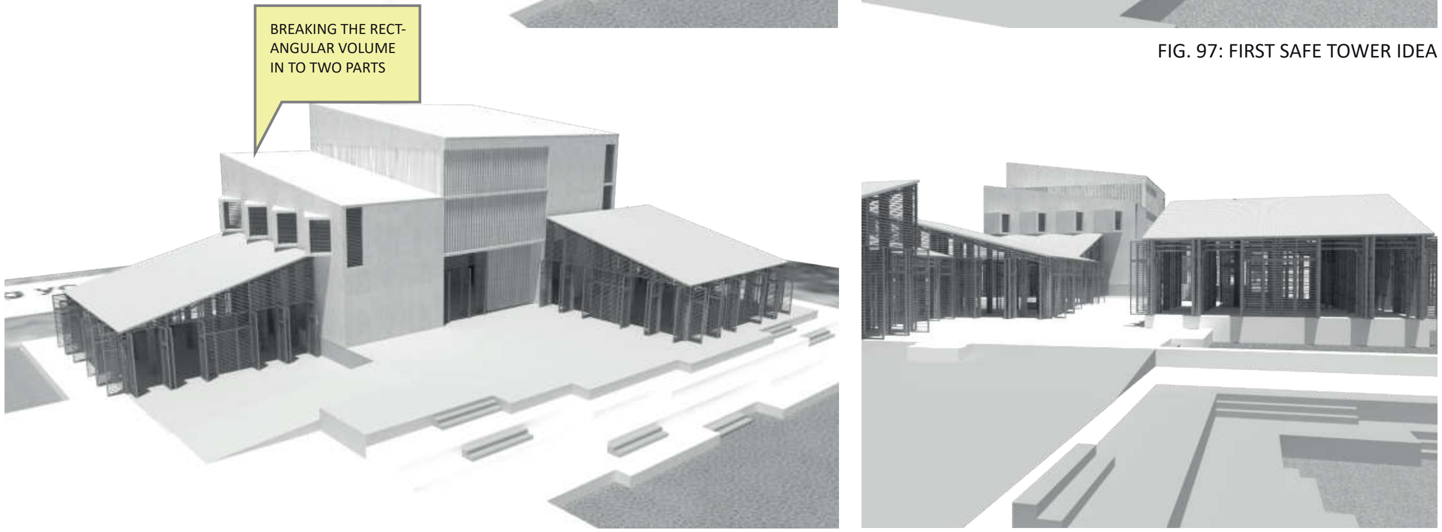


FIG. 98: SECOND SAFE TOWER IDEA

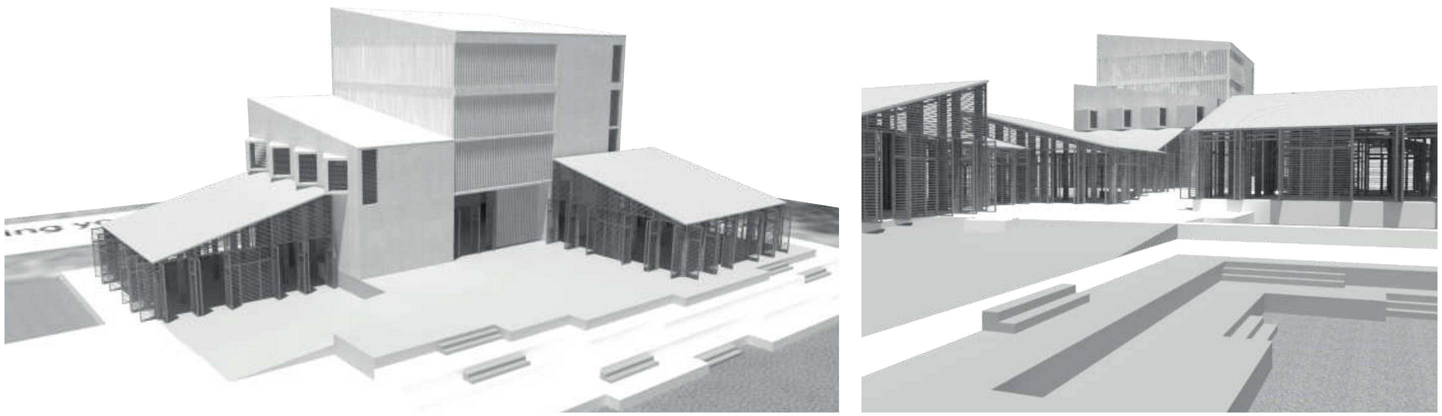


FIG. 99: THIRD SAFE TOWER IDEA

THE TOWER

On this phase, we decided to work with the expression of the concrete tower. We decided to design our tower as a cubic concrete volume as it also expresses stability in aesthetic terms. But as our tower will also be incorporated with passive controls, we though to express the tower as a perforated structure. We decided to develop different kind of facades to achieve that idea.

On the first iteration of the facade development, we wanted to incorporate the idea of the tree expression in the facades. It created an interesting dialogue, but it was thought that it could become rather complex to construct this kind of facade in the local context of our site area.

So in the later iteration, we tried to simplify our approach towards designing the perforated facade in the tower. We incorporated simple vertical louvers in our facade to express the verticality of the tower. Our tower will have its electric power generated by the solar cells installed on the roof. So during the disaster times, the artificial lighting from inside the tower will help the local inhabitants to spot the structure and seek refuge.

Also, it was decided to raise the solar panel from the roof of the tower to create a ventilated gap between them both. In this way the installed solar panel would also work as an secondary roof which would increase the climatic efficiency of the concrete structure.

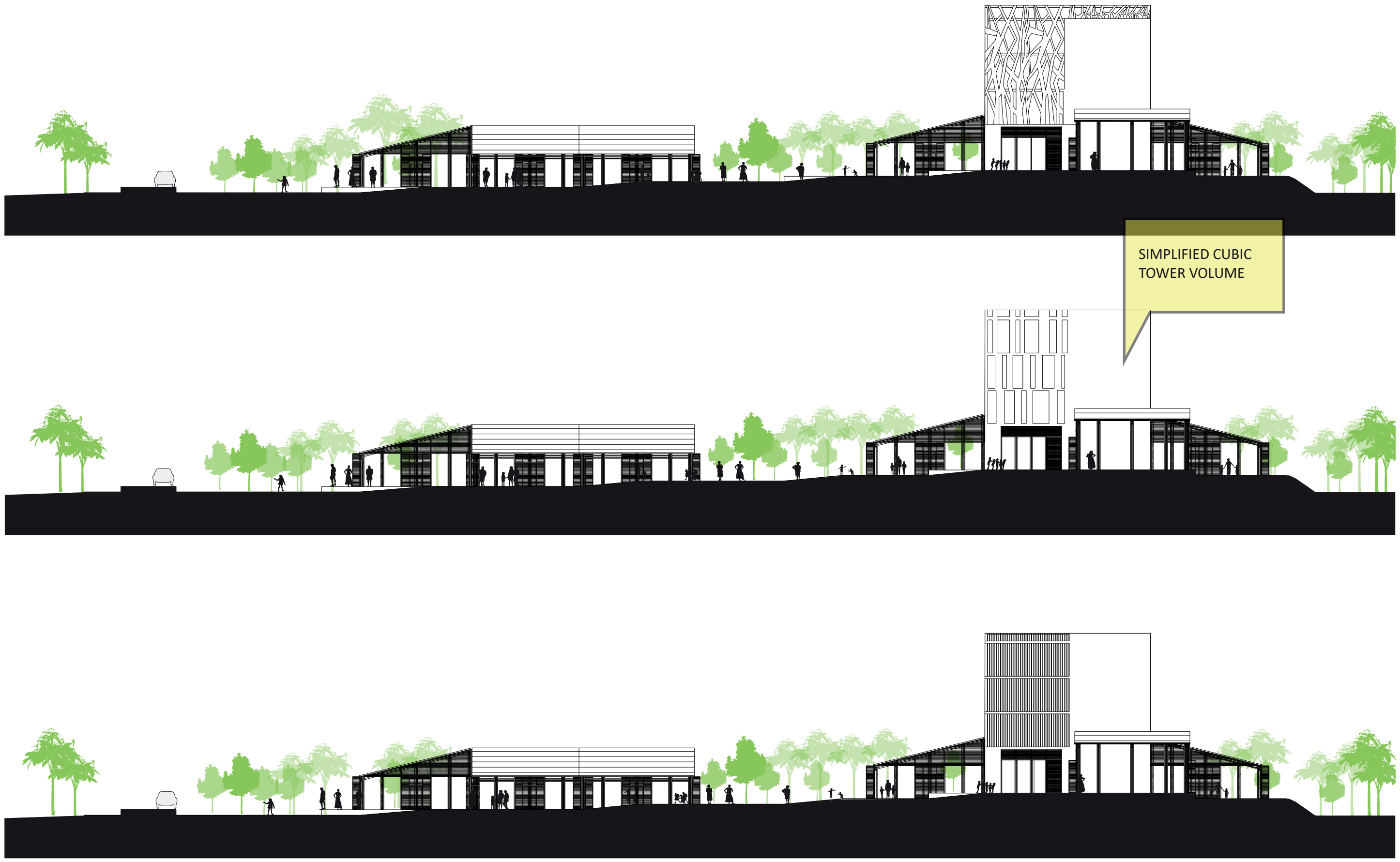


FIG. 100: FACADES IDEAS

‘Architecture belongs to culture not to civilization.’

Aalvar Aalto

12

PRESENTATION

FIG. 101: VISUALIZATION FROM THE FIELDS

FIG. 102: MASTER PLAN

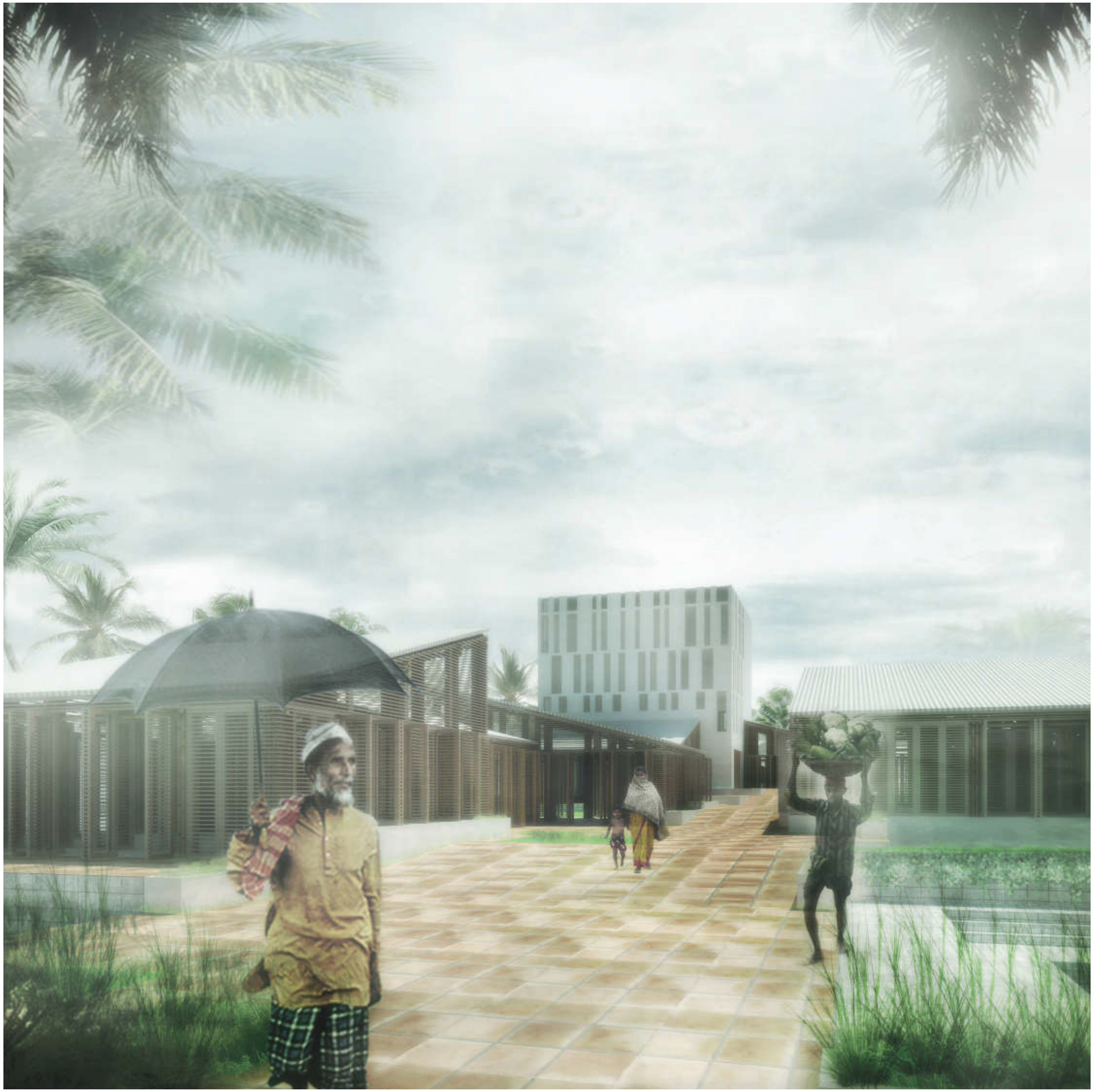


FIG. 103: VISUALIZATION FROM THE SITE ENTRANCE

MASTER PLAN

In the master plan one of our major ideas were to create elevated areas on the site which will also work as safe places during cyclones and floods. To be able to keep above the highest flood level in the site area, the safe zone must be elevated at least 2 meters. But to raise the whole site area to stay above the maximum flood level would be very expensive and not economically viable. It was decided to excavate some area on our southern periphery of the site and use that excavated ground to gradually raise our designed spaces. The functions are prioritized and the most essential functions which are compulsory to ensure the functionality of the community as a refuge during the periods of natural calamities are designed in the area which is elevated 2 meter and has the least possibility to be flooded and are constructed as a concrete tower which can also withstand extreme wind pressure during cyclones.

The other structures as the meeting zone, educational zone, administration, dining area and conference room are all constructed with locally available materials like bamboo as structural elements and wooden louvers as the facades. The site is approached from the road on the west side and the functions which are mostly used by the community were intended to keep as close to the main entry to ensure easy accessibility to the local inhabitants.

A simple pathway is designed reflecting the intimate rural scale of the local context, connects all the functional zones both indoor and outdoor and gradually terminates in the elevated platform of the tower. The excavated area on the site is converted in to a water body which provides the possibility of evaporative cooling in the overall functional areas and also adds aesthetic value. The central circulation is defined by the use of terracotta blocks which will be produced by the local inhabitants.

FIG. 104: GROUND FLOOR PLAN

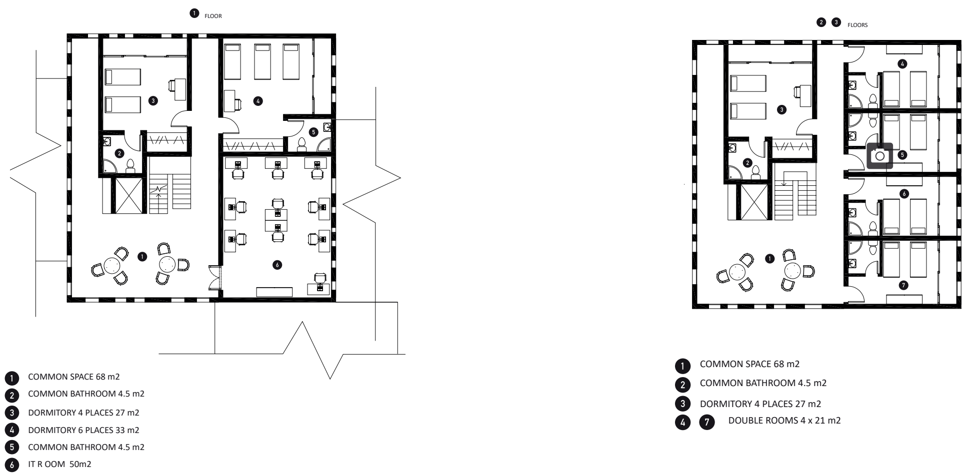


FIG. 105: 1ST, 2ND AND 3RD FLOOR PLANS OF THE TOWER

FIG. 106: VISUALIZATION OF THE ROOM

PLANS

MEETING SPACE

Upon entering the meeting spaces, the lobby functions as a nexus and provides access to toilet facilities and two flanking meeting areas. The areas again provide access to outside connected through circulation spaces that, also presents with a double facade. Outside meeting areas are designed with concrete seatings and have a tree.

EDUCATIONAL SPACE

After entering the education area, the circulation space provides direct connection to the workshop and educational modules. The workshop provides access to the teacher's room as well as toilet facilities. For both educational spaces, staircases lead down to the rooms, which provides a panoramic view of the southern water body, that encroaches the whole compartment on one side.

TOWER

The concrete tower a 4-story building connected to 3 bamboo modules that hosts the dining area, conference space and the administration area, which are all accessible from the lounge. These modules also have access to their own outside meeting spaces, where the dining area shares its outside space with them meeting area. For the administration area, a small eastern pocket is provided while the concrete tower and the conference room shares a long external area by the water-body. Inside the concrete tower, the lounge also provides access to the staircase and lift. A connected corridor provides access to the kitchen, technical room and the toilet facilities. On the upper floors an IT/Multimedia room is located, as well as general accommodation for the complex in the form of double room apartments and dormitories.

GATHERING PLACES

AMPHITHEATER

The amphitheater is placed near the entrance to the site, and is intended for cultural and traditional festivities, and consists of a central platform intended for performers, with a surrounding staircase and sitting platform for the viewers. Visually, the amphitheater is providing panoramic surroundings under the shading central tree, making it possible for the performance to become almost omni directional.

FIG. 107: AMPHITHEATER AREA

WATER BODY

The water body stretches along the southern band of the site, and provides a peaceful element to the area, where it is especially accessible from the eastern part of the site, with staircases leading straight down to the water level from the concrete tower. As such, this access to the water body becomes the prime outside space for the tower and its occupants.

Another important function of the water body is the evaporative cooling effect it applies when the wind direction is from the south (majority of time; see page 24), which in terms ensures that it can provide slightly cooler ventilation to the rest of the site.

FIG. 108: WATER BODY AREA

'There is a powerful need for symbolism, and that means the architecture must have something that appeals to the human heart.'
Kenzo Tange

FIG. 109: GATHERING AROUND THE TREE

MEETING SPACES

The meeting spaces are intended for gatherings for the local community and social interaction. These spaces are also be used to organize meetings with the NGO and the community. There are two types of meeting spaces in this project; indoor meeting spaces and outdoor meeting spaces. Both of the indoor meeting spaces are adjoined with outdoor meeting spaces.

The local tradition of meeting in courtyards or under the shade of a tree gave us inspiration to create both indoor and outdoor meeting areas. The use of perforated facades in the indoor meeting areas defines the spaces but also does not create a strict separation between them. If the door of the indoor meeting spaces is totally opened the outdoor meeting then becomes a part of the indoor meeting area.

The use of perforated double facades provides a space that appears to be an enclosed space, while still allowing for a sense of privacy without appearing either unventilated or too dim in terms of daylight. The use of locally available materials like bamboo and wood also makes these spaces more acquainted with the local community.

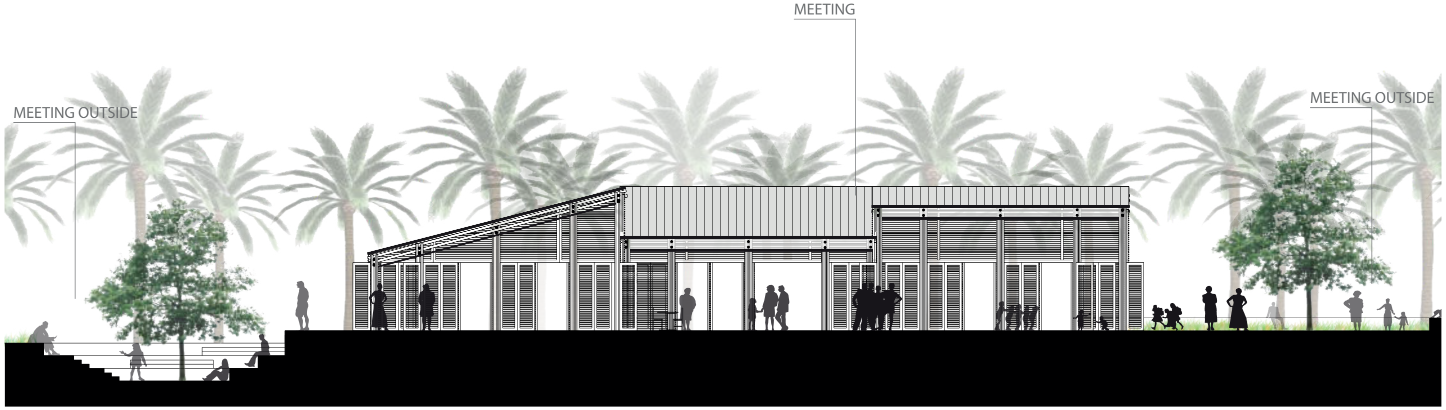
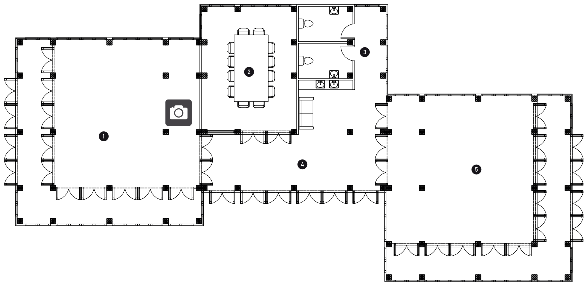


FIG. 110: MEETING SPACE ELEVATION



1 MEETING SPACE 100 m2
2 PRIVATE MEETING ROOM 30 m2
3 TOILETS [M/F] 15 m2
4 LOUNGE 45 m2
5 MEETING SPACE 100 m2

FIG. 111: MEETING SPACE PLAN

FIG. 112: VISUALIZATION OF THE MEETING SPACE INTERIOR

FIG. 113: EDUCATIONAL SPACE SECTION

FIG. 114: VISUALIZATION OF THE CLASSROOM INTERIOR

EDUCATIONAL SPACES

The educational space provides with a place for the local rural community to have a comfortable learning environment for the disadvantaged children of the local community. The southern view of the perforated facades provides a panoramic view of the water body that extends along the southern side of the educational compartment.

There is also a workshop area included in this zone. The workshop will be used by both children and adults of the local community. The idea of perforated double facades especially on the south and the west side are also used in this functional area. We intended to design a learning environment which is flexible and always naturally ventilated and shaded from the warm sun but still permits the infiltration of natural day light.

The teacher's room is adjoined with the workshop. The class room and the workshop are very close to the water body which increases the effect of evaporative cooling. Safe drinking water will be ensured which will be collected and filtered by our rainwater harvesting policies.

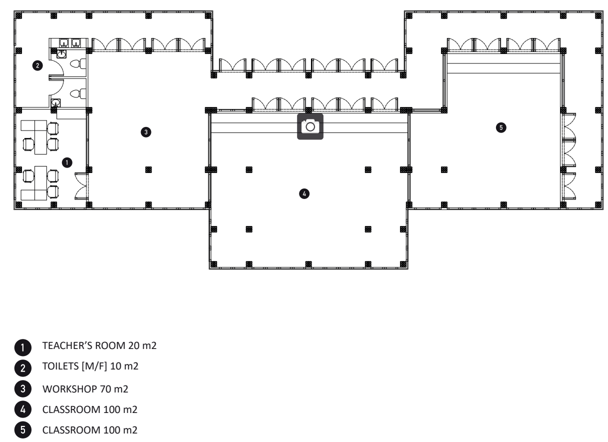


FIG. 115: PLAN OF THE EDUCATIONAL AREA

THE TOWER

The concrete tower has a cubic volume and externally provides a sense of structural rigidity and safety from the elements, especially during periods of disaster. On the ground floor, the user is provided access and view to all connected bamboo modules such as the dining area, which also connects to a shared outside meeting area.

The conference room and the office area is connected through the lobby, which also has external spaces. From the upper floors, the south and western facades provide with especially good views of the local neighborhood.

The first floor of the tower has dormitories and I.T room. The single rooms and dormitories which will also be rented to the tourists are situated on the 2nd and 3rd floor of the tower.

During the time of natural calamities the whole tower will be used as safe refuge for the local community.

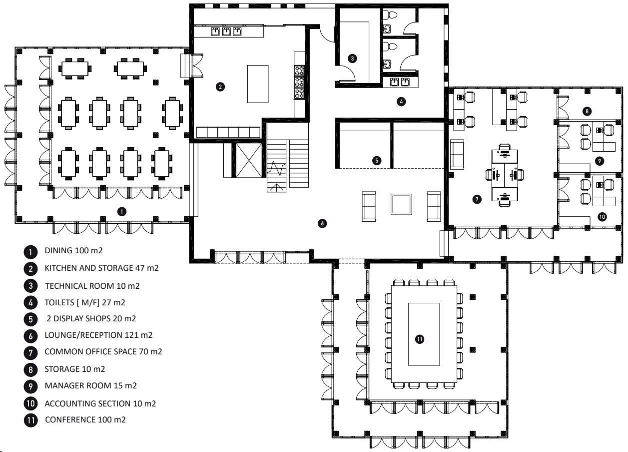


FIG. 116: TOWER GROUND FLOOR PLAN

FIG. 117: VISUALIZATION OF THE TOWER WITH WATER BODY

FIG. 118: SECTION 1

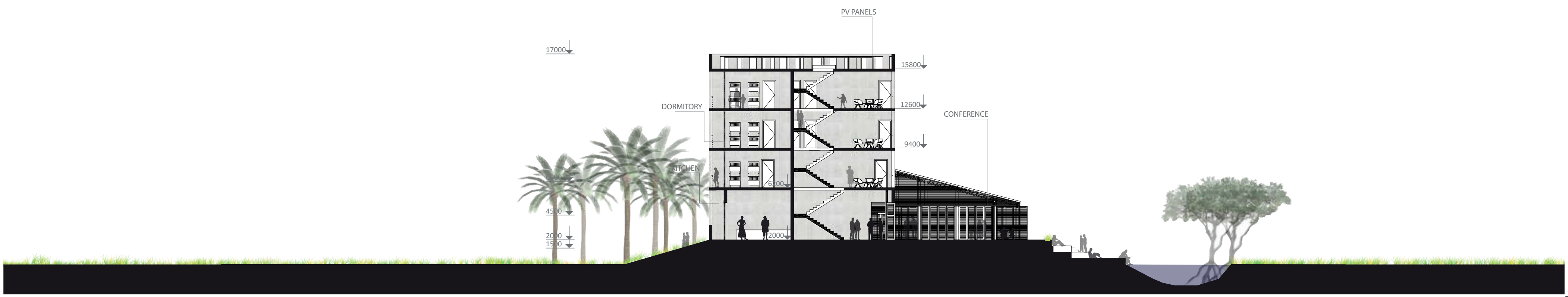


FIG. 119: SECTION 2

ELEVATIONS

All elevations have in common, that the bamboo modules produce silhouette of a baseline foundation upon which the concrete tower rises and stands tall with its differing materiality and window directionality. From the south and north elevation, a slow gradient from one side is sloping up towards the tower, which suddenly appears. For the west and east elevation, the elevation is grading from the water body with the stairs leading up to the educational zone.

The form which is adjacent to the concrete tower is designed in such a way so that it expresses that low heighted forms are clinging on with the concrete tower but also supporting each other. The use of perforated double facade gives the essence of transparency in the form which ensures natural daylight and continuous ventilation. It also provides a sense of semi privacy.

During the cyclones all perforated facades can be easily closed and it helps to avoid many damages after the storm. Therefore, corner bracing is provided in such way, that it makes the bamboo structure more stable and also helps during the times of disasters.

Finally, the height of the tower is 17 meters from the ground level which makes it appear like a landmark in the local context and will also be visible from the adjacent local communities.

FIG. 120 - 121 : DETAILS OF THE ELEVATIONS

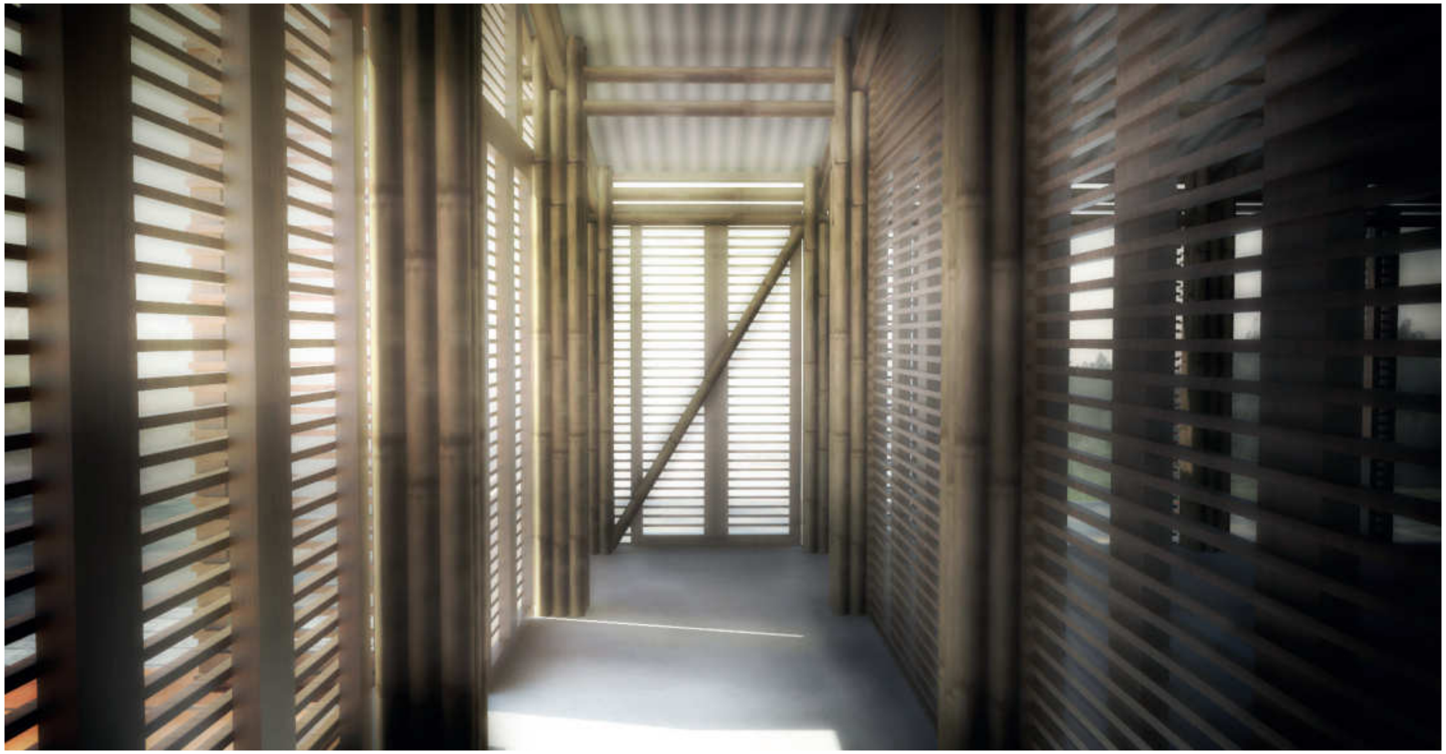


FIG. 122: VISUALIZATION OF THE DOUBLE FACADE AND CORNER CROSS BRACING

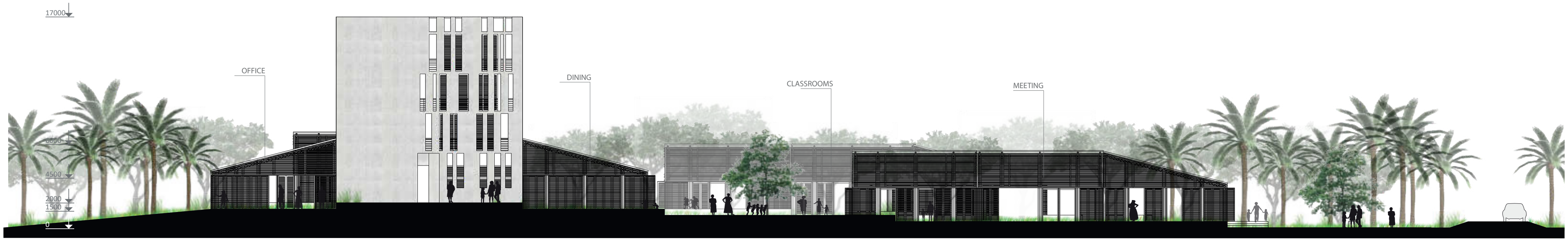


FIG. 123: NORTH ELEVATION

FIG. 124: EAST AND SOUTH ELEVATIONS

DISASTER SCENARIO

During times of disasters with the surges accompanying the cyclones, the ground elevations are made so that the area surrounding the concrete tower is above the highest surge levels. During floods the top half of the bamboo huts provides an entrance-like appearance from the roadside, while the concrete tower can be seen from far away.

As the power generated by the solar panels are stored in the concrete tower, so the artificial lighting inside the tower will make it even more visible on the night times appearing as a beacon from safety from distances. The kitchen and food storage in the tower will be helpful to ensure safe food and drinking water during disasters.

The master plan is done in such a way that the functionality of the whole project can adapt with different water levels during the floods. If the water rises less than 1 meter only the meeting area will be flooded but the rest of the project will be functional. If the water rises less than 1.5 meter the educational and meeting zone will be flooded but the forms adjacent to the tower like Dining, Office, Conference and the tower will not be flooded. Lastly if the water rises less than 2 meters (which is very unlikely) everything else will be flooded but the tower will still remain safe from flooding.

Nowadays the early detection system of cyclones in Bangladesh is really efficient, so the people gets informed at least 10 to 12 hours before the cyclones make landfall. Our idea was for that reason to design the facades in such a way so it can be totally closed down during the cyclones. And also the functions which are more vulnerable to flooding in the project do contain minimal furniture and no electrical equipment are installed there. So the management of the community center will always have enough time to remove anything valuable from the lower parts of the project to the tower if needed before the cyclone actually makes landfall.

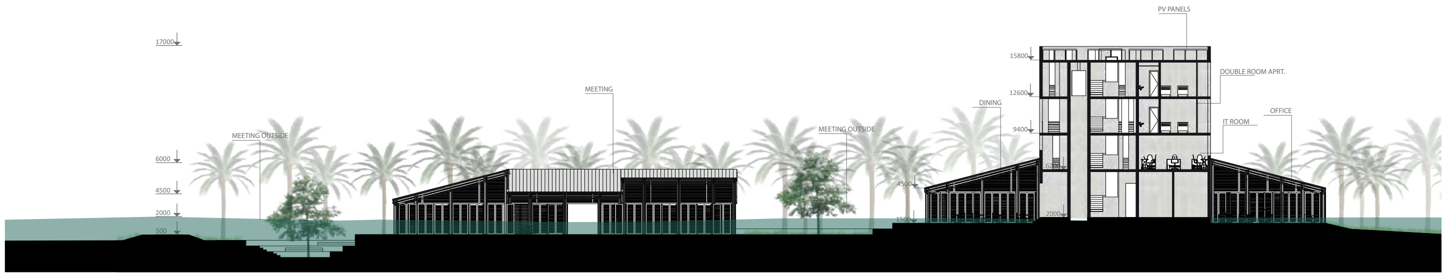


FIG. 125: SECTION OF THE FLOODED AREAS IN THE COMPLEX

FIG. 126: MASTER PLAN WITH FLOODED AREAS

FIG. 127: VISUALIZATION OF THE FLOODED SITE

‘We do not create the work. I believe we, in fact, are discoverers’

Glenn Murcutt

FIG. 128: VISUALIZATION OF THE FLOODED SITE AT NIGHT

FEEDBACK TO THE COMMUNITY

An important factor for the project is to not only provide insight and possibilities to the community center itself, but also serve as a constructional inspiration for the local population and the community.

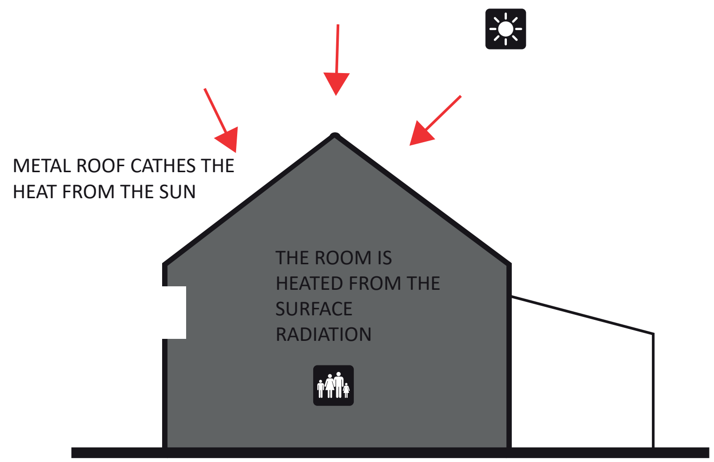
In the project, the constructional elements are comprised of four principles. First principle is a measure for structural stability, where diagonal bracing towards the columns at the supporting columns is reinforcing the overall structure, by making stabilizing ways to transfer the horizontal loads from the roof to the ground. This is especially useful during the cyclone storms, where an omni-directional structural rigidity is an important feature to prevent structural collapse.

The second principle is a simple mean to provide better thermal indoor climate, by reducing the heat conducted from roofs, especially in the case of the rural huts with corrugated iron sheets, where these heats up from the continued solar radiation during the warm summer days.

By adding a suspended ceiling to these structure with a naturally ventilated gap space. As analyzed with the example of the rural hut (page 29), the indoor climate can generally be improved by a large margin through simple means.

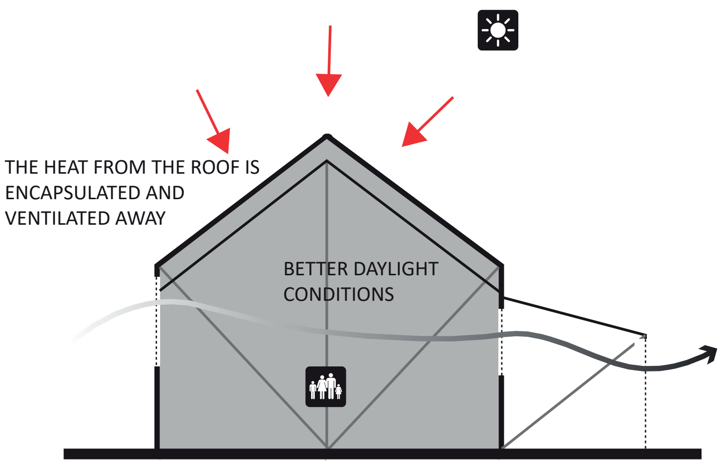
The third principle revolves around the idea of using a double layer facade with perforation, in order to allow for indoor areas that are both private as well as ventilated. The perforated facades allow for rooms that are both lit with daylight as well as shaded from the sun. The perforation also has the advantage, that the lack of resistance against wind and flood decreases the actual pressure the structure would sustain if the wall was solid, thus in this way the bamboo walls are able to last even during the periods of harsh environmental conditions.

EXISTING SITUATION



1 OVERHEATING FROM THE ROOF
2 BAD DAYLIGHT CONDITIONS
3 VENTILATION ISSUES

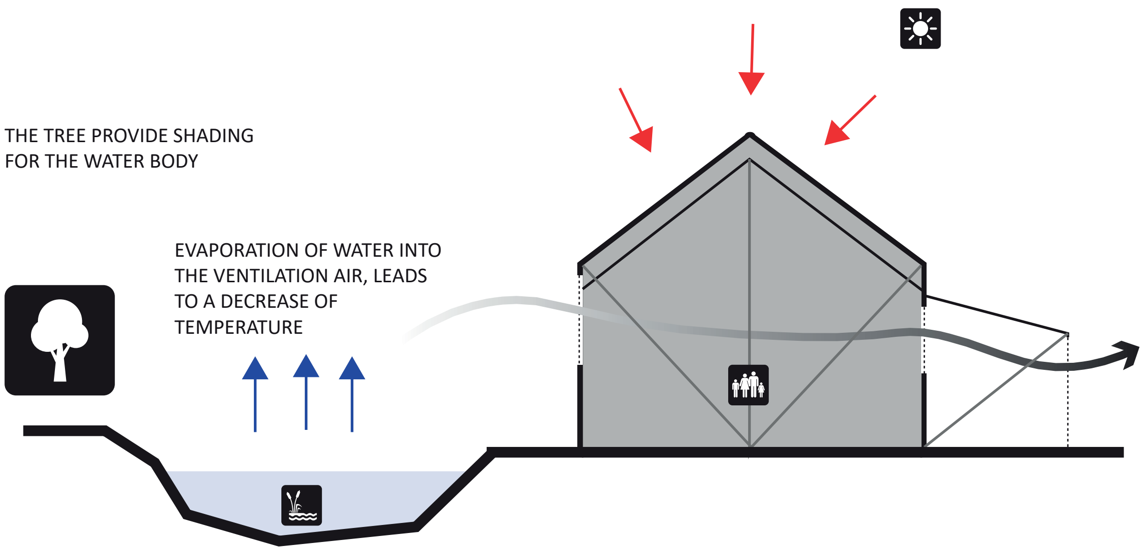
SUGESTIONS



1 CREATE CAVITY ROOF
2 ADD VERTICAL LOUVERS
3 CREATE CROSS VENTILATION
4 INCREASE STABILITY WITH A CROSS BRACING

FIG. 129: FEEDBACK TO THE COMMUNITY DIAGRAM

ADDITIONAL SUGESTIONS



1. RAISE PERMANENT PLINTH
2. IF IT IS POSSIBILITY HAVE WATER BODY

The final principle is the usage of evaporative cooling to introduce a way to cool down the air inflow before it enters the building, by having a water body in the general wind direction of the site, which in terms will provide with ventilated wind that is cooled by the evaporative cool down from the water.

The usage of trees to shade the surrounding water body is another part of the principle, where the trees can also be a speed-breaking obstruction for cyclone winds from the given direction.

The actual thermal impact from the evaporative cooling effect haven't been integrated into the project due to the advanced CFD software required to accurately simulate and quantify such an effect, which means that the actual measurements used in the report potentially could lead to even better thermal comfort, once taken computationally into consideration.

13

EPILOGUE

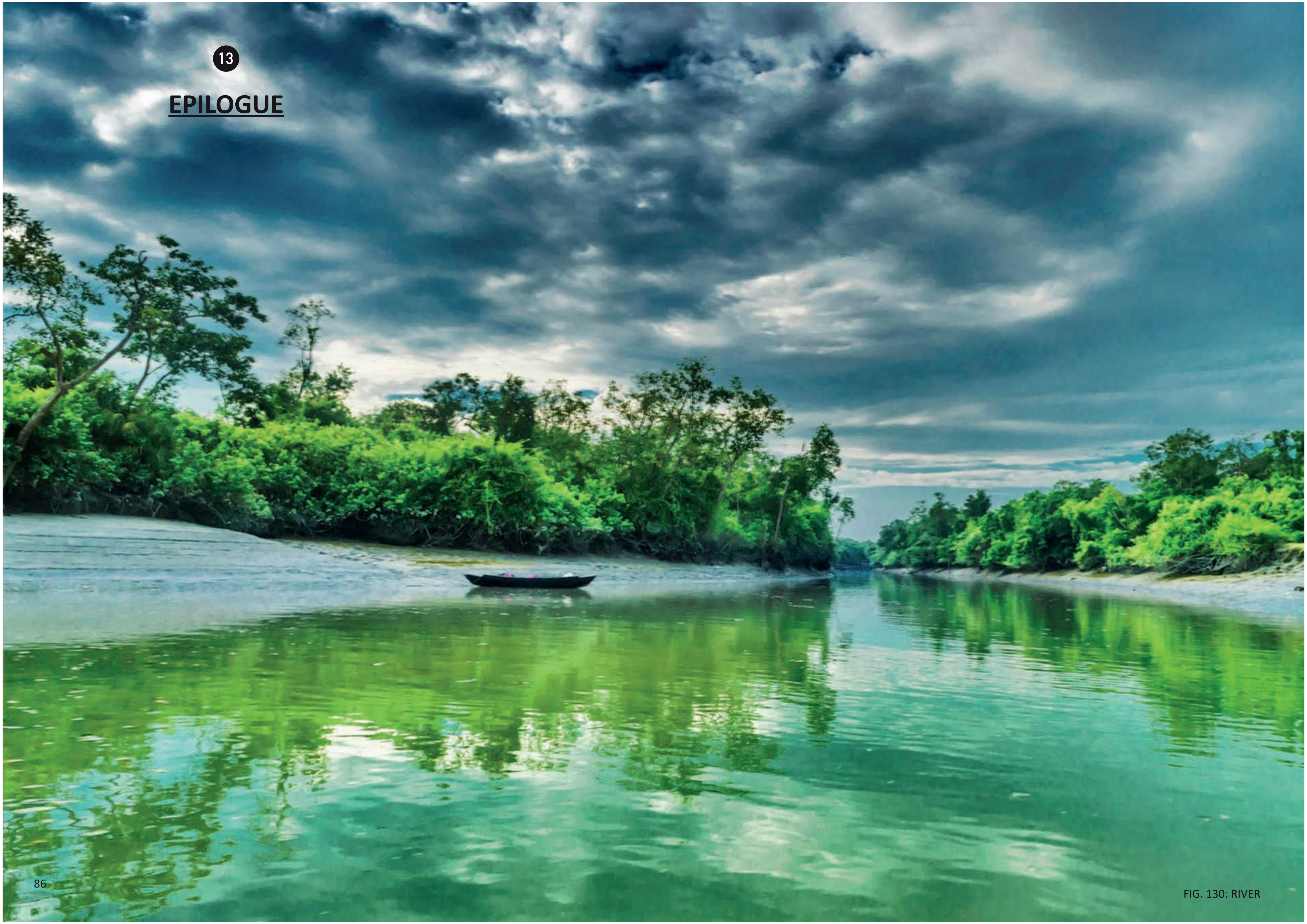


FIG. 130: RIVER

REFLECTION

Upon reflecting on the project and the overall process of developing a proposal for the community center, it has shown the different fields needed to make a project of this scale and scope come together into a holistic project, that reaches out into both the architectural principles and engineering techniques, applied through the usage of the integrated design process.

For the process, the lack of opportunity (the lack of information early in the semester about the availability of the funding) for a site-survey in Bangladesh during the analysis process could have made more impact on the project result. Such examples include the on-site investigation and both quantitative and qualitative analysis of both the context and population that could have been beneficial to the project, and the revealed information about opinions on local materiality and flow, along with the general atmosphere of the site, where more phenomenological surveys could have been carried out.

In terms of atmospheric comfort, some calculations for the concrete tower rooms was made to assess how much of an air change would be required to acquire a comfortable atmosphere, although the potential for more accurate measures of the average ventilation efficiency through CFD-measures could have been made.

The economic focus has primarily been on an overall sustainable scale with focus on cheap local materials and low constructional complexity, and potential economic quantification of the actual building costs and an iterative comparison between component costs and structural/thermal/ daylight- efficiency would have been a possibility, but was generally considered out of the scope of the project.

CONCLUSION

The purpose for the project was to create a sustainable community platform in a country prone to the harsh changing climatic conditions caused by the global warming.

A PLATFORM FOR THE COMMUNITY

The premise of creating a design proposal for a community center is the active use and involvement of the local people. Emphasis have been set in creating a center where the architecture would embrace the local culture and traditions in a way that would allow for the local population to identify with the building rather than feel alienated by it.

In that way, the primary intentions of the community center, the gathering and meeting of the local inhabitants can join and interact through social activities, support, traditions and information. Another intention of the center is the role of an educational center, working with the thematic of the rural learning environments, but providing comfortable and contextually optimal conditions to provide learning in.

In order to provide an economic foundation for the future of the center, a commercial perspective was also proposed implemented into the project. This aspect includes the display shop, conference facilities, dining and dormitories.

The connection of the community is to be further strengthened by the usage of locally available materials and locally founded building techniques, where the actual production of the building itself is something that will also be partaken by the local populace and in that way also create a closer connection and emphasize the intention of being a center based on the community.

HOLISTIC IMPLEMENTATION OF SUSTAINABILITY

The usage of the local materials is furthermore an exemplification of the economic sustainability of the project, where the focus on the economy is not only done through the aforementioned commercial zone of the center, but also the utilization of locally available and economical materials supports this intention.

The project concern of environmental comfort through the project is shown by the usage of passive cooling strategies such as cross-ventilation, evaporative water cooling and ventilated heat buffers, where such measures have been implemented to decrease the thermal over-comfort hours to comfortable levels. Environmental benefits from the electric power autonomy is present from the usage of on-site solar grids that helps provide a solid low energy foundation for the sites electrical facilities and equipment.

BUILDING IN A DISASTER-PRONE AREA

The priority of safety amongst the community has also been primary, and as such the possibility of the community center to transform in an emergency refuge. The bamboo huts are dimensioned structurally to be able to last wind loads up to 25% larger.

Structurally taking the possibility into consideration, that future climate changes might provide with wind speeds larger than currently, while still being able to alleviate the overall wind-pressure from both wind and surfaces with the perforated facades that allows wind and water to flow through temporarily.

The bigger and more structurally rigid concrete tower is situated at a higher altitude on the site and features the most water sensitive equipment, as well as act as the general shelter able to protect the local community during periods of emergency. Furthermore, aesthetically the concrete tower is taking shape of a tower that is visible over long distances, giving the impression of being a beacon of safety.

GIVING TO THE COMMUNITY

Throughout the project, there has also been focus on providing some feedback to the community, where either new techniques or techniques built upon existing building techniques is elements that the local community can adapt to their own buildings.

‘We shape our buildings; thereafter they shape us.’
Winston Churchill

REFERENCES

[Dr. P.K.Mishra, 2001, Guidelines for cyclone resistance constructions of buildings in Gujarat. Available from: http://www.tn.gov.in/tsunami/digitallibrary/ebooks-web/31%20Guideline%20_for%20_Cyclone%20_Resistant_%20Construction%20_of%20_Building.pdf Accessed on 22 02 2017]

[Dr. K.Iftekhar Ahmed, 2005, Design and Construction of Housing for Flood-prone Rural Areas of Bangladesh. Available from: http://www.adpc.net/Igo/category/ID189/doc/2013-p74Wob-ADPC-handbook_complete-b.pdf Accessed on 22 02 2017]

[M.R.Alam, 2016, International Journal of Disaster Risk Reduction, Vulnerability assessment and construction recommendations of local houses in the cyclone prone coastal areas of Bangladesh. Available from: http://www.sciencedirect.com/science/article/pii/S2212420916302242 Accessed on 23 02 2017]

[A.Agarwal, 2007, Cyclone resistant building architecture. Available from: http://nidm.gov.in/PDF/safety/flood/link2.pdf Accessed on 23 02 2017]

[P. Patnaik, 2015, Cyclone-Resistant Design of Buildings as Per Indian Standards. Available from: http://urst.org/siteadmin/upload/2517U1015325.pdf Accessed on 24 02 2017]

[Q.Alam, 2016, Sustainable dwelling for the disaster prone coastal villages in Bangladesh. Available from: https://www.researchgate.net/project/Sustainable-dwelling-in-the-disasterprone-coastal-areas-of-Bangladesh Accessed on 24 02 2017]

[D.M.Hasan, 1985, A Study of Traditional House Forms in Rural. M.Arch Thesis. Bangladesh University of Engineering and Technology.]

[T. Cao Duy, 2007, Typhoons and technical solutions recommended for existing and new houses in the cyclonic regions in Vietnam. Available from: http://www.ejse.org/Archives/Fulltext/2008/Special2/VET200802.pdf Accessed on 25 02 2017]

[N.Uddin, 2007, A study on the traditional housing technology of Bangladesh. Available from: http://www.niscair.res.in/sciencecommunication/ResearchJournals/rejour/ijtk/Fulltextsearch/2008/July%202008/IJTK-Vol%20%207(3)-%20July%202008-%20pp%20%20494-500.htm Accessed on 25 02 2017]

[M.S.Ullah, 2000, Rural housing in Bangladesh: An inquiry into housing typology, construction technology and indigenous practices. Available from: http://salekseraj.com/TP6.pdf Accessed on 25 02 2017]

[M.A.Muktadir, D.M. Hassan, 2001, Traditional house form in rural Bangladesh. A Case study for regionalism in Architecture. Available from: https://archnet.org/system/publications/contents/3676/original/DPC0287.pdf?1384775936 Accessed on 25 02 2017]

[V.Agrawal, 2013, Regionalism in architecture as an expression of appropriate technology and sustainability. Available from: https://www.scribd.com/document/222031633/Regionalism-in-architecture-pdf Accessed on 26 02 2017]

[A.L.Palmer, 2008, Historical Dictionary of Architecture. Available from: http://www.politicalavenue.com/108642/ARCHITECT-BOOKS/Historical%20Dictionary%20of%20Architecture.pdf Accessed on 26 02 2017]

[Dr. M.Ahmed, 1999, Rainwater harvesting potentials in Bangladesh. Available from: http://wedc.lboro.ac.uk/resources/conference/25/363.pdf Accessed on 29 03 2017]

[K.Frampton, 1983, Towards Critical Regionalism: Six points for an Architecture of Resistance. Available from: http://www.modernindenver.com/wp-content/uploads/2015/08/Frampton.pdf Accessed on 26 02 2017]

[Friendship Centre / Kashef Mahboob Chowdhury/URBANA in ArchDaily, 2013. Available from: http://www.archdaily.com/423706/friendship-centre-kashef-mahboob-chowdhury-urbana Accessed on 26 02 2017]

[Pani Community Centre / SchilderScholte architects" in ArchDaily, 2015. Available from: http://www.archdaily.com/600713/pani-community-centre-schilderscholte-architects/ Accessed on 26 02 2017]

[Gandhi Memorial Museum (Sabarmati Ashram) / Charles Correa in ArchEyes, 2016. Available from: http://archeyes.com/sabarmati-ashram-museum-gandhi-residence-charles-correa/ Accessed on 26 02 2017]

[Charles Correa – Parekh house in ArchiBlog, 2011. Available from: https://thearchiblog.wordpress.com/2011/01/09/charles-correa-parekh-house/ Accessed on 26 02 2017]

[M. Knudstrup, 2004, The Integrated Design Process - A more holistic approach to sustainable architecture. Available from: http://vbn.aau.dk/files/1624830/The_Integrated_Design_Process__IDP____A_more_holistic_approach_to_sustainable_architecture Accessed on 25 02 2017]

[Jong-Jin Kim, 1998, Qualities, Use, and Examples of Sustainable Building Materials. Available from: http://www.umich.edu/~nppcpub/resources/compendia/ARCHpdfs/ARCHsbmIntro.pdf Accessed on 28 03 2017]

[Dr. U.Rahman, 2013, Rainwater harvesting in Bangladesh. Available from: https://issuu.com/shafiqsaeed/docs/rhs_book-f Accessed on 29 03 2017]

[A.Ahmed, 1993, Prospects for rainwater Catchment in Bangladesh and Its Utilization, Proc. 6th Int. Conf. Rainwater Catchment System, Nairobi, 1-6 August. Available from: http://www.eng.warwick.ac.uk/ircsa/abs/6th/abs6.pdf Accessed on 29 03 2017]

[K.Vaghela, 2013, Bamboo construction source book. Available from: http://communityarchitectsnetwork.info/upload/opensources/public/file_14062013022345.pdf Accessed on 14 04 2017]

[G.Z. Brown and M. DeKay, 2015, Sun, Wind, and Light, p. 184, Available from: https://sustainabilityworkshop.autodesk.com/buildings/wind-ventilation Accessed on 14 04 2017]

[Kwok, Alison G.; Grondzik, Walter T., 2007, The green studio handbook: environmental strategies for schematic design. Architectural Press]

[National Centers for Environmental Information (NCDC) Available from: http://www.ncdc.noaa.gov/ Accessed on 17 04 2017]

[BR 10 : 6.5.2 - Danish Building Regulations - Daylight Requirements. Available from: http://bygningsreglementet.dk/br10_04_id102/0/42 Accessed on 17 04 2017]

[prEN 17037 (DSF/prEN) - European Standard for minimum recommendations concerning light. Available from: https://webshop.ds.dk/da-dk/standard/dsf-pren-17037 Accessed on 17 04 2017]

[GKB, Hyldgård, et al; 1997, Available from: http://vbn.aau.dk/files/55667325/Grundl_ggende_klimateknik_og_bygningsfysik.pdf Accessed on 20 04 2017]

[DS/CEN/CR 1752; 2001, Available from: https://webshop.ds.dk/da-dk/standard/ds-cen-cr-17522001 Accessed on 20 04 2017]

[DS/EN 15251; 2007, Available from: https://webshop.ds.dk/da-dk/standard/ds-en-152512007 Accessed on 20 04 2017]

[Autodesk Sustainability Workshop - stack ventilation. Available from: https://sustainabilityworkshop.autodesk.com/buildings/stack-ventilation-and-bernoullis-principle Accessed on 20 04 2017]

ILLUSTRATION LIST

[Fig. 1 Bangladesh forest and river. Available from: https://lh6.googleusercontent.com/-hxhXAXsU6LU/VM-9rXljsIgI/AAAAAAAADjU/IeUdWxAxMOk/w2048-h1357/fatrar%2Bchor%2Bkuakata.jpg]

[Fig. 2 Sustainable architecture triangle. Available from: http://blogwine.riversrunby.net/wp-content/uploads/2013/06/3-Spheres-of-Sustainability.jpg]

[Fig. 3 Foggy fields. Available from: http://i0.wp.com/www.thelifecycle.org/wp-content/uploads/2015/06/DSC02343.jpg]

[Fig. 4 Integrated design diagram. Available from: http://vbn.aau.dk/files/1624830/The_Integrated_Design_Process__IDP____A_more_holistic_approach_to_sustainable_architecture]

[Fig. 5 Kuakata seaside during the tourist season . Own illustration]

[Fig. 6 Kuakata beach. Available from: http://www.tourtravelbd.com/kuakata-beach/]

[Fig. 7 Situation after cyclone. Available from: http://www.oxfamblogs.org/fp2p/wp-content/uploads/0502-mostafa.jpg]

[Fig. 8 - 15 pictures of the surroundings. Own illustrations]

[Fig. 19 Flood. Available from: http://floodlist.com/wp-content/uploads/2015/03/bangladesh-general-2-ddm.jpg]

[Fig. 20 After cyclone. Available from: http://gdb.voanews.com/EB30FAA3-1F56-4DD5-A810-90DECB785E35_cx0_cy10_cw0_mw1024_s_n_r1.jpg]

[Fig. 21 Winter time. Available from: https://spclick.files.wordpress.com/2012/10/winter2.jpg]

[Fig. 22 Rainy season. Available from: https://madventuresdotme.files.wordpress.com/2013/07/img_0903.jpg]

[Fig. 23 Summer time. Available from: https://wattsupwiththat.files.wordpress.com/2016/03/bangladeshi_farmers.jpg]
[Fig. 24 -27 Rural village hut in Bangladesh. Own illustration]

[Fig. 28 Available from: http://comfort.cbe.berkeley.edu/EN]

[Fig. 29 Analyses of rural hut. Own diagram]

[Fig. 30 Rural community meeting. Available from: https://sanitationupdates.wordpress.com]

[Fig. 31 After a disaster in the area. Available from: http://www.oxfamblogs.org/fp2p/wp-content/uploads/SS100247.JPG]

[Fig. 32-35 Own sketches]

[Fig. 36 A house in the coastal village with hipped pitched roof made of CI Sheets. Own illustration]

[Fig. 37 Rural meeting with an NGO employee in the courtyard. Available from: https://sanitationupdates.wordpress.com]

[Fig. 38 Outdoor folk music performance under a tree. Available from: www.lalongeeti.com]

[Fig. 39 Gathering under the shade of a tree. Available from: https://heliumchewinggum.files.wordpress.com/2015/04/2.jpg]

[Fig. 40 A village classroom. Available from: http://www.akdn.org]

[Fig. 41 Outdoor classroom in rural Bangladesh. Available from: https://vid.alarabiya.net]

[Fig. 43 Azuma House. Architect: Tadao Ando 1976. Available from: http://www.architravel.com/architravel_wp/wp-content/uploads/2013/01/row-house1.jpg]

[Fig. 44 Säynätsalo Town Hall. Architect: Alvar Alto 1952. Available from: http://www.architravel.com/architravel_wp/wp-content/uploads/2015/10/S%C3%A4yn%C3%A4tsalo-Town-Hall_main-630x315.jpg]

[Fig. 45 Kandalama hotel, srilanka. Architect: jeoffrey bawa. Available from: https://s-media-cache-ak0.pinimg.com/originals/7c/fd/df/7cfddf4a5b0e4c01b0b8118ff00cc093.jpg]

[Fig. 46-47 Own drawings]

[Fig. 48 Pani Community Centre / SchilderScholte architects" in ArchDaily, 2015. Available from: http://www.archdaily.com/600713/pani-community-centre-schilder-scholte-architects/]

[Fig. 49 Friendship Centre / Kashef Mahboob Chowdhury/URBANA in ArchDaily, 2013. Available from: http://www.archdaily.com/423706/friendship-centre-kashef-mahboob-chowdhury-urbana]

[Fig. 50 Gandhi Memorial Museum (Sabarmati Ashram) / Charles Correa in ArchEyes, 2016. Available from: http://archeyes.com/sabarmati-ashram-museum-gandhi-residence-charles-correa/]

[Fig. 51 Charles Correa – Parekh house in ArchiBlog, 2011. Available from: https://thearchiblog.wordpress.com/2011/01/09/charles-correa-parekh-house/]

[Fig. 52 Desi center. Available from: http://www.designboom.com/architecture/earth-architecture-handmade-school-bangladesh/]

[Fig. 53 Homemade family houses. Available from: https://www.dezeen.com/2017/03/05/bait-ur-rouf-mosque-dhaka-bangladesh-marina-tabassum-brick-aga-khan-award/]

[Fig. 54 Meti school interior. Available from: http://www.oris.hr/files/g/1-404/540x360-9/desi_22.jpg]

[Fig. 55 Meti school. Available from: http://www.oris.hr/files/g/1-404/540x360-9/rihani_18.jpg]

Fig. 56 Batur mosque Available from: http://mat2.materialicious.com/images/meti-school-by-anna-heringer-eike-roswag-o.jpg]

[Fig. 57 Batur mosque. Available from: http://www.akdn.org/sites/akdn/files/media/institutions/aga_khan_trust_for_culture/aga_khan_award_for_architecture/akaa-2016-bangladesh-bait_ur_rouf_mosque_04.jpg]
[Fig. 58 Own diagram]

[Fig. 59 Fields. Available from: https://gallery.bdshop.com/wp-content/uploads/2015/09/Bangladesh-river-3000x3000.jpg]

[Fig. 60 – 62 Own diagrams]

[Fig. 63 Community. Available from: https://s-media-cache-ak0.pinimg.com/736x/9b/1b/ed/9b1bedc26d82a4470bdb85a61c90c1f9.jpg]

[Fig. 64 Employees. Available from: http://www.mindworkingasia.dk/wp-content/uploads/2014/10/IMG_0679.jpg]

[Fig. 65 Tourist. Available from: http://i1.wp.com/www.wefindyougo.com/wp-content/uploads/2013/11/Patenga-Beach-Chittagong-640x360.jpg?resize=640%2C360]
[Fig. 66 Own diagram]

[Fig. 67 – 68 Consequences of the cyclone. Available from: http://www.presstv.ir/Detail/2016/05/22/466824/Bangladesh-Cyclone-Roanu-storm-Chittagong]

[Fig. 69 Own diagram]

[Fig. 70 Bamboo. Available from: https://static.pexels.com/photos/8980/pexels-photo.jpeg]

[Fig. 71 – 129 Own illustrations]

[Fig. 130 River. Available from: https://upload.wikimedia.org/wikipedia/commons/7/7e/Rangamati%2C_Bangladesh-The_Most_Beautiful_place_in_the_world.%2B.jpg]

[Fig. 131 Sunset in Kuakata beach. Available from: https://s-media-cache-ak0.pinimg.com/originals/58/bf/b4/58bfb4ecf2ec433b7900fe8c3b72bdac.jpg]

[Fig. 132 – 139 Own diagrams]

14

APPENDIX

FIG. 131: SUNSET IN KUAKATA BEACH

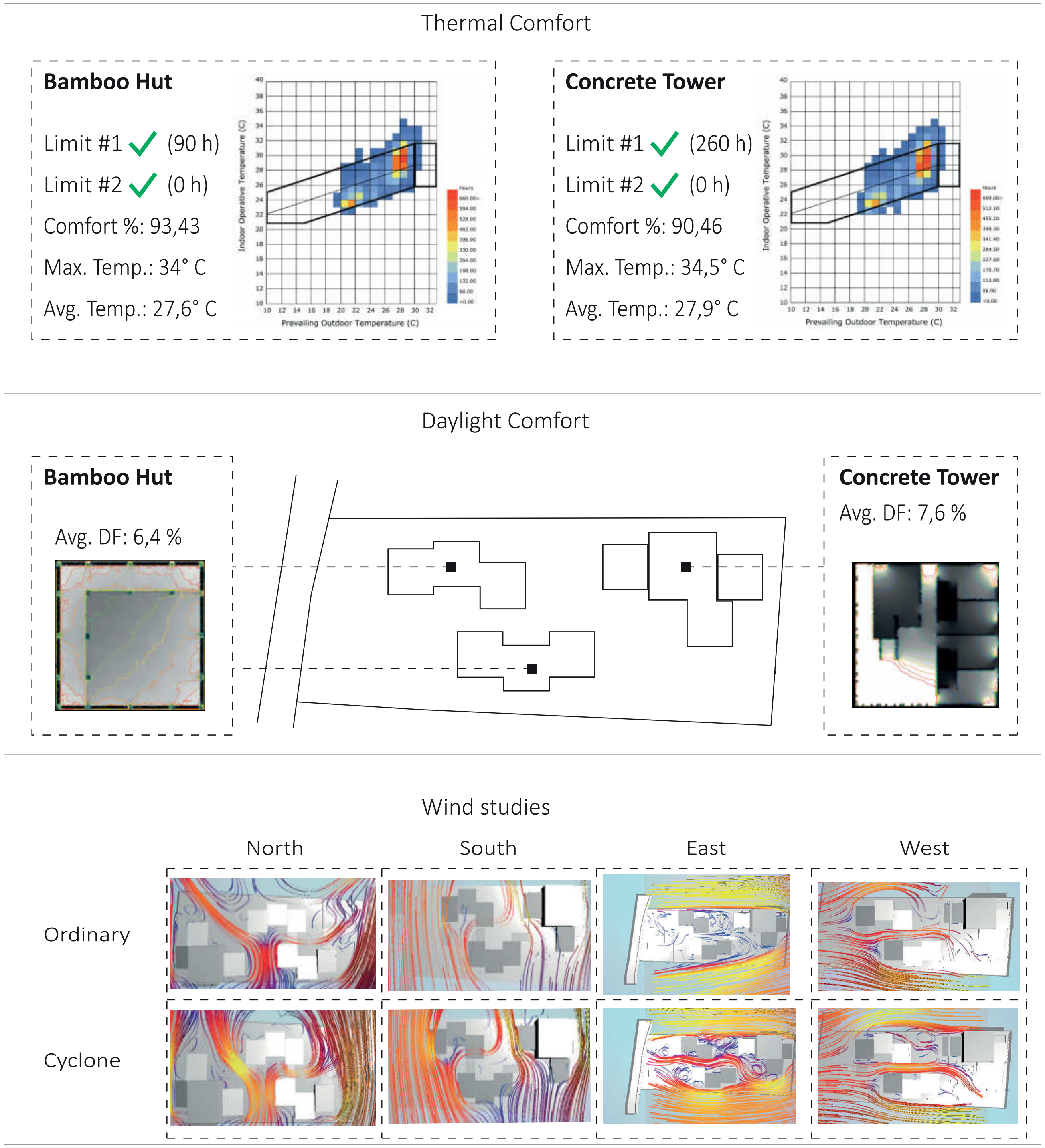


FIG. 132: FINAL TECHNICAL RESULTS DIAGRAM

FINAL TECHNICAL RESULTS

The results presented here includes the final technical data for the daylight comfort and the thermal comfort. For the bamboo buildings, it was already given that the thermal comfort would prove to have a temperature only marginally larger than the outside temperature with the perforated facades. The tower with its high thermal mass would prove to be a bigger problem, solved by providing plenty of ventilation and facade shades.

For the daylight, the overall complex shows to have plenty of daylight for all the areas where it is deemed crucial to sustain a visually comfortable working or living environment. The final wind-studies shows that the complex generally avoid turbulent winds from all 4 corner directions, and that the southward wind most of the time will be able to provide refreshing cross-ventilation during everyday use.

RAIN WATER HARVESTING

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. The idea behind the process is simple. Rainwater is collected when it falls on the earth, stored and utilized at a later point. It can be purified to make it into drinking water, used for daily applications and even utilized in large scale industries. In short, Rainwater harvesting is a process or technique of collecting, filtering, storing and using rainwater for irrigation and for various other purposes.

Rural water supply in Bangladesh is based on groundwater, as it is free from pathogenic microorganisms and available in adequate quantity in shallow aquifers. In Bangladesh, except in coastal and hilly areas, a remarkable success has been achieved by providing 97 per cent of rural population with tube well water. In the coastal belt, high salinity in surface and ground waters and in the hilly areas, absence of good ground water aquifers as well as difficulties in tube well construction in stony layers are the main constraints for the development of a dependable water supply system. At present, the success achieved in hand tube well based rural water supply is on the verge of collapse due to presence of arsenic in groundwater in excess of acceptable levels in the shallow aquifers. Provision of arsenic contamination free water is urgently needed to mitigate arsenic toxicity and protection of health and well-being of the rural population living in acute arsenic problems areas. The people, particularly the women living in the problem areas have to walk long distances to fetch water from an available source (Ahmed, A., 1993).

In order to avoid long distances walk, in the project is going to be implemented rainwater harvesting system. The calculations have been done and it is a need of 41160 l of drinking water annually. It means that for 70 people every day can be 4 l of drinking water.

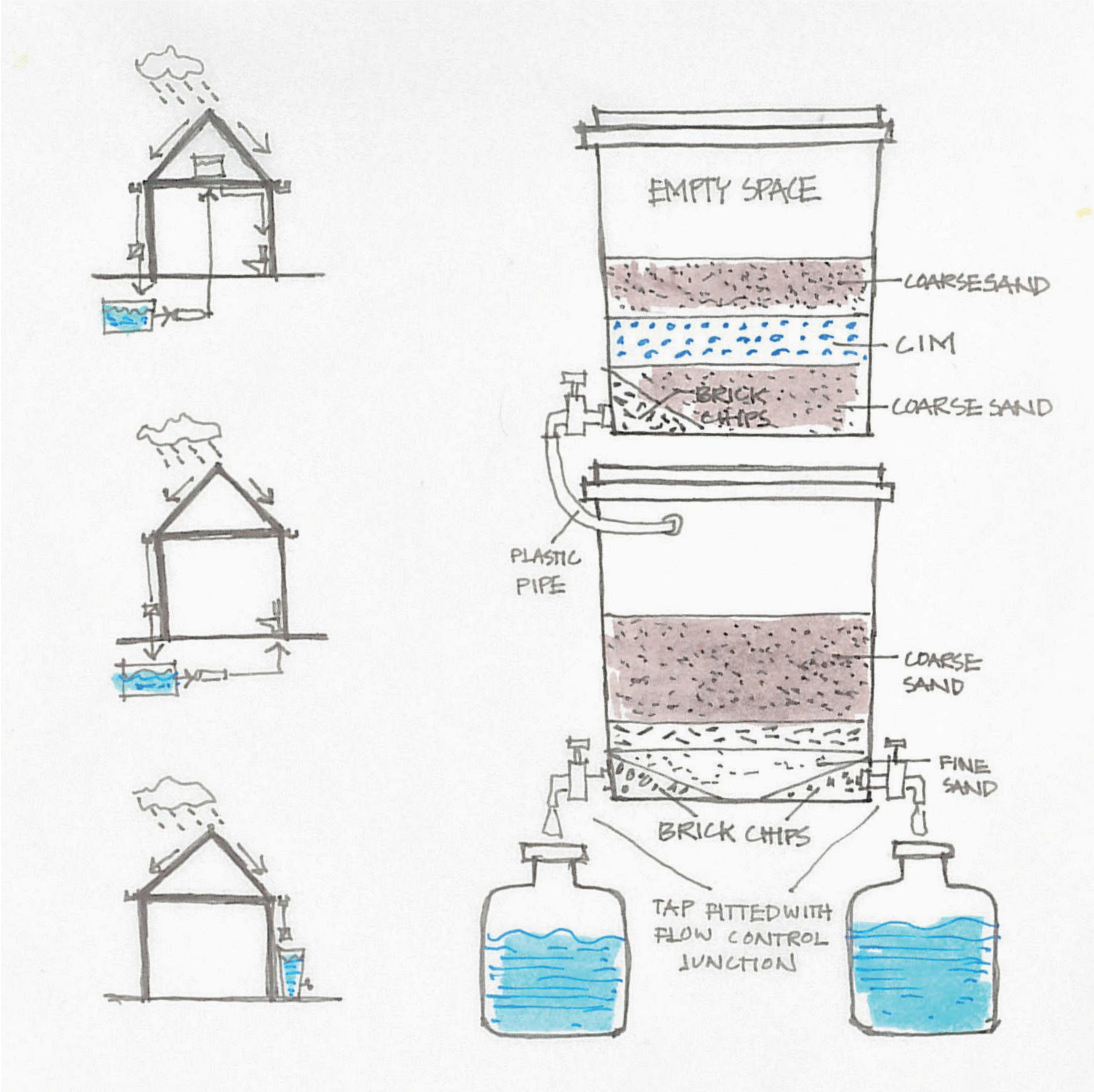
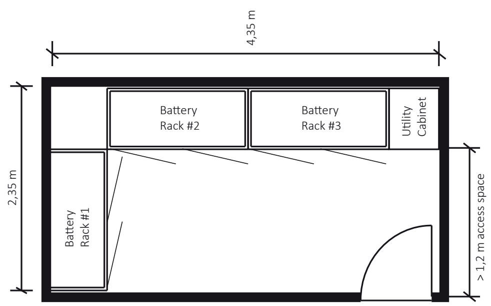
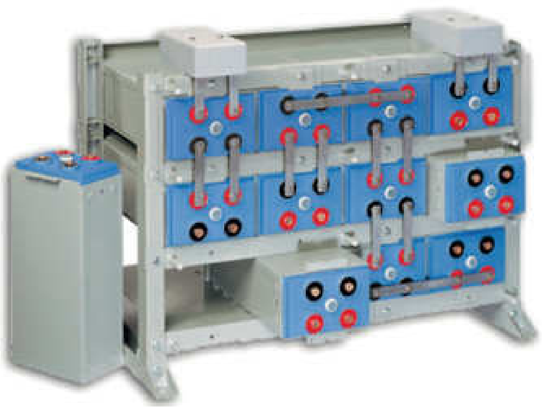


FIG. 133: RAIN WATER HARVESTING



Autonomous Days: 4
Battery Voltage: 48 V
Amp Battery Package: 3x 1148 A



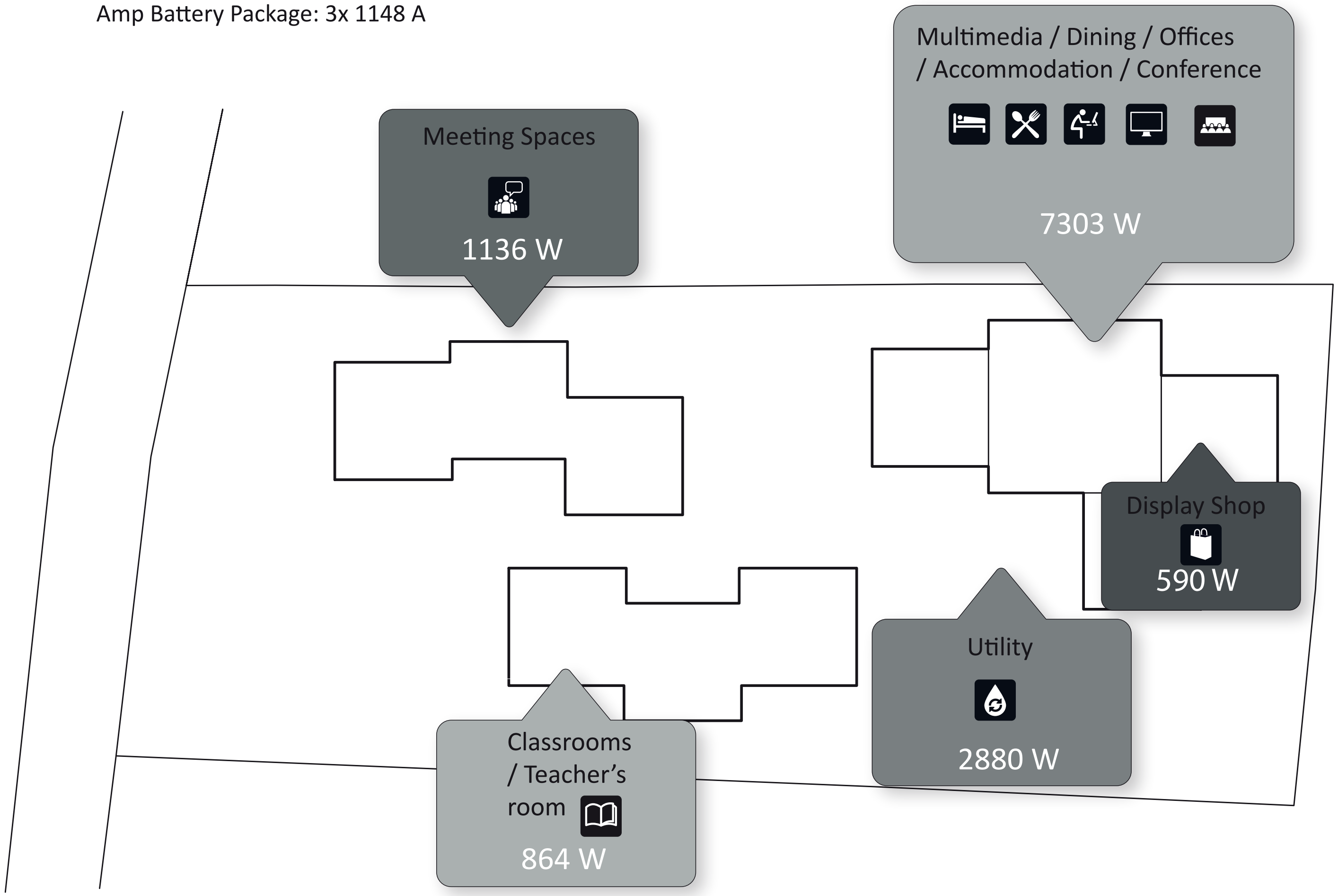


FIG. 134: SOLAR ENERGY STORAGE DIAGRAMS

SOLAR ENERGY STORAGE

Along with the necessary harvesting of solar energy, the off-grid nature of the community center entails the battery storage capability to be dimensioned according to the calculated needs. The battery storage days was estimated based on the general average recommendation of 2-5 days. The weather data for Bangladesh have been analyzed for the average daily sky-coverage, where the highest consecutive cloudy days is 4 on the highest average during the monsoon season. The differences of the potential for the solar cell efficiency between sunny and cloudy days was also analyzed. Here, it was found that on average, the differences between the total potential radiation for cloudy days was about 15% of the peak amount occurring on sunny days. For the battery storage, the fitting deep cycle batteries fitting about 3380 AH at 48 volt, where a 3 string configuration of an industry sealed AGM type battery in a rack (1148 AH) is capable of fulfilling the capacity. To fulfill the requirements for space and access to this battery rack, it will require approximately 10 m2 of space. [Altestore]

The batteries have been dimensioned to fulfill the needs of the whole complex, and doesn't take a possible separation of power compartments into account to seclude the power to the tower. In this case, the power usage could be reduced for about 50%, thus increasing the available battery power.

ANALYSIS OF THE RELATION BETWEEN OPENING RATIO AND PERFORATION PERCENTAGE

For the testing, a 10x10m cube with bamboo material and CA-sheet metal roof was simulated under the climatic conditions from Bangladesh, using UN-climate EPW weather data. The temperature is calculated inside Grasshopper working together with EnergyPlus, using the Archsim plugin as a connecting intermediate.

The average natural ventilation is calculated based on the simplified empiric formulae by Per Heiselberg, combined parametrically with the data for wind speed and direction Grasshopper. Sunlight hours and daylight factors are calculated for the averaged space in Grasshopper using the Ladybug and Honeybee packages.

Overall, the results show a clear change in the amounts of both ventilation and daylight factor as the result of this, with the daylight factor potentially nearing the critical limits the further decreased the daylight view access is (compared to the limits set on the functional requirements page). The maximum temperature sees very minor change, although this was also expected. Testing with the hourly operative temperature as a parameter instead later showed to have a more representative value.

The decrease perforation ratio expectedly seemed to reduce the amount of direct sunlight substantially, as expected, thus potentially removed the direct heat from the solar radiation.

FIG. 135: ANALYSES

Opening %	Perforation %			
		60%	50%	40%
	50%	21,66%	21,45%	21,25%
	33,3%	19,14%	18,04%	17,04%
	16,6%	16,15%	13,88%	11,81%

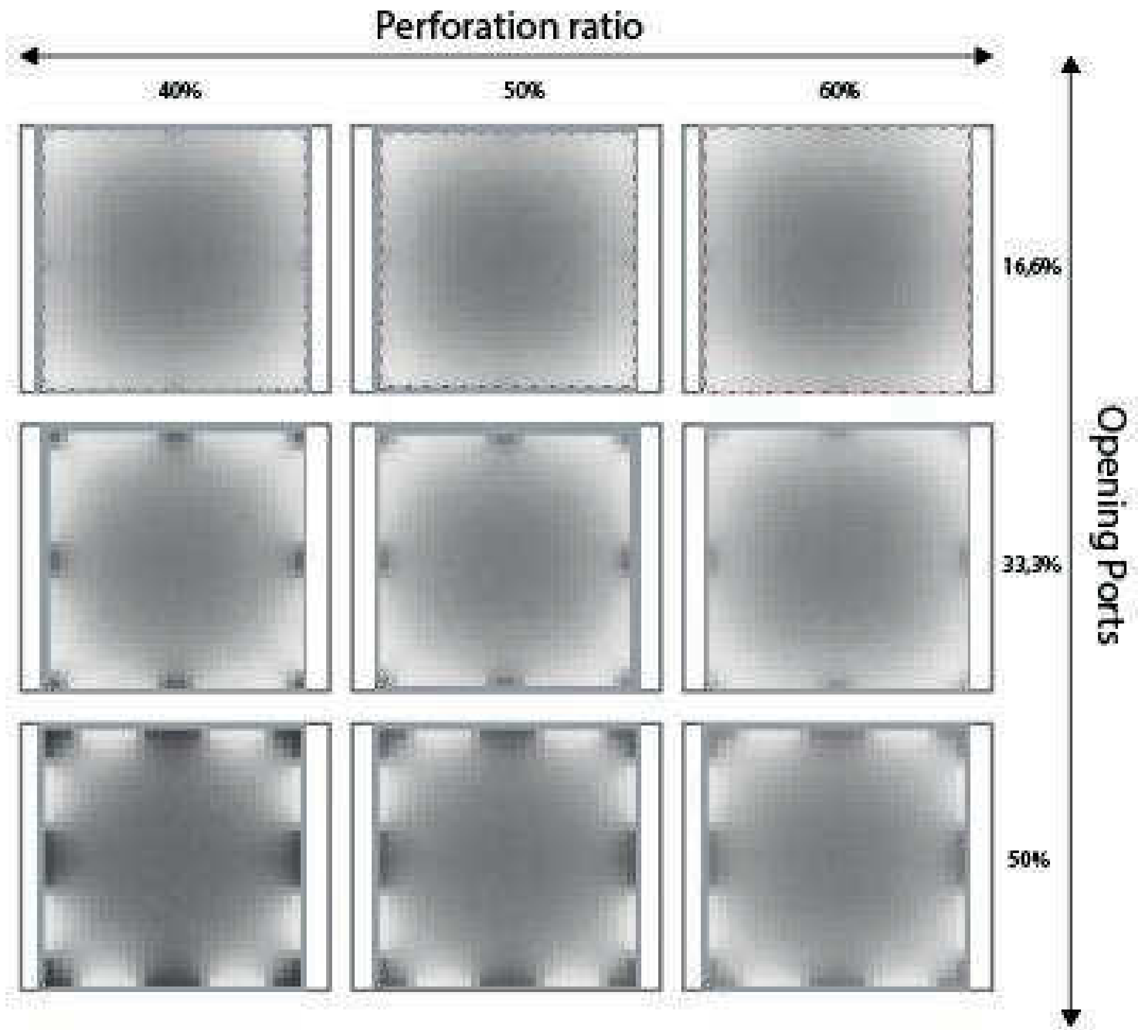


FIG. 136: INITIAL TESTING

INITIAL DAYLIGHT TESTING AND OPENINGS

The relationship between the perforation ratio and evenly divided opening ports (for doorways) was also analyzed, in order to determine the resulting daylight produced on the indoor surfaces.

As can be seen, a lower perforation percentage along with larger opening ports creates sharper more daylight variations, whereas very small opening ports generally produce even daylight

As can be seen from the results, the daylight factor varies between 21,66% to 11,81% on the type with the lowest opening percentage and the lowest perforation ratio, showing that generally it is also possible to achieve good daylight under such conditions. As these tests will show, the possibility of even reducing it to below half by adding another internal layer of perforated wall, while still meeting the functional daylight requirements for the various spaces.

DAYLIGHT CONTROL OF THE TOWER

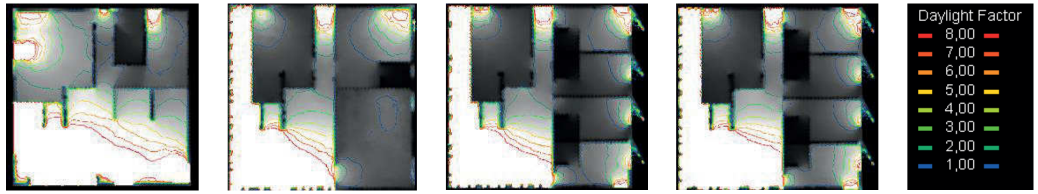
In order to ascertain whether or not the daylight conditions are sufficient in the final iterations of the tower, the tower have been analyzed in Velux daylight visualizer to ensure that no rooms have derived visual conditions below the acceptable levels.

Overall, the results show that the second tower performs best in terms of the overall daylight quality by an average margin ratio of 0,08 (the overall averaged divided). Tower 1 surprisingly showed to have the least overall average daylight factor, which can be attributed to the very contrasted daylight factors between the front and the backside (not displayed, but visible on the floorplan analysis).

On average, the selected model (Tower 2) shows an overall daylight factor of 5,8%, with the IT/multimedia-room on the second floor being the only room lacking substantially in terms of daylight.

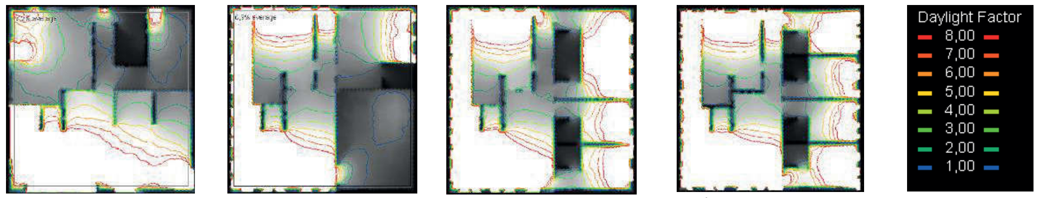
Tower 1 | Tower 2 | Tower 3

Tower 1



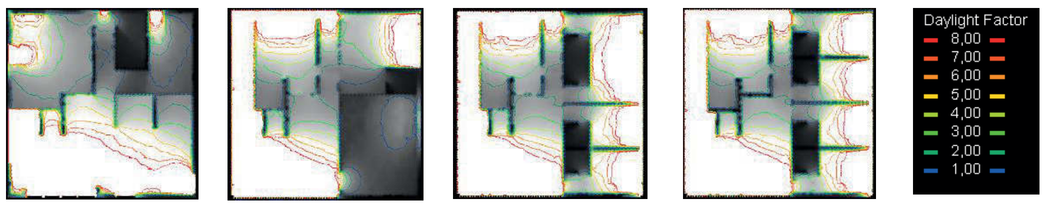
Ground Floor Avg. DF: 6,5% | 1st Floor Avg. DF: 5,4% | 2nd Floor Avg. DF: 5,2% | 3rd Floor Avg. DF: 6,1% | Signature

Tower 2



Ground Floor Avg. DF: 7,2% | 1st Floor Avg. DF: 6,9% | 2nd Floor Avg. DF: 9,2% | 3rd Floor Avg. DF: 8,8% | Signature

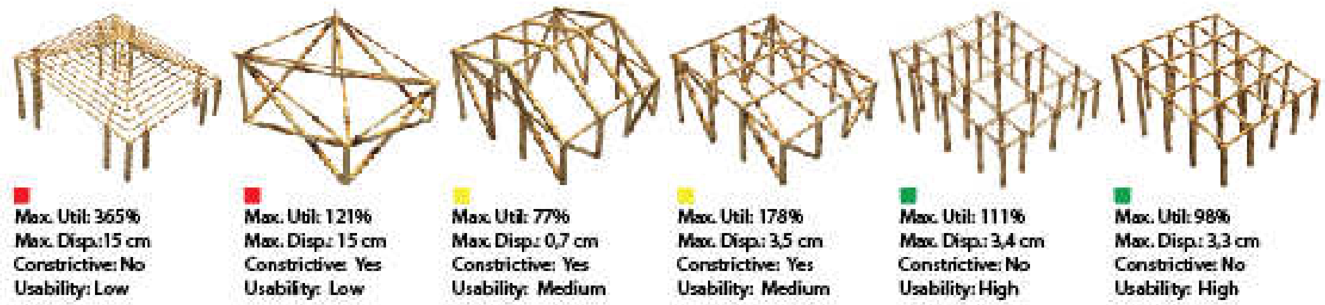
Tower 3



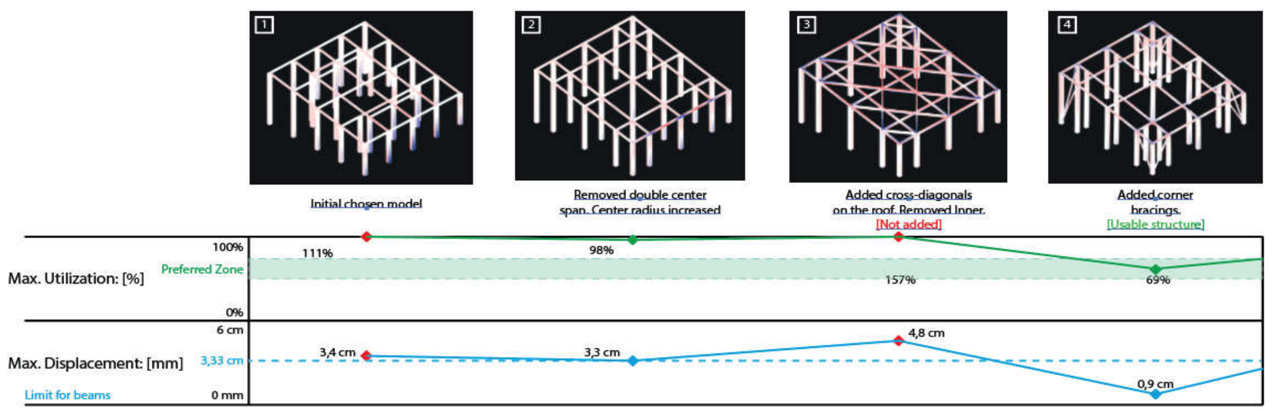
Ground Floor Avg. DF: 7,4% | 1st Floor Avg. DF: 6,4% | 2nd Floor Avg. DF: 7,8% | 3rd Floor Avg. DF: 7,8% | Signature

FIG. 137: DAYLIGHT ANALYSES

Initial structural testing



First structural optimization round



Second structural optimization round

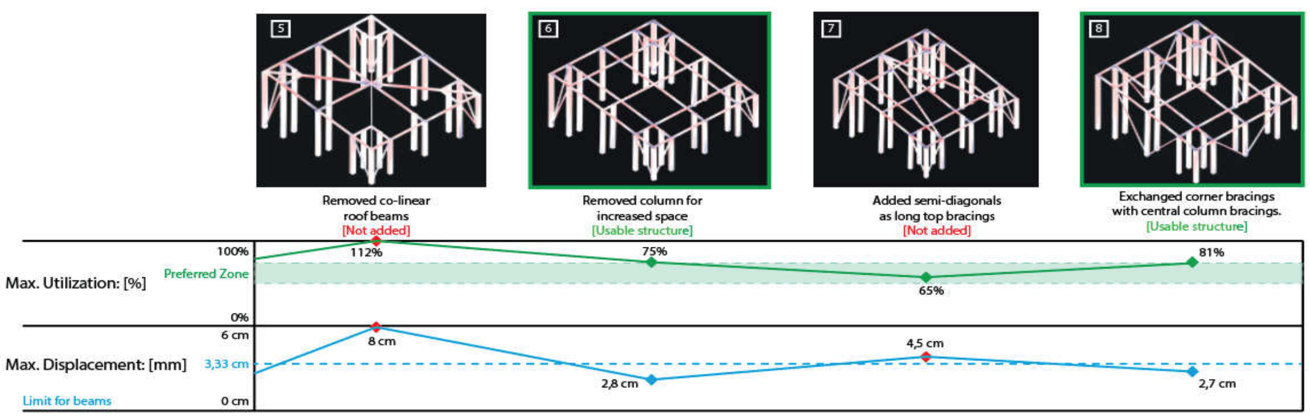


FIG. 138: STRUCTURAL ANALYSES

STRUCTURAL ANALYSIS

The structural analysis for the bamboo has been divided into 3 consecutive stages. The first stage of the structural development for the bamboo hut involved basic shape development, where various structures was tried and testing out according to their structural performance for max. utilization (Weakest element is presumed to break if above 100%) as well as displacement (visible bending of the beams). Secondary was the evaluation of constricting possible entrances by diagonal bracings, as well as the overall qualitative usability in terms of load support, circulation spaces and thermal perspectives. Furthermore, the latter 3 shapes of the initial structural testing came as a direct result of the initial thermal testing.

The two following optimization stages involved more subtle changes to the structural framework to achieve the best overall shape. The preferred zone refers to a margin where there's structural reserve for future climatic loads (such as increased wind speeds) thus more structural rigidity, as well as limiting costly over-dimensioning on the other end.

The result of the structural optimization is 3 usable structural modules, that at the end have been utilized throughout the complex, depending on the external connections as well as requirements for circulation spaces.

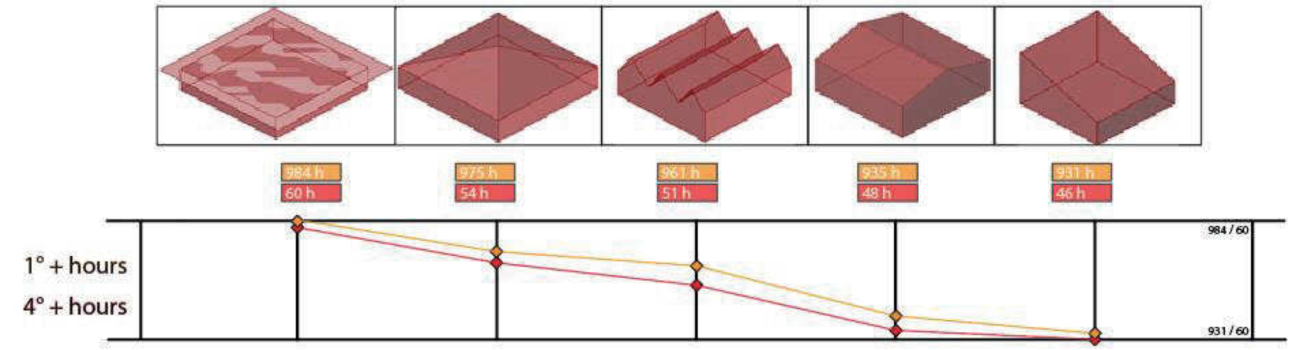
BAMBOO THERMAL SHAPE TESTING

The initial shape testing was conducted with a wide variety of shapes around roughly the same size of 10x10m. Each of them was conducted with iron sheet roofing and bamboo based walls. Each of the initial shapes was tested against annual over-comfort hours (See page 63), and although they didn't show any significant differences (due to the crude nature of the testing), the testing still showed that an effective blockage of southward sun helped limit overheating.

Furthermore, the criteria from the analysis phase restricted the usage of overhangs due to the nature of cyclones. In the end, the pitched roof shape was decided to be the overall best shape, in correlation with the concurrent processes from the daylight studies, wind simulations and structural studies.

In the thermal optimization stage, the process from a standard rectangular shape to the final pitched roof shape is shown, along with the expanded process view, showing derivatives of the specific action for angle, perforation and ventilation gap. The daylight especially influenced the process, as can be seen during the perforation test stage, where the slight decrease of over-comfort hours is overturned by the loss of daylight (as compared to the section about daylight and perforation studies).

Initial shape testing



Thermal optimization

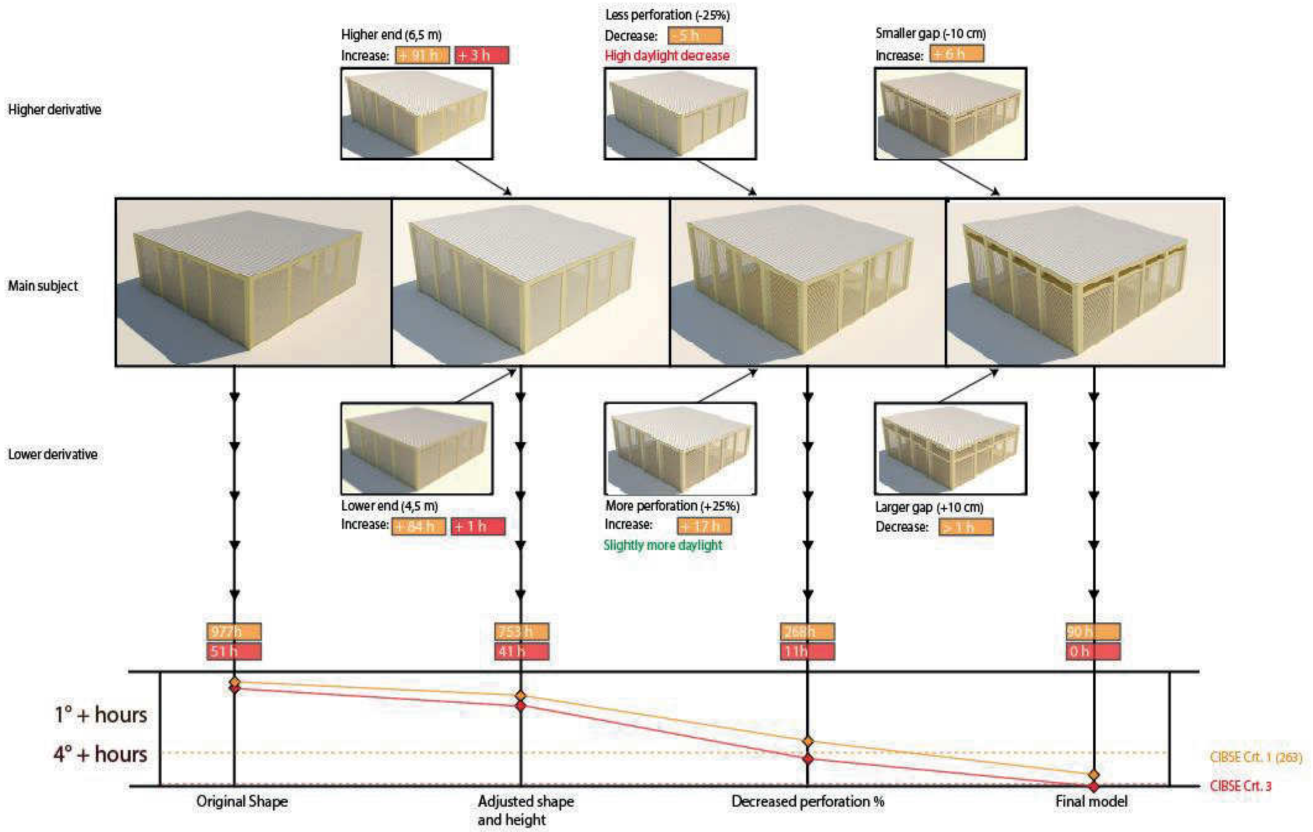


FIG. 139: THERMAL ANALYSES

Calculation of Atmospheric Comfort Ventilation

In order to assess the ventilation required to ventilate both carbon-dioxide and olfactory pollution away, these have been calculated for selected rooms.

Due to the large amount of perforation for virtually all the other functions, the necessary ventilation has been calculated for the IT-room and the accommodation as they were estimated to have the least amount of ventilation area in terms of the window size (inlet) available. The calculations are meant for comparative measures and evaluation of the natural ventilation, rather than for the sizing of mechanical ventilation, and thus cannot be regarded as an evaluation of the building performance.

As Bangladesh have no national information for the coefficients and factors involved, the default Danish one have been used to provide the examples. [CR 1752; GKB; DS 15251]

The results of the necessary air change rates are the following:

IT/Multimedia-room: 5,52 h-1

Double rooms: 4,31 h^{-1}

Dormitory: 4,29 h^{-1}

In this example, the necessary ventilation has been calculated as the highest for either CO_2 or sensory pollution in the IT-room.

Required ventilation for CO_2 pollution:

The steady-state CO_2 dilution equation looks like the following, where the result will be the hourly air change rate **n** needed to ventilate the pollution away (**q** and **c_i**):

$$c\ [ppm] = \frac{q\ [\frac{m3}{h}]}{n[h^{-1}] * V[m3]} + c_i\ [ppm]$$

The amount of pollution **q** is calculated as the amount of carbon dioxide polluted hourly by persons in cubic meters:

$$q[m3/h] = \frac{\frac{l, CO_2}{h} * persons * activityLevel\ [met]}{l/m^3}$$

First, the amount of CO_2 pollution is calculated, as the amount of carbon dioxide exhaled each hour, multiplied by the number of persons and the activity level (1 as standard):

$$q_{v,co2} = \frac{19\ l/h * 10\ persons * 1\ met}{1000\ l/m^3} = 0{,}19\ m^3$$

As per DS 15251, category B (same class as used for the thermal comfort), the max. ppm CO_2 value for the 90% satisfaction of occupants is 850 ppm, thus the air change **n** needs to be calculated. The standard outside preconditions for Denmark is used (CR 1752; due to lack of data otherwise) with 350 ppm:

$$850\ ppm = \frac{0{,}19\ m^3/h}{n * 144\ m^3} * 10^6 + 350\ ppm = 2{,}63\ h^{-1}$$

Required ventilation for olfactory pollution:

For the ventilation of the sensory (olfactory) pollution, the formula is like the one for CO_2 as a steady state solution, where the hourly change rate isn't included (the conversion of units is done further down), with **q** as pollution, **Vl** as the fresh flow needed to remove pollution and **c_i** as existing pollution:

$$c\ [dp] = \frac{q}{Vl} * 10 + c_i\ [ppm]$$

The amount of pollution is a result of the persons and the materials, the values have been set as (GKB):

$$q = 1\ olf * 10\ persons + 0{,}3 \frac{olf}{m^2} * 48\ m^2 = 24{,}4\ olf$$

Again, according to the specific category B, the satisfaction percentage for 90% is 1,4 decipol, combined to find the fresh flow in liters/second:

$$1{,}4\ dp = 0{,}3\ olf + 10 * \frac{24{,}4\ olf}{V_l} = 221\ l/s$$

Finally, the units from liters and seconds is converted to hourly cubic meter rates and divided with the room volume to find the hourly air change rate:

$$n = \frac{221 \frac{l}{s} * 3600\ s/h}{1000 \frac{l}{m^3} * 144\ m^3} = 5{,}525\ h^{-1}$$

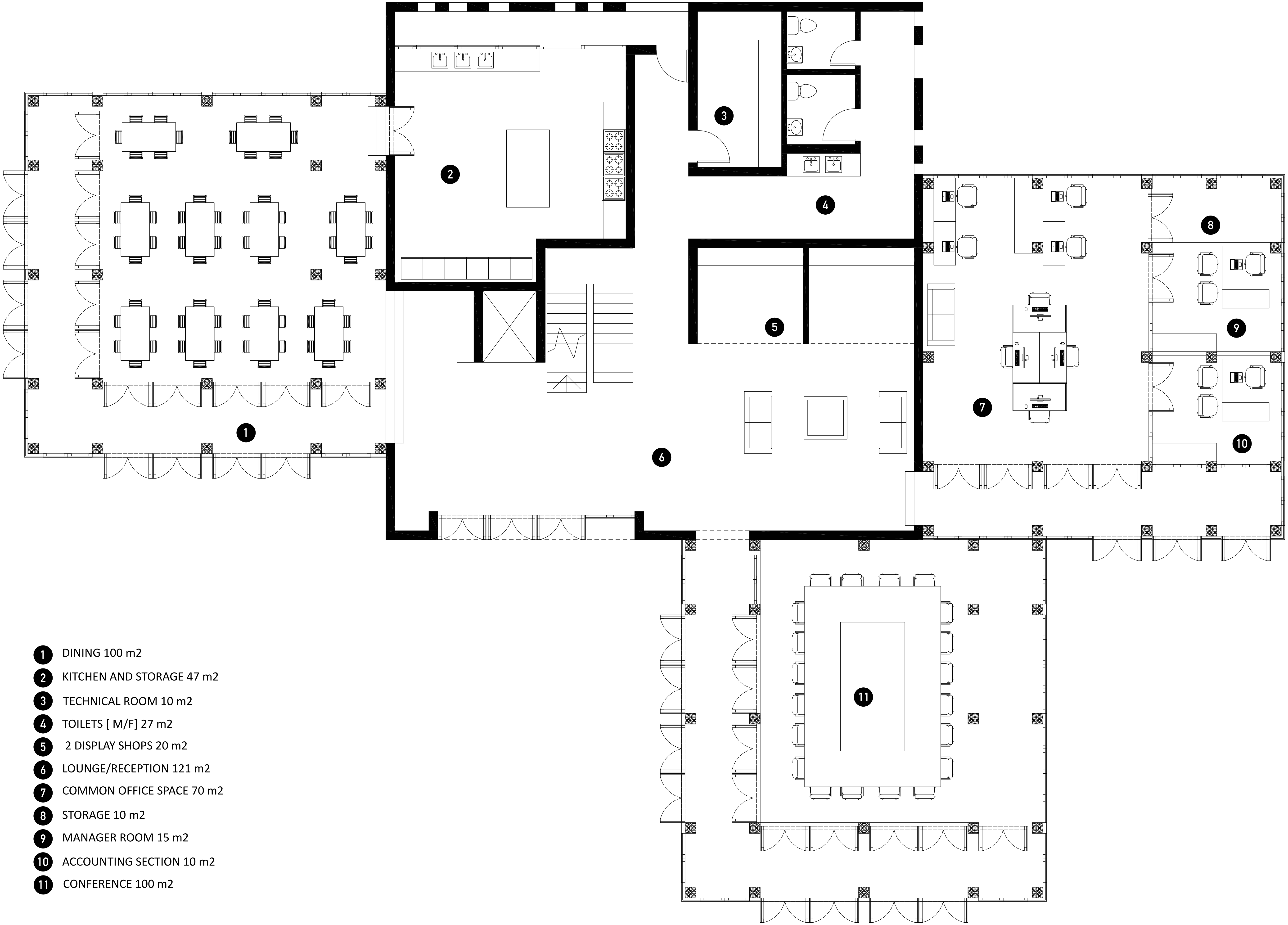
The minimum ventilation found as:

$$Max \begin{cases} CO_2\ Airchange = 2{,}63\ h^{-1} \\ Olfactory\ Airchange = 5{,}525\ h^{-1} \end{cases} = 5{,}525\ h^{-1}$$

NOTES

AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA	
	MASTER PLAN	
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 300	18 05 2017

+1.50
+0.50
0.00
+0.50
+1.00
+1.50
+2.00
+1.50
+1.50
-1.50
+0.50
+0.50
SITE AREA: 4365 m2
BUILT AREA: 1185 m2
DENSITY 27%
SITE LINE
BUILDING LINE
CONCRETE 316 m2
TERRACOTTA 1050 m2
WATER 690 m2
GRASS 1124 m2
ENTRANCE
AGRICULTURE FIELDS
MAIN ROAD
1 GUARD ROOM
2 PARKING
3 AMPHITHEATER
4 MEETING AREA
5 EDUCATIONAL AREA
6 MEETING AREA OUTSIDE
7 DINING AREA
8 THE TOWER
9 CONFERENCE
10 ADMINISTRATION
AALBORG UNIVERSITET
COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA
GROUND FLOOR PLAN
GROUP 29 A&D (MSc04 ARC)
SCALE: 1: 300
18 05 2017

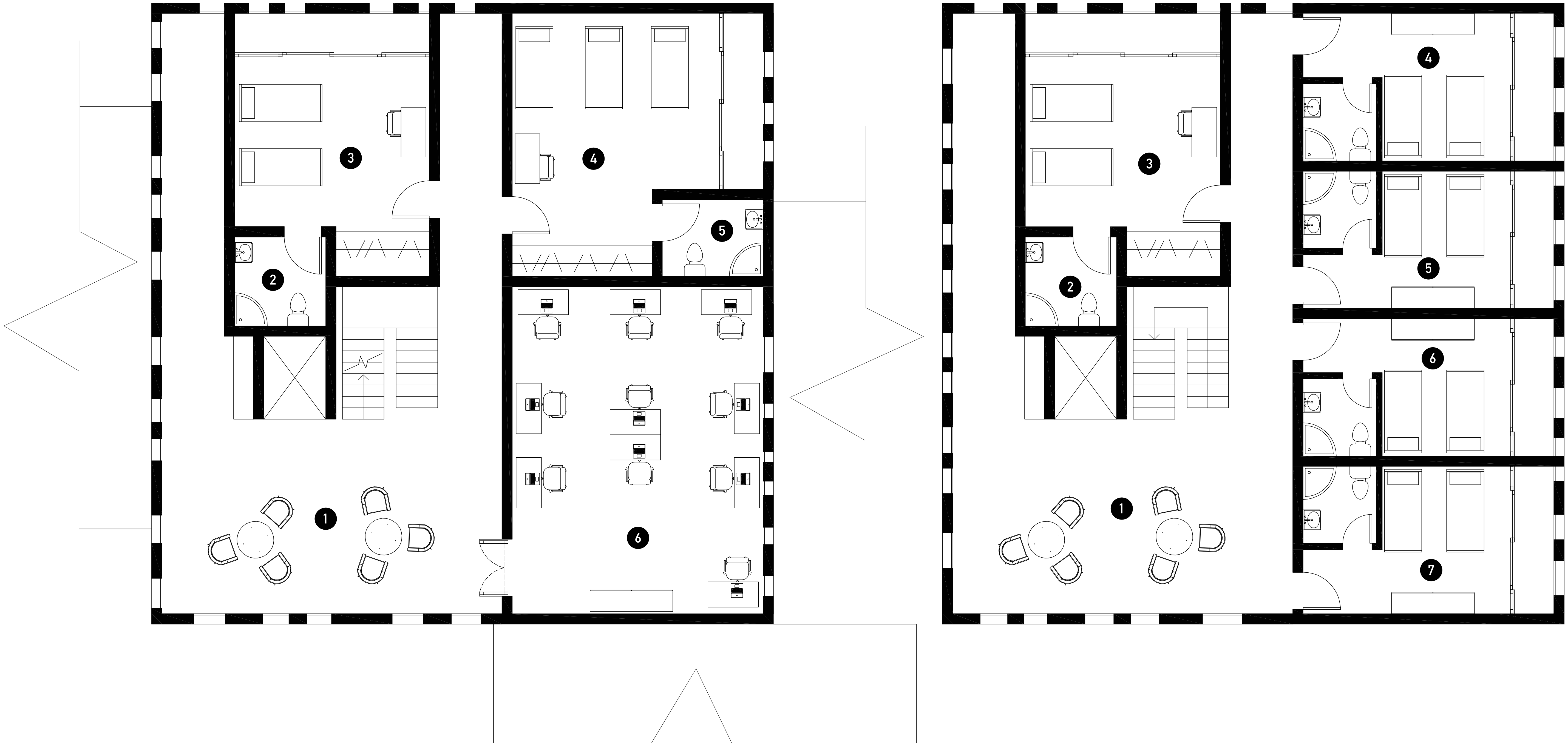


1. DINING 100 m2
2. KITCHEN AND STORAGE 47 m2
3. TECHNICAL ROOM 10 m2
4. TOILETS [M/F] 27 m2
5. 2 DISPLAY SHOPS 20 m2
6. LOUNGE/RECEPTION 121 m2
7. COMMON OFFICE SPACE 70 m2
8. STORAGE 10 m2
9. MANAGER ROOM 15 m2
10. ACCOUNTING SECTION 10 m2
11. CONFERENCE 100 m2

AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA
	TOWER GROUND FLOOR PLAN
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 100 — 18 05 2017

1 FLOOR

2 3 FLOORS



1 COMMON SPACE 68 m2

2 COMMON BATHROOM 4.5 m2

3 DORMITORY 4 PLACES 27 m2

4 DORMITORY 6 PLACES 33 m2

5 COMMON BATHROOM 4.5 m2

6 IT R OOM 50m2

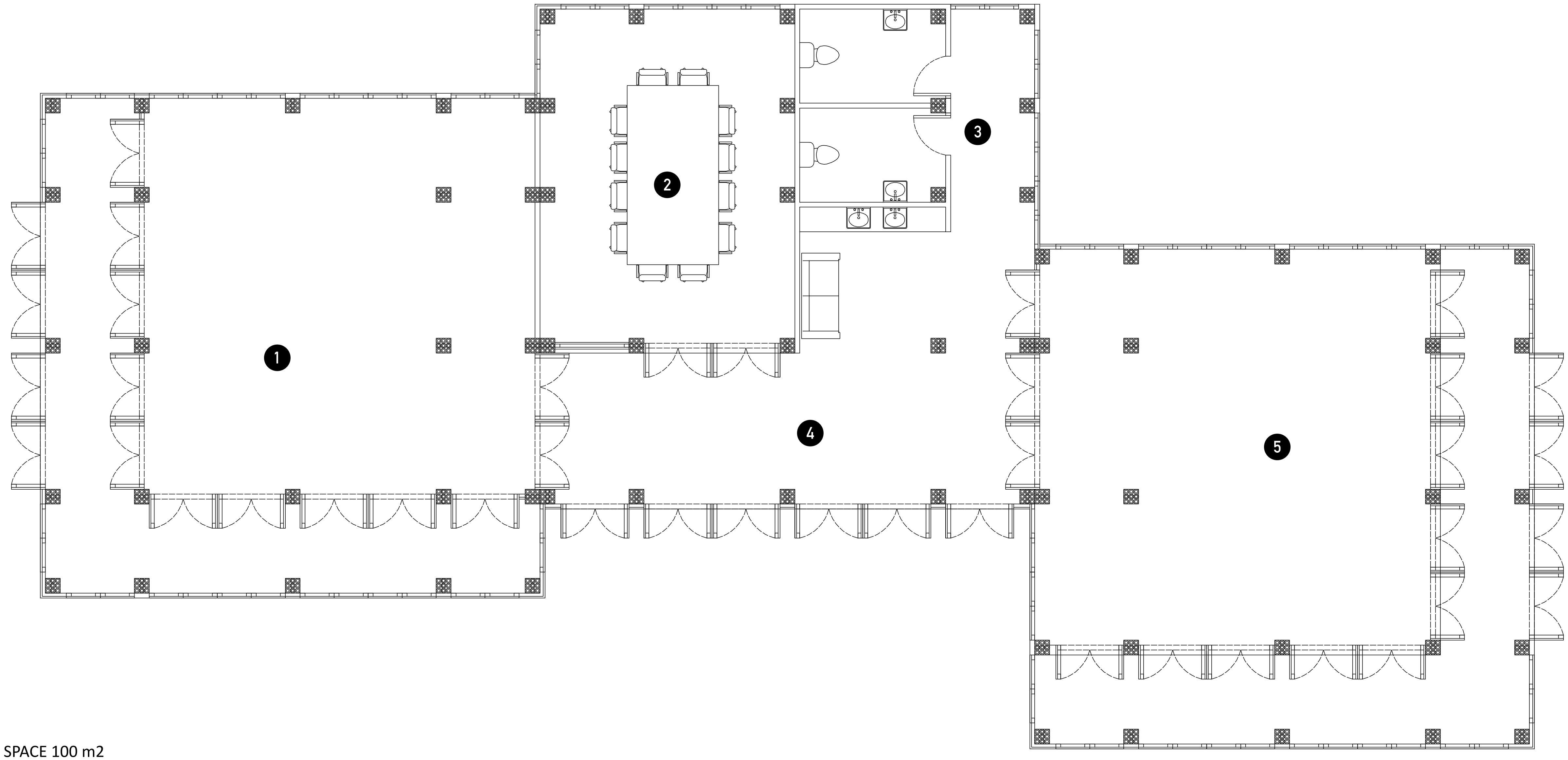
1 COMMON SPACE 68 m2

2 COMMON BATHROOM 4.5 m2

3 DORMITORY 4 PLACES 27 m2

4 7 DOUBLE ROOMS 4 x 21 m2

AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA
	TOWER 1ST AND 2ND FLOOR PLANS
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 100 — 18 05 2017



1 MEETING SPACE 100 m2

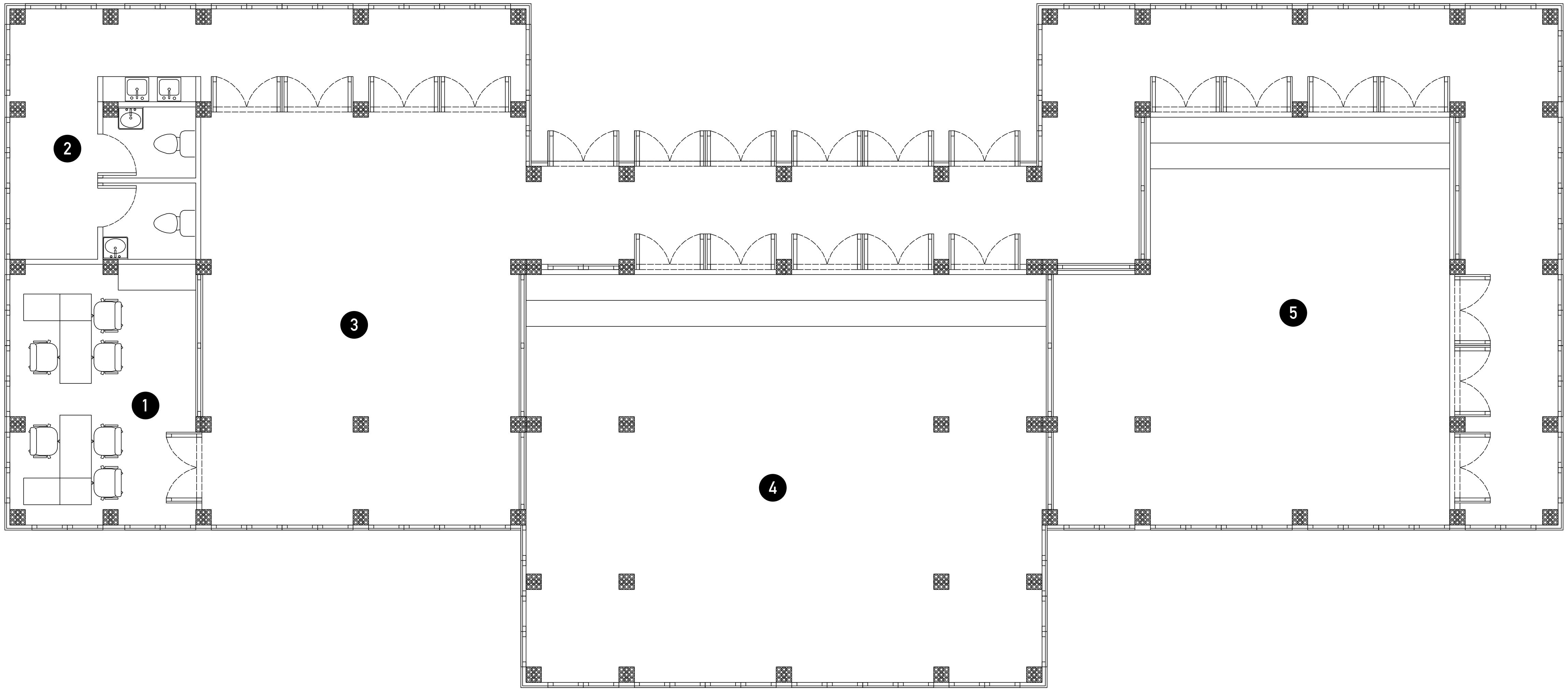
2 PRIVATE MEETING ROOM 30 m2

3 TOILETS [M/F] 15 m2

4 LOUNGE 45 m2

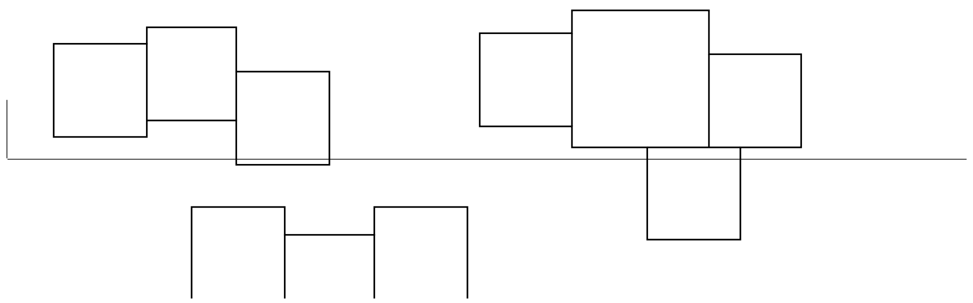
5 MEETING SPACE 100 m2

AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA	
	MEETING AREA GROUND FLOOR	
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 100	18 05 2017



1 TEACHER'S ROOM 20 m2
2 TOILETS [M/F] 10 m2
3 WORKSHOP 70 m2
4 CLASSROOM 100 m2
5 CLASSROOM 100 m2

AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA	
	EDUCATIONAL AREA GROUND FLOOR	
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 100	18 05 2017

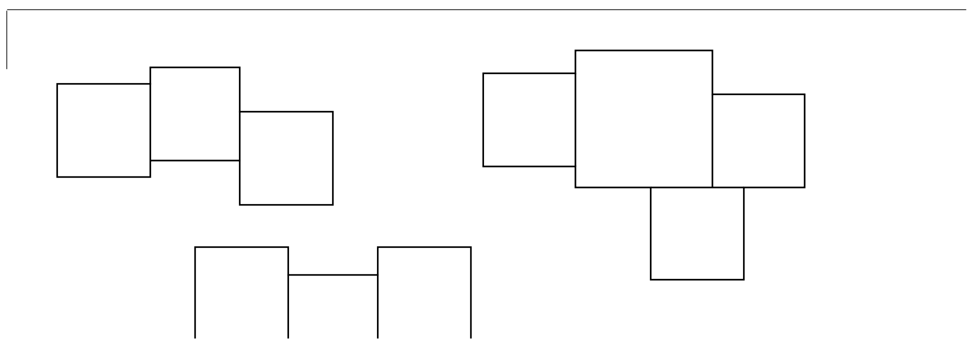


AALBORG UNIVERSITET

COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA

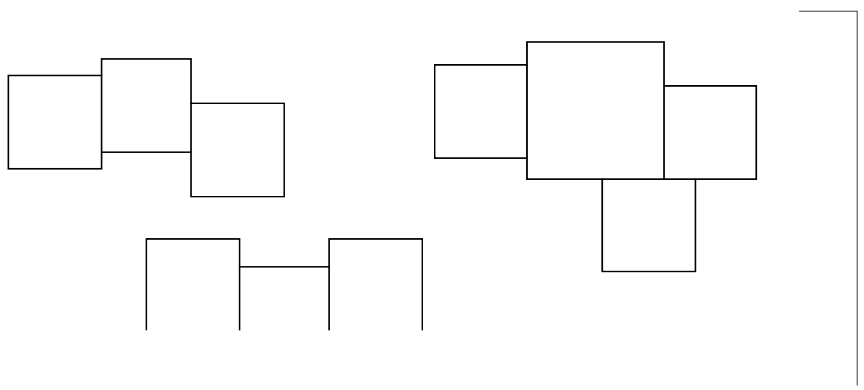
SOUTH ELEVATION/SECTION

GROUP 29 A&D (MSc04 ARC)	SCALE:	1: 300	18 05 2017



AALBORG UNIVERSITET

COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA		
NORTH ELEVATION		
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 300	18 05 2017



AALBORG UNIVERSITET

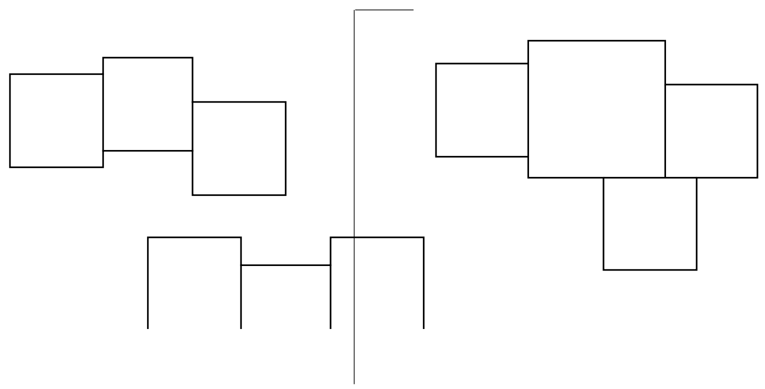
COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA

EAST ELEVATION

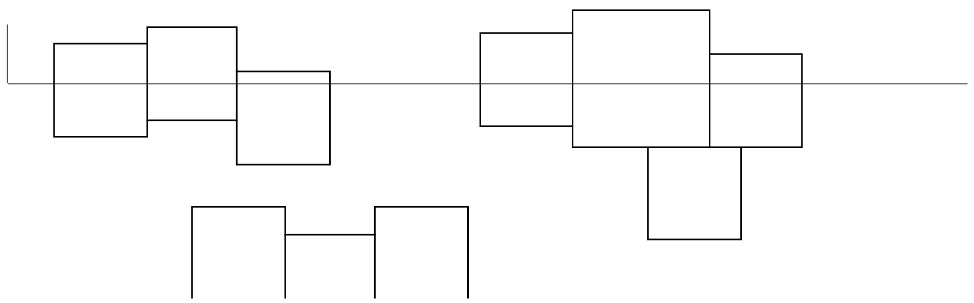
GROUP 29 A&D (MSc04 ARC)

SCALE: 1: 300

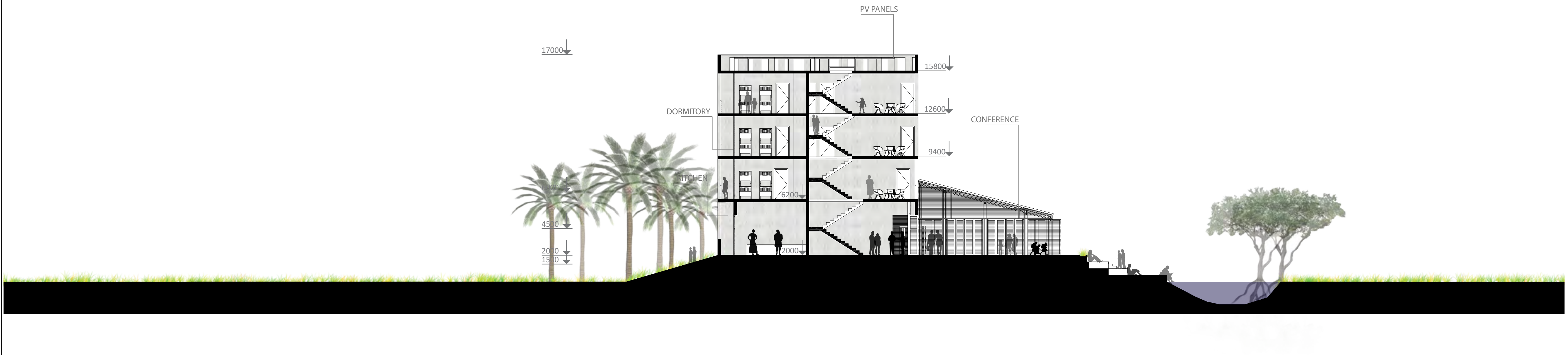
18 05 2017

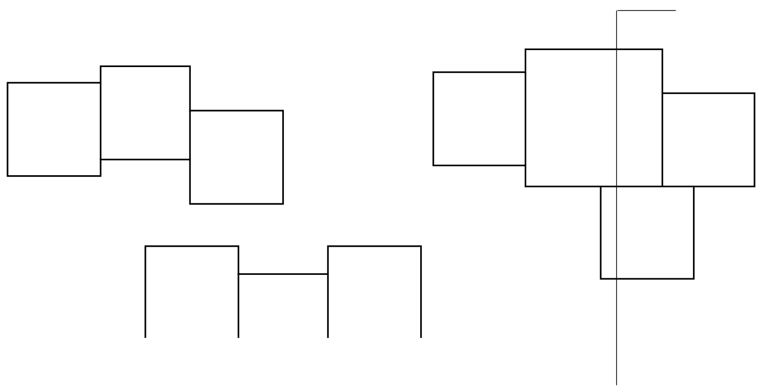


AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA	
	WEST ELEVATION/SECTION	
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 300	18 05 2017



AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA	
	SECTION A - A’	
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 300	18 05 2017





AALBORG UNIVERSITET

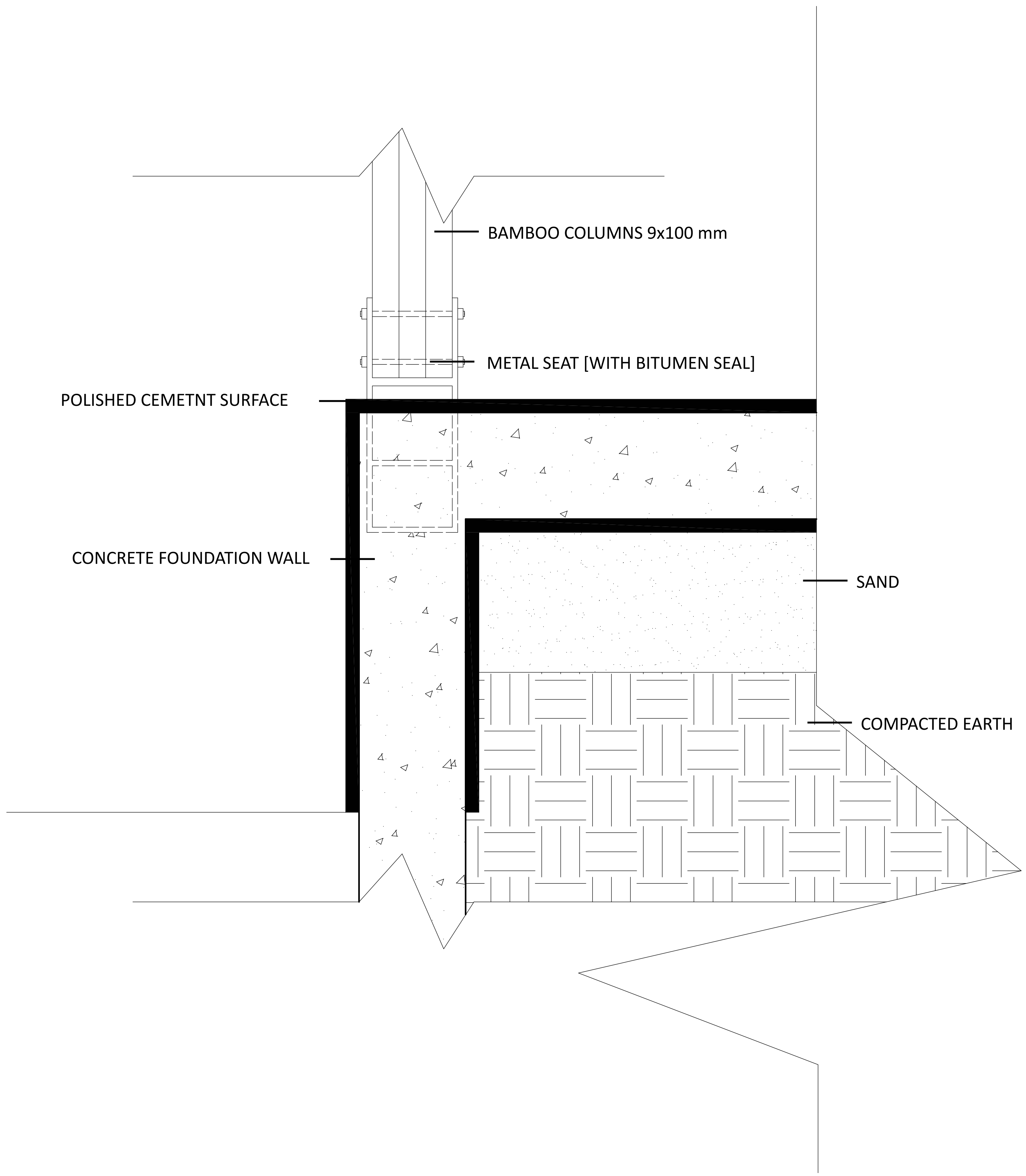
COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA

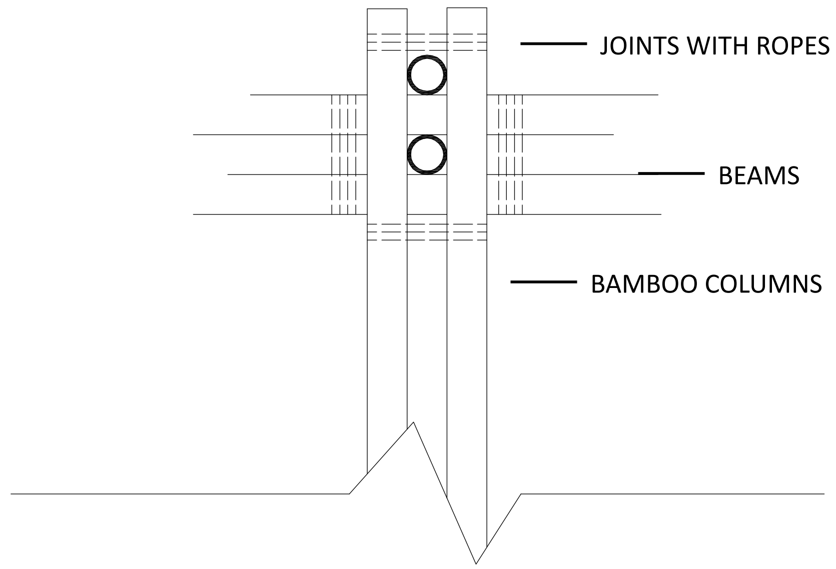
SECTION B - B'

GROUP 29 A&D (MSc04 ARC)

SCALE: 1: 300

18 05 2017





AALBORG UNIVERSITET	COMMUNITY CENTER IN A DISASTER PRONE COASTAL AREA	
	BAMBOO STRUCTURE DETAILS	
GROUP 29 A&D (MSc04 ARC)	SCALE: 1: 20	18 05 2017