THE NEW MILES2SMILES CENTER

Master Thesis

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The New Miles2Smiles Center

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PREFACE

The master thesis is the final project of the Masters program in Architecture and Design at Aalborg University. Through this project students are to manifest their skills and knowledge achieved through their field of study in both architectural and engineering subjects.

This report is a documentation of a master thesis with focus on the sustainability of aid architecture and educating through architecture. The project is developed by two students in spring 2014.

SYNPOSIS

The theme for this thesisproject is environmental and ethical sustainability. This implies a project which deals with the technical approach related to low-tech sustainable architecture as well as the sensory qualities of designing architecture for children in developing countries. This report presents a sustainable center for children in Kampala, Uganda, where an integrated design process has been used to find the aesthetical, functional and technical solutions. The conclusion of this report will present how designing architecture for children can represent a sustainable solution in developing countries, seen from both an ethical and environmental point of view.

TABLE OF CONTENTS

Why aid architecture?

As architects we have a great opportunity to design our physical environment.

As architecture students we may have learned how to design architecture in a prosperous context, however few lessons have been taught about designing for the ones who might need it the most.

For our master´s thesis, we want to place our knowledge and skills in the favour of those who might appreciate it the most.

We want to learn a new lesson;

DESIGN LIKE YOU GIVE A DAMN!

Ill. 1

THE LITTLE ANGEL IN THE MARKET

One day I went to get my hair braided by a woman in the market of Kampala. My eyes rested upon this other woman, selling food while caring for her little baby. The litte baby looked so small and frail, and I would have guessed it to be no more than 3 months old. When I later asked about the child's age I learned that it was 11 months old, and I remember my heart sank.

This was the brutality, – I realized, – for many struggling mothers working long hours in the local market with minimal income. They could not afford to leave the child in a day care center, and they could not afford to stay home, taking care of the child. As bringing their child to the market would lower their chances of making money, their only solution was to leave their children at home during the day, often locked up in small, dark spaces. This was done by loving mothers with the purpose of protecting their children, but with woeful result of the child being undernourished and under-developed, and often seriously or even fatally ill.

A great desire to help encouraged me to create an organization to help found a day care center for the children of mothers working at the market. I founded an organization, found a place with an affordable rent close to the market and engaged people who were willing to help me run the day care. I was now eager to finally welcome my first child, who I wanted to be that little baby I had seen on the market that day.

When I returned to the market, excited to give the mother the uplifting news and a promise of a better future for this child, I learned that the baby had died few days ago.

It was too late for this child, but there were many children still to be saved.

Seeing this little baby with its mother on the market that day was the inspiration that initiated the Miles2Smiles wellfare center. This little angel in the market of Kampala set out the course for many, many children to come.

– Based on a story told by the founder of Miles2Smiles, Catherine Kitongo

PROJECT DESCRIPTION

The slum-area of Ugandas capital, Kampala is home to many children of mothers who work at the local market to provide their only income. Many of these children are left alone during the day and often locked up in small dark spaces by their mothers, with the intention of protecting them. This is a desperate condition for these poor mothers, as they depend upon the income they get from the market. As a tragic result, many of these children are suffering from under-development, starvation and sometimes the conditions are even fatal. The Miles2Smiles foundation seeks to help these mothers by providing a safe shelter for their children during the day so that they can focus on earning as much as possible.
Our project is designing The New Miles2Smiles center for approximately 265 children. The new center will be designed to reach aims of a highly functional multi-use building including functions as child care center for children 0-6 years old, a pre-school education facility and microfinance and nutrition education possibilities for the mothers who are market vendors. In other words, this center is crucial for the local community and it provides hope for a brighter future for many people.

"The educational possibilities can be a starting point to break the poverty cycle that these children have been born into...", Catherine Kitongo, Director of the Miles2Smiles Center

The project looks to explore the possibilities of ethical and environmental sustainability in development assistance projects for children in developing countries. The ethical sustainability aims to use architecture as a mean of educational development for children in the slum of Kampala, and to educate the local community in how to design sustainable and energy efficient architecture providing comfortable indoor environment based on the local culture, local climate and the use of local building materials. The environmental sustainability aims to use low-tech solutions for energy efficiency based on local building techniques, local climatic conditions and sustainable materials. The project has a long-term ambition of improving the local living conditions through educating simple techniques of energy efficient design in terms of temperature, water usage and solar control. This should increase the local community's awareness of the possibilities of good and non-expensive living conditions. The technical aspects will be enhanced as an integrated part of the aesthetics of the overall project.

In addition to the mentioned sustainable aspects, we will look further into the possibilities when designing for children in developing countries and the aesthetical qualities and tectonics of African architecture. Tectonics will be investigated through studying African vernacular architecture and possibilities of adapting such principles to our design. The tectonic focus will create honest and readable architecture to further empazise the ethical purpose of educating through architecture.

MILES2SMILES

The Miles2Smiles Organization:

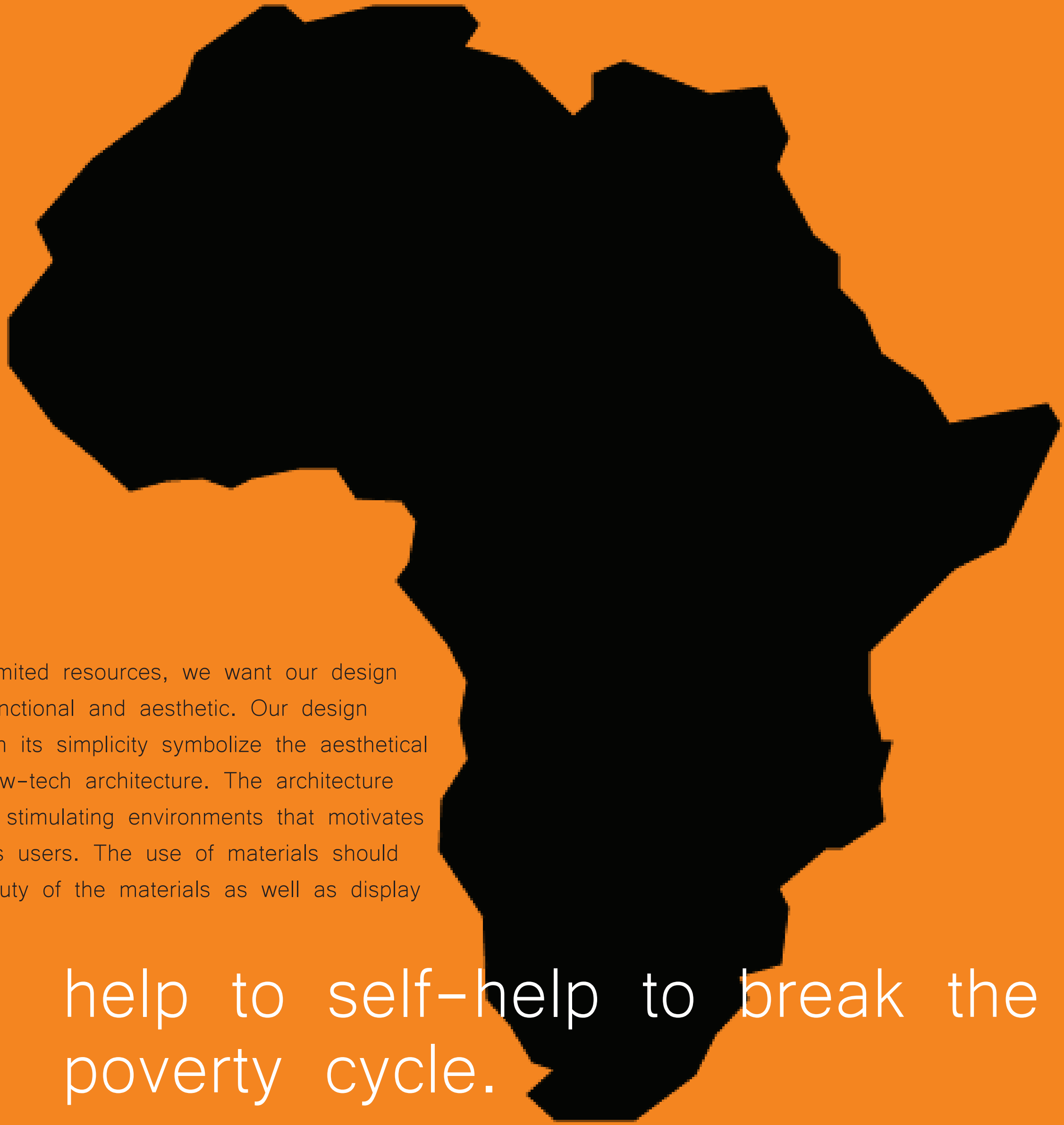
Miles2Smiles is a day-care and welfare center which aims to help families living in the slum of Kampala with day-care for the children and education in financial management and microfinance for the women.

When the local authorities passed a law forbidding the mothers to bring their children to the market with them, as it was thought of as unsafe for the children, many of these women only had the option to leave their children at home all day, locked up and alone. The center was therefore founded in 2006 close to the local market where the mothers work to earn their only income, as a day-care center where the women could leave their children safely during the day.

The center is run as daycare and nursery school, where they help children as young as 2-3 years old to learn the alphabet and the numbers, so that when they "graduate" at the age of six, they have a solid foundation for starting school and getting an education. The New Miles2Smiles center will in addition provide education for women outside the day-care's opening hours.

The Strømme foundation in Norway supports Miles2Smiles to help offer good day-care facilities at very low cost, and in addition offer microfinance education for the mothers to help them out of poverty. Strømme is a non-governmental organization that focuses on the principle of "help to self-help" through the means of education and microfinance in the fight against poverty worldwide.

VISION



Our visions for the New Miles2Smiles center is to educate local community, – both children and adults. Through introducing low-tech and integrated solutions based on their own building culture and material utilization, we seek to educate the community through architecture and increase awareness of the possibilities of good and non-expensive living conditions. Through a sustainable approach focusing on passive and low-tech techniques, we hope that the result of the project is a highly functional building with reduced maintenance and minimal ecological damage.

Despite being an aid project that includes a low budget and limited resources, we want our design to be both functional and aesthetic. Our design should through its simplicity symbolize the aesthetical potential of low-tech architecture. The architecture should create stimulating environments that motivates and inspire its users. The use of materials should show the beauty of the materials as well as display its abilities.

help to self-help to break the poverty cycle.

METHODOLOGY

Through site analysis we investigate the specific plot's possibilities in regard to climatic adapted low-tech principles for sustainable design. A theoretical analysis through literature is conducted in order to investigate children's functional needs, mentality and perception of space, physical environment and architecture and the theme African vernacular and Tropical climatic adaptive architecture. This analysis is supplemented with case studies. In addition, we study the potentials of sustainability regarding ethics and environment.

During the process, we also visit the building site and the existing Miles2Smiles center in Kampala to get a better understanding of the children's situation, local climate and culture, building culture and materials. We interview the director of Miles2Smiles, staff and users, and a representative from Strømme Foundation's office in Kampala for further information of the daily running of the center, possible improvements, experiences and effects of aid architecture. Interviews and conversations with some market vendors, mothers, the children, a local builder, a board member of Miles2Smiles and a local architect along with thorough observations contribute to a better understanding of functional needs, building culture and architecture in Kampala.

Integrated design process

The design process is carried out as an integrated design process (IDP) (Knudstrup, 2004), where the architectural design and functionality is investigated through sketches, models, calculations and simulations. This represents a holistic approach to architectural design. A scientific process which emphasizes the importance of identifying the problem prior to commencing a process with a holistic approach, is secured by combining an integrated design process with the academic Problem Based Learning (PBL) used at Aalborg University. Through an integrated design process, all the different aspects of building design are considered through different phases in order to find the best solution for aesthetics, functionality, indoor environment, technology, construction etc. Investigations and simple initial calculations are done for each potential design to secure that the optimal alternative for all the different aspects is chosen. This way, all the different phases affect each other by revealing limitations and possibilities of each other and all contribute to the overall direction of the architectural design.

Preliminary calculations and simulations of the building's indoor climate is implemented from the very early stages of the design process in order to get an impression of the building's energy performance. The building's performance regarding indoor environment and energy is investigated through the design process to secure an optimized design solution.

To be able to discuss, analyze and present concepts and solutions during the design process, sketches, illustrations and models are used. The result is presented in a project report containing technical and architectural drawings and illustrations, and as a 3D model.

Digital tools

To produce digital drawings of plan, elevations, sections and details, Graphisoft's ArchiCAD 17 is used and files are processed in Adobe tools. BSim, which is developed by the Danish Building Research Institute, is used as the main tool for simulating indoor environment of the design throughout the process to determine the final result. AutoDesk Ecotect Analysis 2011 is also used to compare and cross-check results. Velux Daylight Vizualizer is used to simulate daylight and extract information of daylight factors and luminance throughout the process. For acoustics, hand calculations are made and some Excel spread sheets are used for calculations regarding U-values and ventilation. For these calculations knowledge and material obtained from courses at University of Agder and Aalborg University are used. BSim, Excel spread sheets and Velux Daylight Visualizer is used in an iterative design process.

Standards and Guides

To determine the indoor environmental parameters and energy use, Danish standards DSEN 15251 and CR1752 are mainly used. Due to a very different climatic setting in Uganda higher temperatures and more ventilation is acceptable, but ideal bodily comfort is global and as human beings we ideally need and prefer the same temperatures, ventilation quality, humidity levels, lighting and acoustic settings. EmiEA`s guide to aid architecture in East Africa is used to determine building related parameters.

1.1

THE POTENTIAL OF AID ARCHITECTURE

Although we live in a fortunate part of the world it does not mean that what we do here does not affect others. This is why the focus on sustainability is important in every architectural project.

Ill. 2

Ill. 3

ENVIRONMENTAL SUSTAINABILITY

Sustainability, especially in an environmental context, is a subject that has gained more and more attention through the recent years. The background for this is fundamentally the growing population on the planet and their growing needs and the consequences of the planet's use of resources. From the famous Brundtland definition of sustainability, we know that the term reflects upon satisfying the current generation's need without reducing the same possibilities for the upcoming ones (Bokalders and Block, 2010). This means that we have to, as much as possible, look away from resource craving processes to get a better overview of what we can achieve with simple, sustainable means. Human activity and the natural environment are in daily contact, and it is therefore important that both can enhance and adapt to each other in their existence. The environment has no other choice than to adapt to what we do, but it is our choice to respect the environment and do less harm to it. Therefore, an environmentally sustainable set of thoughts is important to fulfil what was defined in the Brundtland Commission.

With technological and economic growth, the world has become more resource craving. In developing countries the same level of economy or technology is not always present. Human life has existed and continued in a state of world where there were less or no such opportunities – life was still functional at that time. This means that it is still possible to continue a highly functional life with simple and available material and tools, if we are willing to give this reversed technological development a chance.

A focus on low-tech, climate adaptive, passive solutions integrated with local building culture based on available resources and tools is attractive for this project in order to maintain a sustainable approach. By including the local community in the process they will also learn how to use local material and suitable techniques in an efficient and sustainable way. The mentioned, combined with thoughts of off-grid systems for water and, if possible, electricity will make the design further sustainable and more self-sufficient. This will help the community to develop and enhance itself further with new knowledge that is still based on something familiar. The design should be affordable without compromising efficiency and aesthetics. To further investigate possibilities of making the design and its function more efficient it is interesting to look at what active solutions could be incorporated.

When choosing materials from a sustainable point of view, it is important to focus on materials that are locally available and not scarce. Earth is a primary and commonly available material in Uganda. It is also associated with their building culture and with vernacular architecture in Africa. As innovative projects around the world show, material that are originally thought to become waste or those that have the possibility of recycling, can also be used in constructions, as furnish and decoration. Tyres of vehicles can be embedded in walls, they can be stacked as stairs, be sat on or used as playful elements on playgrounds. Plastic and glass bottles are also usable in walls and they can create interesting and fun architectural elements with their transparency, if they are not thought to be covered in earth as part of a wall element.

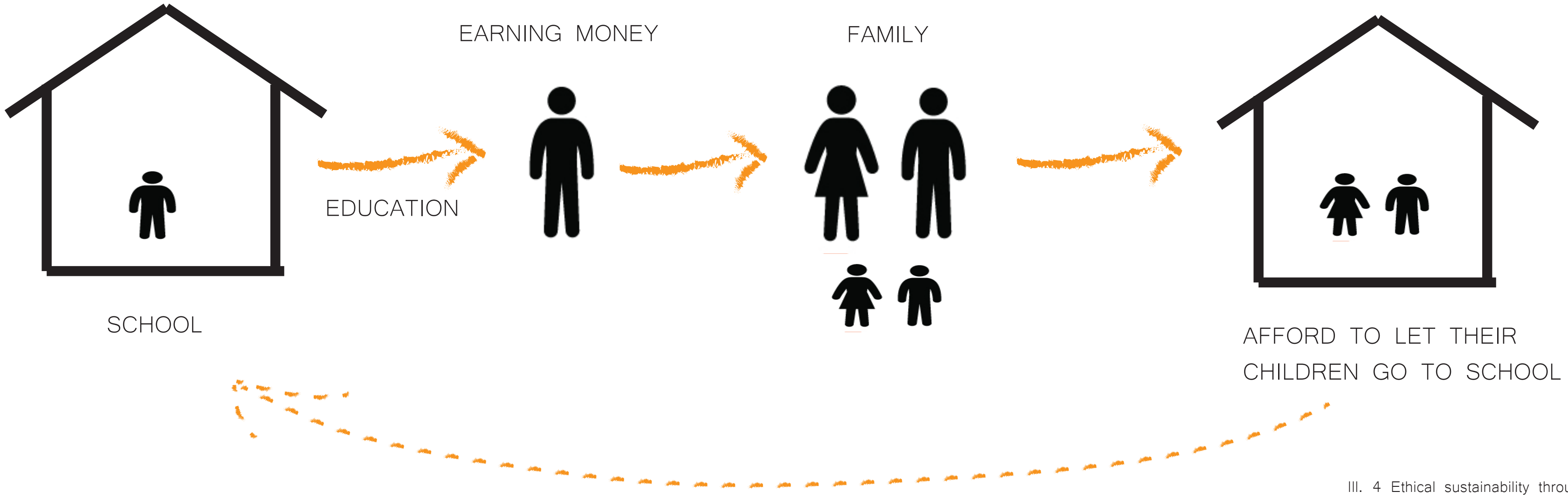
THE ETHICAL POTENTIAL OF AID ARCHITECTURE

Developmental potential when designing for children in developing countries

According to UN's 2010 estimate of population and UN's 2009 estimate of population under the age of 18, about 54 % of the population in Uganda fall under the category of youth (S.O.S Children, n.d. a). One of the reasons for early deaths is bad health which often is a result of malnutrition. Numbers of WHO between 2000 and 2009 point to that about 16 % of children under the age of five are underweight (S.OS Children, n.d. a). A reason for this can be the amount of care and the situation of poverty that these children are born in. Many mothers in poverty have a desperate situation of tending to family and children and at the same time earning an income to provide her family. Nutritional food is not always a given for them, but they try their best to maintain health - especially of their children.

Poverty is closely linked with poor cognitive and educational performance in children in developing countries. In most developing countries, national statistics of children's cognitive or social-emotional development are not being registered, which contributes to the invisibility of the problem. But the percentage of disadvantaged children (per definition: children living in poverty) under the age of 5 years old is estimated to be above 60% in Uganda (2004)(Grantham McGregor et al., 2007). Uganda is classified as one of the poorest countries in the world, with the average daily income of less than 1,25 $ (9 DKK) by the World Bank Group's poverty analysis (2011) (The World Bank Group, 2011).

To define poverty, there are different factors that have to be considered. Poverty is often associated with inadequate food, poor sanitation and hygiene, and further affecting the children's development; poor maternal education, increased maternal stress and depression, and inadequate stimulation in the home. According to Feed The Future (The U.S. government's Global Hunger and Food Security Initiative), The percentage of undernourished and/or stunted children in Uganda is estimated to 38 % (Feed the Future, n.d.). Children born into poverty in developing countries are often exposed to malnutrition, poor health and unstimulating environments, which all affect their cognitive, social-emotional and motoric development. They are unlikely to succeed in school and will therefore have low incomes, and not be able to provide for their own children, thus contributing to the transmission of poverty through the following generations.



Ill. 4 Ethical sustainability through education

The first 5 years of a child's life are of high importance because this is when the vital developments occurs. The development of the brain happens rapidly and in different stages, which all affect and build on each other, meaning that small perturbations in these development processes can have significant and long-term effects on the brain's functional capacity (Grantham McGregor et al., 2007). The development of the brain is closely affected by the environment, which put a great importance on to designing good stimulating physical and psychological surroundings. But even if the brain has already been affected by early perturbations in its vulnerable stages, recovery is often possible with correct interventions. As a rule of thumb; the earlier the interventions the greater the benefits. Early cognitive and social-emotional development are both important factors to determine the child's school progress. This is especially important in developing countries, as education is the key factor to break the poverty cycle. Children in developing countries who are not able to reach their full developmental potential are less likely to complete an education and attain good income as adults, meaning that poverty and stunting are closely linked with reduced years of schooling. Fewer years of schooling together with less learning per year of schooling are factors that may further reduce their productivity. According to a study by G. Psacharopoulus and H. Patrinos from 2004, each year of schooling increases wages by between 7-11 % (Grantham McGregor et al., 2007).

There are also other factors that contribute to keeping a lower share of children getting an education in developing countries, - besides the physical and mental development of children. Such factors are inadequate schools, economic stress for the family related to the children's education, and little knowledge about and sometimes also little appreciation of the benefits of education. In Uganda, poor children are ten times more likely to start school late than the richest children (Grantham McGregor et al., 2007). Loss of education because of the family's economic situation is another cause for reduced years of schooling. The importance of introducing numeric and literacy skills as early as possible is therefore a great advantage, as there are uncertainties of how many years the child is able to attend school after "graduating" from the new Miles2Smiles center. Their years at the center may, for some of the children, be the only education they will get, so it is important to set a good foundation for these children. By introducing the small children to preschool education, they are also more likely to succeed when starting school.

The ethical and environmental sustaina-ble potential of the New Miles2Smiles center

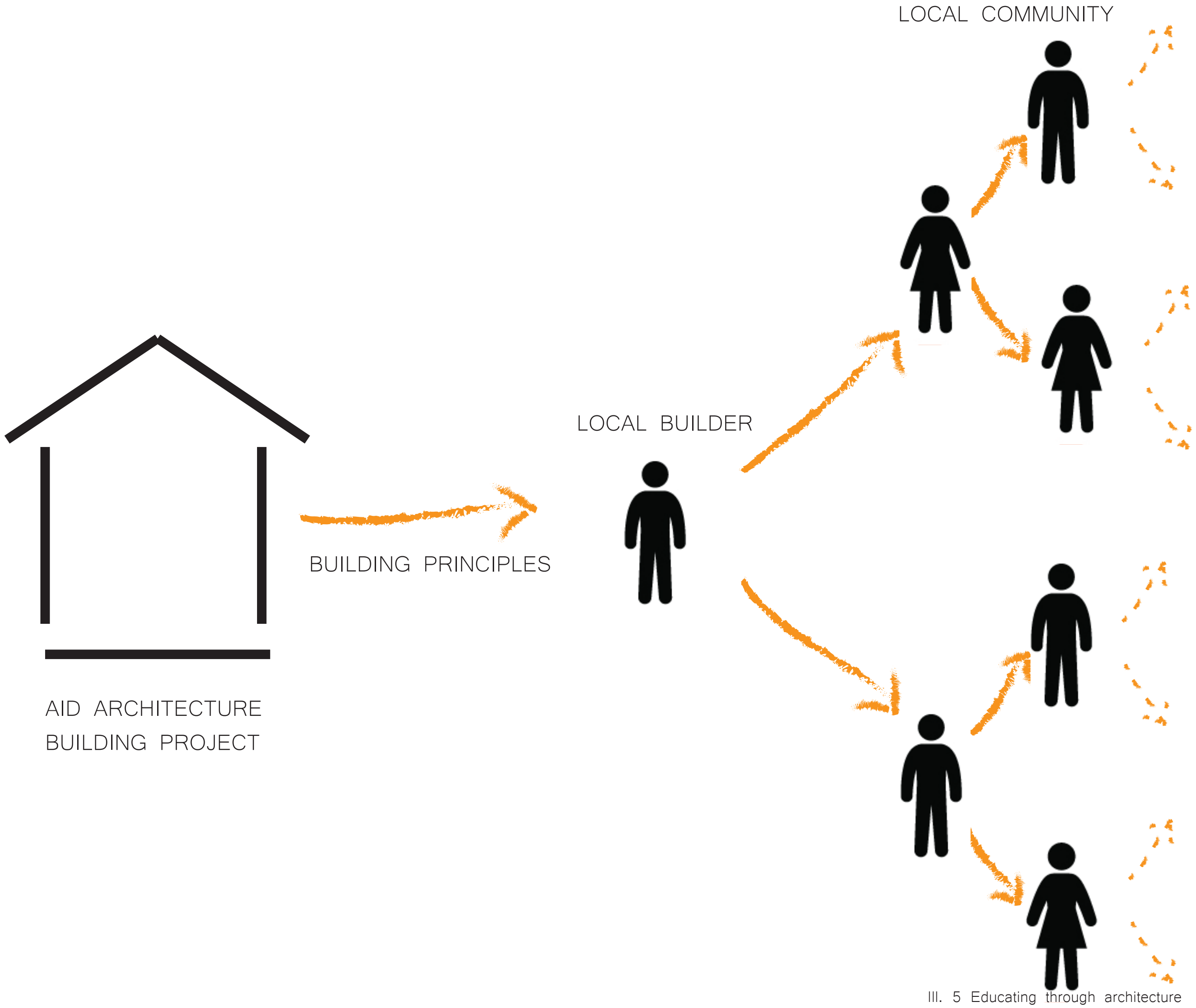
The project`s focus on ethical sustainability relates to the potentials of designing architecture for children in developing countries, of empowering women and of strengthening the community spirit. The ethical potential lies in using architecture as a mean of educational development for children, and as a mean of educating the local community in sustainable and low-tech building techniques based on the local culture, local climate and the use of local building materials. The project has a long-term ambition of improving the local living conditions through educating the local community simple techniques of energy efficient design in terms of temperature, water usage and solar control, which will increase the local community's awareness of the possibilities of good and non-expensive living conditions.

Through our project with designing The New Miles2Smiles center, we seek to enhance and tackle many of the issues related to poor child development and poverty in Uganda's capitol, Kampala. As the children are the future of Uganda and an important ticket out of poverty, the new center provides great possibilities in an ethical sustainable context. The New Miles2Smiles center can through the means of low-cost daycare, pre-school education, nutrition programs and microfinance education for women break the poverty cycle in a long-term time perspective, by focusing on the children and women. Stunting and poverty is the two main factors that are closely linked with reduced years of schooling. Malnutrition may lead to stunting of children, which further often leads to low performance level at school and reduced years of education. Through the nutrition program provided through the Miles2Smiles center, the risk of malnutrition can be reduced greatly.

The New Miles2Smiles center will provide stimulating and inspiring environment for education and development. The children will be educated from an early age, and this will be a starting point to break the cycle of poverty that they have been born into. Pre-schoolers at the age of 2-5 years will be equipped with basic literacy and numeracy skills and provided with higher chances of succeeding at school and get an education. Through the mean of architecture we want to create physical surroundings to encourage learning and mental growth, curiosity, social interactions and developing through playing.

The center will also function as a community center which will provide education in nutrition and financial skills for the women, and provide the mothers with a chance to make a better life for themselves and for their children. The microfinance group at the Miles2Smiles center will help, educate and encourage saving and marketing so the adults of the community are given knowledge and possibilities to save for and invest in better housing, the child's future education or own business.

The New Miles2Smiles center will also be designed with a focus on environmental sustainability. Low-tech and low-cost techniques for utilizing the local climatic conditions will enable cost efficient future running of the center, while at the same time educating the local community in different passive techniques that can further improve their own living conditions.

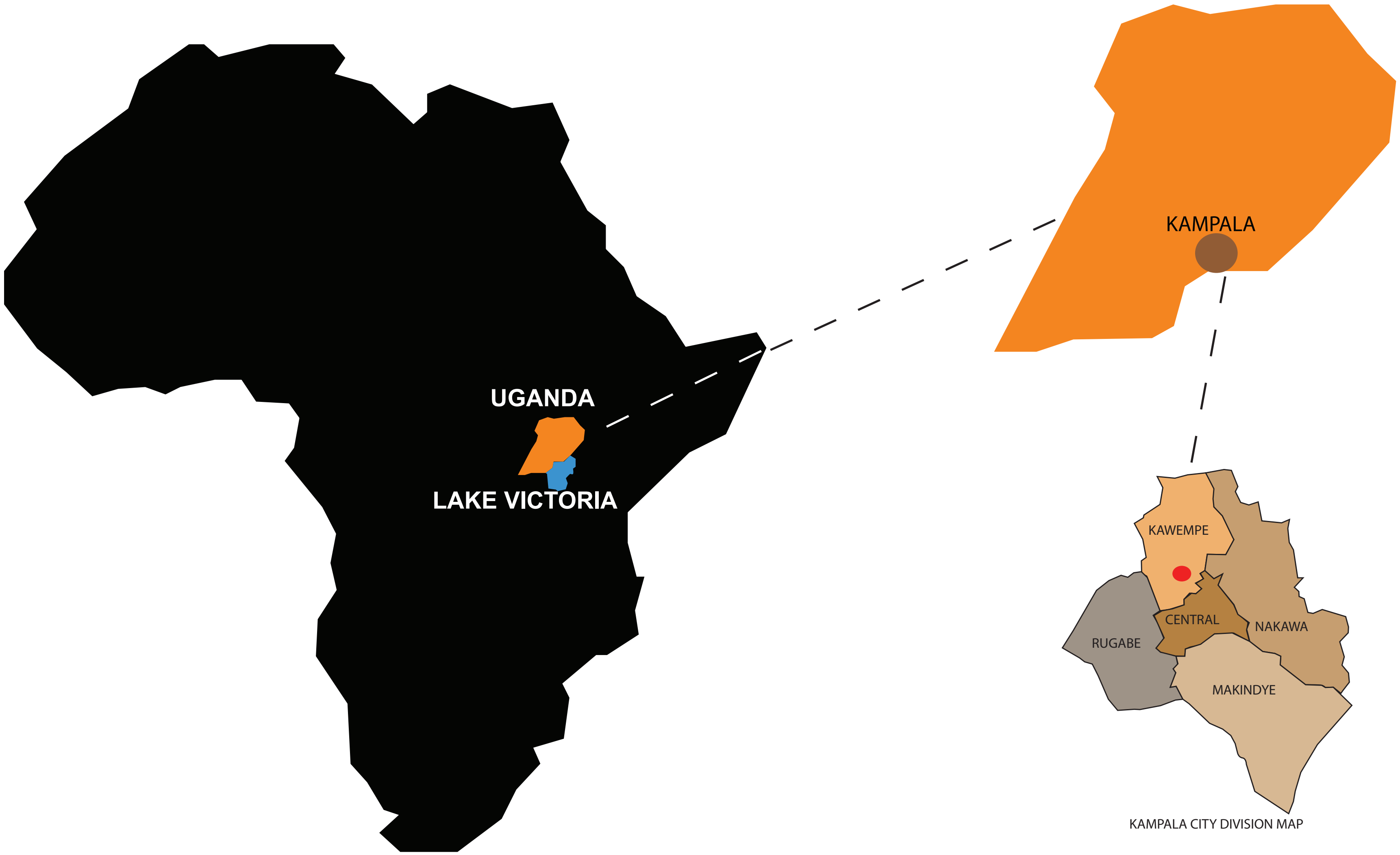


Ill. 5 Educating through architecture

02 ANALYSIS

Ill. 2.1

PROJECT LOCATION



Ill. 2.2 Location

ABOUT UGANDA

Since the project is to be located in Kampala, the capital of Uganda, it is important to know what the country´s and city's background and situation is like. Of equal importance is getting an overview of what the country has to offer and what it relates to in order to create a design that suits its location and larger surroundings; that it finds its place in the daily situation of its surroundings. It is also important to see what possibilities and potentials there are to enhance the quality of living for the children growing up in Kampala.

The Republic of Uganda, or the "Pearl of Africa" as it is called, is situated in the east of Africa and has a population of 35,6 million (UN 2012) (BBC, 2013). It is bordered by South Sudan to the north, Kenya to the east, Congo to the west and Tanzania and Rwanda to the south. The capitol Kampala is located in south-east of the country by Lake Victoria.

After the country became independent of Great Britain in 1962, political unstableness, war and epidemics like HIV/ AIDS claimed several lives (Otiso, 2006). In a history with many tragic incidents, it has slowly been progressing from civil war, human right abuse and economic crisis since the 1970s and 80s. Through the new president elected in 1986, Yoweri Museveni, democratic reforms were introduced and human rights were greatly improved (BBC, 2013).

Today, Uganda is a country that is under development, both economically and socially. This is also reflected in its growing middle class, shopping malls and other commercial buildings (SOS Children, n.d c). However, sights of poverty, less education and jobless are still visible in the daily life of Ugandans. Despite the natural traits and resources, the country faces environmental issues to meet the human needs for a population that is growing with a rate of 3,6 % per year (Uganda Tourism Board, 2014). Because of poverty, conflicts and epidemics the mortality rate of infants have been 128 per 1000 likely to die below the age of five according to WHO's estimates of 2009 (SOS Children, n.d. a) and the expected age of living in the country is 54 for men and 55 for women (BBC, 2013).

Electricity is not common throughout the country. In fact, fewer than 10 % of the population has access to it (Agency, Fund & Department, 2012) and the majority therefore depends on wood for their daily routines. Power-cuts are also not unfamiliar in this country. Two hydroelectric facilities have supplied much of Uganda's electricity, but since the fall in water level of Lake Victoria and the following energy crisis, the nation has explored ways of differentiating energy sources.

Urban areas are facing problems since the cities' capacity of delivering urban services such as housing, sewerage and electricity is progressing slower than the growth of the population. This is why many Ugandans live in slums in urban areas - in an environment of crowded and unhealthy living for many.

Ill. 2,3

ABOUT KAMPALA

Kampala is the capital in both a political, educational and commercial sense. The city is divided into districts, five in total, and is the largest city of Uganda with a population of 1 189 100 inhabitants in 2003 (Store Norske Leksikon, 2005-2007).

From the 1908s the city has developed significantly with modern buildings and renovations of the old (Broadus, n.d.). This has also increased the confidence of the city and its inhabitants.

"Uganda is truly The Pearl of Africa,"

Winston Churchill, 1908 (My African Journey)

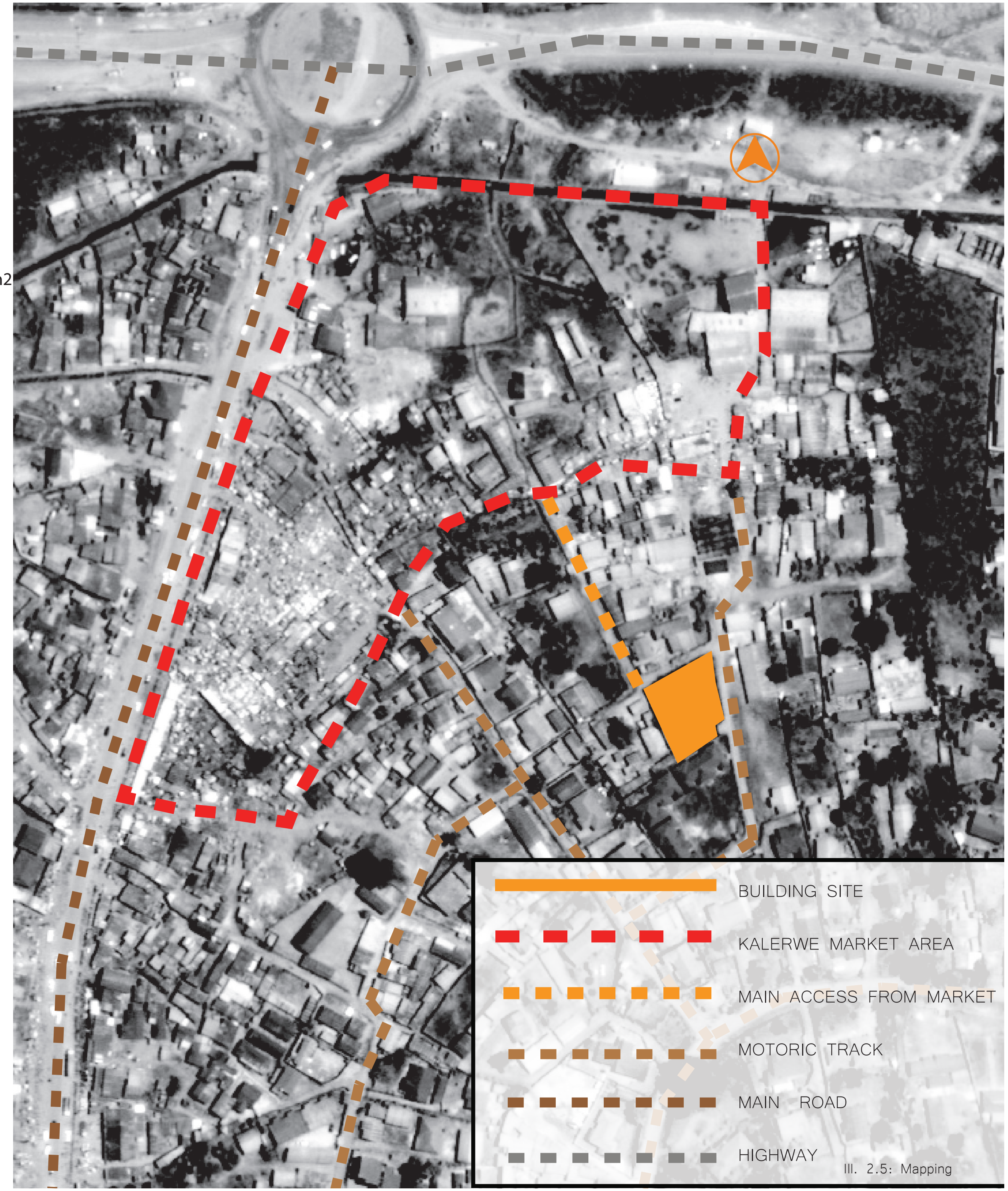
Lesson learned:

Regarding what was mentioned about Uganda and Kampala, we see that, although the country has a developing course, it still needs further opportunities to enhance and accelerate the progress, especially for the poor and the growing middle class. Nutrition and educational and economic possibilities must be improved for these people. The situation of Uganda makes it even more important to incorporate the right values in this project to make a better living for the people, especially the children who are the seeds of tomorrow.

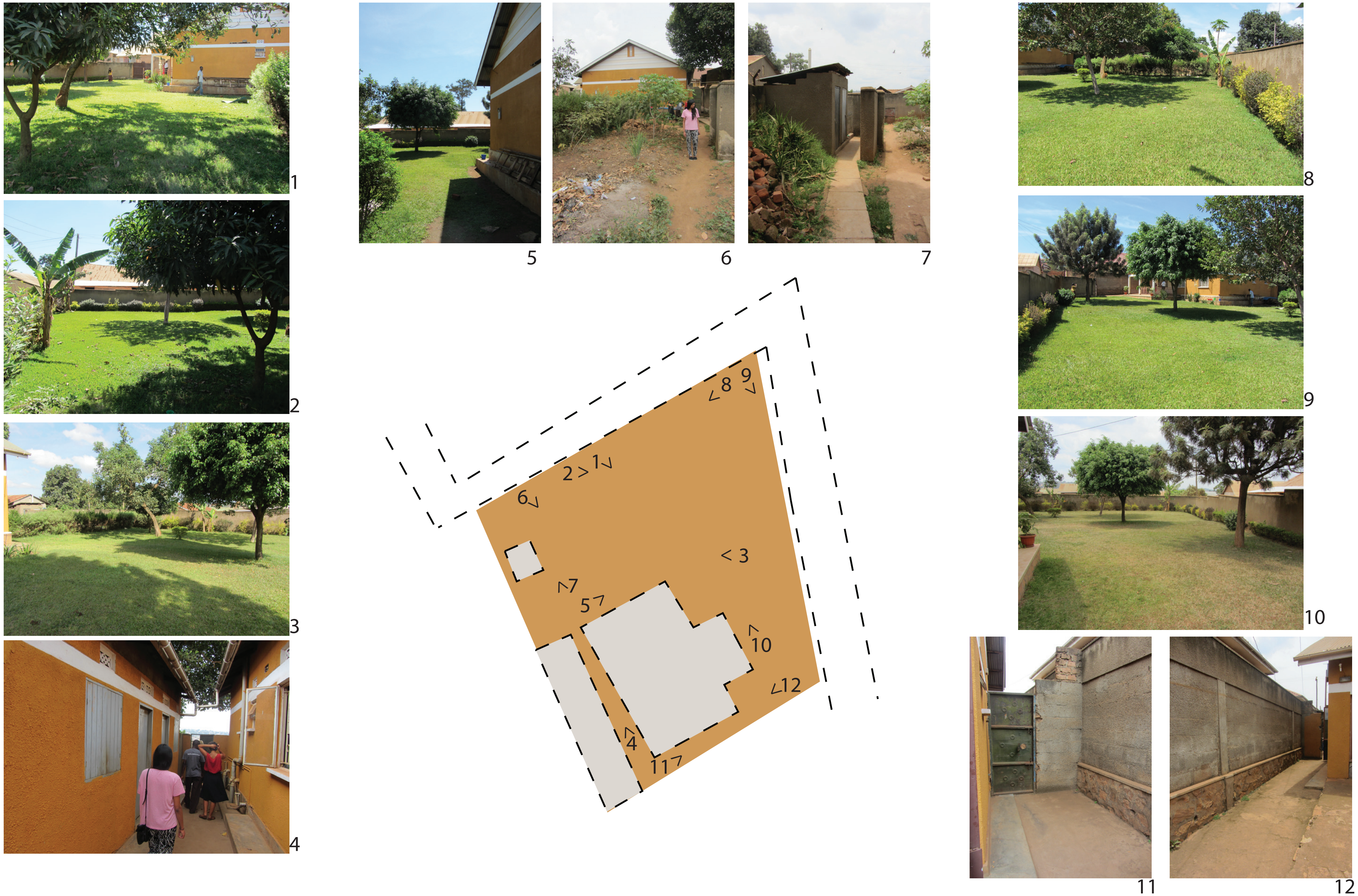
SITE

Ill. 2.4: Mapping of site

The site is located in the Kawempe division close to Kampala city center. The location close to Kalerwe market benefits the project´s purpose of a child day-care center to enbale the mothers to work at the market and still be close enough to be able to feed their infants during the day. The plot is located in a smaller street with little motor-traffic. Access to the site can either be from the north-west corner of the plot from the market, or from the north or east side from the motor track connecting the plot to the rest of the city´s road-system. About 200 meters towards the north runs the larger Kampala Northern Bypass Highway.



Ill. 2.5: Mapping



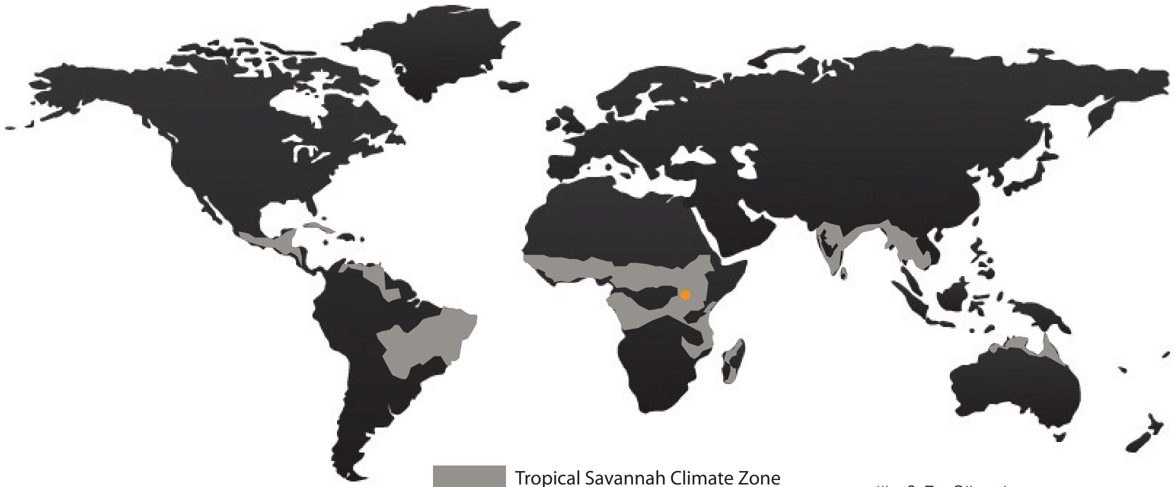
Ill. 2.6: Site photo collage

CLIMATE

Location: Kampala, Uganda

Altitude: 1190 m above sea level

Coordinates: 0° 18' 56" N / 32° 33' 56" E



Ill. 2.7: Climatic zone map

Since this project is located in Africa, it brings up a lot of issues and conflicts with the ways we are taught about climatic adaptable design here in Scandinavia. This calls for a more thorough study on climate and local weather, in order to best prepare for building in the Tropical region of Africa.

The fact that Equator crosses Uganda provides a tropical climate with plenty of sunshine. Because of the large varieties in climate within the country it cannot be categorized into a single climatic zone. It can generally be classified as Tropical, but there are varieties within the country that are differentiated mainly by altitude and rainfall. The north-east area towards the border to Sudan has a Hot/Semi-Arid climate, while the southern part mainly has Hot/Wet climate and green deciduous forests and savannah vegetation (Lauber 2005).

The KÖppen-Geiger climate classification system divides the Tropical climate zone into three sub-classes: Monsoon (AM), Rainforest (AF) and Savannah (AW). According to KÖppen-Geiger, Kampala and our site falls under class AW (Tropical Savannah climate). Because of Kampala´s elevation above sea level, the capital never experiences the extreme heat and the climate can therefore be classified as moderate tropic climate with temperate climatic conditions in relation to other areas in the same climatic zone. The temperature and humidity levels in Kampala are lower than in other areas near the equator in the same climate zone. The air humidity level in Kampala is not very high, except in the rain seasons (Lauber, 2005).

Vulnerability of future climatic changes

According to a research conveyed on Uganda's climate by C. McSweeney et al. at the University of Oxford the mean annual temperature has increased by 1.3°C between 1960 and up to 2000. This corresponds to an average rate of 0.28°C per decade. Through daily temperature observations they found a significantly increasing trend in the frequency of hot days and nights (defined by the temperature exceeded in 10 % of days or nights in the current climate of that particular region and season (McSweeney et al., 1999). The same research indicates a general decrease in annual rainfall, with an average rate of 3,5 mm per month. This corresponds to an annual decrease in rainfall of 3,5 % per decade. These observations are, however, strongly influenced by particular high rainfall totals in the period of 1960-1961 when the research started.

Rain

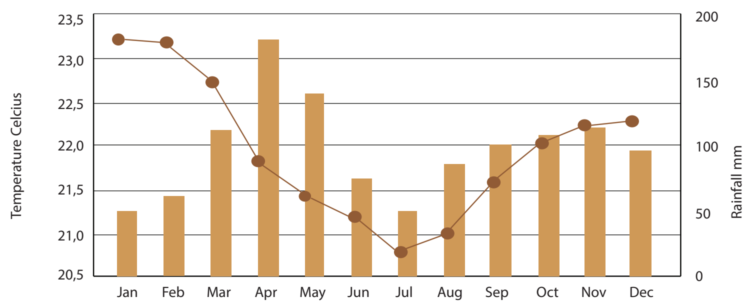
The total rainfall in Uganda is well distributed, - except for the northeastern corner of the country, where the lowest mean annual rainfall can be as low as 200 millimeters. The rest of the northern half of Uganda experience occasional rains of 500 millimeters yearly, mainly between April and October, with a peak in April and again in October (Omari 2009). The driest months in the north are in June and December (Ill. 2.8). The Southern region has two main rain-seasons, the first one starting in early April and the second one in October/ November, with a high risk of thunderstorms. The yearly rainfall often exceeding 2100 millimeters in the Lake Victoria region (Kampala), while the mountainous regions of the southeast and southwest receive more than 1500 millimeters yearly. The driest seasons in the southern region is during the months of June and December (Omari 2009).

Temperature:

The temperatures in Uganda varies due to the change in altitude throughout the country. The highlands of the southwest have a mean annual temperature of 16°C, while the mean annual temperature in the northwest is 25°C. The northeast has again a higher temperature, and exceed 30 °C about 254 days per year (Byrnes 1990).

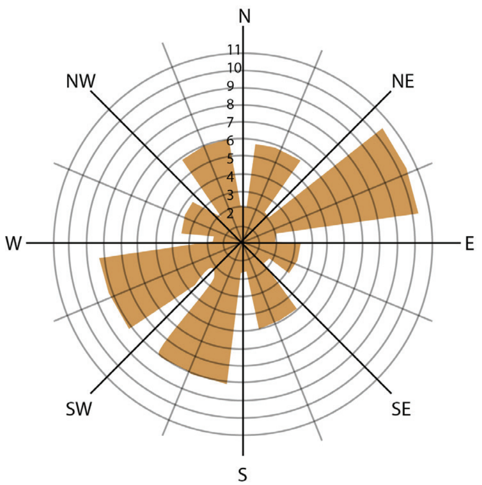
But although the air temperature varies over the county, the site specific temperature in Uganda varies little during the day or throughout the year (see ill. 2.8).

The temperatures is generally about fourteen degrees Celsius lower in the southwest, while in the region around Lake Victoria, - where Uganda's capitol Kampala is located, the average daytime temperatures is about eight to ten degrees Celsius warmer than the nighttime temperatures (Byrnes 1990). The warmest months of the year in Kampala are January and February when the average temperature is just over 23°C, while the coldest months are July and August at 16, 5°C and below.

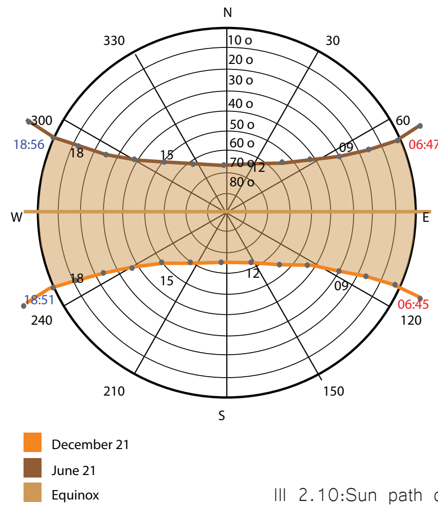


MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVERAGE	23,25	23,2	22,75	21,85	21,45	21,2	20,8	21	21,6	22,05	22,25	22,3
MAX	28, 4	28,3	27,5	26,1	25,4	25,2	25,1	25,6	26,6	27,2	27,2	27,2
MIN	18,1	18,1	18	17,6	17,5	17,2	16,5	16,4	16,6	16,9	17,3	17,4

Ill 2.8: Rain and Temperature



Ill 2.9: Wind rose diagram

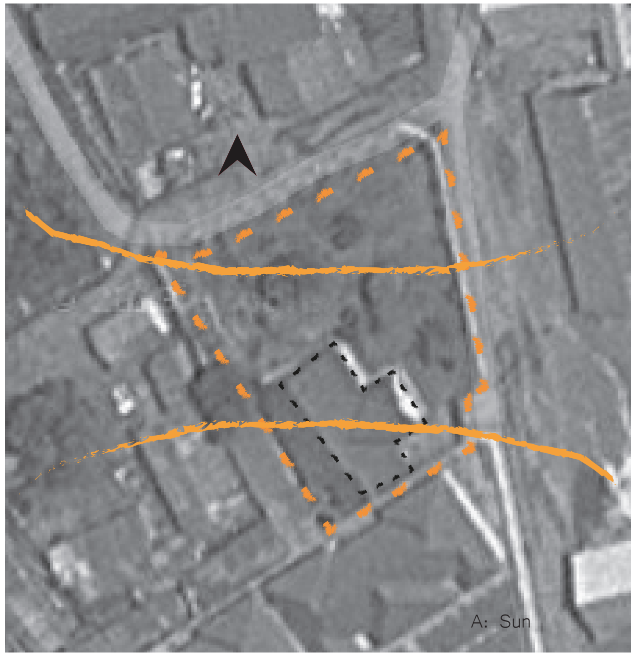


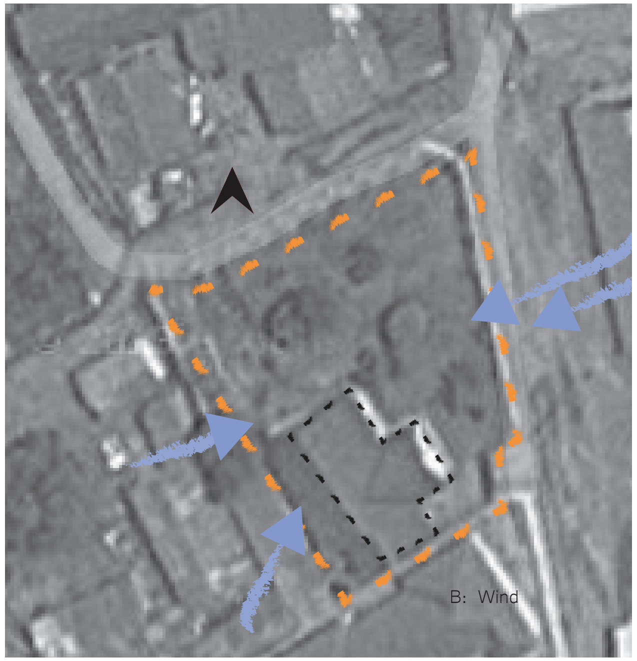
Ill 2.10:Sun path diagram

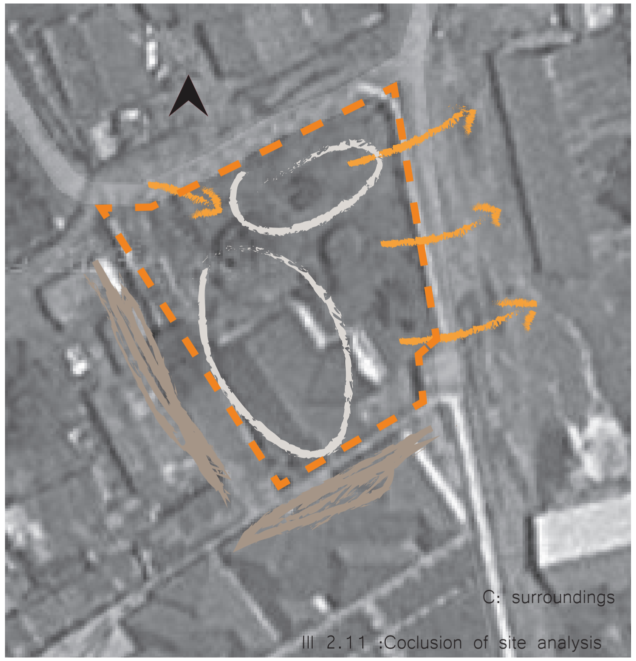
CONCLUSION OF SITE ANALYSIS

The building site is located in a residential area south of the Kalerwe market area. The surrounding buildings are all residential, except for a wooden abandoned building east for the site, on the other side of the road. Next to this building is an open grass area, which creates a natural opening towards the east and contributes into making the east experienced as the “front side” of the site. The site is enclosed by close buildings towards south and west, and an earthen access road towards east and north. This creates a “back side” towards south and west, while the access road opens the site up towards the east and west. Although the site is located in a dense suburban area, it is experienced excluded and because of the surrounding massive walls which creates a private and calm atmosphere in its own space within its surroundings.

The building complex should be oriented with its “front side” and outdoor play area towards the east, to achieve a more light and open outdoor area. The main access to the site should preferably be from the North (and the Kalerwe market), and the building should divide the site into a natural entrance area separate from the play area, to create natural zones of function and a readable plan. The orientation should also consider the prevailing wind direction from the north-east. The wind from west is obstructed by neighbour buildings.







Ill 2.11 :Coclusion of site analysis

2.1 DESIGNING FOR CHILDREN

Before designing something for children – a space or a tool, it is important to consider what a child is. What do they think? How do they act? What do they appreciate? What do they react to and how do they perceive what is near or around them? All adults have once been children, but it is not easy to remember how our way of thinking and acting upon our thoughts used to be.

III 2.11

WHAT IS A CHILD?

Children are very different from adults. They are smaller, immature and have different ways of thinking and perceiving environment and objects and different expectations and ways of understanding life. They are new to the world, and thus they are more vulnerable and easily confused, but they are also observant and imaginative beings. Their perspective on life, especially children under five years, is holistic, broad and concurrent (Olds,2001). Adults frequently think of the future and how their choices and actions affect it. Children, on the other hand, have a "here and now" way of living and therefore they use their senses and bodies to great extent to experience their surroundings. They absorb the memories and impressions via the colours, odours, sounds, tactility, light and shades, movement and forms rather than the given meaning or objective of an element, object or a space. Children are easily enthused, amazed and fascinated by details or elements that we hardly notice or recognize and they often have a different meaning or use from their point of view.

To understand these children better, it is important to try to understand how they think and react and slow down our pace – we have to see the world through their eyes and experience through their actions. Since the youngest children have not fully developed speech or clear ways of expressing themselves it is even more important to try to understand them through their behaviour. Imagination is strong in a young mind, because it is not as bound to the details or logic of the real world as much as in adults' who have lived in the same world for a longer time. With open senses we have to deepen our consciousness of properties and details that exist in our surroundings and try to imagine and see various potentials in a chair, the steps and so on.

Children relate well to nature and what seems more natural. The nature is filled with sensorial richness – it is a place where all senses can be used when identifying, exploring and playing. This is why they appreciate spending time outdoors and that their favourite places resembles or have qualities of nature. In the nature there are no limits, they spend timeless play without rules or with own rules and give own meanings to items they can find.

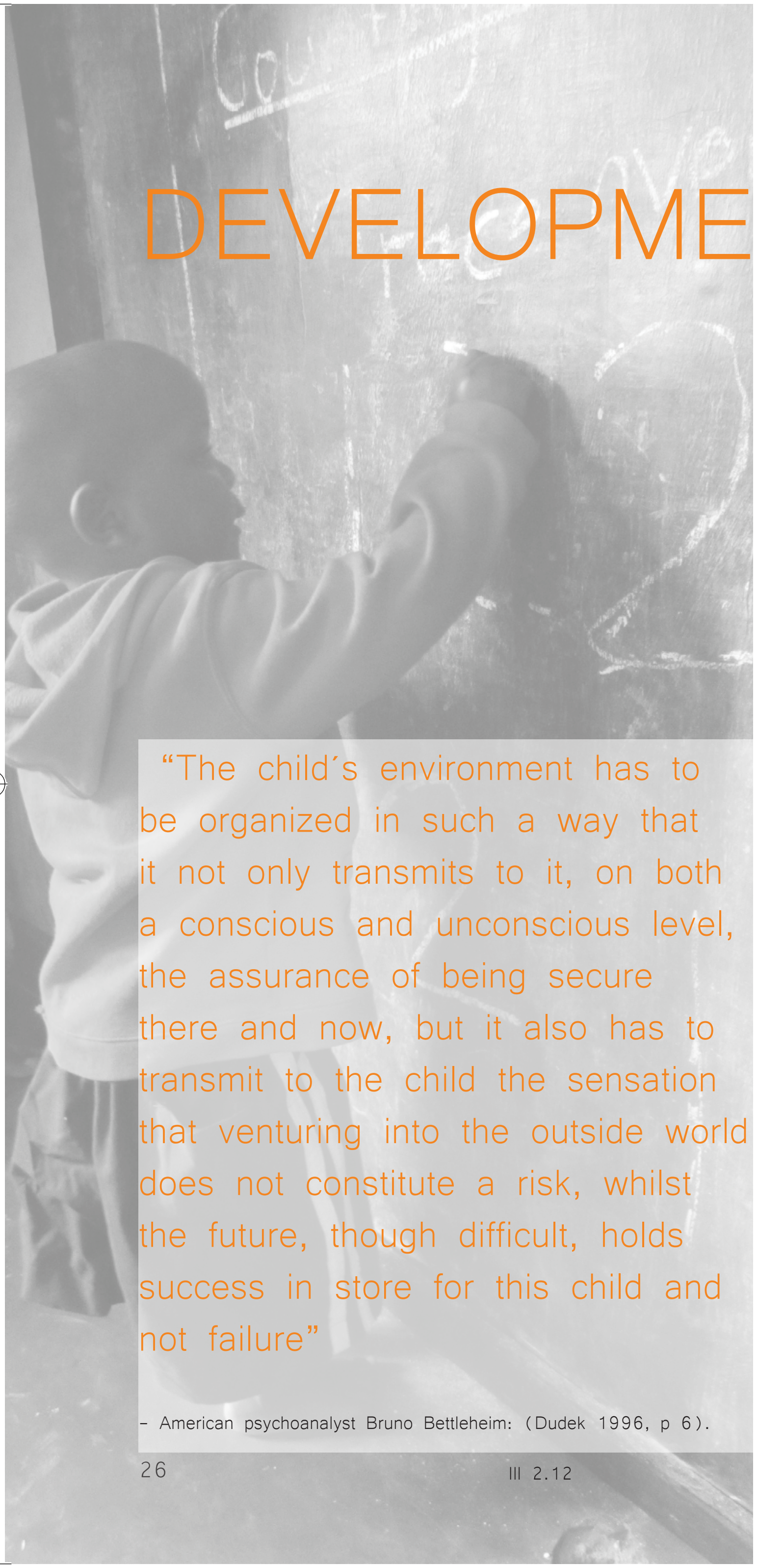
Young children put a lot of focus and attention in their physical activity in order to execute or master them. Their bodies and minds are not only being introduced to the world and its possibilities, but also their own possibilities and potential. Children look at almost everything as if it is interactive. For them, surfaces, objects and elements can be decorated, touched, felt, played with and leaned against - they can be good companions.

Children have different needs, understanding and activities according to their age. In institutional settings, it is normal to divide them into groups to give them age-appropriate settings for their development and stimulation. This is important to give them a better boost in their development, but it is also important to give them opportunity of contact with children of different age to recreate the settings of being in a family with siblings. Generally, children fall into four groups: infants, toddlers, pre-schoolers and school-age. These groups do not have a universal norm when it comes to age, especially for infants and toddlers. Pre-schoolers are usually thought to be children between 3 and 5 years and school-age children from 5 and up to 12 years (Olds, 2001).

"If a child is not allowed to be a child, it will remain a child."

- Mark Dudek (Dudek 1996, p 6).

DEVELOPMENT & ENVIRONMENT



"The child´s environment has to be organized in such a way that it not only transmits to it, on both a conscious and unconscious level, the assurance of being secure there and now, but it also has to transmit to the child the sensation that venturing into the outside world does not constitute a risk, whilst the future, though difficult, holds success in store for this child and not failure"

- American psychoanalyst Bruno Bettleheim: (Dudek 1996, p 6).

Ill 2.12

The child is where the human being goes through significant development toward becoming a mature, independent being. To obtain a good development process it needs stimulations of different kinds – intellectual, creative, comfort, emotional and physical. But the stimulation must not be overwhelming. There is a certain comfort zone at moderate levels of stimulation where children perform and behave their best. Too much or too little stimulations might induce boredom, deprivation or hyper-arousal that affect children's behaviour and might leave them feeling powerless. Too much restriction might lead to frustration, restlessness that can distract them from their learning and make them behave inappropriately. This, in a repetitive manner, can sometimes be misunderstood as poor motivation, attention deficit or hyperactivity. Children like to have control of their selves and display what they are capable of. They are curious in figuring the mysteries of what surrounds them and tend to explore and feel excited by daring.

Since children perceive their surroundings different from adults it is important to create an environment that can stimulate them in suitable levels and in different moods. Since they are in the introductory stages of their contact with the world and their personal development, it is important to give them appropriate environments to go through these processes – the environment becomes their greatest curriculum in how to deal with the world. Through engaging in different environments, children learn about ownership, exclusion, access and control. The environment consists of the physical space and its details and contents, as well as the atmosphere and people in it.

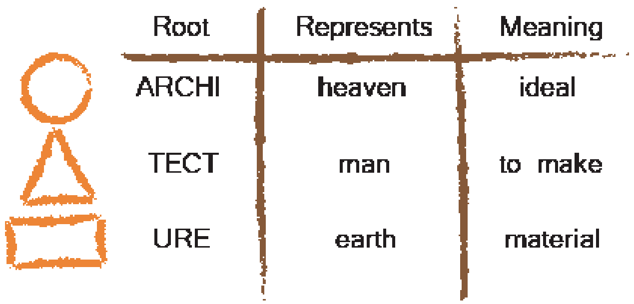
In the very early stages of life, the new born goes from being completely dependent to managing walking, talking, sensing, touching and understanding – the organizing framework, belief systems and ways of acting and perceiving are founded. According to experts, it is within the first three to five years that we develop our foundation of our personality, belief system and ways of perceiving and being in the world. The development of the child´s brain is closely affected by the environment and different forms of stimulation (Grantham McGregor 2007). The brain absorbs much information and changes occur rapidly. This fact puts a great importance on designing good and stimulating physical and psychological surroundings to encourage learning and mental growth, curiosity, social interactions and developing through playing. At the same time, the surroundings should provide a sense of peace and calmness and provide a feeling of safety and comfort.

Architecture can stimulate the children´s imagination and inspire them to further exploring and learning. They explore and investigate their way through their life and surroundings with their body and senses at these early stages. The very essence of childhood is in fact exploration and playfulness, stimulated though the surroundings. They do this by extracting meaning from the people around them and their surroundings. The environment in which they learn these aspects works as a framework and sets out the basis of which the child builds its own theory of time and space (Dudek 2007).

A spirited place

Children need a space filled with spirit – a spirit that suits their physical and psychological needs. They need a place they can feel safe and comfortable in as well as explore with all of their senses. For them, the space or elements are more about the holistic experience than just the physical tactility or visual input; they are also connected to the sound they make when moving or by contact or the odour they emit. The spirit of a place is what children see to be its characteristics, its energy and atmosphere. A space that combines peace and comfort along with excitement and mystery is considered to be stimulating. Although some qualities of the spiritual expression are physical or visual, it is the sensorial qualities of an environment that what affect children the most and their actions and behaviour are responses to it. They can sense lack in the integrity and wholeness of an environment intuitively.

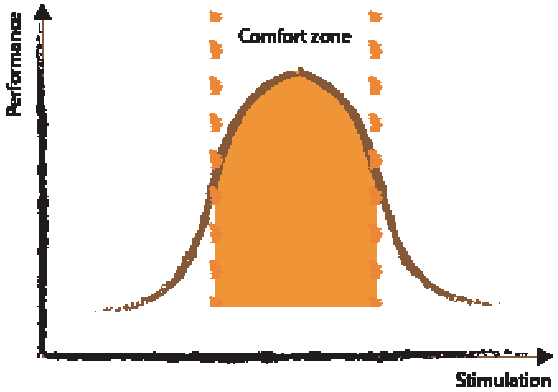
Architecture is an important tool in giving children their spirited atmospheres. Through this tool we are able to manifest a spirit into material or space. Some important elements that can help enhance or even create the spirit of a place are natural light that changes throughout the day and through the seasons, modest variety (difference-within-sameness) that are stimulating, safety that diminishes worries and makes one relax, and aesthetics that stimulates the mind, inspires, is regenerative and gives a feeling of wholeness and tranquillity. Since children interact with almost everything around them, they see materials as transformation of substances of spirit and beauty and through this a space gains "life" and becomes interactive as it invites imagination, play and response.



Ill. 2.13: Etymology

4 environmental needs

In addition to a safe and consistent environment, children need environments that encourage movement, that give comfort, cultivate competence and give them a sense of control. These four environmental needs, as stated in Child Care Design Guide (Olds 2001), can help create a good environment for children also when it comes to their learning.



Ill. 2.14: Graph illustrating comfort zone

Since movement is considered to be the base for intellectual development, it is important that the children are provided with an environment that gives them various possibilities to move around. Motion is important for children to develop their physical abilities and to allow them to freely locate themselves in a space, set own limits, enter other territories and explore their skills. To achieve this, environments that make room for a large variety of muscle movement are most suitable.

In order to move around and explore, the children must feel comfortable in their environment. Since our organs detect changes in stimulation they require movement and change, but too much or too little variation can make them uncomfortable. Therefore, moderate alternation in patterns and motion is preferred to keep responsiveness and comfort at optimal levels, so that performance and behaviour also becomes optimal. Changes inspired by nature's rhythm and patterns of e.g. changing seasons are comfortable since they relate to our own psychological rhythm.

Another feeling that is important for the children is the feeling of being successful and competent, especially when dealing with the world around them. Their size and level of maturity compared to adults is smaller and this might leave them feeling powerless when they cannot reach tools, switches etc. to do what they want to. Therefore, they need an environment that can support them to fulfil own needs and tasks. When doing so, they will become more confident and they get the opportunity to exercise skills and control. In order to have a good environment to work with the mentioned, children need to have a variety in things to do as well as spaces to do them in.

The spaces and the tools or equipment in them must be well-organized and accessible. When being competent, the child also feels that she or he has control. As much as control of one self, the child needs to feel that he or she has control over their environment.

Privacy is required for them to retreat and relax, but also to exercise control of their personal environment. The surroundings must also not confuse the child, but be readable so that he or she can locate themselves in the surroundings and predict where others might enter or where they themselves can go in and out of a space.

If one of the four needs (movement, comfort, competence and control) is limited, the others must be given extra focus. To explain this with an example, a child who is expected to sit still has to be given the opportunity to follow or participate in something intriguing while sitting comfortably and having overview of the room. In this example movement is limited, while competence, comfort and control are enhanced.

As stated by Lilliard Montessori in the book A Modern Approach; “Children use the environment to improve themselves; adults use themselves to improve the environment. Children work for the sake of process; adults work to achieve result”- This makes it even more important for us to consider how we design the environment for children (Olds, 2001, p.21)

Creative Environment

The environments must not be over-idealized with safety. It must also give room for the broad, imaginative and creative mind of a child. Children tend to relate to and enjoy their presence in nature. It might be because of the elements and objects in nature that they, themselves, can give meaning to and use in the way they want. They can see a log as a part of a tree, a bridge over dangerously flowing lava or even their stallion. This stimulates their creativity and expands their boundaries of playing.

AREA REQUIREMENTS

A child needs adequate space to play freely, run around and be active and unfold its abilities, but it also needs space and time to be with itself and reflect. Children up to pre-school age need a minimum of 2,3 - 2,5 m^2 (ideally 4 m^2) per child for available play area (primary space) (Scott, 2010, p 37). Primary space includes spaces that are available for the children and can be used for playing. Bathrooms, storage and kitchen space are for example not to be included when calculating primary space. The minimum requirements are for optimizing social interactions and reducing the risk of aggressive behavior often caused by low social interactions (Olds, 2001). Not included in this minimum area of primary space are secondary spaces (bathrooms, potty rooms, kitchenettes, storage, laundry...) and tertiary spaces (entries, corridors, walls, stairways, mechanical installations...) (Olds, 2001). One can also argument that this minimum indoor space requirement can be reduced, if the space can be replaced by outdoor play space in a climate that allows for much time spent outdoors. The minimum requirements and standards like the mentioned relate directly to the budget provided and the specific country´s own regulations and standards (Dudek, 2007). For grouprooms used during classes, a minimum of 1 m^2 per child is set by Ugandan standards

Ill 2.15

CHILDREN AND SPACE

A day-care center for children must encourage social play and interaction at different social levels, both at macro and micro levels. The close relationships are made at micro levels, in the smaller more private spaces, in the shadow from a large tree or around the water pond, while larger and more open spaces facilitate for social interactions at macro level, with common and casual play in larger groups (Scott, 2010).

Semi-private spaces

Semi private spaces are those places that are neither open nor close, but a thing in between. These spaces provide a more intimate and secluded environment and encourage to social interaction between pairs or small groups of children where they can converse and build relationships (Scott, 2010). Examples of such spaces can be transition zones, in a corner of the play area, on a bench in the back of the outdoor area, under low hanging branches or behind larger physical objects. This type of spaces can simply be created through a change of light, color or materials, or simply by placing out small and discrete places to sit to encourage children to linger for a longer period of time.

Private spaces

A child needs places to be alone where it can spend time with itself and reflect. The spirit of this place should encourage self-realization and self-appreciation through an intimate, safe and psychologically enclosed environment where the child can spend time with itself. This type of space can be both physically or psychologically enclosed or secluded, like small structural niches, shielding spaces created by vegetation or under staircases.

Common spaces

Common spaces should encourage social interactions and general relations through active play in larger groups. The spatiality of a common space should dictate an inclusive atmosphere with large spaces to enable more children to play together. A space for common activities should facilitate for different activities within this one place, like storytelling, active play and educational and creative common activities. The aesthetical environment should be carefully designed to be able to adapt to and fit all the different activities that are supposed to take place within the space.

Outdoor areas

The outdoor space should encourage to active and exploring play and enable activities like climbing and balancing, sliding and swinging, but also provide different tactile experiences (Dudek 2007). An environment for play which includes as many natural elements (sand, mud, plants, dirt, water) as possible is beneficial, as these elements can be easily shaped and included in their play and help the child develop skills about the elements of nature (Dudek 2000).

Semi-outdoor areas

In the climate of Kampala, semi outdoor spaces are highly usable as multifunctional spaces. A shaded semi-outdoor space can function as classroom, common space for storytelling or play area. A part of the site could function as a place for social gatherings, designed as a semicircle/amphitheater to be used for shows arranged by the children for special events. Shaded walkways or pergolas that allow the free flow of fresh breezes can function as transition zones and more intimate spaces for social interactions in smaller groups.

Children`s perception of space

As mentioned, children have broader and more holistic views than adults: the context, the elements and the details create the whole. They absorb the world with all of their senses and this regards spaces as well and here, the sensorial experiences are what they cherish and remember the most. A place is remembered mostly by what it feels like to be there and other places are compared with the same parameters. They need spaces that are predictable, but also spaced that invite to explore. The spaces must have some sort of challenge; some possibilities for variations. For this, the presence of contrast is important. As stated in The Good House by Jacobsen, Silverstein and Winslow, the six contrasts In/Out, Up/Down, Light/Dark, Exposed/Tempered, Something/Nothing and Order/Mystery can enhance a good design of spaces (Olds, 2001).

In/Out: Children feel attached to and comfortable in spaces that suit the scale of their own body, thus nooks and hideaways become attractive. Besides this, they also need space for their expressive nature and move freely.

Up/Down: When being in these higher places the children can obtain a feeling of power and privacy, and get to learn the perception of scale.

Light/Dark: While light and bright spaces invite for more expressive activities, the shaded or darker places are more suitable for retreat and privacy. The play between light and shade can give a rich and stimulating experience of a place that can leave deep impressions on children.

Exposed/Tempered: This contrast regards physical qualities especially connected to climate and the link can create an experience that can leave memories of a place and the spaces they retreat to and from. By retreating under a dry place during rainy days or seeking shade from the sun children experience this contrast quite often.

Something/Nothing: This is a contrast between presence and absence. When something (a presence of mass, form or decoration) is present in nothing (a plain wall or empty space), it gives children a point of reference and reassurance. The contrast; a space with nothing can give more room to express their play and creativity.

Order/Mystery: Order is found in the predictable patterns of a place and structure while mystery often is related to the handmade, hidden or unpredictable. These two elements can help create interesting transitions between spaces and also gives freedom to children's creativity.

In/Out
Light/Dark

Up/Down

Exposed/Tempered

Something/Nothing

Order/Mystery

Ill 2.16: 6 contrasts to create stimulating environment

CHILDREN & ARCHITECTURE

CONCLUSION

HOW CAN ARCHITECTURE RESPOND TO THE UNIQUE NEEDS OF CHILDREN AND STRENGTHEN AND SUPPORT THE PEDAGOGY OF A CHILDREN´S CENTER?

Architecture for children should embrace a "life-related" approach; children should gain as much knowledge and learning as possible through movement and experiencing spaces, rather than through instructions (Dudek 2007). This puts great responsibility on the architectural decisions regarding materials, spaces, organization, etc. and that these decisions are taken with the child´s interest in mind. A child day-care center should provide both spaces for social and common group activities, and quieter and smaller spaces for individual withdrawal and self-realization. This duality provides the children with the possibility to play alone or in groups that can build the foundation for social interactions and for the ability to cooperate in their adult lives (Dudek 2007).

A design for a children´s day–care center should not only provide functionality regarding space and the children´s activities, but should also (of equally importance) engage the children´s imaginative powers. This is best achieved if the architect can put his- or herself into the mind of the child and think like a child and experience the world from a child´s level. The world is seen from a totally different angle and the surroundings may seem very different from a child´s perspective. The focus point will have to be moved down, both in scale and in height. For small children, their whole world is experienced from floor level. This puts a great importance on the choice of floor materials and tactility to create stimulating environment even on this level.

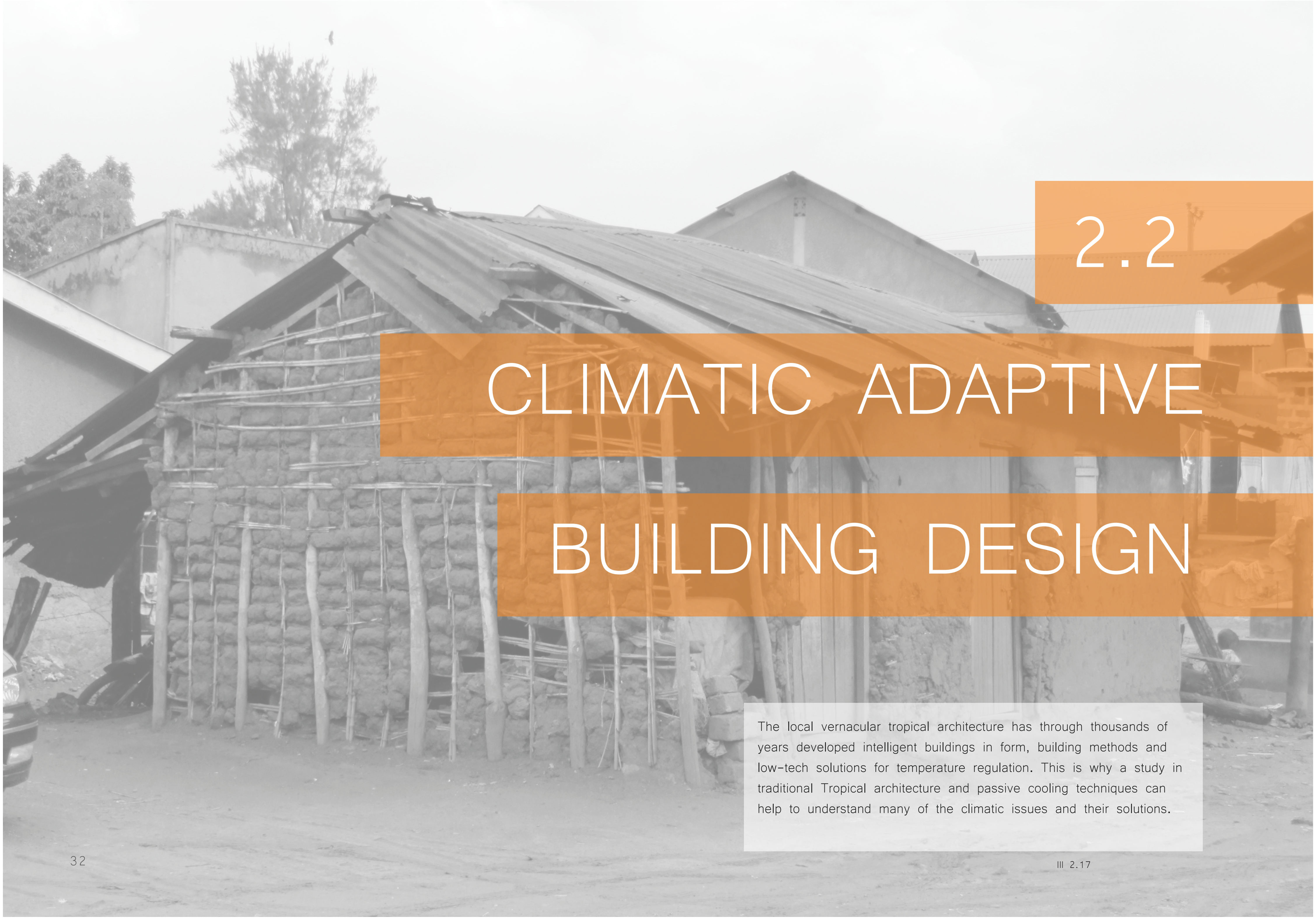
Spatial design with different types of spaces

The physical surroundings should be designed with high focus on stimulating spaces and elements to help develop children´s cognitive, social, emotional and motoric skills. Interesting spaces can be designed by varying architectural elements in scale, floor height, ceiling height, lighting, tactility and textures of finishes, color, light and access to and connections with the outdoors. Visual connection to the outdoors awakens a calming effect and a sense of inclusiveness rather than enclosure (Scott 2010). Different room heights will allow the child to perceive different types of spatiality. Different types of lighting can help to strengthen the perception of spatiality, and different and stimulating use of natural daylight should be preferred compared to artificial light. A creative use of light can help to articulate a room and its spatiality; the source of daylight be located close to the floor (for example in the infants` playroom where most of the activity happen at floor level), and high up under the ceiling (for example in spaces used for activities like storytelling or sleeping).

Good acoustic properties in a space is important to avoid high noise levels and unwanted sound-effects. High noise levels can cause stress and anxiety, and can be reduced by avoiding hard surface materials and applying acoustic elements in spaces with high expected noise level. The reverberation time should be calculated in order to document if the acoustic properties are acceptable.

Large spaces should perhaps be broken into smaller, perceivable spaces to encourage more concentrated play and activities. By placing a table with chairs in a larger space, a sense of "space within a space" can be created where a smaller group can gather around for creative activities and create smaller groups within a larger group.

The physical environment should be designing with simplicity in mind, yet they should be stimulating. A natural order is desired with little visible clutter to form a peaceful space (Scott 2010). Bright chaotic colours and patterns everywhere may cause a feeling of "disease", and should be avoided. The sense of space should be comfortable, protective and stimulating, which can be achieved architecturally by the use of soaring ceilings, contrasted against smaller structures, flooding open voids with natural light (drawing the focus of the eye up), and creating the diffuse spaces on the other side of windows or openings.



2.2 CLIMATIC ADAPTIVE BUILDING DESIGN

The local vernacular tropical architecture has through thousands of years developed intelligent buildings in form, building methods and low-tech solutions for temperature regulation. This is why a study in traditional Tropical architecture and passive cooling techniques can help to understand many of the climatic issues and their solutions.

Ill 2.17

BUILDING IN THE TROPICS

Architects and builders in moderate climatic zones (Scandinavia) fight cold and moisture through thick insulation in external walls, high-tech heating systems and by avoiding thermal bridges where heat escapes to the outdoors. When building in the tropics, the situation is quite the opposite. Here, the fight is against the heat and solar radiation. Low-tech and very often non-mechanical cooling techniques replace the heating systems of the North. The importance of allowing the design itself to provide comfortable indoor environment is high as a mechanical system requires about six times more energy to cool a space than to heat it and is generally produced by from primary energy sources (Lauber, 2005).

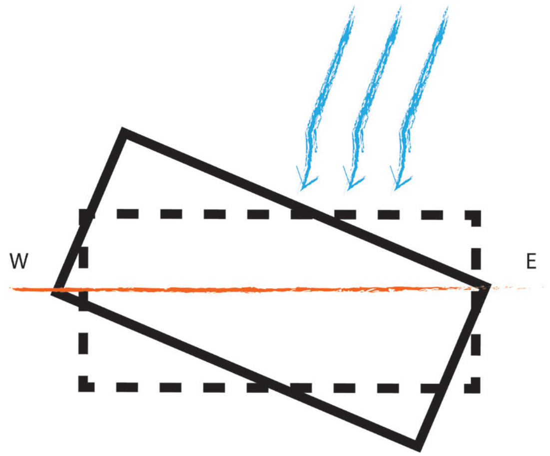
Building orientation

The best orientation of a building in the Tropics is is one that is optimized in terms of both prevailing wind directions and solar radiation. To achieve and maintain a comfortable indoor environment through natural ventilation, it is important to orientate the building so that it can utilize the prevailing wind. This does often not coincide with the best solar orientation, and which to pay the most attention to will have to be decided through further analysis of the specific situation, and possible ways of diverting the wind direction (e.g. through the use of vegetation and structural arrangements). But as a rule of thumb, orientation utilizing the prevailing wind is preferable, especially for low rise buildings with smaller wall surfaces as these will not receive that much solar radiation. (Gut and Ackerknecht 1993).

Our site is located in a suburban residential area and surrounded by a 2 m high brick wall, so the prevailing wind of the location is meeting alterations before reaching the site. Because of this, the prevailing wind is not the strongest factor in determining the organization of the buildings.

Shape and volume

Besides the functional and social factors, the climatic conditions should be allowed to contribute in defining the shape of the building. The surface-to-volume ratio (SVR) is an important factor, as large exposed exterior surfaces allow for a high amount of heat exchange with the environment. A compact building volume will gain less heat during the day, and lose less heat during the night, but on the other hand, forms with large surfaces favour ventilation and larger heat emissions during the night (Gut and Ackerknecht 1993). Building height should in general not exceed 3 storeys, because higher buildings receive more radiation and will obstruct the wind for the neighbours.



Ill 2.17 Optimal compromized building orientation

Building components

All building elements should be seen as a system and function together in order to achieve and maintain a comfortable indoor climate.

Climatic screen

The building envelope should provide protection from sun, rain, wind and dust. The sun is a determining factor for climate adaptive building design and Tropical architecture and it is of high importance to keep the external walls protected from the sun's radiation in order to exclude heat and keep the indoor climate comfortable without the use of mechanical equipment. The building envelope should control heat exchange between the exterior and interior environment and modify the exterior climate to create a new interior microclimatic zone.

Roof

The design of the roof has great influence on various aspects of climatic adaptable building design in Tropical Africa: solar gain, ventilation, water collection and glare. The roof is the building element that receives the most solar gain and represents the strongest thermal impact from both heat loss and heat gain. Materials with high reflectivity, such as bright metals and light colored surfaces should be used in exposed roofs to reflect as much of the solar radiation as possible and reduce heat gains. The shape and surface materials of the roof has a great influence on the thermal performance, while the load bearing structure (e.g. truss system) does not have great influence in this matter.

Thermal mass and time lag

The concept of thermal mass has both pros and cons in a tropical relation and have to be considered out from each specific building project. The building component´s time lag parameter determines the time between the outer surface reaching its peak temperature and the inner surface reaching its peak (and maximum heat is emitted) (Gut and Ackernecht, 1993) (Ill. 2.18 and 2.19). Materials with high thermal storage capacity and long time lag can prevent some of the heat from reaching the interior spaces during the day and re-emit the heat into the spaces during the night. For buildings used only during the daytime, like a day-care center, the use of thermal mass and materials with a certain heat storage capacity and adequate time lag can reduce the indoor temperature by a few degrees, depending on the diurnal temperature differences. The structure´s time lag should ideally take effect in the late evening, when the building is not used. If a space needs cooling during the day, the principle of thermal mass described above can be reversed by defining the time lag as the time between the period of maximum heat loss to the night sky and the period when the interior receives passive cooling. The time lag should be calculated to achieve the desired effect for the different rooms and their use.

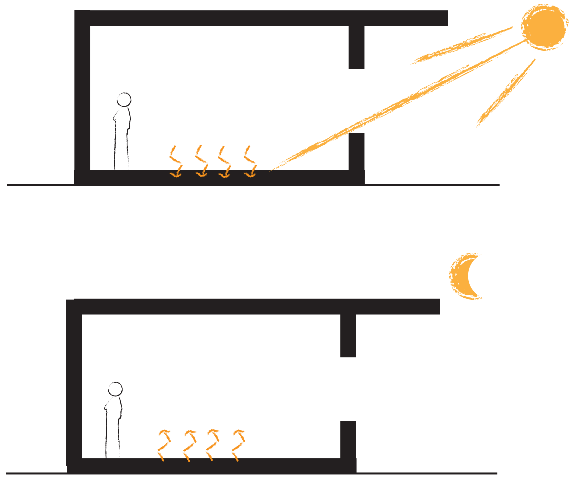
Thermal mass can also contribute in maintaining more even interior thermal conditions and help to eliminate the problem with condensation that may occur in the morning hours when the surfaces may be cooler than the air, due to the high relative humidity (Gut & Ackernecht, 1993). In temperate Tropical climate zones, such as Uganda, a compromise may be necessary, as too low heat storage capacity in the materials used will cause overheating during the warm months while making the building difficult to heat during the cold months.

Thermal insulation

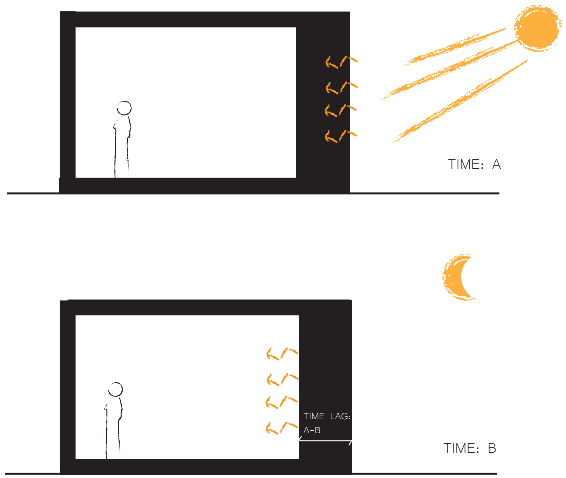
Energy in the form of heat always moves from hot to cold. This process can be reduced by thermal insulation. In Tropical climates, this has the consequence of reducing the amount of heat entering the building during the day, but prevents the often desired natural cooling at night. For this reason, thermal insulation may not be suitable for buildings which are designed to be naturally-climatized. Due to the free flow of air, thermal insulation has very little effect as the ambient air temperatures on the inside and outside of the building are very much the same. When applied to surfaces exposed to direct sun, thermal insulation may be effective to some extent, but the use of reflective material are far more effective in keeping the temperature of the inner surface low. Properly ventilated double skin constructions can also give the same effect.

Biological problems

Biological pests like termites, midges, flies, rats, mice and fungi are a threat to organic material. Hard materials like concrete, masonry, mortar, stone and metals are resistant (Lauber, 2005).



Ill. 2.18: Section of thermal mass principle



Ill. 2.19: Time lag principle

PASSIVE COOLING

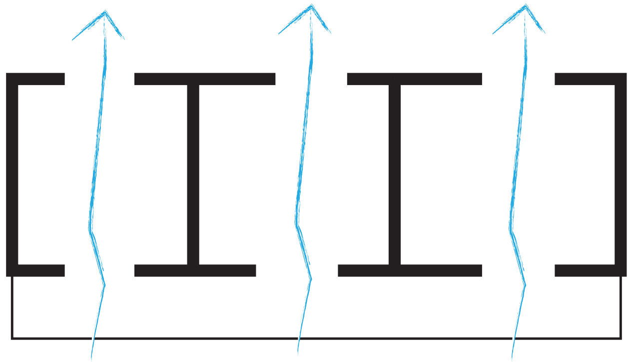
In a tropical climate the aim is to achieve a cool and comfortable indoor environment. As environmental sustainability is one of the main focus points in this project, a comfortable indoor environment should be a result of a climate adaptive building design that facilitates for passive cooling. In order to enable optimal utilization of wind and sun in climate adaptable building design, it is important to study the local wind and sun conditions, the site`s microclimate and the different means of passive cooling.

Utilizing wind for passive cooling includes various types of natural ventilation. When it comes to solar design, there are two categories; passive solar design (building is designed to maintain a comfortable indoor environment through its design), and solar design with active means (implementing active techniques such as solar panels and solar collectors to produce hot water or electricity to run mechanical equipment like fans and lighting). In this project, the focus will be put upon designing a climatic adaptable building that relies on natural resources only to achieve and maintain comfortable indoor environment. Active means will be implemented secondary.

Analyzing solar radiation on the different surfaces over the day and seasons can help decide where the openings are best located and where shading devices are needed. The orientation should still allow for adequate solar radiation during the cool months and some compromises may have to be made in order to achieve the best conditions in both hot and cool months. Facades facing east and west receive the highest intensities of solar radiation and should be kept small and with as few windows as possible, or be properly shaded.

The main living functions should be located towards the north, and the south side of the building should be designed with efficient sun shading devices. The organization of different rooms and functions should be done with close attention to the solar orientation and into temperature zones with functions demanding the same cooling or heating grouped together. A shaded porch or gallery (preferably located on the south facade) or a shaded courtyard can help to prevent direct sunlight from reaching the exterior facades and will consequently cool the air in the adjacent interior spaces and minimize conductive heat gain through walls. Natural lighting should be utilized, and the layout should facilitate for a building depth of only one room, to enable natural light from two sides. To enable the best conditions for both natural ventilation and daylight, the depth of the building is preferably limited to one room. This layout enables cross ventilation and daylight from two sides of the room (Ill. 2.20)

The best orientation of a building in regards to wind is generally to place it with the main face in a transverse direction +/-30 degrees to the main wind direction (Ill. 2.21). A divergence of 45 degrees to the main wind direction reduces the pressure of the incident wind flowing against the façade with about 50 % (Lauber, 2005). This may often not coincide with the optimal orientation for solar radiation, which is orienting the building with its elongated axis in the east-west direction (Ill. 2.22). This orientation minimizes exposure to the east and west and to the direct morning and evening sun to reduce the demand for cooling. A compromise should be made considering how strong the influence is from both sun and wind. The wind direction can to some extent be diverted



Ill. 2.20: Plan layout to enable cross ventilation

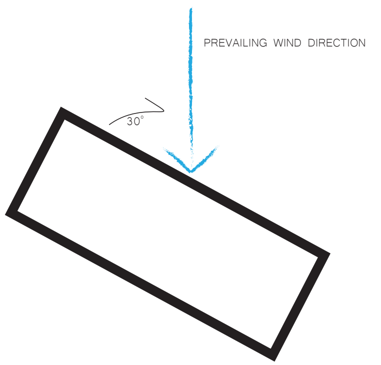
into a desired wind direction by intentionally designed physical obstructions. In our case, the site is located in a dense suburban area, which affects the prevailing wind direction As a rule of thumb for cross ventilation, the depth of the space should not exceed 5 times its height and the openings for inlet and outlet should be a minimum of 5 % of the floor area (Heywood, 2012). Partition walls in right angle to the air flow should be avoided as these obstruct the air flow.

Sun Shading

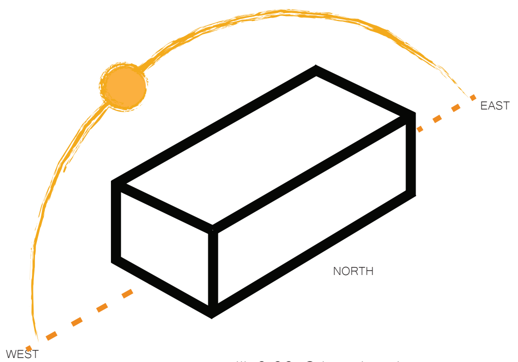
The solar radiation is best cut off before it hits the building and is allowed to penetrate the building envelope and reach the interior spaces. Shading can be provided through the building's construction itself, vegetation (ill. 2.23), through shading parasol roofs, large ovehangs, cantilevred upper floors, covered access galleries, pergolas or double-shell construction. If shading thorugh double-layer construction is chosen, it is important to ensure proper ventilation between the layers and that the materials should have reflective surfaces to prevent direct diffuse radiation. Other means of shading can be attachable devices like screens and louvres placed on the exterior of the building. Shading devices for openings should ideally be designed in a way to minimize the obstruction of air flow through the opening and also to protect from rain while still allowing breezes to pass. The materials used in devices for shading openings should have low thermal capacity to allow them to cool quickly after sunset. Each facade has to be considered separately to decide the best shading technique for each orientation. Shading the exterior surfaces is the first point of action in reducing solar radiation and can greatly reduce the total solar heat gain. By limiting the amount of heat that is absorbed by thermal mass in the building construction, one can cause a great reduction in cooling demand.

Our project is located on the equator, and the closer one is to the equator, the easier it is to provide adequate shading of the facades by the use of overhangs (Cleveland, 1999). The east and west facades should have minimal window glazing, and/or have exterior control devices to limit direct sunlight, as these facades are suffering from the variation in the sun's position in the sky over the year. Because of this fact, it is impossible to provide shade for the west and east facades with fixed devices and they will have to be adjustable to be able to follow the direction and angle of the sunrays. Interior shading devices like blinds, panels or drapes are generally easier to control, but are less efficient than exterior shading devices and perform best during the day to simply block or limit direct sunlight.

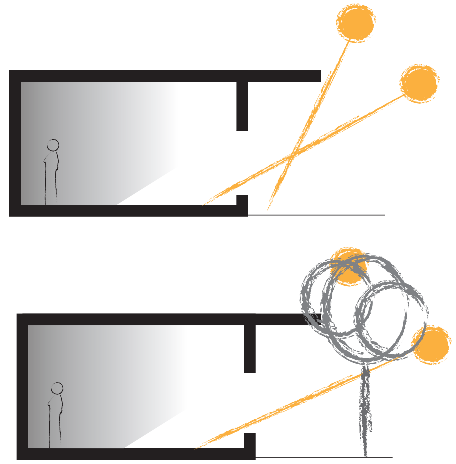
Three steps to properly investigate the different shading



Ill 2.21 Orientation due to wind



Ill 2.22 Orientation due to sun



Ill 2.23 Shading principles

devices (Cleveland 1999):

- Determine the times when shading is needed (overheated period)
- Determine the position of the sun during this period
- Determine the type and position of the shading device by investigating the device´s shading mask. These masks can be resolved into one of the three basic types: vertical (mask shape is bounded by radial lines), horizontal (mask of segmental shape) or a combination of these two (egg-crate)

As a rule of thumb, vertical shading is most efficient on east and west facades, as the sun is low, while horizontal shading is most efficient on south and north facades. Horizontal shading elements are best placed detached (10-20 cm minimum (Gut and Ackernecht, 1993)) from the facade to enable rising hot air to escape. A combination (egg-crate) has the best effect if used where vertical or horizontal shading alone does not provide enough shading (e.g. on facades facing east to southeast or west to southewst) (Gut and Ackernecht, 1993).

Windows and openings

Openings should be located to catch the prevailing wind and concentrate the airflow at body level, where it is the most effective. Windows, vents and doors should be shaded in order to avoid direct solar radiation and glare, without obstructing the airflow (ill. 2.24). Clearstories (windows placed high under the ceiling) enable natural light while avoiding problems with privacy, glare and, to some extent, excessive solar heat gain (if placed high up under overhangs). These can either be tilted or vertically placed. Mosquito screens reduce the air flow, but are essential in the Tropical regions. Larger openings should generally be oriented to the south and north because it is easier to shade these facades from direct sunlight. Openings towards east and west should be smaller and have fixed louvers to control sunlight from lower angles. Louvers can be designed to block angled rain, but still allow some natural ventilation to enter.

Vegetation

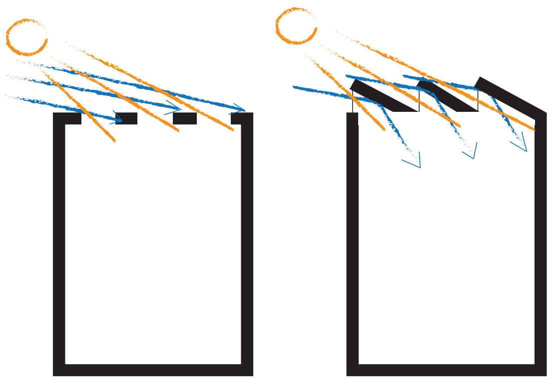
Large deciduous trees can be utilized for shading and will help to prevent heat build-up in the earth around the building, and as many existing trees on the site as possible should be preserved. Row shrubs and small bushes planted around the building will reduce the reflected solar energy from paved ground surfaces. Building trellis to allow climbing plants to naturally form a shading screen allows air to cool down and pass through. Deciduous trees will also help to cool down the wind and air through evaporative cooling before entering the building.

Structure

Heavy constructions and correct use of thermal mass in floor, walls and ceilings can absorb heat during the day when temperatures are high and release heat in the night when the temperatures are lower, and helps to keep a more steady indoor temperature. Common materials with sufficient thermal capacity are concrete, brick and stone.

Natural ventilation

When it comes to natural ventilation, there are two categories; wind induced ventilation and temperature induced ventilation.

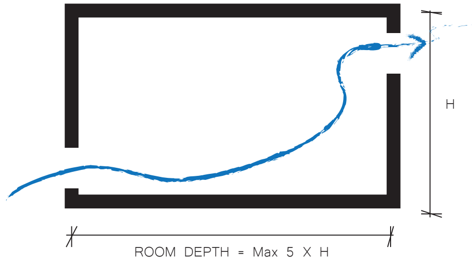


Ill 2.24 Facade principles seen in plan

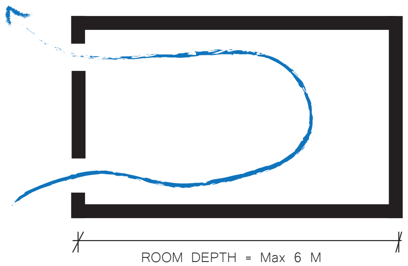
Ill. 2.25: Preassure difference due to wind

When designing a wind induced ventilation strategy, it is important to find the dominant wind direction at the site to find out where the different pressure areas will occur over the building´s surface. When a breeze hits a building, air movement is interrupted, and the air piles up in front of the building (windward side) creating higher air pressure until it is forced to move up and over or around the building (upwind). This creates a lower pressure (downwind) on the back of the building (leeward side) (Ill. 2.25). Air moves from areas with high pressure to areas with lower pressure (Cleveland 1999), therefore the inlets should be placed on high pressure areas of the building (windward side) and outlets on low pressure areas (leeward side) to enable air movement and cross ventilation. The air flow is most effective for ventilation when the wind direction is within 30 degrees of normal to the inlet opening on the windward side (Cleveland, 1999). The faster air moves, the more moist it will remove from the human body through evaporation, but if the air velocity indoors gets too high (maximum 8 m/s) the environment gets uncomfortable for humans (Lauber, 2005).

For temperature induced ventilation, it is important to understand the basic physics that hot air rises due to pressure differences between the body of hot air (high pressure) and areas with lower pressure to which it moves (usually higher up). This phenomenon is called the stack effect (Cleveland, 1999) and can be used to exhaust hot air up through the building. This is especially effective at night when the cooler night air can be brought into the space and then bring the heat absorbed by the building during the day out of the building through an opening placed higher up than the inlet. If stack ventilation is to be used the required temperature difference between indoors and outdoors should be more than 2°C, because it is driven by thermal buoyancy. A strategy of stack ventilation can work together with cross ventilation, because even a mild breeze can overcome air movement caused by thermal differences and exhaust the heat (Cleveland, 1999).



Ill. 2.26: Section of cross ventilation principle



Ill. 2.27: Section of single sided ventilation principle

Lesson learned

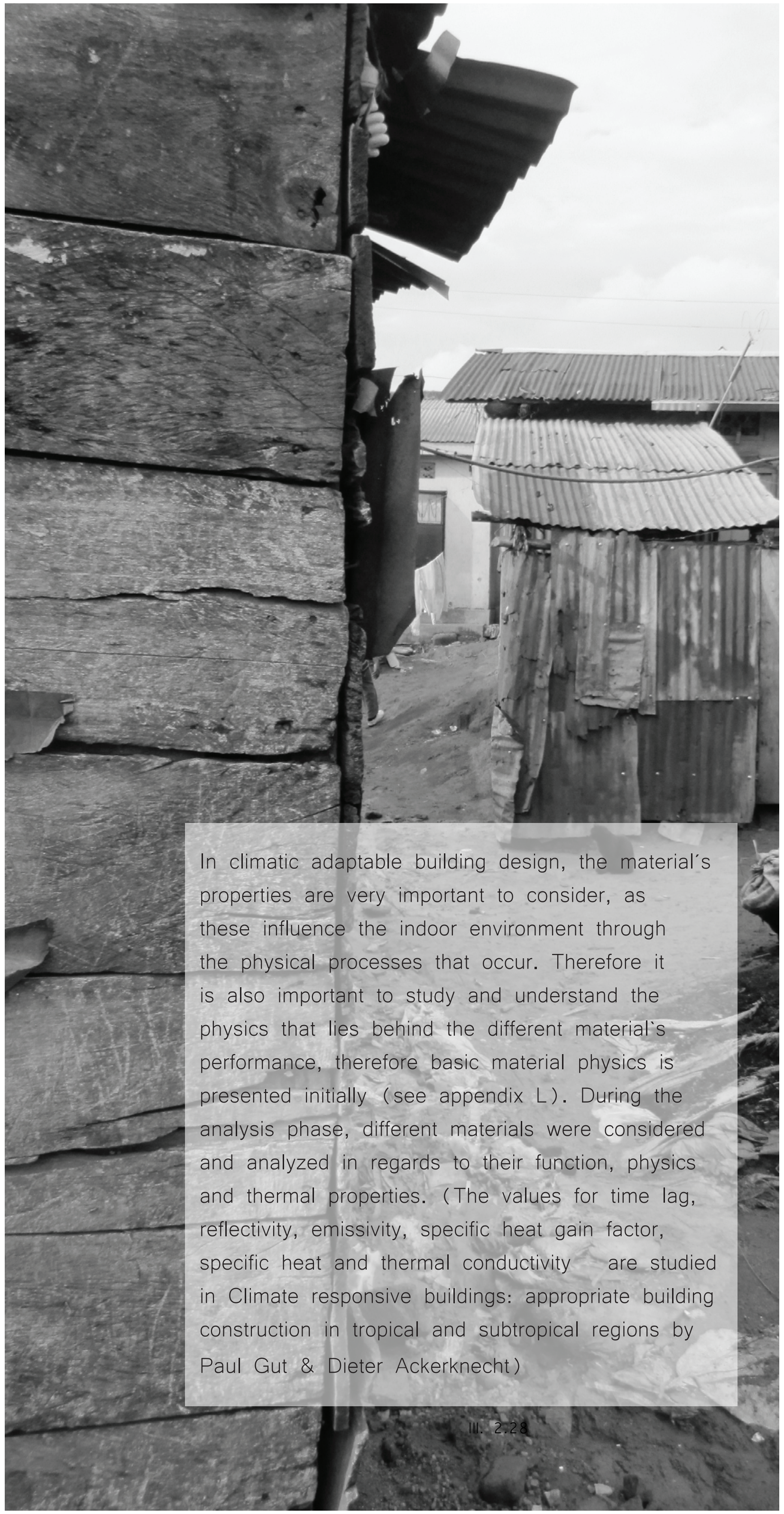
· Provide maximum ventilation (cross ventilation) and free air movement by large openings.
· Provide maximum shading of direct and diffuse solar radiation.

· Focus the orientation of the building with its longest axis is the east-west direction
· Minimize internal heat gain

· Material´s reflectivity and emissivity is important to regulate radiation, and highly reflective material should be used for external surfaces.
· Use ventilated double roofs.
· Use vegetation to regulate the solar impact

· Optimize the structure regarding to thermal mass and time lag (consider each different function and room)
· Thermal insulation is only effective on surfaces exposed to direct sun and double layer wall-elements should be considered

It is highly important to know the climate in order to best utilize the natural resources for creating comfortable indoor environment and sustainable building designs. This study of Tropical architecture (appendix XX) in general has raised the awareness of implementing a good integrated design process when working out the best possible climatic adaptable building design. The local climate is the main design parameter and can be utilized through the building design itself. The ideal situation would be one where the design is balanced with the climate, - a situation where these two adapt to each other.



In climatic adaptable building design, the material´s properties are very important to consider, as these influence the indoor environment through the physical processes that occur. Therefore it is also important to study and understand the physics that lies behind the different material`s performance, therefore basic material physics is presented initially (see appendix L). During the analysis phase, different materials were considered and analyzed in regards to their function, physics and thermal properties. (The values for time lag, reflectivity, emissivity, specific heat gain factor, specific heat and thermal conductivity are studied in Climate responsive buildings: appropriate building construction in tropical and subtropical regions by Paul Gut & Dieter Ackerknecht)

Ill. 2.28

MATERIALS

Light weight roof structure

The main property cosidered when choosing a material for the outer light-weight roof was high reflectivity to reflect most of the solar radiation to minimize the heat gain. A material with low heat storage capacity would allow the roof to cool down during the night. A material that is light in weight is beneficial for enableing a light support construction to be able to achieve an overall light and soaring architectural expression.

Aluminium was found to be the best suitable material for the outer light-weight roof, as it reduces the heat load due to the high reflectivity. For polished aluminium sheeting the reflectivity factor is 60-90% (20-80% emissivity of thermal radiation), while bright aluminium, gilt or bronze have a reflectivity factor of 50-70% (40-60% emissivity of thermal radiation). Whitewash coating increase the reflectivity to 80 %. The time lag for single new aluminium sheeting (without ceiling) is 0,5 h and the Solar heat gain factor is 10% (Gut & Ackernecht, 1993). Aluminium sheeting is durable and has a long life span. The high durability of aluminium and that it is available in a local context can defend the fact that this is a relatively expensive material. Aluminium will also work as a great material for collecting the rainwater from the roofs.

Recycled car tires will be used as additional heat insulation with the aluminium, and these will also work good as sound insulation during heavy rainfall.

Main building volumes

Earth bricks were chosen as main material on the basis of its thermal properties, sustainability, availability, easy construction and local building culture, but also on the basis of the architectural expression and the tactility of the earth plaster finishing. Earth as the main building material will emphasize the massive architectural expression we wanted for the building volumes, and contribute to create the contrast between the light outer roof and the heavy building volumes underneath. Building in earth will also allow the building to blend more into the surroundings.

Earth bricks have the ability to regulate the indoor climate naturally, by its natural moisture-regulating and heat-accumulating properties (which are preserved because the earth bricks are not burnt). Unburnt compressed stabilized earth bricks have better thermal conductivity value compared to fired bricks (Rahman, 2010). Depending on the material`s thickness and time lag, compressed earth blocks help reduce the indoor temperatures during the day and allow for heat emissions when the temperature drops, and keeping a more even indoor environment with fewer temperature fluctuations. This will reduce the energy need for indoor temperature regulations. Hand made earth blocks may limit the building to one-storey, while machine-made blocks can allow for two to three storeys (ISSB, HICSEB, - depending on the type of earth) (Oskam, n.d.). The use of renderings and soil stabilizing techniques can increase the durability of earth bricks.

Compressed earth bricks have good sound insulation properties, and a 40 cm thick wall has a sound insulation of 56 dB (Oskam, u.d.).

A solid Earth brick wall of 230 mm (U = 2,7) have a time lag of 8 h and a solar heat gain factor (SHF) of 10%. If painted with whitewash externally, the SHF drops to 3,5 % Gut and Ackernecht, 1993). By increasing the thickness to 40 cm, the time lag can be up to 12 hours. A solid earth brick wall of 280 including 50 mm cavity (U = 1,7) have a time lag of 10,5 h and a solar heat gain factor (SHF) of 6%. If painted with whitewash externally, the SHF drops to 2 %. Stabilized soil/mud bricks have a slighter lower time lag (e.g. 8,1 h with 30 cm thickness) (Gut and Ackernecht, 1993).

Earth blocks represent a sustainable solution in many ways. Since this type of bricks does not need to be burnt, it means saving a lot of wood. The bricks are uniform and therefore the use of mortar can be minimized, decreasing the construction time and cost (OSkam, n.d.). The bricks can be made on site, meaning saving a lot of transportation costs and C02 emissions, and the earth from digging out the plot could be used to make the bricks (depending on the type of earth). For making the compressed earth blocks, a machine needs to be rented, and the construction workers will have to be taught in the skills of brick making to ensure high structural qualities. This will then work with both the ethical- and environmental sustainability aspect of this project. The production of compressed earth blocks need about 1 % of the energy needed to produce a building brick (Oskam, u.d.). The need for maintenance is none, and smaller repairs can be done with earth plaster.

Compressed earth blocks (CEB)

Compressed earth blocks (CEB) are made with either motorized hydraulic or hand-operated machines. The bricks can be made of solely soil and a small ammount of water (CEB), but they are usually stabilized with cement to increase the structural quality (CSEB) (EmiEA, 2012). The blocks are of comparable strength to burnt bricks, but without the need for burning wood in the process of making them. A special attention has to be paid in the production process, as the quality of the bricks depend upon consistent quality controls throughout the process to ensure high quality. CEB provide good compressive strength, but require reinforced concrete columns to provide lateral stability (during earthquakes) and ring beams in the same material tied to the columns.

Another option when using compressed earth bricks are interlocking stabilized soil blocks (ISSB). These blocks are made with a ratio of 1 part cement to 11 parts soil, and like CEB do not require wood for burning (EmiEA, 2012). The bricks can be laid in an interlocking system, reducing the need for mortar to every 4th course and allow quick construction as the blocks are self-aligning. ISSB provide more lateral stability than CEB, but still not sufficient in earthquake-areas. Hollow interlocking compressed stabilized earth blocks (HICSEB) can be used for buildings up to two storeys, and is similar to ISSB (EmiEA, 2012).

A bricks wall`s properties regarding reflectivity and emissivity depends greatly on the finish used. In general, plaster finish have an emissivity of 97%, while the colour decide the reflectivity. (Orange have a reflectivity of 45 %, light brown 35 % and white 80%) (Gut and Ackernecht, 1993).

Intermediate slab

The ground slab and intermediate slab is constructed out of reinforced concrete/elements, A concrete slab of 300 mm (U = 2,5) have a time lag of 9,2 h, and a solar heat gain factor of 7% (Gut and Ackernecht,1993).

Windows

The most common window type in East Africa is single glazed windows with safety bars integrated in a shared metal frame (EMIEA, 2012). A single glazed window (U=4) has a time lag of 0 h and a SHF of 85% (Gut and Ackernecht,1993).

Materiality of secondary functions

The secondary functions (bathhouse and kitchen area) will have a different material-expression than the main building volumes, while at the same time showing signs of belonging to the main building volumes as a whole. Massive earthen walls with areas of recycled glassbottles. For the light walls (solely partition walls), braided wood or similar organic materials laid horizontally will enable constant ventilation and diffuse light. All these materials are highly sustainable as they can be made on site without the use of burning wood they are locally used and available, and cheap.

Seen from an ethical sustainable point of view, the implementation of multiple and different materials in the design would represent a wider range of gained knowledge for the local community to adopt about different materials, their areas of function, different building techniques and aesthetic qualities.

Ill. 2.29 Color scheme

Ill. 2. 30 Material pallette

2.3 HUMAN COMFORT ZONE AND INDOOR ENVIRONMENT

The physical and mental comfort resulting from the indoor environment helps stimulate the users and can help to enhance their well-being and thus their performance. The user`s health and comfort is directly related to the indoor environment, a fact that puts a high importance on studying the parameters of indoor environment and how to achieve and maintain the best possible indoor environment. It is also important to consider the psychological functions of the human body, and to study the thermal conditions in which the human being feels comfortable.

Ill. 2.31

INDOOR ENVIRONMENT

Feeling uncomfortable, getting allergic reactions and sometimes even developing illness or diseases can be related to buildings we use or visit often, and thus it is important to give attention to the indoor environment during the design process. Children, our main user group, are even more vulnerable to insufficient indoor environmental factors. Indoor environment is not only important for our somatic well-being, but also for our psychological and psychosocial well-being. As WHO defined in 1948: “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (NTNU & SINTEF, 2007, p.100). Since the indoor environment regards more than one aspect of our surroundings it consists of several factors that can affect each other. Components of primary importance for the indoor environment (Gut & Ackerknecht, 1993):

- Thermal conditions (air temperature inside rooms, surface material temperature, clothing and activity level)
- Humidity (absolute humidity, relative air humidity)
- Air velocity (ventilation, comfort achieved in the immediate proximity of the users)
- Air quality (pollution and particles)

In addition to this there are certain components that have a great saying for fulfilling tasks, for focusing and stimulation of the users:

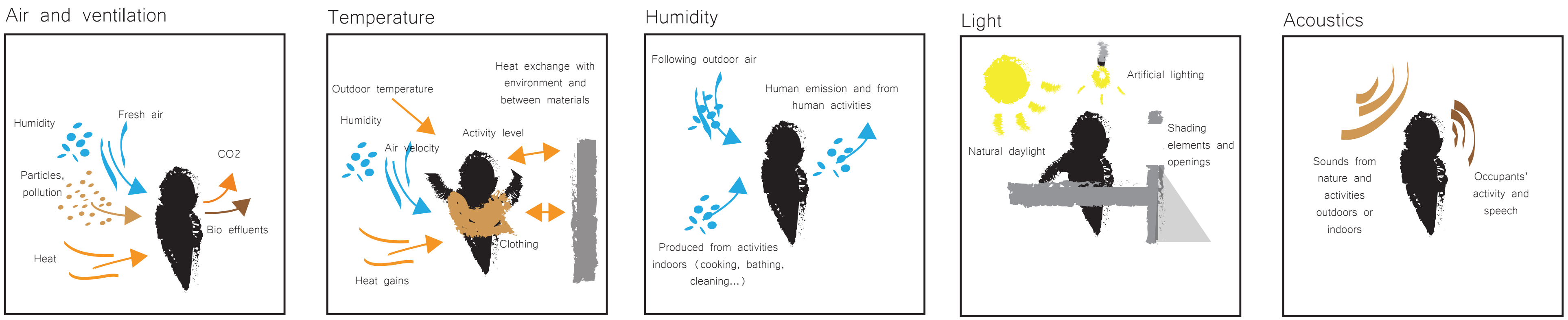
- Lighting
- Acoustic environment

How to design to achieve a good indoor environment

In a building with no technical means for heating or cooling, the indoor environment will systematically follow the outdoor climate and is determined by different factors (Lauber, 2005):

- The flow of energy from outside due to solar radiation
- The flow of energy and emissions released by

What affects the different parameters for indoor environment?



Ill. 2.32 Paramteres for indoor environment

the use of the building and its users

- The resistance of the building's mantle to the transport of energy (thermal insulation)
- The heat storage capacity of the building's structure
- The airflow rate

The indoor environment can therefore be controlled by means of affecting these factors. Such affecting means can be the design and layout, arrangement and size of windows, the construction, shape of the roof, building mass, thermal insulation, materials and colours, shading devices and the utilization of airflow rates in natural ventilation (Lauber, 2005). If used correctly, all these means can contribute to keep the indoor climate within given limits and requirements. By designing architecture that relates to its immediate surroundings, it enables a functional relationship between the architecture and the site's microclimate that can fully utilize the sun, wind and water, - all natural sources of energy.

It is usually impossible to design a building that meet ALL indoor-requirements for ALL the inhabitants under ALL prevailing conditions at ALL days of the year, so as a general rule the indoor conditions are acceptable when 80 % of the users are satisfied approximately 90 % of the time during a year. The hottest and coolest 10 % of the days do generally not have to be considered as a greater degree of comfort can be accepted (Gut & Ackerknecht, 1993).

The Human body and its thermal comfort zone

The human body holds an optimal internal average temperature at around 37°C and the body has the ability to balance its temperature through the principles of conduction, radiation and evaporation (perspiration and respiration) in contact with the environment (Gut & Ackerknecht, 1993).

The process of convection depends upon the temperature differences between the skin and the air, and the air movement, and can to a certain extent be regulated through proper clothing.

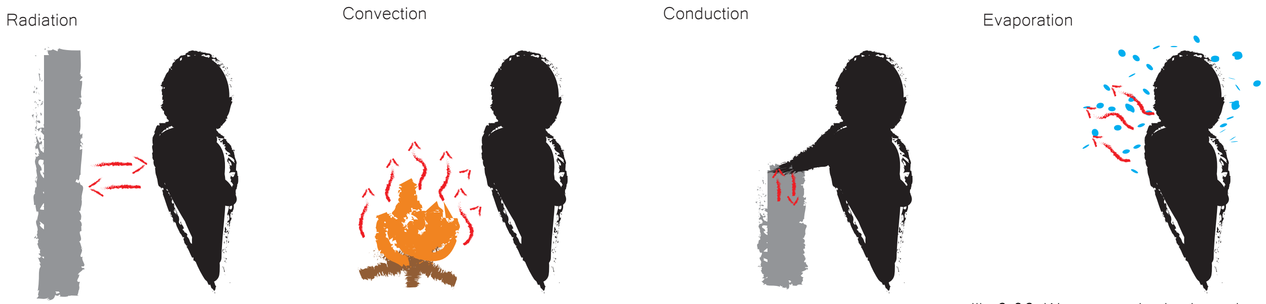
Conduction is possible through heat exchange through physical contact between the human body and another material and depends upon the material's thermal conductivity.

Heat exchange through radiation happens between the human body and its physical surroundings. This process depends on the difference in temperature between the skin and the surface or enclosed surrounding, and on type of clothing. Different types of clothing have different levels of insulation, defined as Clo (Clothing value, 1 Clo = 0,155 m2xK/W) (Gut & Ackerknecht, 1993).

Evaporation is a process when the human body loses heat to its surroundings through perspiration (and respiration) and generates a cooling effect. Dry indoor air (low vapour pressure) and high air movement works in favour of the evaporation potential (Gut & Ackerknecht, 1993).

These four different ways to maintain thermal comfort of the human body depends on temperature. At an ambient temperature of about 20°C, 80 % of the body's produced heat is transported to the surroundings in a "dry manner" (mainly through convection and radiation) and 20 % is transported to the surroundings in a "wet manner" (evaporation of moisture) (Lauber, 2005).

Good indoor environment for a human being is when the body requires as little effort as possible to maintain thermal balance with its surroundings (Gut & Ackerknecht, 1993). Optimal comfort condition is when the human body uses no extra energy to maintain thermal balance



Ill. 2.32 Ways to maintain thermal comfort

and the heat balance is regulated by the autonomous nervous system alone (latent physical heat regulation) (Lauber, 2005). The optimal condition is not consciously perceived by the human sense. When the climate differs from the optimal values, the sensible regulation of heat takes over and this condition is often connected to a feeling of low well-being and a reduction in productivity. This is almost impossible to avoid in the Tropics due to the hot climate (Lauber, 2005) and the aim for the building would be to provide an indoor climate as close to optimal as possible. Within a certain range close to the optimal indoor climate, the indoor environment is still experienced as comfortable, and can be defined as the human comfort zone (or acceptable indoor climate). The human comfort zone differs somewhat from person to person and depends on physical activity, health, clothing, psycho-social conditions and age. A person's geographic location plays a role, as human beings are able to acclimatize to the climate after a longer period of time spent in the same climate(Gut & Ackerknecht, 1993).

The human body's internal heat load depends on the level of activity (metabolic activity) and is measured with the unit Met (1 Met = 58 W/m2) (Gut & Ackerknecht, 1993).

Optimal conditions

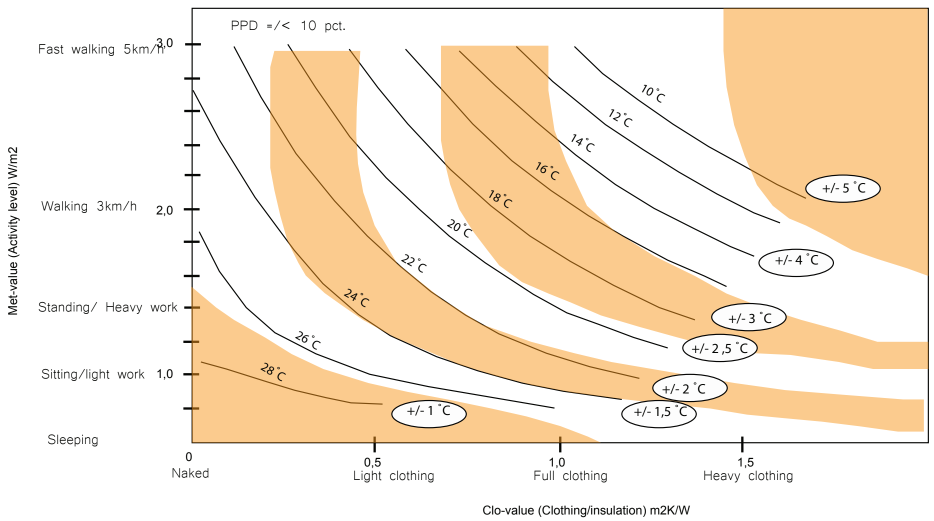
The optimal room temperature is 22-26°C, with only slight air movement (velocities under 3,0 m/s). Temperatures up to 29°C can be perceived as comfortable if the air movement also increases. Although, if the air movements comes above 8,0 m/s, the condition is no longer perceived as comfortable by humans(Gut & Ackerknecht, 1993; Lauber, 2005).

Acceptable conditions

In the warm Tropical climatic zones, temperatures up to 30°C can be accepted with almost still air. In contrast to the Optimal conditions, humidity has, for acceptable conditions, a significant influence on human perception of the indoor climate. For an acceptable indoor climate, air movement over 0,5 m/s is necessary. An air velocity of 1,5 m/s is considered as the maximum limit for acceptable indoor climate(Gut & Ackerknecht, 1993; Lauber, 2005).

Ventilation and air circulation

The quality and amount of air plays an important role for our health and thus in the indoor environment. In terms of basic needs, air is what we need most to survive (NTNU & SINTEF, 2007). Acceptable indoor air quality is defined as followed in ASHRAE 62-2001: "Acceptable indoor air quality: air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80 % or more) of the people exposed do not express dissatisfaction" (NTNU & SINTEF, 2007, p.104). When it comes to quality of air, ventilation calculations are based on pollution loads (odour, particles) and CO_2 level. Ventilation also helps regulate comfortable temperatures



Ill 2.33 Clo-met environment diagram

by cooling down or getting rid of warm or hot air, and this is where the circulation, velocity and amount plays a greater role. The hot air can be a result of temperature outdoors or internal heat gain which is heat emitted from occupants and their activities, equipment or materials found within the space. In a warm and humid climate, sufficient air movement is a prerequisite for comfortable indoor environment for human beings, especially in living rooms. Air velocities of at least 1 – 1.5 m/s are necessary in the warmest months (Lauber, 2005).

Humidity

Humidity affects the human comfort zone by affecting the process of perspiration and further the thermal balance. In a climate with high humidity levels, like the Savannah climate zone (Lauber, 2005), the maximum comfortable temperature is reduced, while a low humidity level gives a higher tolerance for higher temperatures (Gut & Ackerknecht, 1993). According to Wolfgang Lauber, humidity has only a slight influence on the human perception of comfortable indoor climate in the Tropics and can actually range between 20 and 90 % (Lauber, 2005). Although, there are some key values to consider: low values (30 % and below) causes irritation of the skin and the human mucous membranes, and high values (80 % and above) cause a risk of condensation (Lauber, 2005). Although the humidity has very little influence on the thermal comfort alone, it is of high importance when it is combined with air circulation. The wind circulation affects the felt temperature, as the cooling effect of the wind increases with increased velocity. This has the consequence of higher tolerance for higher wind velocities in a hot climate. Normally, an increase of 10 % in the relative humidity is perceived as 0,3°C increase in the operative temperature (CR 1752:1998).

Lighting

Light is an important factor when considering indoor environment. Adequate light is important for the visual environment that includes perception, execution of tasks and guidance. Natural daylight is preferred and should be enhanced in relation to health, energy and comfort. Glare and blinding should be avoided since it is uncomfortable and can reduce the efficiency of executing tasks (NTNU & SINTEF, 2007). Daylight is often connected to glazing and therefore it is important to balance the thermal environment and lighting when designing the glazed areas.

Acoustic environment

The acoustic environment is not only important when considering noise pollution or not being disturbed, but also for the perception of sound and speech. This varies from different types of building. In some buildings, it is preferable to dim the level of sound while in others it is desirable to increase it. This can be modified through design of and materials used inside the spaces. In a classroom it is important to have a clarity of speech and a spreading of the sound so it reaches the listeners, but it should not create echo or too much reverberation as this can disturb the clarity of speech.

LESSON LEARNED

The felt temperature depends on seasonal changes, clothing, activity level and acclimatization, and the tolerable temperature range decrease with psycho-social factors. With additional clothing and increased activity levels, the range of tolerable temperatures extends.

The temperature should be lower with increasing humidity at the upper limit of the human comfort zone

Air circulation should be increased with increased air temperature.

Drastic temperature changes should be avoided

Both frequent change of air and sufficient air movement is needed

Due to the minimal air temperature differences in the Tropics, the air does not give that much effect in cooling down the building components. But to humans, the flow of air creates a cooling effect felt through the increased perspiration. This effect is highly depending upon the humidity level in the air; high humidity will decrease this cooling effect on humans.

DEFINING INDOOR PARAMETERS

As the human physics is basically the same across the world, there are certain intervals of optimal values regarding air quality, sound, light, humidity and temperature we find comfortable or uncomfortable. The difference is that our boundaries of tolerance might vary depending on the daily climate and exposures of these values we are familiar with.

At the very early stage of the design process, the parameters of the indoor environment have to be determined. Whether these parametric values are to be met by the use of mechanical or passive techniques have to be decided, and this sets out the initial guidelines for the planning and design.

In this project the criteria for indoor environment are based on the Danish standards DS/EN 15251 and CR 1752. DS/EN 15251 regards both the indoor environment and the energy performance of a building (their relation to each other) and contains parameters regarding these topics. CR 1752 focuses on the indoor environment of ventilated buildings. Both these standards provide input parameters regarding indoor environment for relevant energy and indoor environment calculations. In these standards acceptable values are given but they also contain categories of the environmental quality indoors. In the two standards there are mainly three different categories and they are similar but have different naming (DS/EN:2007; CR 1752:1998).

Based on the classification of these categories, this project focuses on achieving category II (category B) as it is a new building. Although the primary users of the design are young children, it can be challenging to achieve category I (category A), because of the climate and the fact that it is an aid architecture project with limited resources. The climate and the natural habitat of the Ugandans also make it more realistic, tolerable and less drastic to choose a category with lower expectations, like category II or lower because too much difference and drastic changes in the environments their body and mind is in contact with throughout the day might result in health related issues and a feeling of dis-ease. Even though it is acceptable to exceed thermal comfort values, it is unacceptable to exceed values that regard the health of the users. Further, the project only focuses on the summer criteria, because winter criteria are more relevant in a European context with larger variations between seasons and lower temperatures than what is found in Uganda.

The table below defines some of the chosen criteria for the project taken from these standards. There has been a special focus on ventilation and daylight in this project. The temperature range is derived from DS/EN 15251, but modified to suit the climate of Uganda. There are not large seasonal variations in temperatures and therefore an annual range from 21 °C to 26 °C is considered as good.

For acoustics the criteria is to achieve sufficient speech clarity in classrooms. This is done based on a formula from a lecture in the course Engineering Architecture at the 1.semester of the Masters in Architecture and Design study at AAU (see page 71).

	Parameter	Value	Source
Ventilation	CO_2 concentration above outdoor level	500 ppm (if occupants are only source of pollution)	DS 15251
	Minimum Air change rate	0,6 ACR	DS 15251
Thermal environment	Temperature range	23 - 26 °C	DS 15251
Atcnic environment	Avarage daylight factor	minimum 2 % and preferably 5 % or more	
Acoustic environment	Clarity of speech		Kirkegaard, 2012

Table 2.1 Parameters for indoor environment

Category in CR 1752	Category in DS/EN 15251	Applicability (as stated in DS/EN 15251)
A	I	Recommended for spaces occupied by very sensitive and fragile persons with special requirements like handicapped, sick, very young children and elderly persons (high level of expectation)
B	II	Should be used for new buildings and renovation (normal level of expectation)
C	III	May be used for existing buildings (acceptable, moderate level of expectation))
	IV	Values outside mentioned categories should only be accepted for limited part of the year

Table 2.2 Standards for indoor environment

LOW ENERGY BUILDING CONCEPT

Energy goal

The main aim for the New Miles2Smiles Center as a climatically adapted architecture is to design a building that provides comfortable indoor climate and ensure good health for the users while using as less energy as possible and preferably without the use of technical equipment.

The energy goal of this design is to achieve as low energy demand as possible for the building's use and maintenance. Passive strategies integrated in the design like e.g. choice of sustainable and local materials, water collection, ventilation principles and shading solutions should help reduce and keep the energy demand of the building as low as possible. In addition to this, as much as possible of the already low energy demand should be covered by on-site energy generation through renewable means and off-grid systems (e.g. PV panels). As mentioned earlier in this report, the electric supply in Kampala is not always reliable because of frequent power-cuts.

The building should be able to achieve and maintain a comfortable indoor environment through passive cooling techniques during the hours of use (08.00-16.00), while may if necessary rely on energy produced on-site by renewable resources (PV panels) if the center is used outside this time-period.

Energy strategy

Through an integrated design process with an active use of energy modelling programs and calculation tools seek to:

- Reduce cooling demand through climatic adaptive building design that reduce the heat gain from solar radiation through passive means: solar shading, orientation, vegetation for shading, window design, use of materials that control the admission of heat into the interior spaces, reducing internal heat gains, reducing solar heat gain through the construction itself and through optimizing for natural ventilation.
- Reduce the energy demand for the daily running of the center: utilizing natural daylight, natural ventilation and cooling
- Facilitate for water-supply from rain water: design roofs to collect rainwater and tanks to store water to be used for the functions needed for the daily routines at the center, and utilize solar radiation for primitive hot water systems
- Provide an on-site renewable energy source: solar collectors/Pv panels as an additional solution, which produce enough energy for lighting and ceiling fans that may be used when the center is used outside service hours (as the design is optimized to meet the required values for indoor environment in main service hours (8-16).

2.4

VISITING KAMPALA AND THE MILES2SMILES CENTER

Our objective for our trip to Kampala was to get a better understanding of our user group in order to ensure the best possible design solutions. Since we are designing for a life quite different from the one we are used to, it was important to experience this situation for ourselves, especially regarding living conditions and climate. Through our visit to the existing Miles2Smiles center we got to observe the daily routines, how and when the different spaces were used, and what could be done to improve the situation for both the children and staff.

Ill 2.34

VISITING THE EXISTING MILES2SMILES CENTER

The daily routine at the Miles2Smiles center

The day of the children starts when their parent or elder sibling drops them off between 6.30 and 8.00 AM. They are met just inside the gate by a member of the staff who registers each child as they arrive. For this function they use a simple wooden bench where they sit and greet the children, and make the registration in a notebook.

At around 8.00 the children are gathered in the largest room (approximately 80 children in a room of 20 m2). Here, the children are taught to dance and sing and at the same time get physical education to develop their motoric skills. The room they use is later on used as a classroom.

After the morning gathering, the children are divided into different classes depending on their age: the 3 year-olds (baby class) are being introduced to numbers and letters, while the 4 year-olds are learning simple words and how to count. The classrooms are all very small and since they were originally bedrooms, the daylight conditions are very poor. The walls are covered with the teacher`s hand-made posters presenting the numbers, the letters and illustrating simple words. These are actively used during the classes together with the blackboard installed in the front of the classroom. Closed doors between the classrooms are not common and the noise can travel unobstructed. The rooms are all the size of a medium bedroom (12-25 m^2) and are filled to its maximum potential during classes (e.g.: a class of 65 children were taught in a room of 20 m^2!).

The early classes are followed by breakfast-time at 10.00. This is a simple meal consisting of porridge made from soya and corn flour that the staff prepared during the morning classes. The food is prepared over a large so-called «energy saving stove», which basically is a large solid bench with large open holes under where they burned coal or wood. The food is served to each child in plastic cups and they consume it sitting on the ground outside, on the elevated foundation around the main house or inside if it rains. After the meal, all the children`s backpacks are scattered around on the ground and each child find theirs to collect their snack if they brought one from home. Although there are no clear places to sit and eat, most of the children prefer to sit on the elevated foundation around the building.

After the first meal, the children are let free to play while the staff collects the empty cups and do the dishes. The play area is mainly a sanded area shaded by a temporary tent construction. The children`s way of playing is very active and loud: children running around, chasing each other and climbing everything that is possible to climb. Some children are also sitting around on the elevated foundation of the building or the wall surrounding the site talking or exploring things together in small groups. Many children play with sand and use the water in the gutter at the end of the site to create wet sand for building. The only tree on the site is very tiny and thin, but still frequently used for climbing and preferred above the climbing frame constructed for this purpose.

After play-time follows more classes which lasted until lunch-time around 12.45. Before lunch, all the children line up for a toilet visit followed by hand wash. The toilet facility consists of two pit-latrines. These are basically just small sheds built up around holes in the ground. The pit-latrines are located next to the kitchen area, which naturally leads to some hygienic issues.

The lunch is served indoors with all the children sitting around on the floor eating. After lunch, the children are again let out to play, while the staff swipe the floors and prepare for sleeping by putting out carpets and blankets all over the floor. Before sleeping, all the children are washed (hands and feet) in a small bathroom adjacent to one of the classrooms.

Conclusion

As the rooms have multifunctional purpose as classrooms, eating-, and sleeping-area, the rooms should have minimal furnishings. The rooms should be designed to facilitate for multifunctional use, and the floor materials should emphasize this. All potential furnishing of the rooms will have to be highly portable, not fixed and preferably multifunctional. The new Miles2Smiles center would preferably need a separate larger space for common gatherings; optimally a large semi-outdoor space to accommodate more children at the same time. Since this gathering is taking place early in the morning when the sun is yet modest, this morning gathering can on clear days be held outdoors.

Storage for the sheets and mattresses is needed, and this has to be close to the rooms used for sleeping. From an interview with the teachers working at the center we learned that they need storage space for objects used during classes. Today they store the teaching materials in a resource room in another building, and this room also functions as the office for the microfinance group. One of the teachers said that she would like a shelve going around the classroom, on which she could display all the objects used in teaching. A smarter solution for the storing and displaying of the backpacks should also be considered.

The toilet facility will have to be improved and preferably be upgraded with water closets. It will also have to be separated from the kitchen area, but be located close to the potty area and washing area. The older children are more independent and are able to wash their own hands and tend to their own personal hygiene. They should be provided with the possibility to do so, to strengthen their independence. They would need a space with simple wash basins or sinks with water supply for washing. These functions may be combined with the possibility of using water as an active part of the children's playing area.

The observations made at the playground confirmed our idea of the children preferring the natural elements. Ideally, a play area providing safe, inviting and stimulating possibilities for active play should be combined with the possibilities to sit around and interact socially in smaller groups. We observed that most of the children preferred to sit on the elevated foundation around the building, and this inspired us to integrate seating into the architecture of the new M2S center.

The new M2S center should provide office space for administration, micronfinance programme and a separate office for a nurse, who visit the center occasionally. They also need storage for teaching objects and materials.

Ill 2.35-37

The daily routines at the baby center

Because of the lack of space in the other center, the classes for the 5 year-olds (top class) are held at the baby center. They use the garage space as classroom, and have to keep the gates open in order to let in day-light. Long before the teacher had arrived the children started the lecture by themselves. This stated how eager these children are to learn and how much they appreciate this opportunity. The daily routines for the 5 year-olds are the same as for the other pre-shoolers at the other Miles2Smiles center, and they eat and sleep at the same time as the infants do.

The registration routines at the baby center are the same as for the other Miles2Smiles center; the day of the children starts when their parent drops then off between 6.30 and 8.00. The plot on which the center is located is a rented residential property consisting of a house with an attached garage. This is the same situation for the other Miles2Smiles center. The infants stay in the house, while the 5 year-olds stay in the garage. Minor adjustments were made to the house to make it more suitable for its function as a day-care center, with for example a potty area outdoors under a temporary roof construction. The infants spend most of their time inside the house, sitting on the floor playing. The space for the infants consists of two open rooms connected by an open hallway. Some of the children have a tendency to withdraw into corners seeking privacy or shelter, while others play actively with the other children. Sometimes, the staff members turned on some music and danced with the children, and the children really seemed to enjoy this.

Before the first meal of the day is served, all the toys are collected in two plastic baskets. The children seem to know the drill, and they all help. The first meal of the day is served around 10.00 and consists of porridge served in plastic cups. Most of the children are able to eat by themselves, while the youngest children need assistance from the staff members. After the meal, the floor is swiped and the toys are poured back onto the floor. The same routine is applied at lunch time: all the toys are collected before the food is served. Some of the oldest children help to collect the plates after they had finished eating, and they seem well trained in the daily routines. The routines seem to benefit both the children in terms of predictability and they always seem to know what is about to happen next, and the staff in terms of structure and gaining help from the children.

After lunch, the children are allowed outside for the first time during the day, and just to be washed. The reason why the children are not allowed outside during most of the day is that they need close attention, and the staff do not have the resources to look after all of the children at the same time over such a large area. Two staff members are washing the infants one by one in a washtub, before they are let inside again for their daily nap. The 5 year-olds are also let outside to play after lunch, and the older children automatically take care of the infants and integrate them into their play. While the infants are outside getting washed, the other staff members do the dishes, wash the floor and put out the mattresses on the floor of the playroom and the classroom of the 5 year-olds. At 14 o`clock all the children take their nap, and so does some of the staff members.

Not all of the infants are potty-trained and wearing a diaper did not seem to be a common thing to do. As a result, many of the children used the floor instead of the toilet, and as the day progressed the smell of urine became stronger and stronger. The staff dried off the floor once in a while with a moist towel when they discovered these small accidents. There was a few potties placed in the hallway in easy access from the play area, but only a minority of the children used them.

Conclusion:

Since some of the smallest children have a tendency to withdraw into corners seeking privacy, we saw a great need for varied types of spaces to meet all the childrens` different preferences.

The mattresses are stored in a separate room, which also functions as a “quiet” room if some of the children want to take an early nap. This is a smart solution that may be considered to adapt into the new center; combining the functions of storage for mattresses and quiet room. This room would not necessarily need windows and daylight, but need proper ventilation.

Since the infants area not allowed outside for safety reasons, it would be nice for the new center to have a safe and limited outdoor area in which the infants can play without the risk of anyone wandering off.

To solve the potty-problem, a wet room with possibilities for washing the infants close to an area for potty training should therefore be planned in relation to the infants` section of the new center. This would ease the situation for the staff, as they would not have to take all the children outside to the potty area, or to wash them.

Some of the staff members live at the center, and they should be provided with a sleeping area (preferably a space used by the children during the day, which can be adjusted to the staff in the evening). The staff would also benefit from a relax area where they can relax after service hours.

Ill 2.38-43

USER GROUPS

The main target user group for this project are children in Kampala, Uganda – in other words: children in a developing country. The children in the New Miles2Smiles center are children of poor market vendors with a background of poverty. The new M2S center is to be designed to house 265 children between the age of 6 months to 5 years old, which can be divided into two main groups: infants (6 months - 2 years old, 55 children) and children (3-5 years old, 210 children).

Infants, 6 months -2 years old

These children need space to play in safe surroundings and a comfortable and peaceful place to sleep in during the day. The small children will also need space for eating, washing and potty-training. For children 6 months to 2 years of age who have limited mobility and move around mainly by crawling/moving near the floor, their world is centered close to the ground/floor. To best customize a stimulating environment for the infants, the focus must be put upon working from the child's level and "from the floor-up".

Children 3-5 years old

The children from 3 to 5 years old are active and need good and stimulating playing areas of adequate size to enable active play both indoors and outdoors. They need physical activity and the outdoor playing areas should provide possibilities for active playing with enough space to move around. Playground equipment should be specially designed with a focus on physical development. They need a space for learning, either in form of semi-outdoor spaces or indoor classrooms (or both). This space should be shaded from sun and rain and provide good indoor environment to provide them with the best learning conditions. The interior spaces should have a visual order without excessive clutter, to help them keep focus.

Women in microfinance education

The female market vendors or the mothers of the mentioned children work during the day, so that the education possibilities must be facilitated in the evenings after work. It is logical to use one of the spaces used by the children at daytime to house these evening activities.

Staff

The staff of the Miles2Smiles center plays an important role in providing the children and mothers the reassurance and development that they are promised. They are the ones who run the routines at the center on a daily basis and are the ones who are to ensure that the children learn what they are supposed to, feel comfortable and staying healthy. If they are uncomfortable or agitated by constantly facing unpractical solutions, bad indoor environment, it could affect the way they treat the children and motivation to work. This means that they themselves have to experience comfort and be relaxed and motivated in their surroundings. Some of the staff member live, work and sleep at the center.

Ill 2.44-46

ORGANIZATION

Organization of the new Miles2Smiles center

Because the new Miles2Smiles will provide pre-school education, the children will be divided into groups based on age and competencies, after a closed pedagogical concept (Ruhm, 2013). The groups will be taught in different rooms, and these group-rooms will have to be flexible to fit each group`s needs. Although the children are divided into pedagogic groups, they start the day together and they would need a large common group room (preferably a semi-outdoors space) to tie the different groups together.

During the course of the day the children would ideally play freely throughout the building and site or occupy themselves in spaces designed for specific functions, and the circulation plan will have to be planned to enable this. The circulation will have to separate the zones for the children and the zones where the children are to be kept away from, like the kitchen and laundry areas. The layout and plan for the center should be clear and readable and enable the children to move independently and find their way around the center and further improve the childrens` independence.

Combining the infant day-care center with the pre-school day care center will reduce the spatial need, as many of the functions they need can be combined. The situation today is that they are divided into two separate buildings in two different locations. Combining these into one center will reduce the spatial and have economical benefits compared to the existing situation, as they now will need only one kitchen and the daily cooking will require less burnt fuel, they will only need a shared washing and sanitary facilities etc. Spaces can be used for shared activities where the children from the different institutions participate together. A combined center will also make it easier for the parents with children at different ages, as they now only need to deliver their children at one place. This can promote the older childrens` social behaviour by allowing them to care for the youngest children, while the youngest children are being introduced to the school system at an early age.

Layout and plan

Because of the change in position and radiation of the sun during the day, it is important to analyze when the different types of spaces are used during the day in order to design a building plan and site layout in the Tropical Africa. Rooms that are used frequently during the day should be placed where the climate provide best conditions for a good indoor environment. For example, group rooms and indoor play areas should be placed to the north or south as these facades are easier to shade and will avoid the most intense solar radiation. Rooms used only during mid-day can be placed to the east or west, as these facades receive the most solar radiation during the morning and evening. Functions such as meeting-rooms used in evening time should be placed to the east where it is cooler in the evenings. A room on the east side can, however, stay warm in the evening as well with the correct use of thermal mass to adjust and control the thermal condition.

Spaces with considerable heat or moisture loads, especially kitchen, should be separated from the living spaces and preferably put in their own part of the layout, maybe connected through a shaded pathway. Such functions should be located on the leeside of the buildings so that heat and moisture can be ventilated out easily.

Bathrooms and spaces where water and washing is involved, produce internal humidity and should be located where adequate cross ventilation can be ensured in order to avoid the growth of mold. These spaces could preferably be designed as open and semi-outdoor spaces.

Geometry of space and floor plan must allow for natural ventilation through cross ventilation. A layout which arranges rooms beside each other with access from a shaded front gallery is ideal (see illustration 2.22 in the Analysis chapter).

ROOM PROGRAM

	Area(ca)	Location	User group	Number of pers.	Functions	Type of space	Requirements
Pre-schoolers:							
Grouproom1 (a)	35	Next to Grouproom1 (b,c)	3 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Grouproom1 (b)	35	Next to Grouproom1 (a,c)	3 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Grouproom1 (c)	35	Next to Grouproom1 (a,b)	3 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Grouproom2 (a)	35	Next to Grouproom 2(b)	4 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Grouproom2 (b)	35	Next to Grouproom2 (a)	4 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Grouproom3 (a)	35	Next to Grouproom3 (b)	5 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Grouproom3 (b)	35	Next to Grouproom3 (a)	5 year olds	30	Classroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Infants:							
Baby room	75	Near Bathroom 1	0-3 year olds	55	Playroom/grouproom/sleeping	In	Daylight > 5%, good ventilation, good acoustic
Quiet room	12	Near Baby room	0-3 year olds		Sleeping, storage, staff dorm	In	Good ventilation, day and night
Common:							
Common area					Flexible use, stage, eating	Semi-outdoor	Good ventilation, shaded
Bathroom 1	10	Near Baby room	0-3 year olds		Potty training, diapers, washing	Semi-outdoor	Good ventilation, water source, storage
Bathroom 2	10	Near Toilets	3-5 year olds		Hand wash, washing	Semi-outdoor	Good ventilation, water source
Toilet 1	1,5	Near Bathroom2			WC	In	Good ventilation
Toilet 2 (HC)	3,3	Near Bathroom2	HC		WC universal design	In	Good ventilation, turning radius of 1,5 m
Administration:							
Office 1	6		Adm.	1	Administration, paper work	In	Daylight > 5%
Office 2	6		Microfinance	1	Administration, paper work	In	Daylight > 5%

Table 2.3. Room program

NOTES ON BUILDING IN UGANDA

Commonly used solutions for the different building components

Ceilings: Left open to the underside of the roof with the trusses exposed, or enclosed with a wire mesh and plaster ceiling with a textured paint finish,

Walls: Min. 12-25 mm plaster with paint finish on all interior and/or exterior walls, or exposed brick exterior walls with plaster finish on bottom 1m

- Reinforced concrete frame with brick infill: Constructing a reinforced concrete frame with bricks as infills in the gaps as non-structural wall elements. Horizontal strapping set into the mortar between the bricks will tie the bricks into the structure (see Ill. 2.47) (EMIEA, 2012)

Floors: A thickened reinforced concrete slap foundation is seldom used in East Africa but is appropriate where there is consistent rock or sandy ground conditions as approved by the structural engineer (minimum 100 mm). Sand cement levelling screed, painted finish to levelling screed or tiles are commonly used as finishes.

Doors and windows: Using modular doors and windows where possible will save costs and time. To simplify the construction, vents (with mosquito-screens) can be integrated on top in the same opening as windows and doors, and the openings can go all the way up to the underside of the ring beams.

Acoustics

In Uganda, sound insulation materials are unavailable, but ceilings with plaster finishes will generally perform well alone in terms of acoustics for speech absorption.

Noise from heavy rain on thin metal roofs can be a problem for the spaces directly underneath the ceiling, and these spaces should maybe not be used for organized teaching, but only for playing and free activities. Normally just plastering the ceilings would help as sound proof of metal roofs (EMIEA, 2012). For the classrooms it is important with good acoustic qualities. Solid brick or block wall which extend to the underside of the roof provide adequate sound proofing between the classrooms (EMIEA, 2012).

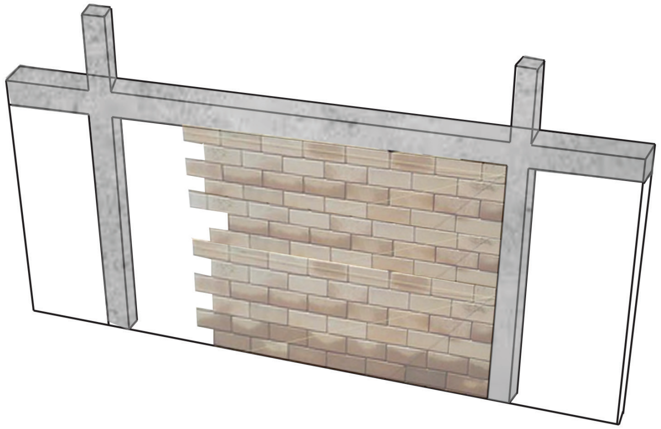
Ventilation

Passive ventilation through cross ventilation is the most effective. Continuous cross ventilation should be provided through openings other than windows and doors. Integrating vents above windows and doors enables ventilation to occur even when the building is not operated and the windows are closed. To create increased airflow through a space, the inlet must be smaller than the outlet. (EMIEA, 2012).

Lighting

Electrical supply in Uganda is irregular, so the building design should instead optimize for the use of daylight as the main source of light. Long and thin buildings provide the best conditions for utilizing daylight, and preferably with light from two sides. The higher the windows are located, the greater will the daylight penetration be into the room. Organizing the building on an east-west axis will give the best conditions for both ventilation and daylight.

REINFORCED CONCRETE COLUMN AND BEAM STRUCTURE CONSTRUCTED PRIOR TO ADIDING BRICK INFILL



Ill 2.47

Plumbing

It is not usual to pre-plumb a building in East-Africa: this is due to the lack of communication between the professions in a building process, and therefore the easiest solution is to chisel the pipes into the walls and floors after the building is constructed. It is not recommended to plan under-slab plumbing unless one can ensure that careful supervision is given during construction to check that all joints are properly sealed. It is also recommended that plumbing fixtures are planned to enable easy access and maintenance.

Drainage

Because of the seasonal heavy rainfall in Uganda, drainage must be paid close attention when designing the site plan. Rainwater must be physically directed away from the building into drainage channels made of hard materials and the foundation on which the building stands must be raised at least 250 mm above ground level (150 mm if the ground is paved with non-permeable materials) (EMIEA, 2012).

Universal design

To eliminate the need for elevators and long ramps in multi-storey buildings, no facility is to be provided on the first floor that is not provided at ground floor.

- Recommended thresholds for external doors: 20 mm

- Recommended dimension for toilet facility for disabled persons: 1,6 m x 1, 9 m

- Door openings should be at least 1000 mm (min. clear opening of 860 mm)

- Slopes and ramps of maximum 5% (1:12) for exterior ramps, and 8% (1:10) for entrance ramps

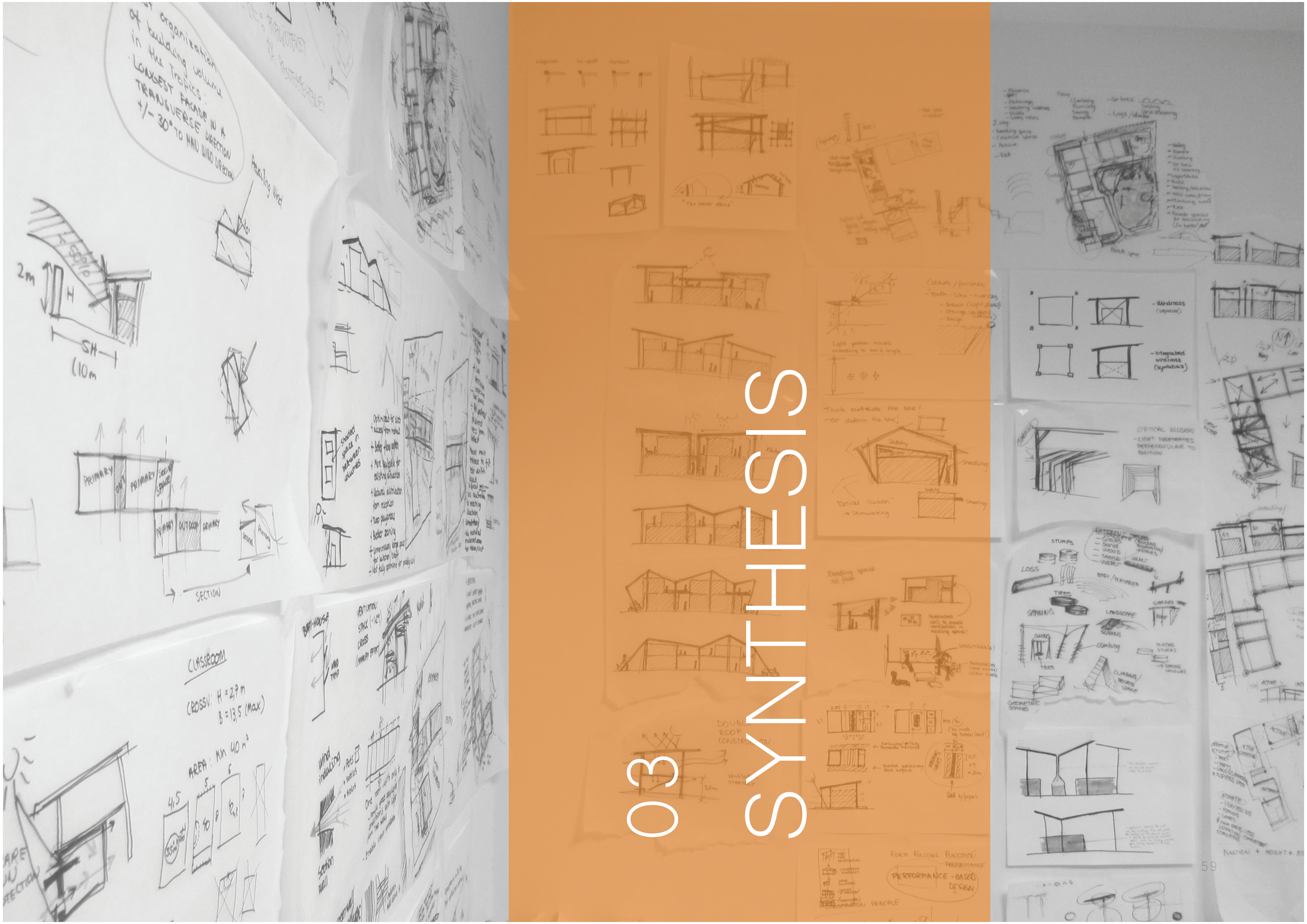
Principles for Cost-efficient and sustainable building design in Uganda

- Use a pattern of building blocks and a repetition of building volumes (rather than designing many different shaped volumes), to ease the construction work, allowing the workers to develop efficient construction methods by repetition.

- Design the floor plan to enable flexible use of spaces, as the functions they serve may change over time

- A series of smaller regular buildings is preferred to a large building, as this will simplify the construction process and allow for more simple building techniques and save time and money.

Note: The area within 2 meters from the site`s boundary should be kept free from permanent massive built structures, as this area is to be used for fire-men in case of fire. This regulation is set by the local authorities.



03 SYNTHESIS

INITIAL CONCEPT:

INTRODUCING NEW AND MODERN MATERIALS AND PRINCIPLES WITH THE AIM OF PROTECTING, EDUCATING AND DEVELOPING THE LOCAL TRADITIONS AND COMMUNITY

THE PROTECTED AND THE PROTECTIVE

UGANDA`s OFFICIAL NICKNAME:
THE PEARL OF AFRICA

POETIC CONCEPT

ARCHITECTURAL CONCEPT

BUILDING CONCEPT

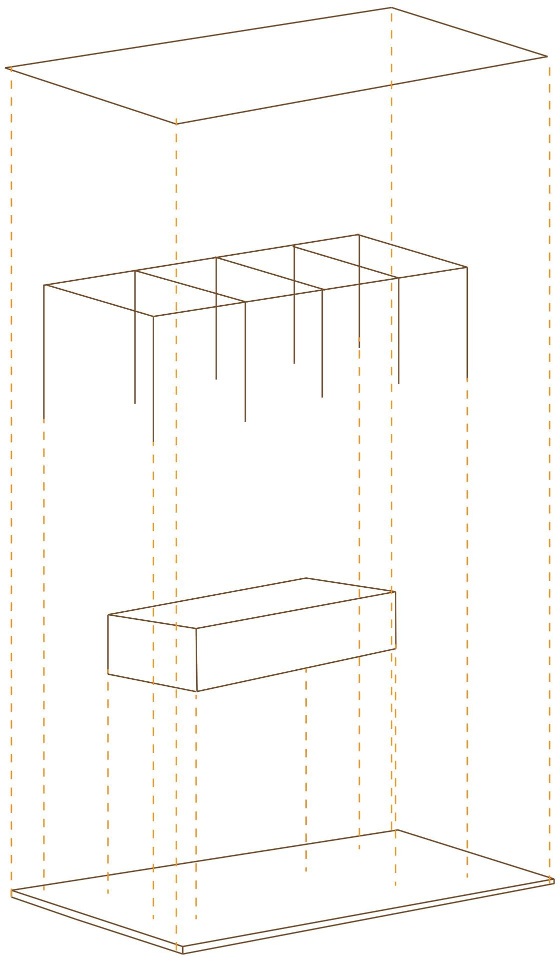
Ill 3.1 Concept illustration

DESIGN CONCEPT

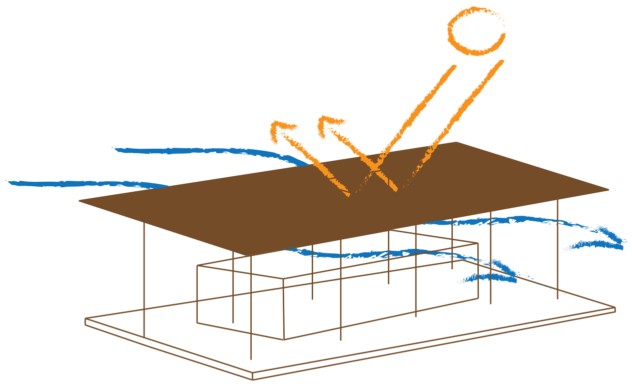
INTRODUCING NEW AND MODERN MATERIALS AND PRINCIPLES WITH THE AIM OF PROTECTING, EDUCA-TING AND DEVELOPING THE LOCAL TRADITIONS AND COMMUNITY

The protective: Oversized outer roof construction of industrial materials representing the introduction of the new

The protected: Shaded adobe building volumes representing the local culture and building traditions through its materiality, and the community through its function.

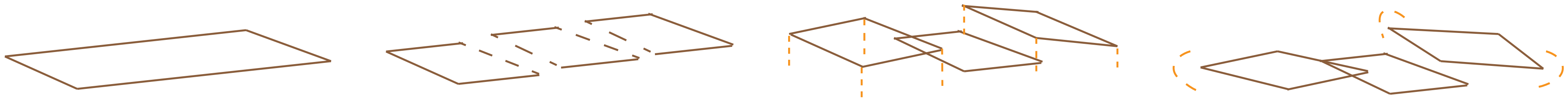


Ill 3.2 Concept diagram



Ill 3.3 Climatic principle of the double roof construction

CONCEPT DEVELOPMENT



OUTER ROOF WITH REFLECTIVE SURFACE

MULTIPLE PARTS TO ENABLE FLEXIBILITY OF FORM & FUNCTION

DIFFERENT HEIGHTS AND ANGLES CREATE DIFFERENT ATMPOSHERES

ROTATE TO OPTIMIZE SHADE EFFECT

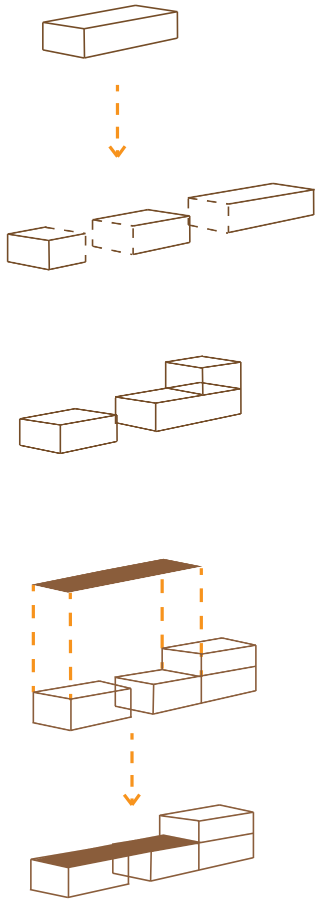
Ill 3.4 Roof morphology

BUILDING VOLUMES

DIVIDING INTO FUNCTIONS

REDUCING THE FOOTPRINT

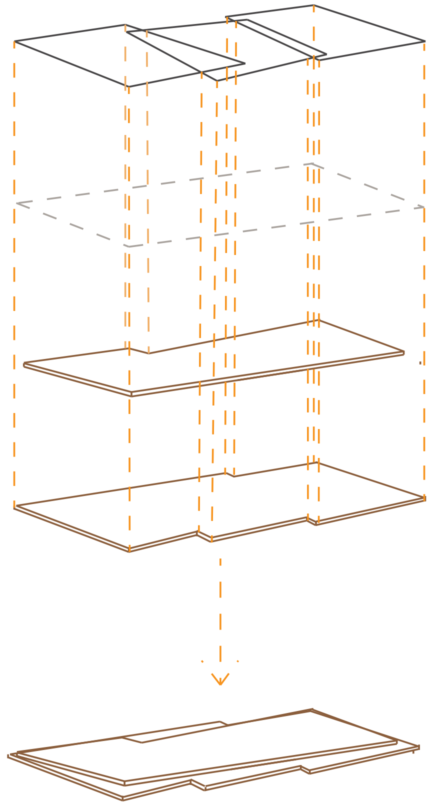
ADDING EXTRA AREA



Ill 3.5 Building volume morphology

GROUND SLAB

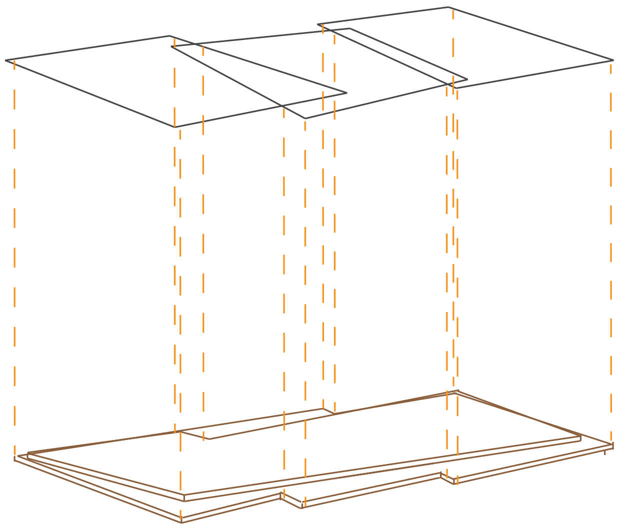
CREATING A DUAL PROJEC-
TION OF THE OUTER ROOF



Ill 3.6 Ground slab morphology

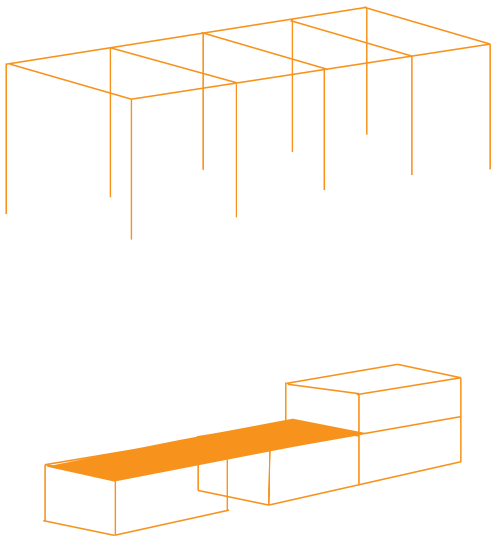
FINAL DESIGN CONCEPT

HORIZONTAL ORDER



Ill 3.7 Concept diagram: Horizontal order

VERTICAL ORDER



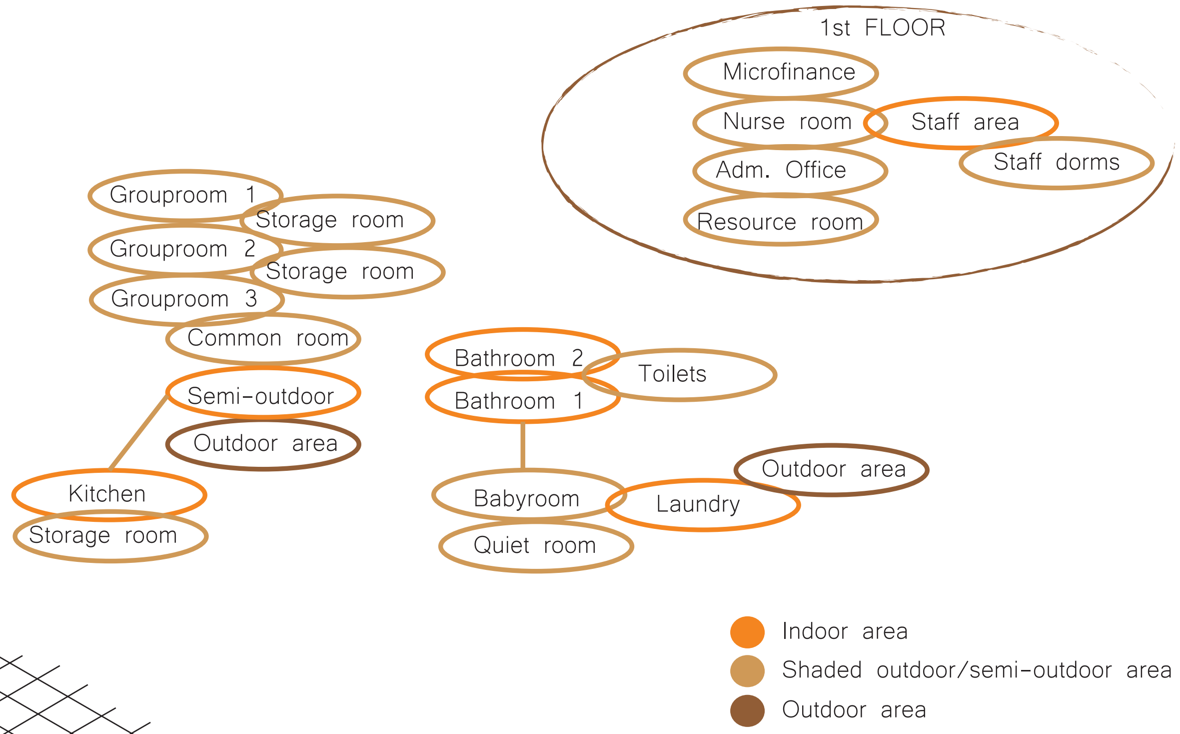
Ill 3.8 Concept diagram: Vertical order

The horizontal and the vertical order

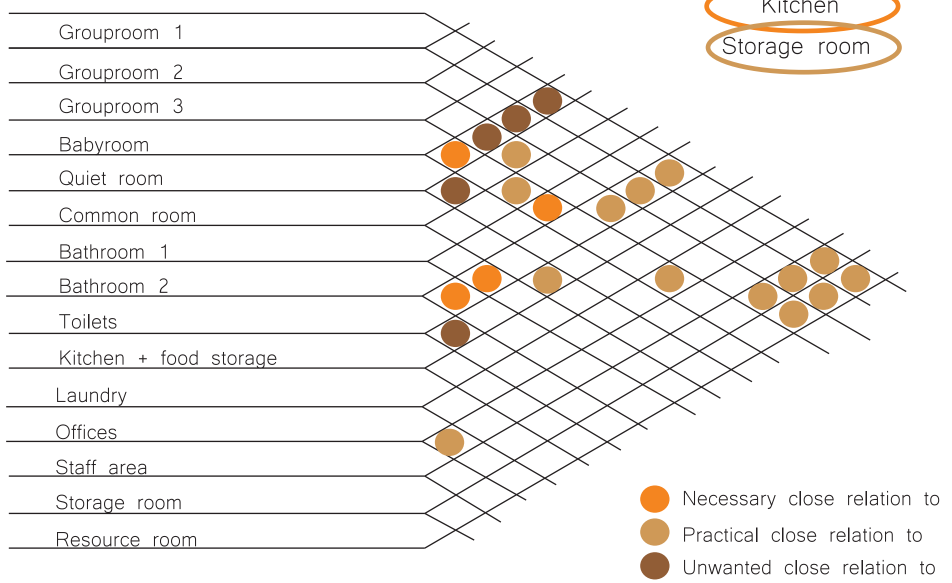
The horizontal ground slabs are a projection of the shape of the outer roof elements. Together these two elements represent the horizontal order.

The vertical columns follow a strict linear and geometric pattern which is reflected in the building volumes facades. Together these two elements represent the vertical order.

LAYOUT AND ORGANIZATION

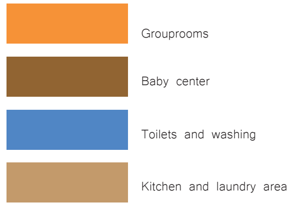


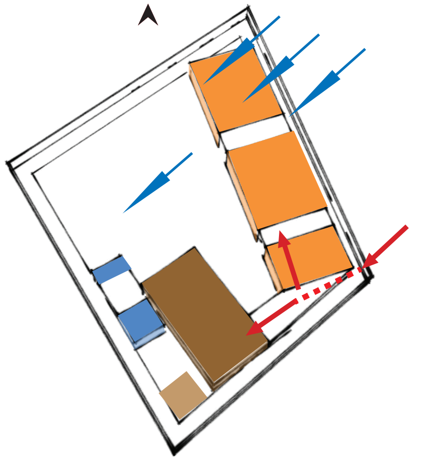
Ill 3.9 Function-diagram



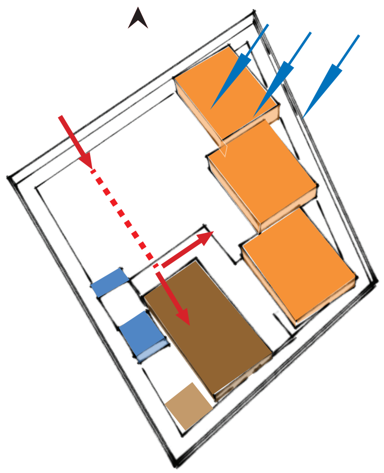
Ill 3.10 Function-relation-diagram

LAYOUT INVESTIGATIONS

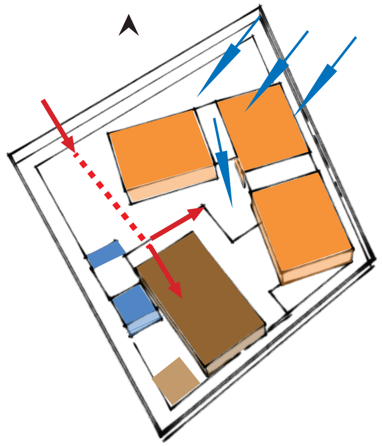




Ill. 3.11 Layout 1



Ill. 3.12 Layout 2

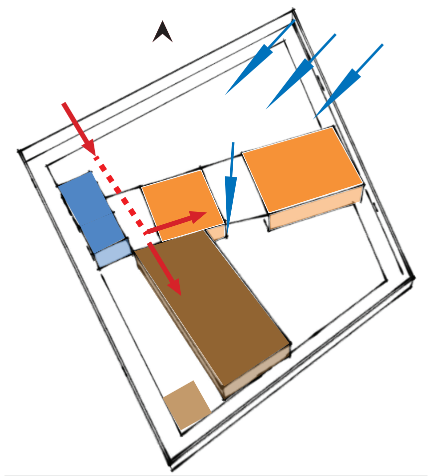


Ill. 3.13 Layout 3

+ Functions naturally divided, clear and readable layout
+ Suitable for existing situation
+ Grouprooms with possibility of expansion towards the outdoors
+ Coherent outdoor play-area
+ Possibilities to use wind capturers to guide wind along grouproom-wing
- Not optimized for direct access from market
- Entrance area may feel small and narrow
- Not optimal wind conditions for babycenter
- Minimal space for potential common area
- Not space for all grouprooms on ground level

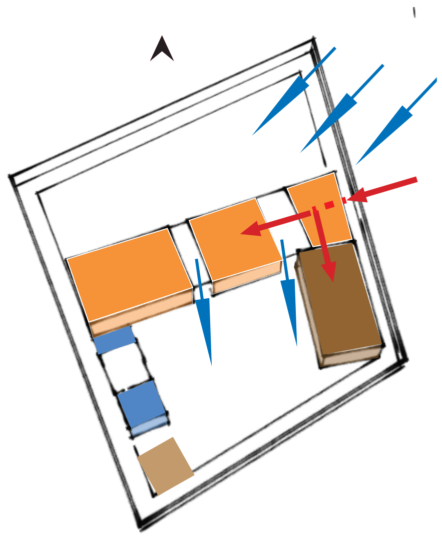
+ Possible to locate all grouprooms on ground level
+ Coherent outdoor play-area
+ Grouprooms with possibility of expansion towards the outdoors
+ Functions naturally divided, clear and readable layout
+ Suitable for existing situation
- No clear connection point from which main circulation derives from
- Not optimal layout to utilize prevailing wind for ventila-tion
-No space for potential common area

+ Not optimal wind conditions (possibility of creating windtunnels to guide wind through the complex)
+ Suitable for existing situation
+ Possible to locate all grouprooms on ground level
- Fragmented layout, non-coherent plan
- No clear connection point from which main circulation derives from
- Minimal open space left for play-area
+/- Common courtyard



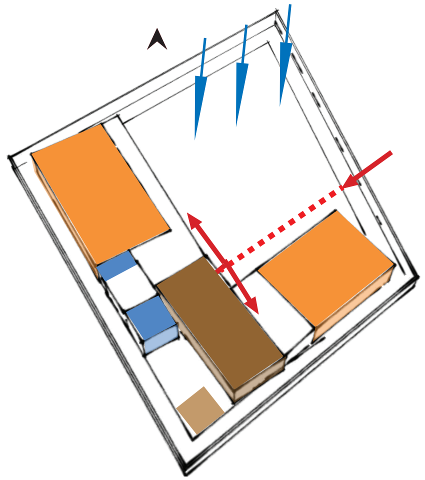
Ill. 3.14 Layout 4

+ Good ventilation conditions (windtunnel guides wind)
+ Optimized for direct access from market
+ Logical circulation flow with natural distribution from entrance
+ Two wings connected to a shared entrance area
+ Suitable for existing situation
+ Clear zoning of site
+ Relatively small footprint
- Not space for all grouprooms located on ground level
- Minimal space for potential common area
- Not space for all grouprooms located on ground level
+/- Two separate playareas with direct access between



Ill. 3.15 Layout 5

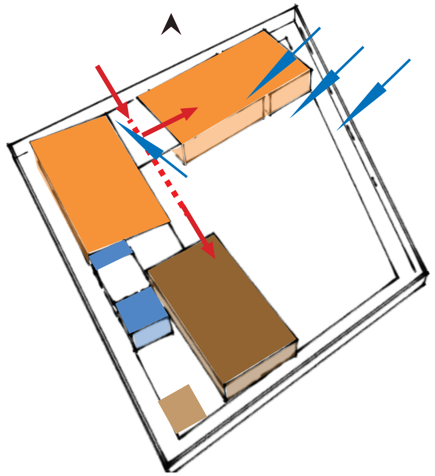
+ Good ventilation conditions (windtunnel guides wind)
+ Logical circulation flow with natural distribution from entrance
+ Two wings connected to a shared entrance area
+ Clear zoning of site
+ Good space for potential common area
+ Large and open play area
+ Clear and simple zoning
- Not optimized for direct access from market
- Not suitable for existing situation
- Not space for all grouprooms on ground level
+/- Two separate playareas with direct access between



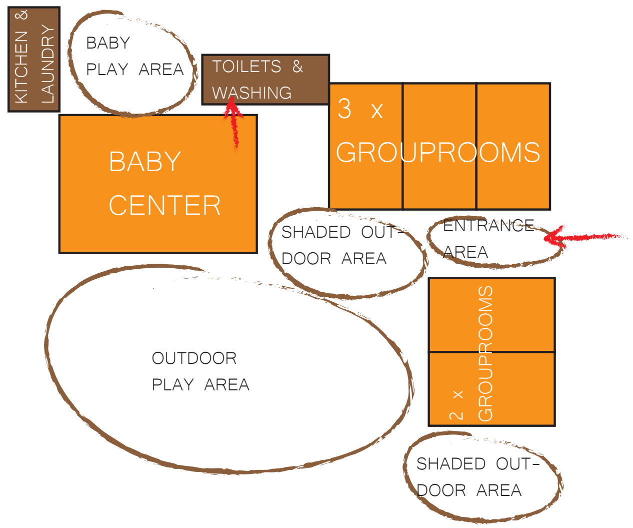
Ill. 3.16 Layout 6

+ Building layout opening up to capture the prevailing wind and enable good ventilation for all functions
+ Suitable for existing situation
+ Large and open play area
+ Clear and simple zoning
- Not optimized for direct access from market
- No clear connection point from which main circulation derives from
- Not space for all grouprooms on ground level
- Minimal space for potential common area

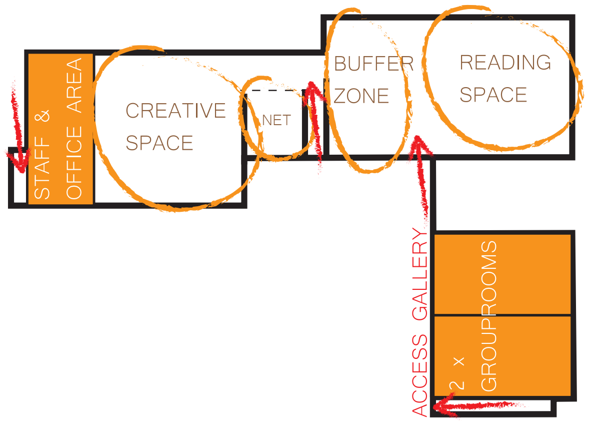
PLACING THE FUNCTIONS



Ill. 3.17 Final layout



Ill. 3.18 Placing the functions; ground floor



Ill. 3.19 Placing the functions; 1st floor

+ Suitable for existing situation
+ L-shaped layout following the wall of the site enables a large and coherent play area in the center
+ L-shaped layout creates a natural common gathering point in the corner (possibility for temporary shading by suspended canvas)
+ Clear and logical zoning (two main wings)
+ Reception area in direct relation to the main entrance
+ Enables cross ventilation for all main functions
- No clear connection point from which main circulation derives from
- Minimal space for potential common area

3.1 DETAILING

Ill. 3.20

GROUPROOM LAYOUT

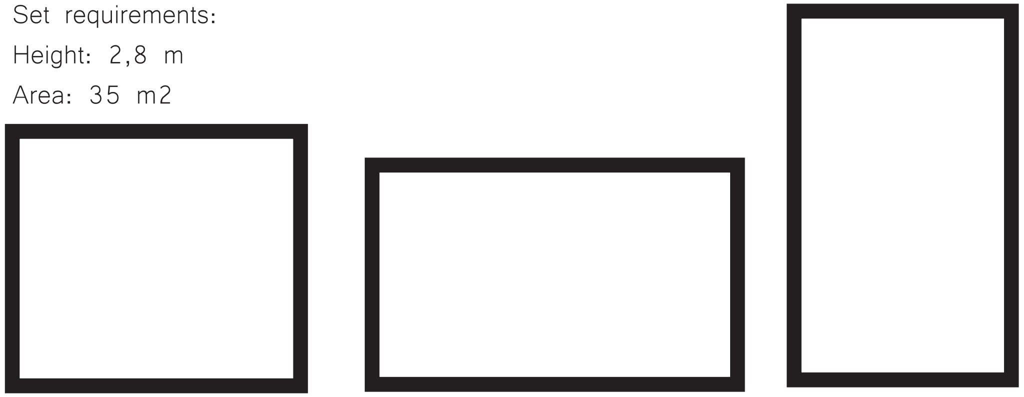
The children sit on the floor during classes, and they use the rooms actively for dancing, eating and sleeping. Introducing furniture like tables and benches would limit the flexibility of the space, and would create impractical situations when the furniture will have to be moved or stacked. The children are used to sit on the floor, and this solution have positive qualities as the children interact in another way than they would have done if seated on benches or chairs. The rooms needed storage for mattresses, bags, displaying objects used during classes and potentially for seating pads. This was solved by integrating a storage wall shared between the two grouprooms within one module.

The parameters we used for deciding the dimensions for the grouproom-modules were a minimum area per child of 1 m2 (EmiEA, 2012), good acoustic qualities, optimizing for cross ventilation and daylight factor.

The ideal dimensioning for cross ventilation: Room depth = max 5 x H (Heywood, 2012)

Dimensioning for daylight: Room depth = max. 2 X H (with light from only one side, but we have light from two opposite facades, meaning this can be doubled) (Heywood, 2012)

Set requirements:
Height: 2,8 m
Area: 35 m2

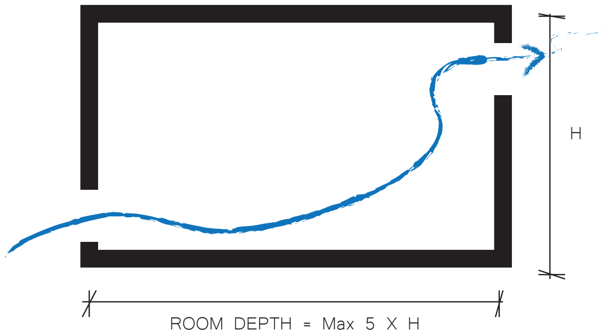


Plan
Depth: 5,9 m
Width: 5,9 m

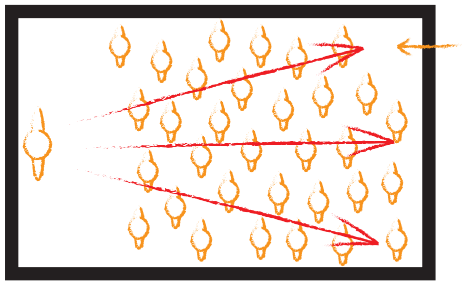
Plan
Depth: 4,5 m
Width: 7,8 m

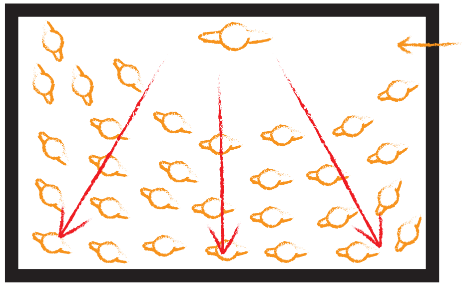
Plan
Depth: 7,8 m
Width: 4,5 m

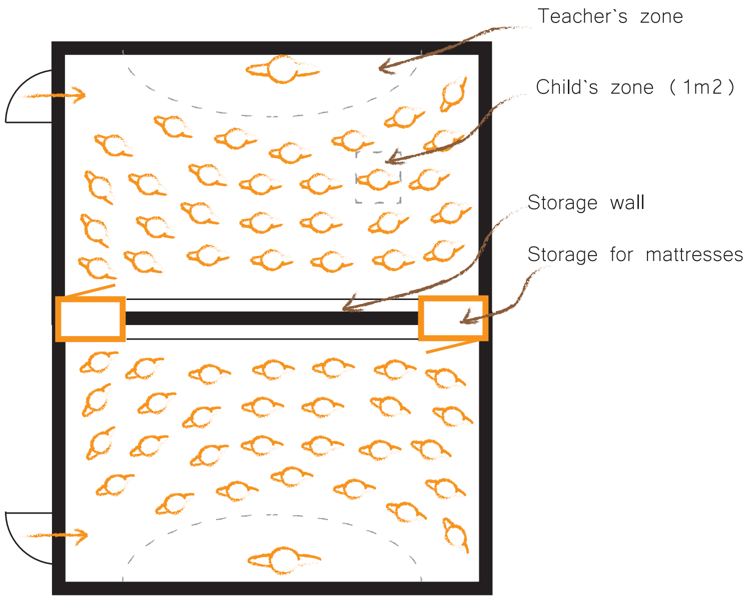
Ill. 3.21 Grouproom layout investigations



Ill. 3.22 Section of cross vetilation principle





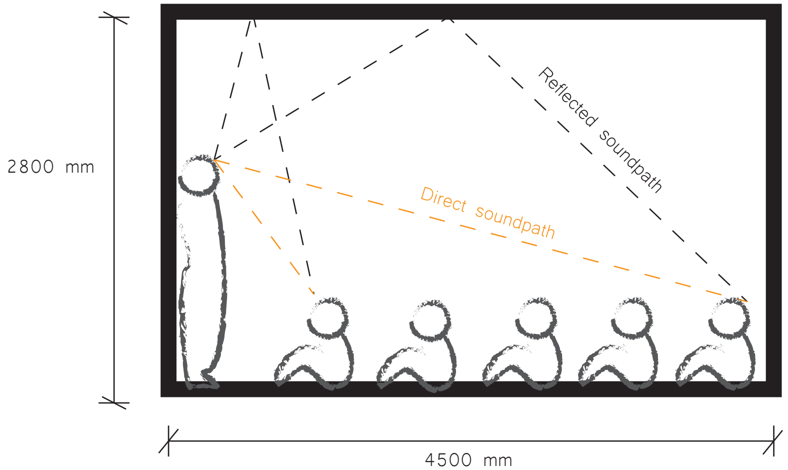


Ill. 3.23 Grouproom module layout

Acoustic

Since the project is an educational facility, the clarity of speech in the class rooms is important. This is why partition walls between the rooms are chosen to be of brick, since the material provides sufficient sound insulation. As the classrooms are located in building volumes physically separated from the metal roof, and with their own massive roof slabs and plastered ceiling, the sound issue will not be a problem. When deciding if the room's dimensions do not disturb the clarity of speech, an evaluation is made through a simple calculation. If the difference between the direct sound path and reflected sound path is less than 5 meters the clarity of speech is considered to be excellent (Kirkegaard, 2012). These paths are measured from the sound source to the listener(s). Difference between the direct and the reflected sound path is shown in illustration 3.25, and calculations in table 3.1. The calculation is made both for a pupil (listener) sitting closest to the teacher (sound source) and for a pupil sitting furthest away from the teacher.

The calculations show that the clarity of speech is excellent since the difference between reflected and direct sound path is less than 5 meters in both cases.



Ill. 3.24 Grouproom acoustics

	Direct sound path (D)	Reflected sound path (R)	R-D
Closest	1 m	1,4+2,2 = 3,6 m	3,6-1 = 2,6 m
Furthest	4,2 m	2,3+3,1 = 5,4 m	5,4-4,2 = 1,2 m

Ill. 3.1 Table: acoustic calculations

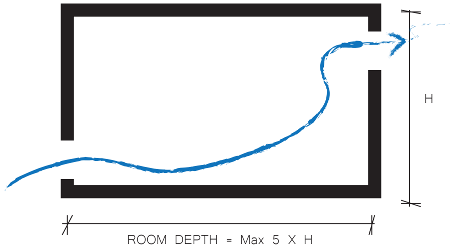
BABY-CENTER LAYOUT

The baby centre should cater for movement and relaxing for the smallest children. Therefore it is important to incorporate spaces and equipment for different levels of activity. A slightly diffuse zoning from active space to more calm (Ill. 3.25), relaxed and quiet spaces will help creating various and interesting spaces with free flow between them. This allows the child to choose its own activity according to what it wants to do. The only space that should be less accessible for them is a quiet room, where children will be sleeping.

These children do not have specific curriculum to focus on, since they are in a learning—by-doing phase of life. Thus, they are given various atmospheres, equipment and small challenges to explore that can help develop their basic life skills. It is also important to remember that these children are smaller in size and the elements should suit their scale.

The outer lines of the building partly originate from an existing house on the plot. As much as possible of this house is to be kept and the existing internal, non-structural walls are to be modified to be incorporated into the children's' play.

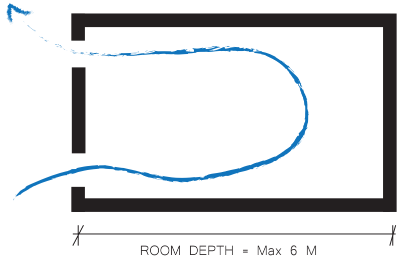
The baby centre's ventilation is based on the same principles as those of the classroom, except for the quiet room for sleeping. Since it is supposed to have minimal disturbance when children are sleeping it will be a closed, but windows and vents within the room allow for single sided ventilation.



Ill. 3.27 Section of cross ventilation principle

Ill. 3.25 Gradient level of activity in babycenter

Ill. 3.26 Different levels of the child`s activity



Ill. 3.27 Section of single sided vetilation principle

FACADES

PROPOSAL A

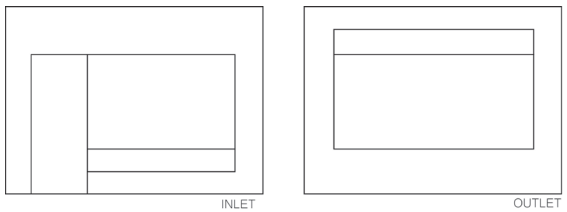
The first proposal that was considered were large windows to fully optimize the daylight conditions, and long narrow ventilation openings under the windows on the inlet side and over the windows on the outlet side. The large windows limited the flexibility in varying amount of ventilation and how much area of the window that can be opened. Architecturally, a more playful façade expression is wanted that could create more interesting daylight in the interior as well.

PROPOSAL B

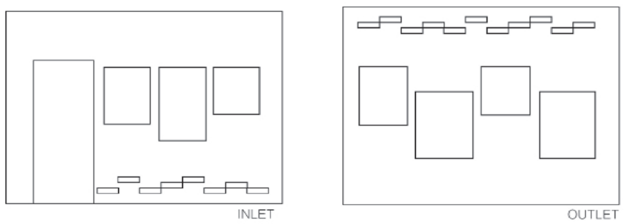
As a second solution a principle of removing a few bricks in an irregular pattern was considered. These openings would function as ventilation openings and were placed as a row at the bottom of the façade on the inlet side and at the top on the outlet side. Because of this principle, the facades were horizontally divided into 3 and the mid part was left for the windows. These were initially thought to be either squares or rectangles in same or different sizes that were shifted to create a playful, irregular pattern. As this would create two irregularities combined with the brick openings, the façade would aesthetically become too irregular and confusing. The windows were therefore adjusted to be of same size and following the same horizontal line. An irregular pattern of brick openings and a regular pattern of windows gave a more clean expression to the façade. However, in terms of ventilation and daylight this did not prove to be sufficient.

PROPOSAL C

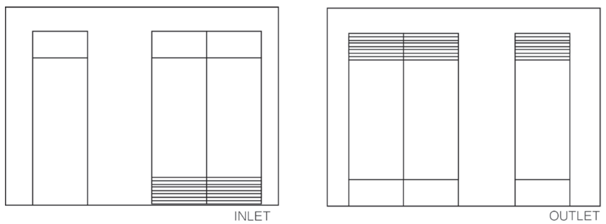
Finally, a concept of a modular system consisting of units of three different sizes; small units (vents and windows) measuring 1000x500 mm and large units (windows) measuring 1000x1800 mm and doors measuring 1000x2300 mm (including an incorporated vent above the door)is chosen. This system creates an aesthetical order in both horizontal and vertical direction. The walls are horizontally divided in 3; the bottom and top section consisting of small units only, while the middle section is reserved for the large unit, together creating long narrow vertical elements. Each vertical element consists of three units: one large and two small units (See illl. 3.30). These high and narrow window elements bring more daylight into the rooms. The vertical elements are placed either as single or double. This system represents high flexibility in terms of ventilation, as there are various combinations of windows and opening-sizes to control the ventilation and meet specific ventilation needs.



Ill. 3.28 Facade proposal A



Ill. 3.29 Facade proposal B

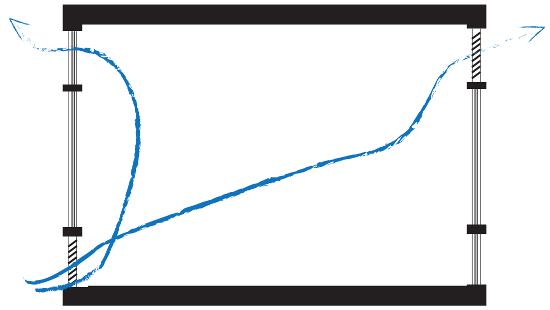


Ill. 3.30 Facade proposal C, Final

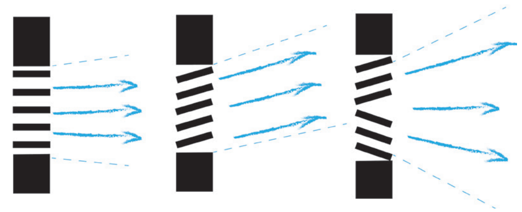
WINDOWS & OPENINGS

The modules are different on the inlet side and the outlet side of the building. To optimize for cross ventilation induced by both wind and thermal buoyancy, the vents are placed in the top section where the ventilation inlets are situated and on the bottom on the opposite side where the ventilation outlets are situated. There is also less inlet-area than outlet-area on the opposing facades to further enhance the potential of cross ventilation. The glazed windows are the main inlets of daylight, but the vents also filter some daylight into the classroom and create interesting light effects, depending on the sun`s angle. The frames, doors and lamellas of the vents are made of the same type of wood, creating a coherent expression.

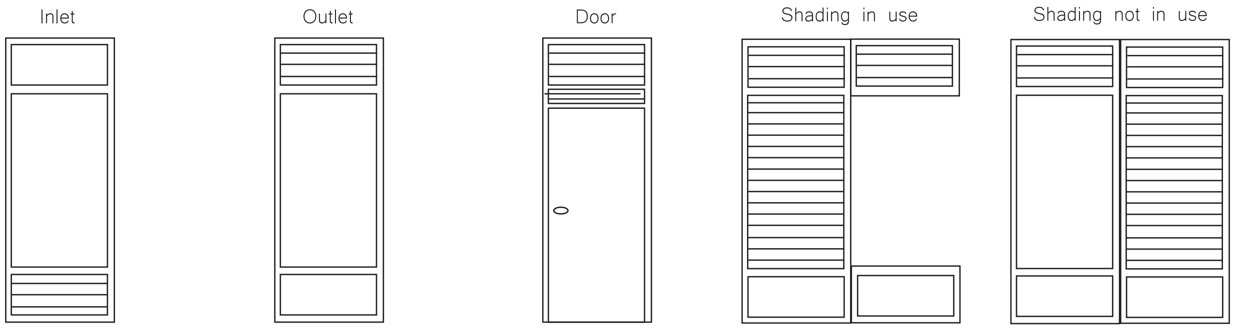
This principle is the same for all classrooms, but the baby space differs slightly. The windows of the baby space also include shutters, since they have more exposed surfaces towards east and west where the sun can reach and heat up the interior if not shaded. When the shutters are not in use, they can be pushed to the side, and here they give an illusion of an extra element being present with a vent above and window underneath (see ill. 3.31). On the west façade the windows are placed higher up in the façade to allow for kitchen furnishing and to create fewer disturbances from the baby centre’s outdoor play area to the sleeping children.



Ill. 3.32 Ventilation strategy



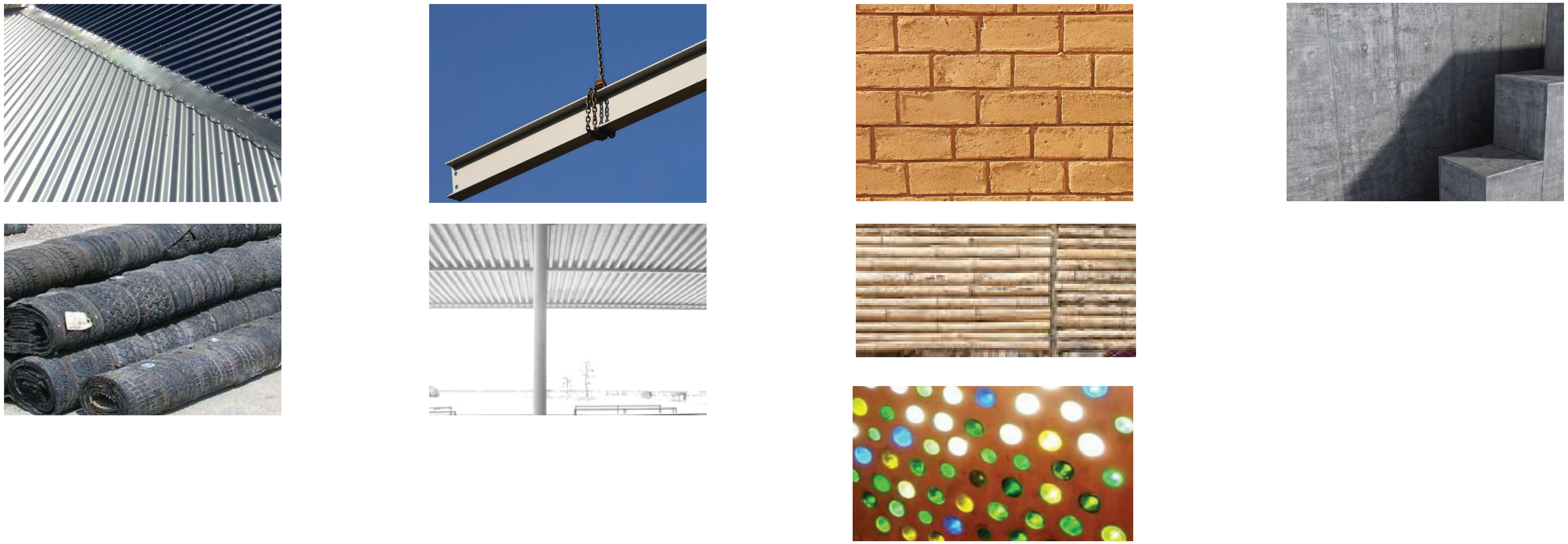
Ill. 3.33 Vent louvre positions

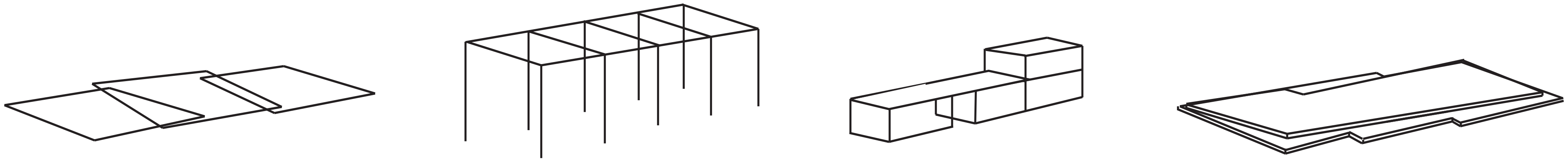


Ill. 3.31 Facade concept

In the staff section there are shorter windows towards south and ventilation openings on top on both north and south. This enables all the windows and openings to be shaded by the roof, since they are pulled in from the main facades. This different expression shows that these rooms have a different function than the rest - administrative.

MATERIALITY

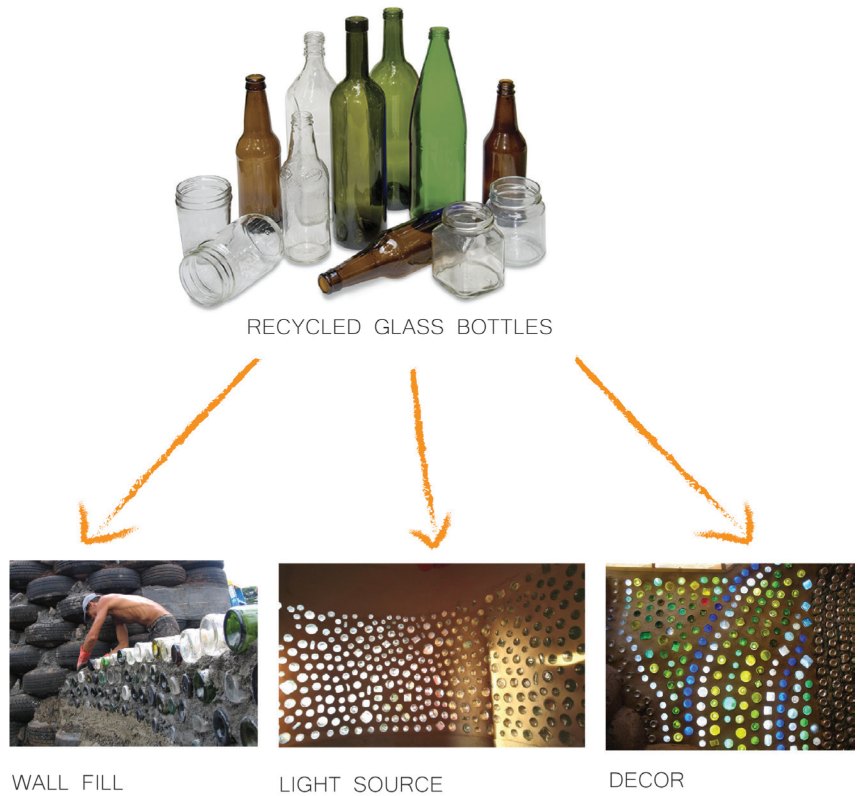




Ill. 3.34 Materiality diagram

RECYCLED MATERIALS

Ill. 3.35 Different use of Recycled car tires



Ill. 3.36 Different use of recycled glass bottles

FLOOR

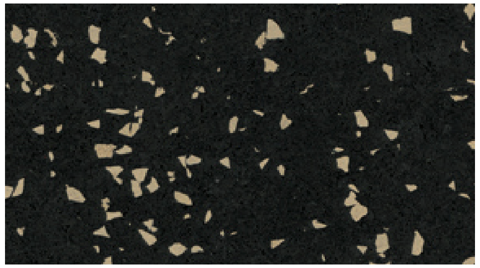
SENSORY QUALITIES OF FLOOR MATERIAL

Ill. 3.37 Sensory qualities of floor

TACTILITY

Ill. 3.38 Rubber floor

Ill. 3.39 Cork floor



Ill. 3.40 Recycled car tire tiles

Ill. 3.41 Wooden floor

Classrooms

The children use the floor for sitting, sleeping and eating, and a great importance is to be put on the deign decisions regarding the flooring. The floor is to be soft and comfortable to sit on and easy to clean and maintain. The floor should also have acoustical qualities.

Cork tiles were chosen for their soft and tactile qualities, as well as acoustical properties. It provides a comfortable surface for sitting which will feel warm, as opposed to the hard concrete surface of the existing M2S center. Cork is easy to clean and maintain, and is a durable material with sustainable qualities (made from bark from cork oak trees that is removed without harming the tree) (Greenbuild, 2012).

Baby center

The choice of material for flooring is of especially high importance in the babycenter as the infants` level of mobility is centered on floor level, and they spend the majority of their time playing directly on the floor. Therefore the flooring should offer a tactile experience and provide comfort and a safe play environment. The floor should also have acoustical qualities to reduce the noise level within the larger spaces. It was also important to choose a material that was easy to clean and maintain.

We chose recycled car tire tiles for the main areas in the babycenter because this material met all the above mentioned criteria and represents a sustainable solution. Cork tiles were chosen for the floor in quiet space. This room is used for sleeping and relaxing, and the cork floor provides a comfortable tactile experience and will feel warm.

Ill. 3.42 Design parameters for floor material

Recycled car tire tiles

- Reduce noise and vibrations
- Durable material
- Easy to clean and maintain (brooming and sponge cleaning)
- Offers a tactile experience, contrast from the hard concrete surface of the ground deck, the hard tiles and earth flooring the children are used to feel.
- Non-slip surface
- Fire resistant to burns left from small heat sources (matsmatsmats, 2014)
- Non toxic, will not release noxious fumes into the air in case of fire
- Soft material, safe for active play
- Comfortable to walk on barefoot, creates a warm surface (instead of cold hard concrete)
- Sustainable, made from recycled car tires
- Interlocking system allows for easy installation and easy removal if needed.
- Can be put on top of concrete surfaces
- Come in different shades and with hints of colours
- Can be available for as little as 2 $ per m2 (about 2014)

ARCHITECTURAL LIGHT

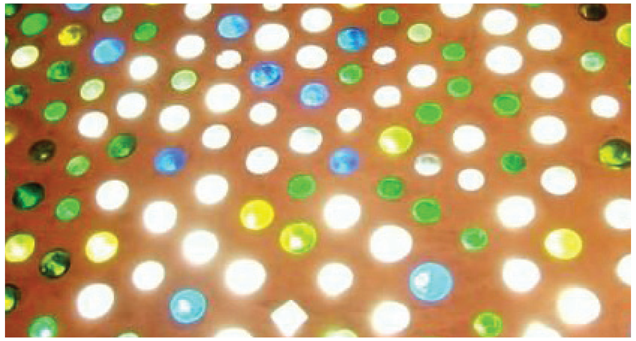
The vision of architectural light in this project is rethinking the potential of sunlight as an active and living part of the design. The principle is to utilize the sun`s different angles during the day to create flexible light-patterns and interesting spaces for the children, and hopefully inspiring the local community to do the same and create more stimulating homes and spaces for the children to grow up in.

By creating different atmospheres with light, this can help to teach the children about the sun`s qualities and properties, and make them more aware of how the surroundings and atmosphere affect us.

We wanted to create the architectural light in a way that corresponded with our concept of sustainable low-tech architecture. The architectural light should emphasize the aesthetical qualities of low-tech sustainable architecture, and vice versa. Only local natural materials are being used to create different types of stimulating interior light, which makes is easy for the local community to adapt the ideas. Recycled glass-bottles embedded into the earth walls create an amazing light effect when the sun hits the wall (see ill.3.45), and represents a sustainable design solution which creates high-quality spaces with very little effort and investments. Natural materials like breaded wood and permeable bamboo-matts allow for both wind and sunlight to penetrate into the interior. The roof can be perforated with holes in different sizes, These holes can be made by integrating recycled local clay-pots missing their bottom part and will create spots of light on the ground and on the interior walls, depending on the sun`s position in the sky (see Ill. 3.44).

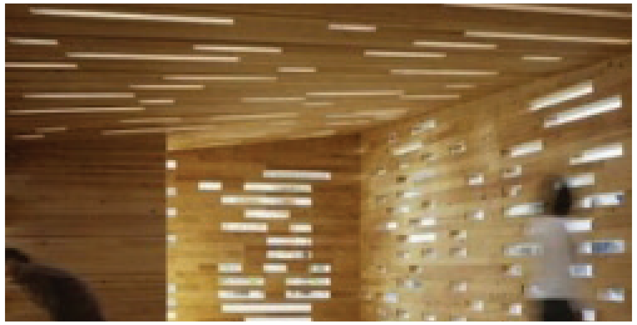
Ill. 3.43 Lightplay by Yayoi Kusama

Ill. 3.44 Lightplay in Gando Public library

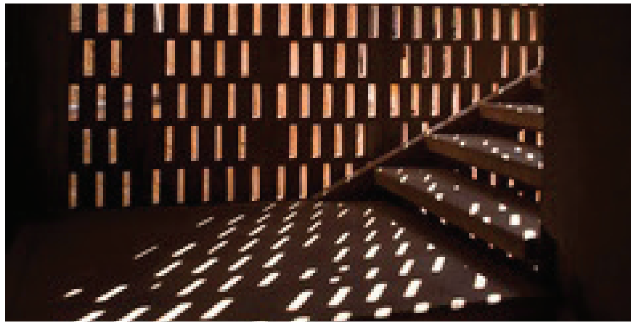


Ill. 3.45 Wall with recycled glass bottles

Ill. 3.46 Lightplay in Giavonile centre in Niafourang



Ill. 3.47



Ill. 3.48

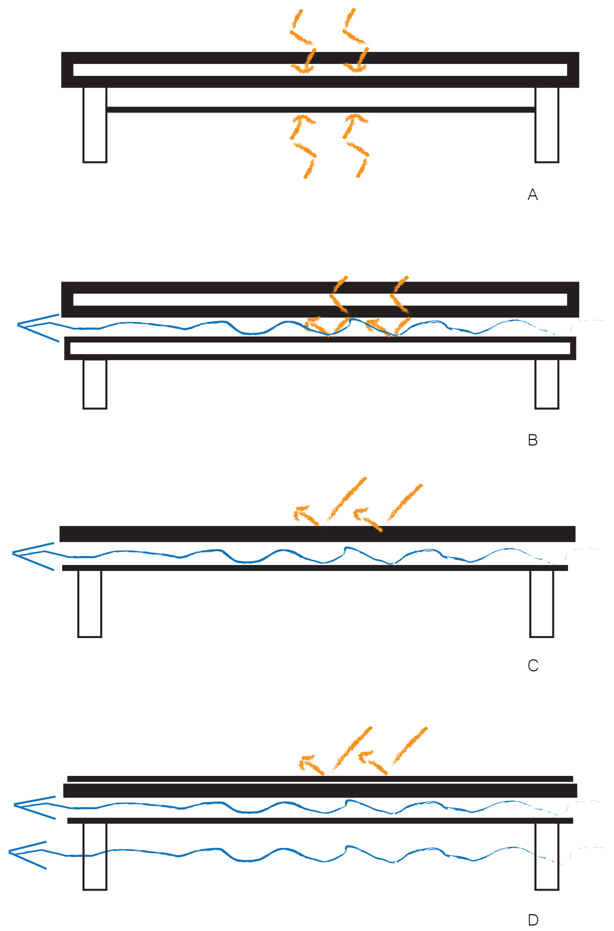
DETAILING THE OUTER ROOF

With a single-layer roof construction, the heat conductance is high and materials should be lightweight with low thermal capacity and high reflectivity (Ill. 3.49 A) Reflectivity can be increased by using metals and light colored surfaces and/or annually painting the roof with whitewash which is affordable. A single-layer lightweight roof construction will generally not satisfy comfort requirements (Fry & Drew, 1982). If a massive single layer roof construction is used, any insulation should be placed above the thermal mass to prevent exposure to the sun and excessive heat storage. Single-layer roof constructions with heat insulation prevents cooling at night and this is not a desired effect for this project, as night cooling is beneficial.

Another solution that was considered was a double-layer construction where the inner layer is insulated with a reflective upper surface (Ill. 3.49 B) This double-layer roof principle has to be combined with a technique for letting the built-up heat ventilate out through an air gap of adequate size. Insulated roofs will prevent heat from entering the interior but will also prevent heat from escaping at night (Gut and Ackerknecht, 1993).

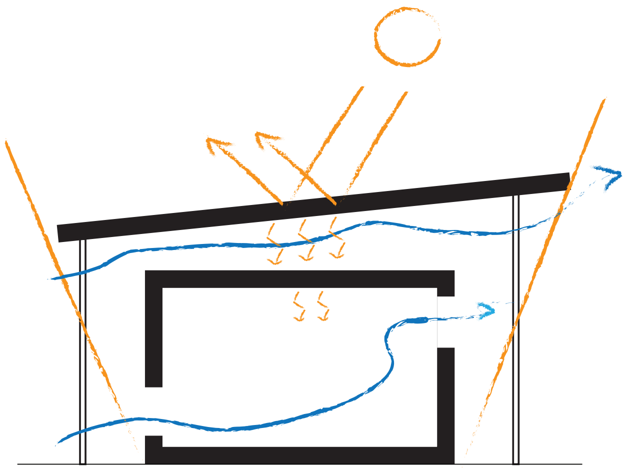
A double-layer roof with a high reflective outer surface and proper ventilation (ill. 3.49 C) would, on the other hand, be more suitable for meeting comfort requirements in warm and humid climates (Fry and Drew, 1982). A construction like this will need proper ventilation between the layers, so that the accumulated hot air does not reach the interior below. The solution reduces the heat load during the day and allows the roof to cool down quickly in the night to utilize the cold night temperature.

This double-roof construction was developed further into a separate double roof construction working as an umbrella providing shade from direct solar radiation for the freestanding building volumes underneath (Ill. 3.49 D). This outer roof will be constructed as a lightweight construction with a highly reflective surface to provide shade and lower the temperatures before it reaches the roof of the building volumes below (see Ill. 3.50). To improve the thermal performance, an insulating material can be added under the reflective surface material. To be able to use the rooftop spaces on top of the building volumes as part of the childrens` play area, the roof will have to be made out of a massive material, like concrete. Concrete will function as thermal mass that will increase the time lag and minimize the temperature fluctuation during the day, due to thermal capacity (Cleveland, 1999). Constructing the outer lightweight roof out of the lightest materials will practically lead to having no reservoir of heat; when the sun sets, it does not take much time before the structure has the same temperature as the night air temperature.

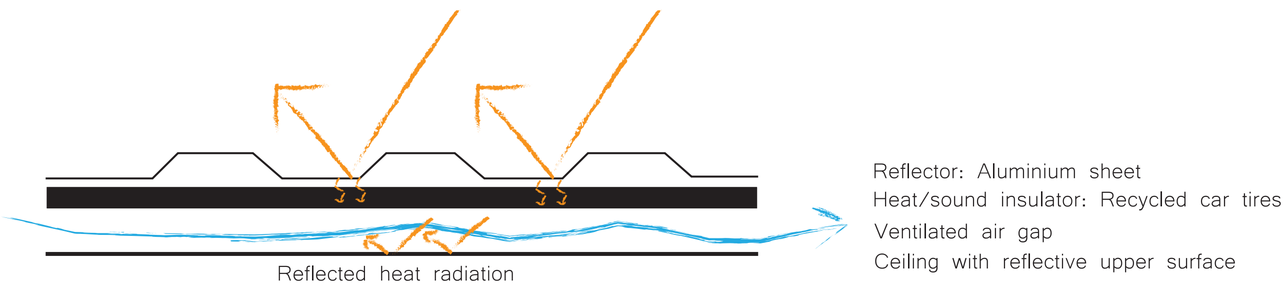


Ill. 3.49 Investigation of different roof composites

The light weight roof construction of the double roof-strategy was developed further to find a way to make if perform better against heat gains. The outer roof was constructed as a sandwich element with two sheets of aluminium, split recycled car tires in between, and a ventilated air gap to allow acculumated heat to be ventilated out (Ill. 3.51). The recycled car tires will work as heat insulation and sound proof from heavy rainfalls. Heat transfer between the two layers happens through radiation and can be prevented by using a reflective surface on the inner layer's outer side. The external layer exposed to the sun should be reflective and have light color to absorb minimal radiation. The insulating material should have a U-value of about 1,5 W/m^2 in order to ensure that the surface facing the rooftop spaces does not exceed the air temperature by more than 4°C (Gut and Ackerknecht, 1993).



Ill. 3.50 Section of double roof principle



Ill. 3.51 Outer roof composite

COLUMNS

Freestanding vs. Integrated

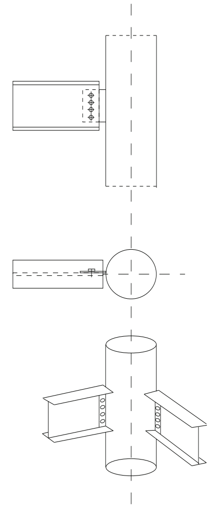
During the design process both free-standing columns and columns integrated into the building were considered (Ill. 3.52). The integrated solution was thought as a means of a two-way supporting collaboration, a symbiosis between the columns and the buildings' walls. While the columns would provide structural support for the walls, the walls could help stabilize the roof structure in consideration to wind. To define the concept of the protecting and the protected element – the independent roof and the sheltered volumes, these two elements must be visually separated. For this purpose the free-standing columns would give a stronger statement of the concept.

Section

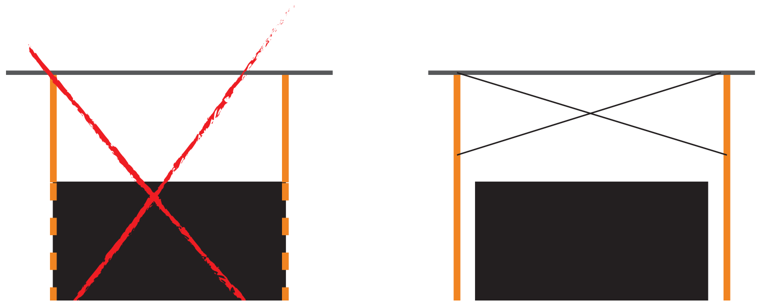
A number of sections were considered for the columns (Ill 3.53). The circular section would create a contrast to the straight lines found elsewhere in the concept and it would further indicate that the roof structure was something separate and independent.

Detail

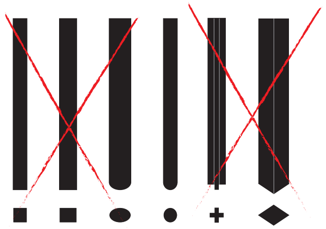
Different solutions for the detail in the connection between the horizontal and vertical order was discussed, all representing different stories (Ill. 3.54). The story we wanted to tell through the detail was the one of the metal construction being visually separated from the building complex. The first alternative is not strong enough as it makes the structure anonymous and makes the roof seem heavier than it is. The second alternative would articulate the roof structure as a separate element, but it would also enhance the column as part of the complex and not the roof. The third and fourth suggestions also indicate that the roof is light, but they also give a sense of which way the connection is focused. With the detail on the top of the column it would create a more anchoring effect in the connection to the ground slab, indicating that the columns belong more to the slab than the roof. When the detail is placed on the bottom of the column, the roof structure is lifted from the ground slab as a separate element. In this detail the column becomes more a part of the roof structure and the roof gives a feeling of "having landed on the slab".



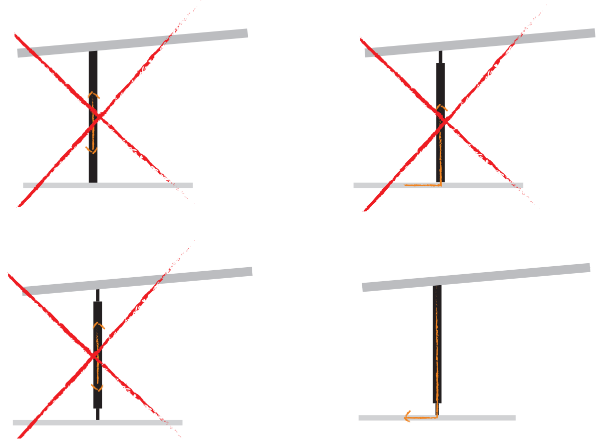
I-beam
Steel column d= 200 mm



Ill. 3.52 Placement of columns



Ill. 3.53 Studying different column sections



Ill. 3.54 Connection between column and slab/roof and between column and beams

SUN STUDIES & SHADING DESIGN

In order to best design the building and shading devices, the sun`s path has to be studied and the times of day with direct solar radiation on the different facades have to be documented. The sun studies (including surrounding buildings) are conducted in Archicad`s Ecodesigner, and is documented in December (the month with the lowest sun angles, representing a "worst case scenario").

The site`s Sun path

Sun rises 23, 5 Degrees north of east in the summer solstice, and sets 23, 5 degrees north of west. Sun rises 23, 5 Degrees south of east in the winter solstice, and sets 23, 5 degrees south of west (Gaisma, n.d.)

Shading techniques

Large overhanging roof construction: The outer roof construction is oversized with the purpose of providing shade for the building volumes and spaces underneath. The high reflective outer surface will reflect a large portion of the direct solar radiation, and reduce the solar heat gains.

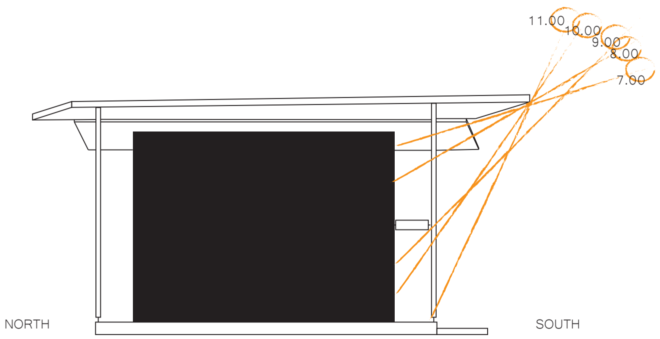
Overhangs from integrated building design: Built in overhangs integrated in the building design will increase the hours the façade is shaded, and provide shading for the lower sun angles which escpaes the outer roof`s overhang.

By placing the access gallery to the 1st floor classrooms on the South facing façade instead of the North, the gallery will work as solar shading where this is needed the most.

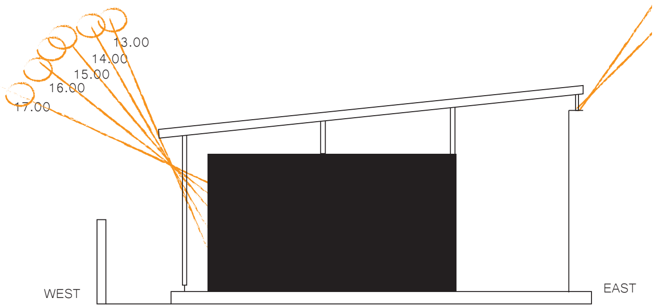
Vegetation: A vegetation belt of decidous trees in front of the east-façade will reduce the direct solar radiation in the morning hours, while still allowing for ventilation.

Movable window shutters: window shading panels installed on the east and west-facing facades will help to further reduce the direct solar radiation from the low sun angles in the morning and evening. These panels are movable, meaning that they can provide shade in the hours of shading-demand, and moved into a passive state when the façade is shaded by other means. The panels are designed to be a part of the façade`s window layout, and will look as part of the design both in passive and in-use situation.

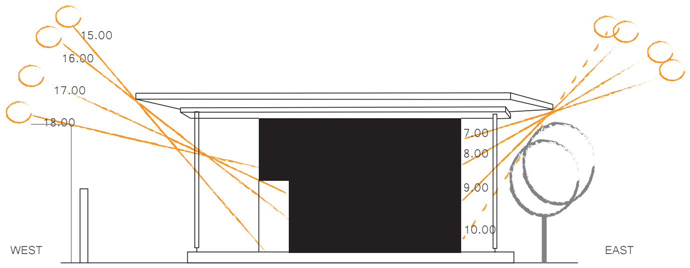
Time lag: The earthwall composite investigated in the analysis chapter has a time lag of 8 hours, meaning that after the outer surface of the façade reaches its peak in temperature, it will take 8 hours for the heat to reach the interior.



Ill. 3.55 Solar studies classroom facing South



Ill. 3.56 Solar studies classroom facing East



Ill. 3.57 Solar studies babycenter

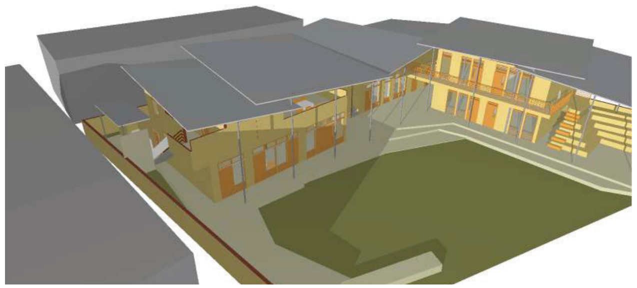
South facade

The South facing facade is exposed to the low morning sun from sunrise to around noon (in the winter season). The classrooms are used during the morning hours and need good daylight conditions, meaning that shading window panels that reduce the daylight factor are not an option. The access gallery connected to the 1st floor works as solar shading for the rooms on ground floor, while the large outer light-weight roof shades the rooms on 1st floor.

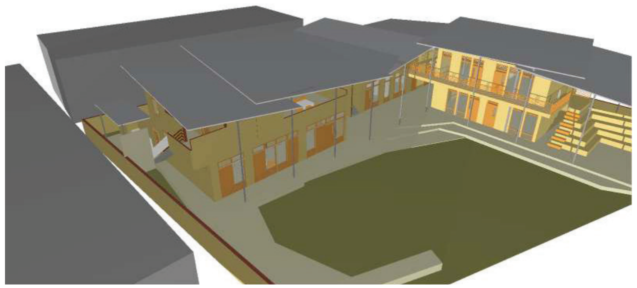
East facade

The east façade for the classrooms are all fully shaded by the outer light-weight roof construction. The east façade for the babycenter is exposed to the low morning sun from 09.00 to around 11.00. Sun shading is provided by movable window-shutters that cover the largest windows during the hours of direct solar radiation, while daylight is still provided from the highest window band. A band of dedicous trees planted in front of the façade help to further reduce the direct solar radiation in these hours. The lightweight roof construction shades the whole façade for the rest of the day.

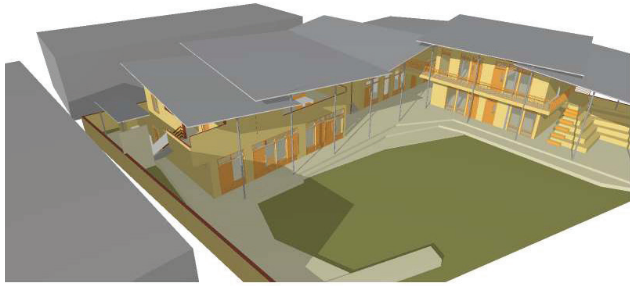
SUN STUDIES SOUTH-EAST FACADES



06.45 - 08.00



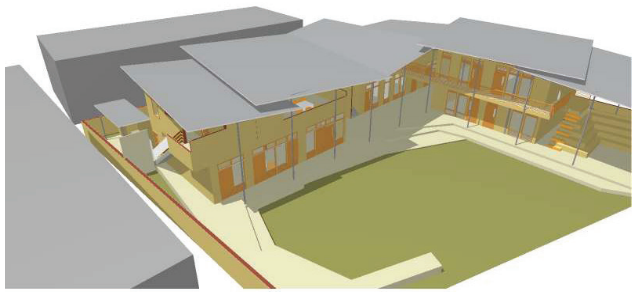
08.00 - 09.00



09.00 - 10.00

10.00 - 11.00

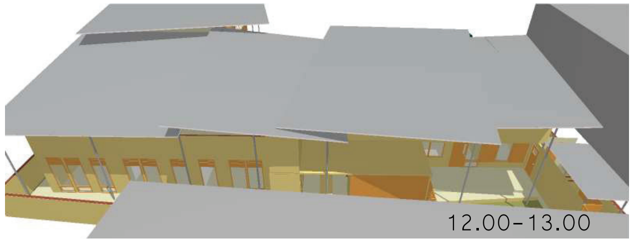
11.00 - 12.00



12.00 - 13.00

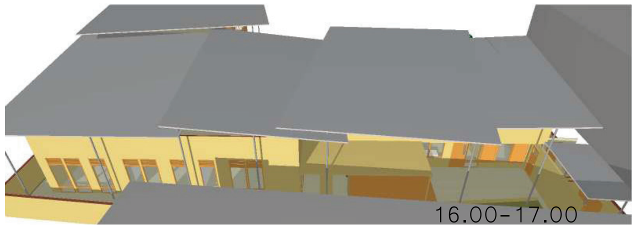
Ill. 3.58 Solar studies from south-east

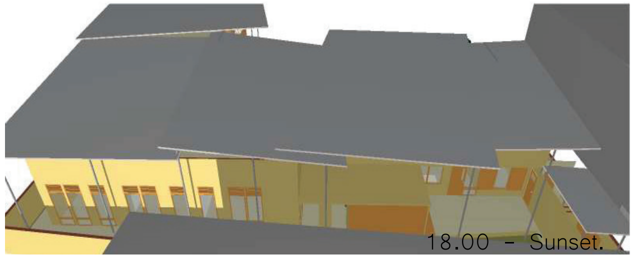
SUN STUDIES WEST FACADES



West facade

The west-facing facade of the classrooms is mainly exposed to direct sun after 13.00, and will need additional shading in form of external roll-down shading louvres integrated into the window elements, The west-facing façade of the babycenter is in need of shading in the late evening hours, from 15.00 to sunset, since the staff may use this area for sleeping. Shading is provided by withdrawing this part of the façade a distance from the façade of the 1st floor, creating an overhang for the façade on ground floor. The façade is not able to reach its peak temperature during the hours of direct solar radiation, and the time lag will keep the indoor temperature even during the night. Any excessive heat gains can be ventilated out. Total shading for the lowest sun angles right before sunset is provided from the building on the adjacent plot.





Ill. 3.59 Solar studies from west

North façade

The North facing façade is not exposed to direct sun during service hours (08.00-16.00), and only gets direct solar radiation in late evening (from 16.00 to sunset). The large overhang roof provides enough shading during the service-hours, and the façade will only have direct solar gain in the late evening hours. Even in situations where the center is used after service hours, there will be no problem with overheating, and there is no need for additional shading means.

Outdoor areas on 1st floor

The outdoor areas on 1st floor are shaded from the sun due to the large light-weight roof construction and heat gains are reduced by the high reflective outer surface. Any accumulated heat is allowed to be ventilated out due to continuous natural cross ventilation.

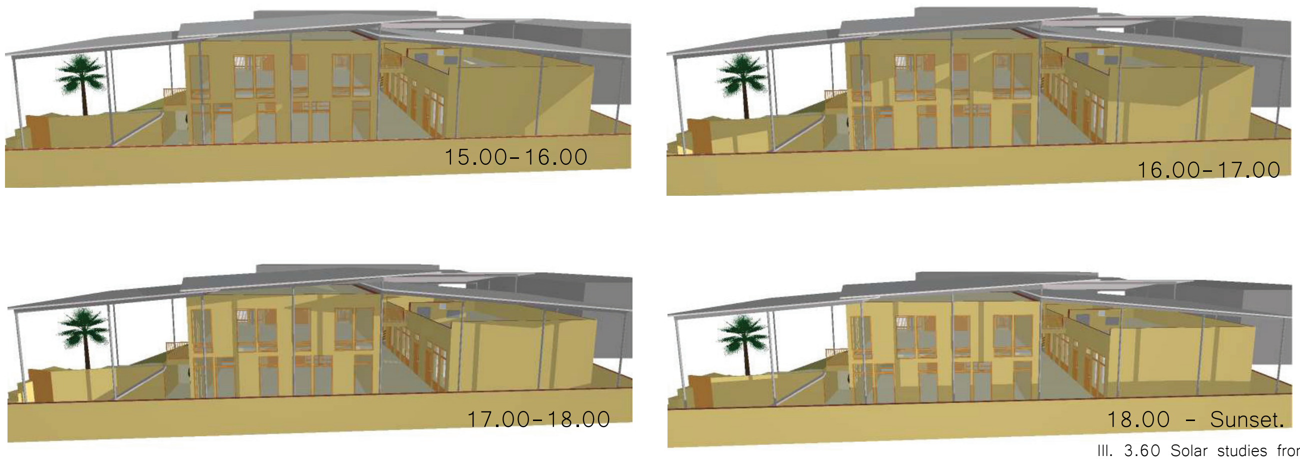
Staff- and office area

The office area on the 1.st floor only have windows towards south and north to eliminate heat gains from the low sun angles from east and west. The north facades is fully shaded by the light-weight roof construction, and the south facade is pulled back from the man facade, reducing the hours of direct solar radiation to a minimum.

Amphi-theatre

The outdoor amfi-theatre is most likely to be used during the hours from noon to late evening, and total shade during these hours are provided by the light-weight roof construction.

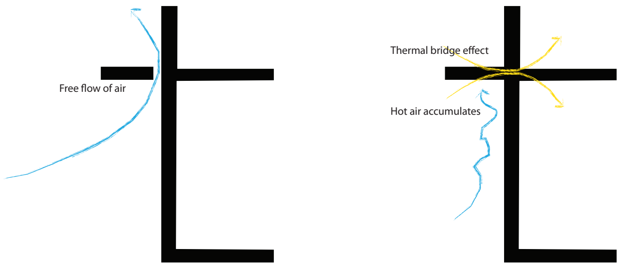
SUN STUDIES NORTH FACADES



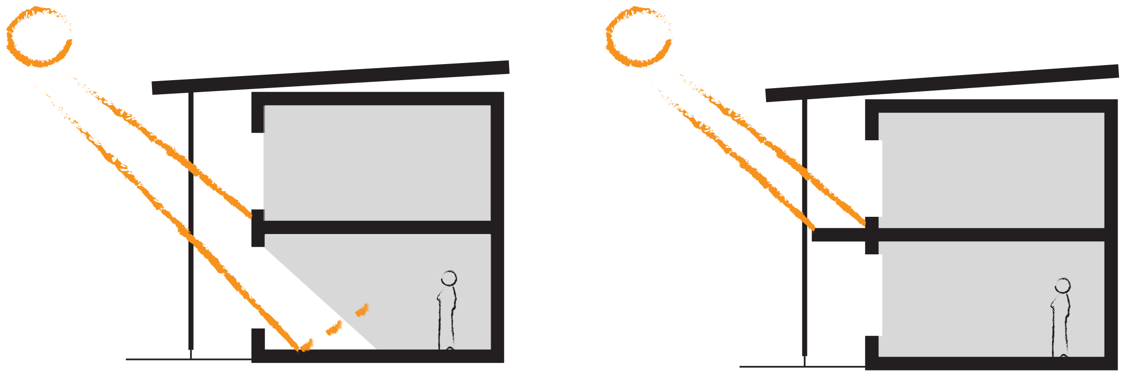
Ill. 3.60 Solar studies from north

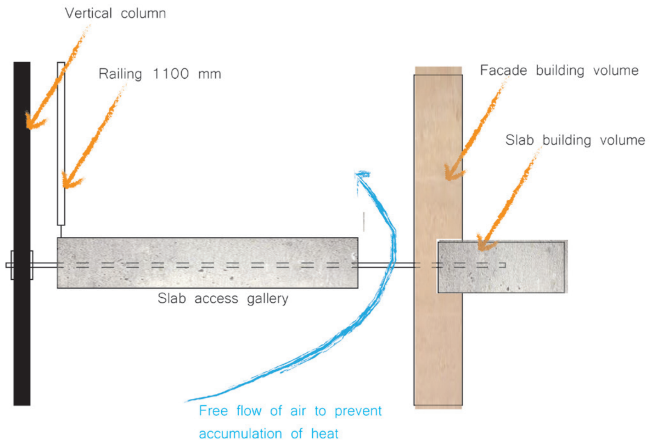
ACCESS GALLERY

The access galleries to the grouprooms on the 1st floor were first thought to be located on the north façade to minimize the distance one had to walk from the stairs to the grouprooms. Also, we wanted to gain as high daylight factor as possible with minimal glazed area on the south façade. An access gallery on the south façade would mean a large overhang shading for the windows below and reducing the daylight. But on the other hand, the solar studies showed that the south façade received a high amount of the low angle sun radiation from the east, and that there was need for additional shading devices. To reduce the need for add-on equipment, the possibility of the access gallery to function both as mean for access and for solar shading was considered. Locating the access gallery on the south façade also created a more logical and natural communication flow through the 1st floor spaces. The same wood-material and expression that is used for the railing is also found in the wall-dividing elements in the 1st floor rooftop spaces, which helps to tie the access gallery together with the rest of the space, and also creates a lighter expression and states a visual division of the 2 storey-façade. The access gallery is visually separated from the south façade of the building, strengthening the expression of the gallery being of a lighter order. It seems to be floating in the air between the columns and the building, and is supported by out-of-sight horizontal steel bars expanding from the intermediate slab and finally grabbing onto the columns (ill.3.62).



Ill. 3.61: Section of principle of separating the gallery slab from main structure


Ill. 3.60 Solar studies without and with access gallery



Ill. 3.62: Access gallery slab section

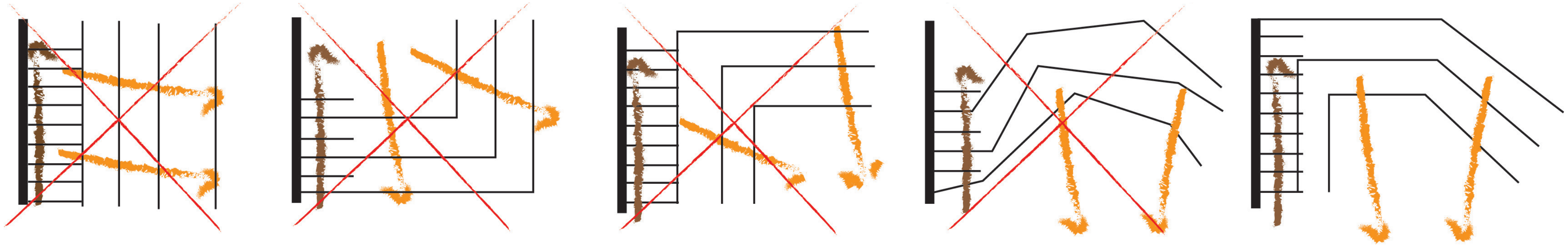
SLAB AND ELEVATIONS

Ill. 3.63: Ways to utilize space under staircases

Stairs and various elevations in the ground deck make the space more exciting for the children, as opposed to a flat area. Different types of stair invite to different use (ill. 3.64); steep stairs indicate access ways, while shorter and deeper steps facilitates for seating, and invites one to be setated and linger longer.

The amphitheathre is designed to function as a part ofthe outdoor play area, and to be used for social gatherings and shows put up by the children. The steps are angled to create a focus point towards the open area of the playground, that will function as an extension of the stage (ill. 3.65). The part closest to the classrooms has a perpendicular angle to connect to the "strict order" of the building and will provide stairs to the first floor.

Ill. 3.64: Different types of stairs and their use



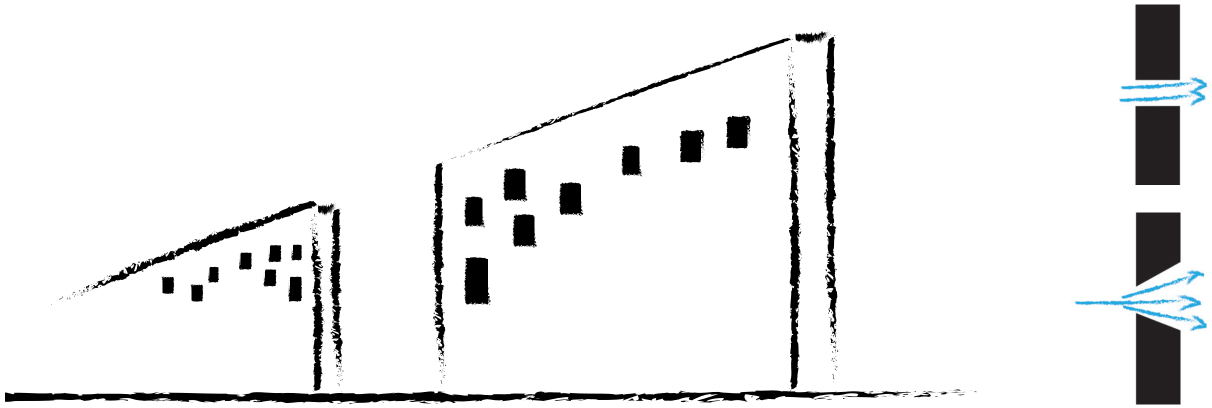
Ill. 3.65: Amphi-theatre layout investigations

BOUNDARY WALL

Due to protection from intruders and to keep the children from wandering outside of the Miles2Smiles' area a boundary wall is to surround the plot. This is a common custom in Uganda. In order to reduce the obstruction effect it might create for the wind, a solution of perforating this wall where the holes might be formed to accelerate wind velocity might be beneficial (ill. 3.67). The holes should be of adequate size and placed in a certain height from ground level, so they do not act as scaffolding to climb and jump over the wall. The perforation pattern becomes denser towards the main entrance as a guiding pattern.

Another common custom in Uganda is to paint these walls with educational motifs such as alphabet and numbers and to enliven them with figures and paintings suited for children. This custom is also embedded in the design of the New Miles2Smiles centre. To enliven the wall even more, it becomes an element integrated in the child's play. By the main playground it becomes a climbing wall. The grip elements are placed at heights that allow the children to climb, but still not reach the top of the wall. Behind the amphitheater, a play of light and shadow is induced by the screen wall at the amphitheater and sun light. Through these elements (ill. 3.66) the wall becomes integrated in the whole design of the center and is not left out as a protecting object that stands alone.

Ill. 3.66: The wall`s different properties and qualities



Ill. 3.67: Proprties of holes in the wall

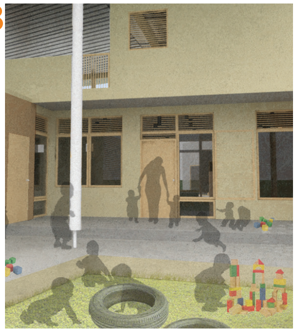
04 PRESENTATION

Ill. 4.1

1

2

3



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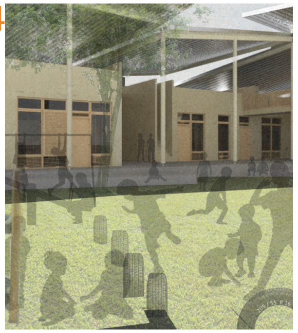

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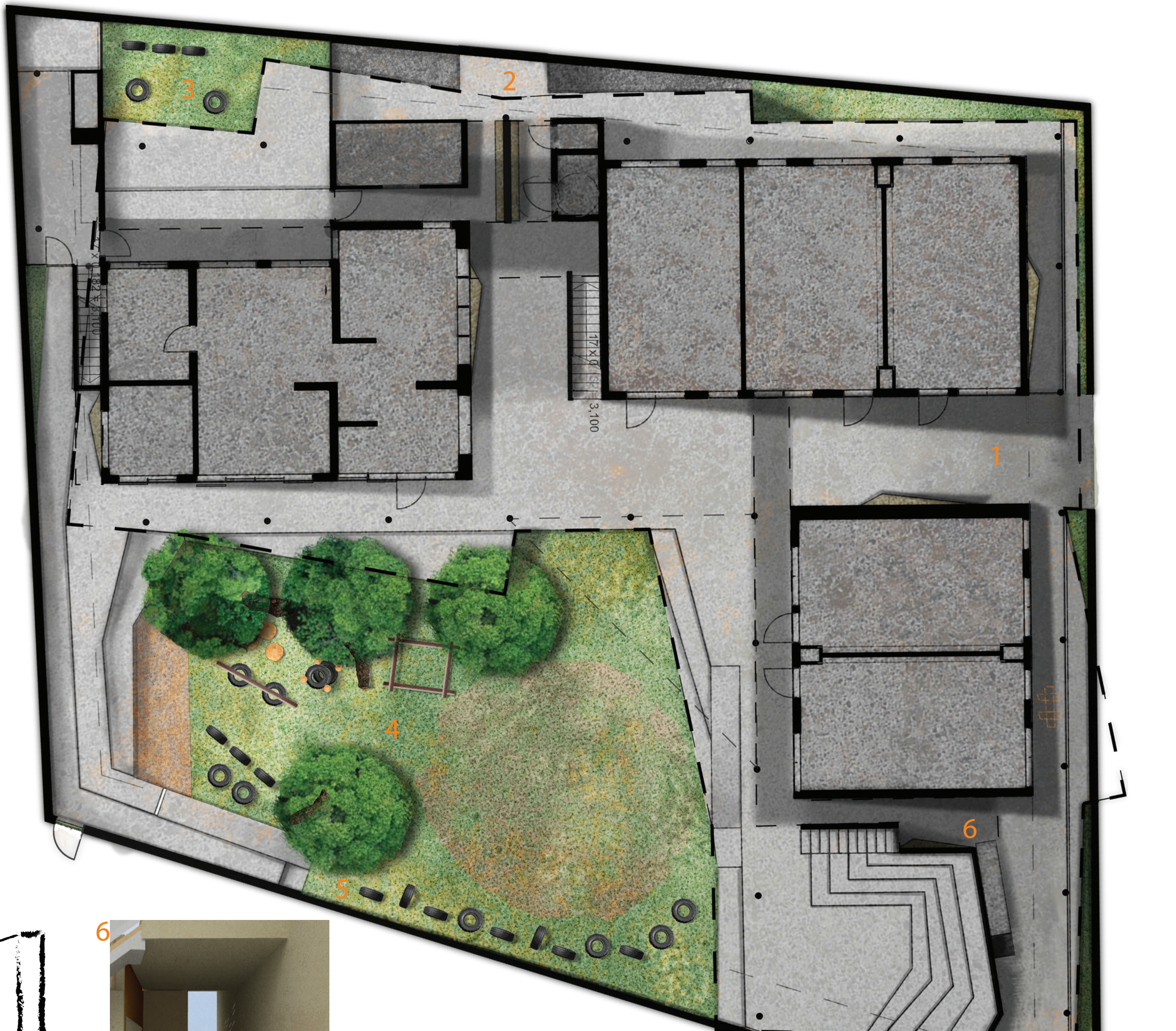
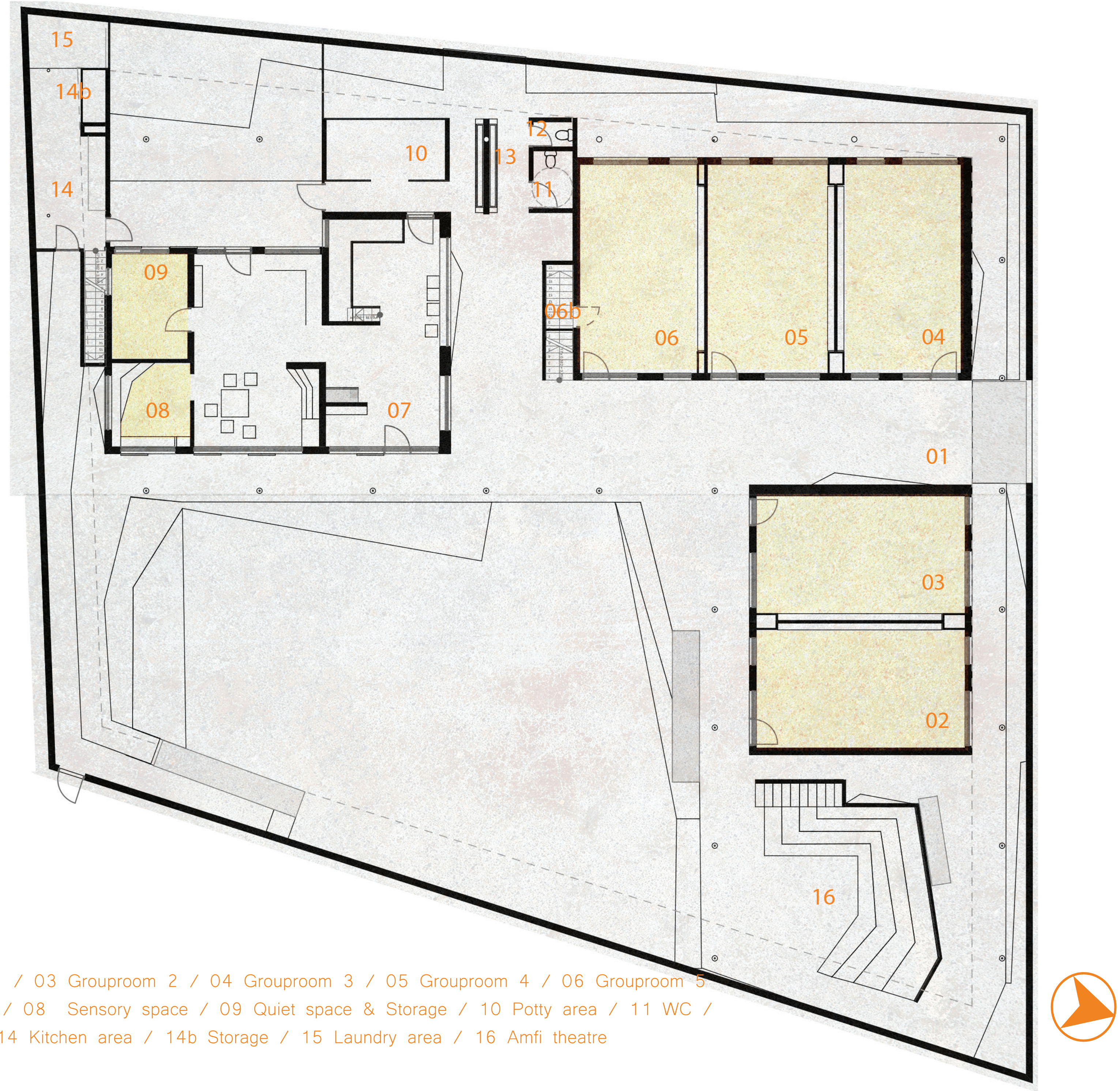


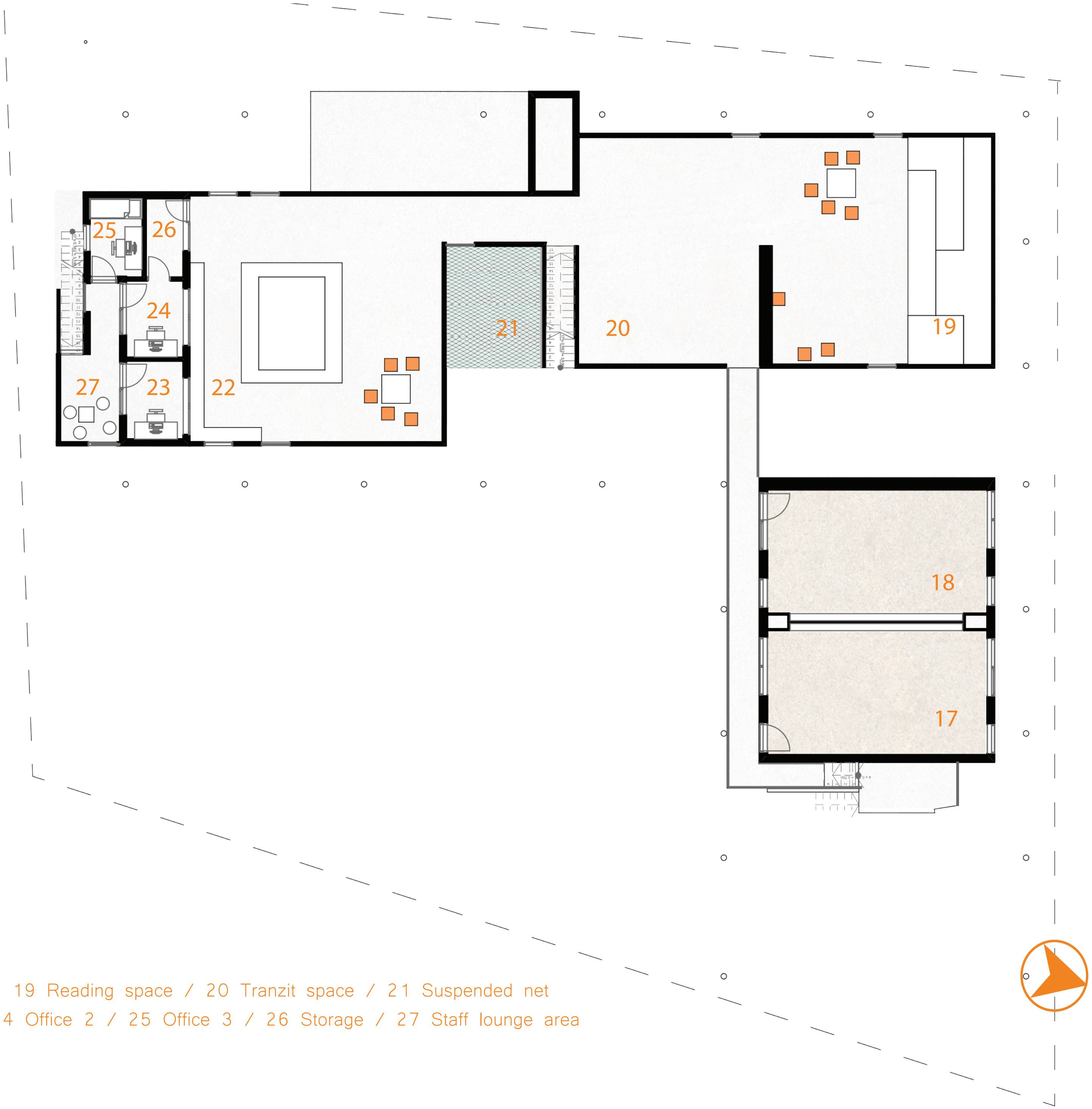
MASTERPLAN 1:200

SITUATION PLAN



PLAN 1:200
GROUND FLOOR

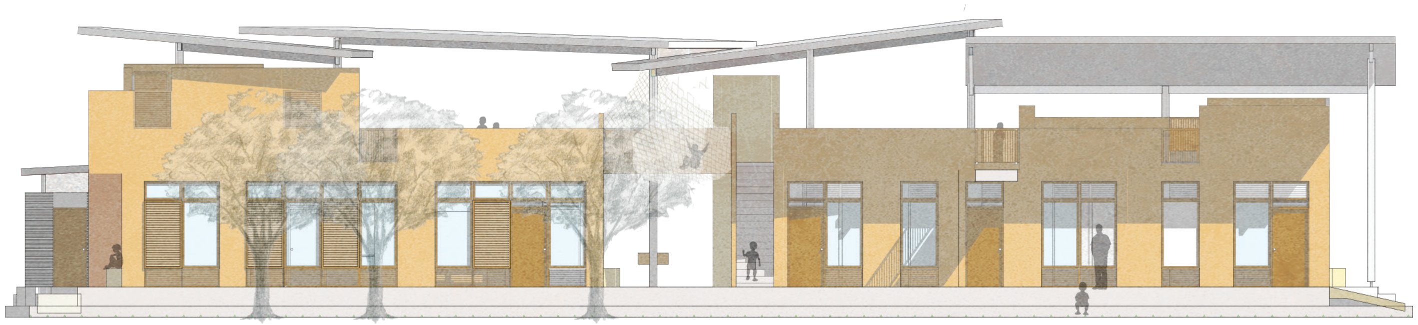
/ 01 Entrance / 02 Grouproom 1 / 03 Grouproom 2 / 04 Grouproom 3 / 05 Grouproom 4 / 06 Grouproom 5 / 06b Storage / 07 Baby-center / 08 Sensory space / 09 Quiet space & Storage / 10 Potty area / 11 WC / 12 HC WC / 13 / Wet area / 14 Kitchen area / 14b Storage / 15 Laundry area / 16 Amfi theatre



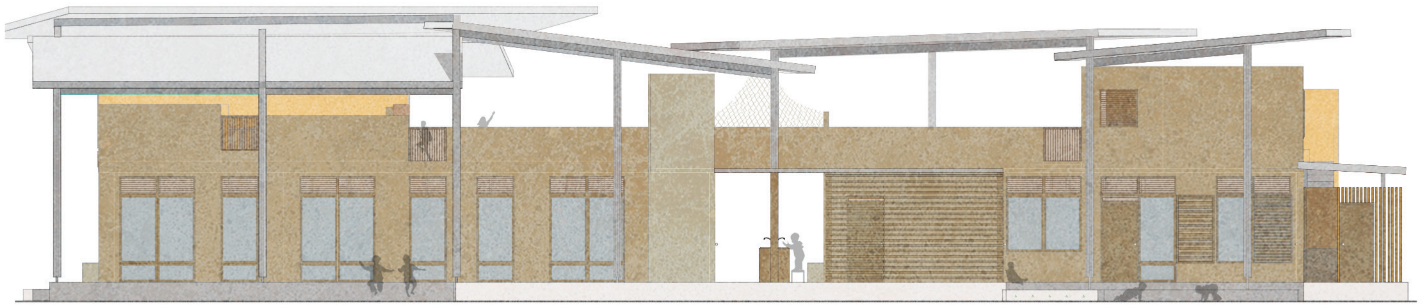
PLAN 1:200

FIRST FLOOR

/ 17 Grouproom 6 / 18 Grouproom 7 / 19 Reading space / 20 Tranzit space / 21 Suspended net
/ 22 Creative space / 23 Office 1 / 24 Office 2 / 25 Office 3 / 26 Storage / 27 Staff lounge area



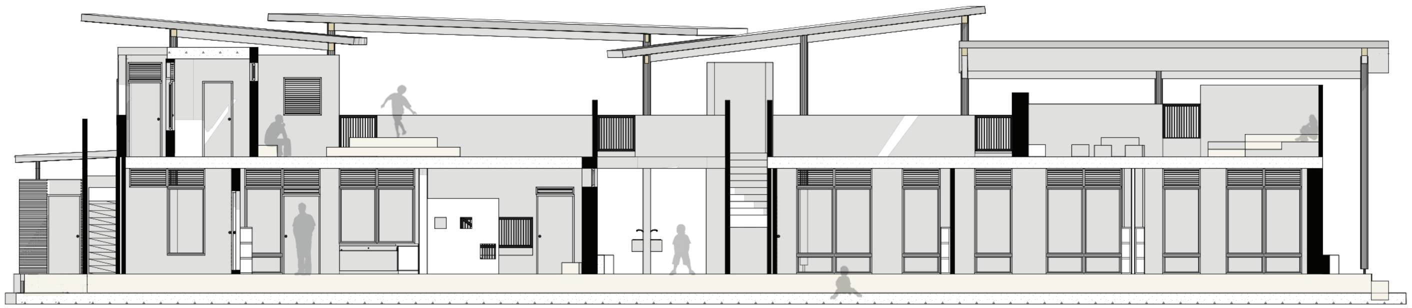
EAST ELEVATION 1:200



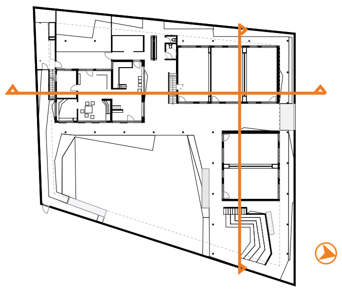
WEST ELEVATION 1:200

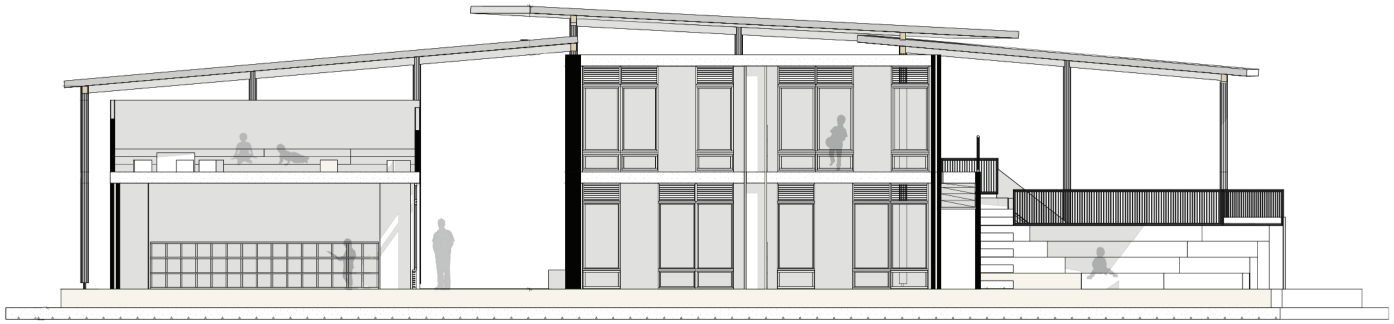
NORTH ELEVATION 1:200

SOUTH ELEVATION 1:200



SECTIONS N-S 1: 200





SECTIONS E-W 1: 200

GROUPROOMS

The grouprooms have multiple functions during the day; as classrooms, eating-, and sleeping-area and sometimes evening meetings and adult education. The design enhances this possibility of flexible use through reducing the permanent furnishing to a minimum of only storage functions. The wall dividing two grouprooms in the same module is designed to provide integrated storage space. Observations made at the existing M2S center called for a solution to the lack of storage space for the children`s bags and for teaching materials. The storage space for each classroom includes a wall of open shelves for the bags and teaching materials, and a horizontal shelve to be used for displaying objects and the like used during classes. The vertical storage space for mattresses enables easy access and will ease the situation for the teachers and staff.

The design of the room emphasizes the use of the floor. The children sit on the floor during classes, and the warm and soft cork tiles provide more comfort than the bare concrete floor of the existing M2S center. The materiality of the cork tiles also contributes to the warm atmosphere reflected in the finishes of the interior walls. The color scheme of the interior reflects the exterior, with walls of focus in orange contrasting to the cream-beige tone. The wall where the blackboard is fixed is orange, to help the children orient their focus during classes and to be able to read the space ore clearly. Tall windows in a vertical order let natural daylight longer into the room and creates a light and open atmosphere. The windows are placed close to the floor in the children`s level to fix daylight onto the floor where the children sit and write.

Ill. 4.2 Interior grouproom

BABYCENTER

The baby center is designed for the youngest children. Here they have the possibilities to play, relax, explore and develop their skills in a safe environment suited to their scale. Steps, play equipment and openings are adjusted to the child's level. In this sense, the floor is also made interesting and comfortable for the small ones who crawl and therefore automatically have more focus towards the floor. The large space has a number of room dividing elements in the form of low walls or walls with holes through them, but it is not separated by closed walls or doors, except for the quiet room. This is done to give the children full access to the various corners, equipment and zones within the space. The space has a gradient in level of activity; from active to creative to quiet and experiencing. The area in which one enters is the most active zone with more equipment to bring the children's motoric skills into play. This part also includes a mezzanine that lets the children experience different aspects and contrasts of a space: up-down, under-above, in-out and light-dark (ill. 4.4). The mezzanine provides extra space and creates a sense of a "space within a space" that encourages to more calm and social play. The spaces underneath create private cave-like zones for withdrawal and more quiet play. There is also a display wall in this space where the childrens' artworks can be displayed.

The creative zone is thought to be suitable for seated activities like painting and drawing, but still they can easily get active by climbing elevated stairs and jump onto a thick mattress or slide into the adjacent active space through a hole in the wall (see ill. 4.5).

The semi-private zone is a room for experience, retreat, relax, reflection and realization of one-self and their skills. This room has a more introvert atmosphere to give them space to disconnect from the surroundings and focus on their selves. The room is equipped with elements for relaxation like hammocks and window-seating. It also contains steps that lead up to a stimulating light play created by a bottle wall (Ill. 4.3). This space is adjacent to the quiet space, which is a separate room for sleeping physically divided from the rest of the space.

The movable shutters in front of the windows provide shade and help change the atmosphere within the space as it can become slightly darker with a play of light filtering through the lamellas of the shutters. It will not be too dark, because of the top windows along the façade. Thus, a stimulating, cosy and enclosed space can be created with minimal distraction from and towards the outside. These shutters will also help to keep heat out so that the building can cool down faster during the evening. This is especially relevant in the afternoons and evenings on the west façade.

Ill. 4.4 Babycenter: Active area

Ill. 4.3 Babycenter: Experience room

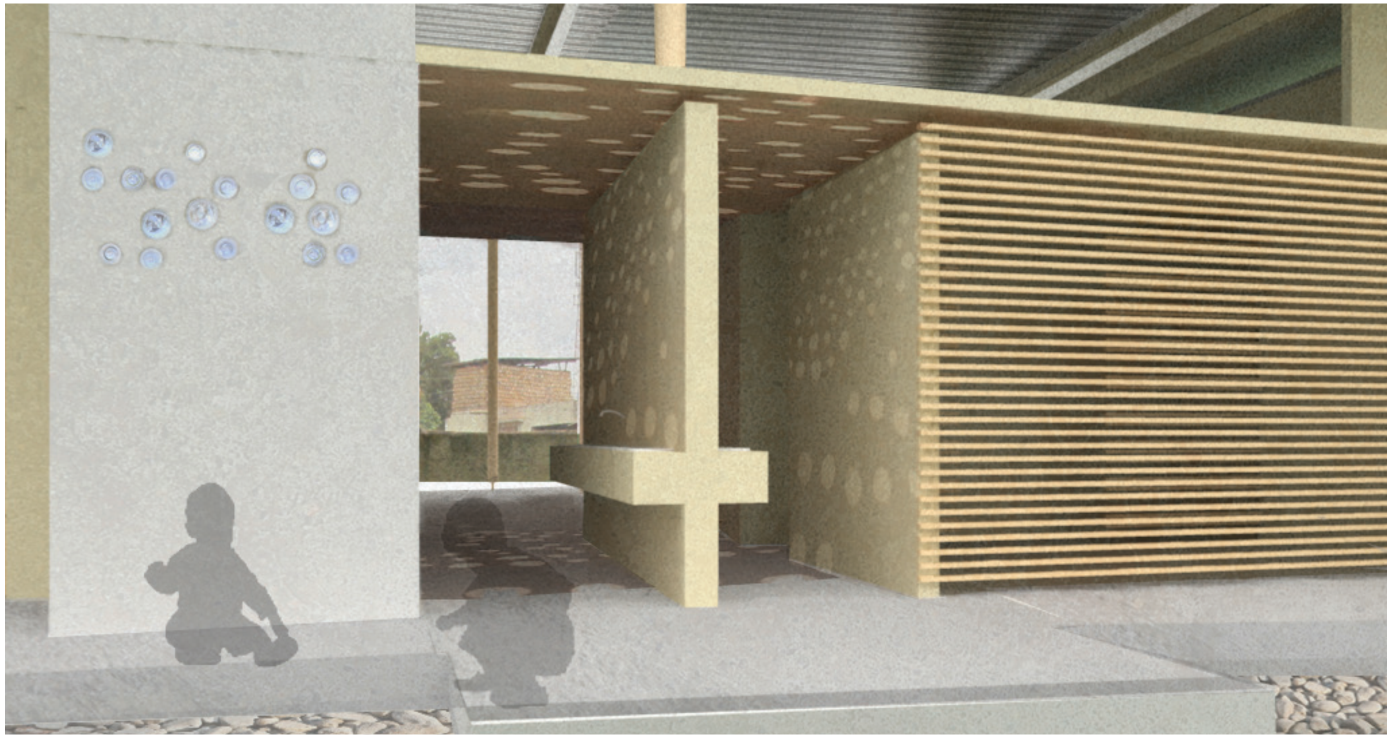
Ill. 4.5 Babycenter: Creative area

WET AREA

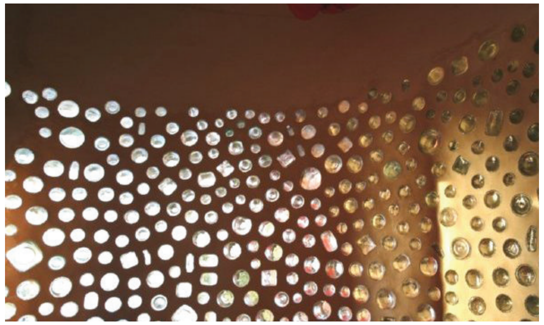
The secondary functions have a different materiality than the rest of the building volumes, articulating a separation from the main complex, while still being a part of it.
A design focus for this area is the principle of utilizing the sun to create different types of architectural light, and to create interesting atmospheres in the spaces that are usually the ones that gets the least attention and architectural qualities.

The area for toilets, potty area and washing-facilities is placed at the far west side of the site, but in visual connection to the playarea through an opening between the babycenter and the grouprooms. The toilet stalls are made out of massive earthen walls with areas of recycled glassbottles to provide light but still providing privacy (ill. 4.6-7). The light non-structural walls in the potty area and the laundry area are made of wood laid horizontally. This allow both wind and sunlight to penetrate into the interior and creates a stimulating light effect in the interior while at the same time allowing for continous ventilation (ill. 4.8)w.

The secondary functions are one story only which means that the roof can be perforated to shape the light. The roof of these functions are protected from the rain by the outer lightweight roof, but with a distance up to the outer roof big enough to enable direct sunlight onto the roof below. This allows for the possibility of perforating the roof underneath with holes of different sizes, which creates moving spots of light on the ground and walls where the sinks are (see Ill. 4.6). By using clay-pots, these also help to catch prevailing breezes and ventilate the space underneath.



Ill. 4.6 Wet area



Ill. 4.7 Light play: Bottle wall

Ill. 4.8 Light play: braided wooden wall

OUTDOOR AREA

The outdoor area facilitates for various activities – both calm and active. The presence of different elements let the children use their body and mind actively or in a more relaxed manner to accommodate for their various personalities and moods. Social or more secluded seating, larger, open spaces to run around or dance in, elements for climbing, sliding, swinging, skipping, learning and various tactile ground covering are all elements brought into this space on ground level.

Entrance

The entrance area creates a shaded buffer zone before allowing you into the light of the outdoor courtyard area. The entrance is shaded by the soaring roofs and is defined by walls of the classrooms on two sides, creating an outdoor space with a feeling of being indoors, and a feeling of being sheltered and welcomed (ill. 4.9). The entrance space feels open and light due to the double storey height of the roof, and set an impression on the visitors and users. At the same time it creates some curiosity because the viewpoint from here is limited to the shaded walkways, and one only sees glimpses of the things happening inside. Seating is incorporated into one of the adjacent walls and provide the ones who enter with a place to sit and relax while waiting or after a long stroll to the centre. This integrated seating is also used for the morning and evening registration of the children.

Amphitheatre

The outer roof provides shade, while the open surrounding gives free flow of air to further enhance comfort. This shaded seating area can be used for outdoor classes, playing, common gatherings or during special occasions like Christmas parties and "graduation". The steps are angled to create a focus point towards the playground that will function as the children's stage when they perform and as a connection to the angled slab towards south. The part closest to the classrooms has a perpendicular angle to connect to the "strict order" of the building. Here, a set of extra steps are integrated, so that the height of the steps are less to clearly show the possibility of ascending towards the upper floor. The remaining amphitheatre has higher and deeper steps to indicate that they invite to linger longer – that they are meant as seating. At the last step of the amphitheatre a light, perforated wood-wall is added for safety and support without compromising on ventilation and light.

Narrow spaces

The 2-meters safety boundary creates narrow spaces between the built elements and the boundary wall. Some

Ill. 4.9 Entrance area

Ill. 4.10 Narrow space between amphi

Ill. 4.11 Baby outdoor play area

of these spaces have a secluded atmosphere and is mostly suitable for smaller groups, pairs or individuals, but in some places it opens up in relation to other spaces (e.g. entrance-area or play-area) and become a connection between the social and private spaces. The boundary wall is painted with playful, educational motifs such as alphabet and numbers according to Ugandan legislation. Thus the 2-meters zone is an educational platform throughout the site. These narrow spaces are further utilized and optimized by the incorporation of seating, climbing elements, slide, skipping games and light and shadow play (Ill. 4.10).

Active spaces

The main playground is an open space that lies in the heart of the site, defined by the buildings and boundary wall. It is subtly divided into two parts, where the northern part is more open to facilitate running, dancing, large group activities and gatherings (ill. 4.12-14). A part of this space can be shaded through a canvas spanning between the columns of the roof elements. The southern part contains equipment and elements for activities like climbing, crawling, swinging and skipping. It also contains a variety of tactility on the form of a sand bed and pebble bed. Besides the natural elements and the built, tyres that are meant to be waste-material are used to form much of the play equipment. This would further enhance the knowledge of sustainable and affordable solutions.

Enclosing these spaces is a trail of various activities. This trial starts with the slab that the children can run around on and a ramp leads them to the grass. Here, the children have the possibility to skip from one stub or tyre to another or to climb on the boundary wall with the help of scaffolding elements or tyres embedded in the wall. After this, the children can run up the steps or the ramp

Ill. 4.12 Outdoor play area

to start on the trail again.

Private spaces

Children also need spaces for retreat, reflection and relax. The in-between spaces create a more private atmosphere which invites to be seated and socialize in smaller groups or alone, but the children are still connected to the other activities through sight and sound (Ill. 4.10). These spaces are clearly articulated with the use of contrasting color-tone on the wall. Seating is integrated as a part of the wall and as an expansion of the building mass, and in some places articulated through cutting out a triangular part of the wall to create niches and more private spaces. To enhance the enclosed and sheltered feeling, these spaces are situated in narrow and shaded parts of the site.

Wet play

On the west side of bathroom facility-area the slab is extended towards the boundary wall and is concluded with a bed of pebbles (ill. 4.6). From the sinks in the bathroom facility the children can bring water to this area to play with, without getting dirty with mud. The pebbles are places on a slightly sloping slab to drain water from this area.

Baby area

In direct relation to the baby-center is a separate outdoor play area for the infants, scaled to suit them and the caretakers' tasks of watching over them (ill. 4.11). Thus it is playful, but still safe. Elements of wood and rubber tyres from the main playground are copied to this space and scaled to suit the infants. Different types of ground materials (grass, paved ground, sand) provide contrast in tactility, and the different levels of the slab encourage provide a variety of height and scale. The variety caters for various activities, moods and motoric practice.

Ill. 4.13 View from grouproom

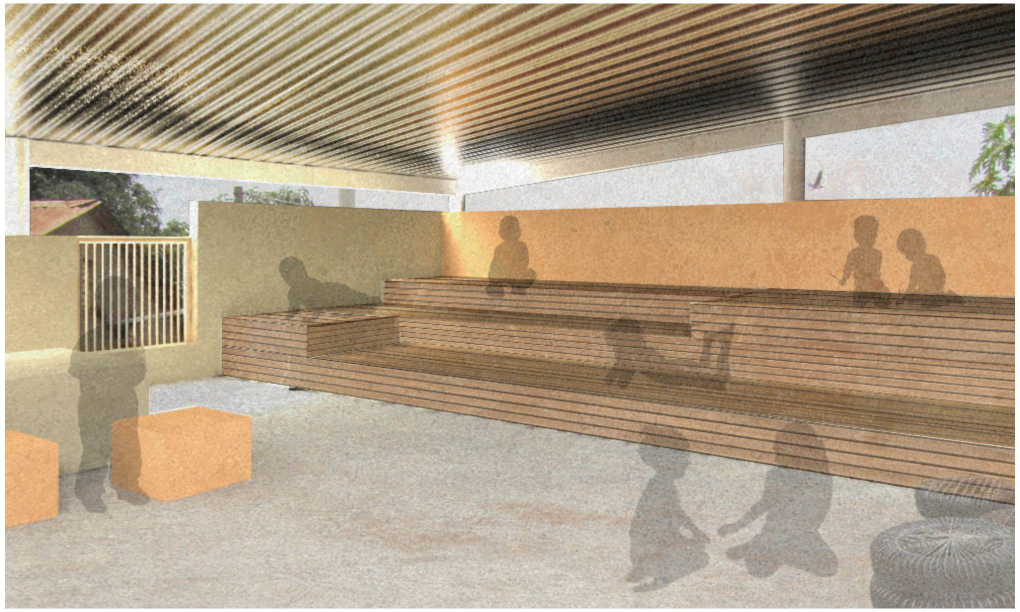
Ill. 4.14 Shaded outdoor area

ROOFTOP SPACES

The different functions in the rooftop spaces are defined by the different atmospheres created from the variations in heights and angles of the protective outer lightweight roof. The spaces created by the lower parts of the roof provides a more sheltered atmosphere which invites to more calm and quiet activities such as reading and storytelling. This space is furnished with low height, deep seating designed to encourage the users to linger longer (ill. 4.16). Spaces with higher ceiling heights provides a more open and social atmosphere, and will be used for creative activities and social interactions (e.g. board games, arts & crafts and stage art) encouraging the children to use their creativity. This space has a multifunctional stage-volume functioning as both stage and a large robust table for creative activities in larger groups (ill. 4.17). Tying these different spaces together is the presence of movable box-objects made from painted recycled wooden boxes with multifunctional purpose as seating, tables, bookshelves or building blocks. The same box-shape is found in the openings in the surrounding walls or cut-out box shapes in partition walls which can be used for private reflections or social conversations (ill. 4.16). Seating in form of recycled car tires are found throughout the space, tying the rooftop space together with the outdoor space on ground level, where used car tires are used as an active part of the play area. The circular tires creates a contrast to the geometric boxes, and creates interesting situations where these two elements meet and interact.

The space between the reading space and creative space will function as a transit or buffer zone, and because this space is placed in relation to the main access route on the 1st floor, this space will not have any physical and

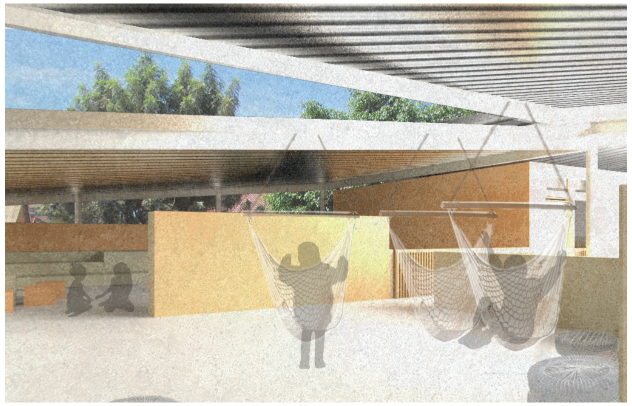
Ill. 4.15 Space for reading and storytelling under outer roof



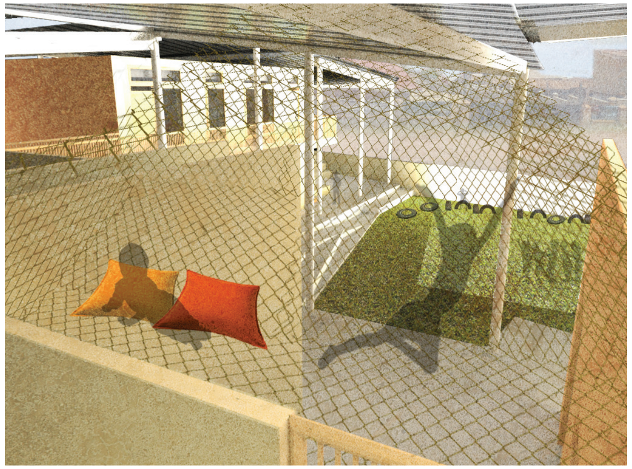
Ill. 4.16 Space for reading and storytelling under outer roof

Ill. 4.17 Creative space under outer roof

permanent furnishing. Soft hammock chairs and a large net expanded over the open double height space next to the staircase (ill. 4.18-19) create an interesting play and social environment, while keeping the floor area free. The tactility of the hammocks and nets contrast to the hard surfaces found in the other types of spaces and present the children to a different tactility and areas of use. Secondary façade elements (additional railings and wooden screen window elements) have a lighter expression than the massive primary functions to articulate that they are separate from the main structure.



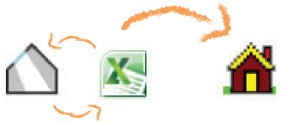
Ill. 4.18 Hammocks in transit area under outer roof



Ill. 4.19 Net suspended under outer roof

05 TECHNICAL SYNTHESIS

INDOOR ENVIRONMENT



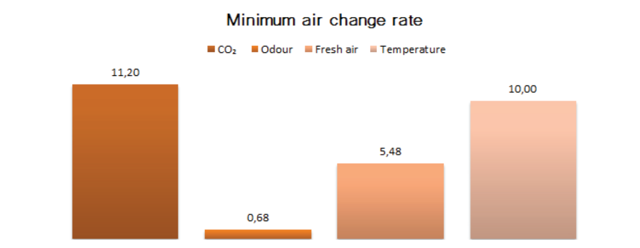
As a result of an integrated design process, many decisions are concluded on the basis of logical thinking, calculations and simulations. As the indoor environment is affected by the outdoor environment, the building envelope becomes the connection and contact between these two environments. In terms of indoor environment light and ventilation have been focused on and therefore windows and openings have been through an iterative design process to achieve the desired indoor environment and architectural expression. The main process in this phase consists of calculating ventilation demand and achievable air change rate through Excel spreadsheets and daylight simulations in Velux Daylight Visualizer to determine openings and glazed areas to use this design in a final indoor environment simulation in BSim.

Ventilation demand calculation spread sheet

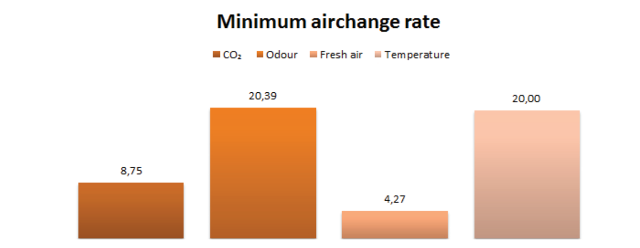
In order to find the required ventilation and air change rate for the occupants' comfort and achievement of indoor environment category II, ventilation demand based on CO_2 level, sensory pollution, fresh air need and thermal comfort are calculated to figure which of these demands require the highest air change rate. This rate determines and becomes the minimum ventilation rate the design desires to achieve.

These calculations are done through an excel spread sheet based on values and formulas found in DSEN 15251 and CR 1752. All the mentioned demands are calculated except for demand based on thermal comfort. This demand is thought to be covered with an air change rate between 10- 20 1/h (which means that the air volume inside the room is changed 10-20 times per hour). For the classrooms it is considered to be 10 1/h, while in the baby space it is considered to be 20 1/h since it is a bigger space with a higher number of occupants. The calculations are also based on the observed daily schedule of the centre and only the day-time use is considered. Since the ventilation is natural and happens through open vents and since there will be less occupants present at evening and night time, the ventilation outside day-care hours will be sufficient.

The results are compared in a graph at the end of the sheet to see which parameter demands the higher ventilation air change. The results show that the dominating ventilation criterion for the classroom is CO_2 and odour for the baby centre (Ill. 5.1-2).



Ill. 5.1 Results of ventilation demand calculation for classroom measured in number of air change per hour (1/h)



Ill. 5.2 Results of ventilation demand calculation for baby centre measured in number of air change per hour (1/h)

Natural Ventilation spread sheet

To experiment with the size and placement of windows and openings to achieve sufficient ventilation, an Excel sheet provided by the University for calculating natural ventilation is used (see appendix G). This sheet calculates potential of natural ventilation through thermal buoyancy and wind pressure. It is used to determine number and size of vents and windows to obtain desired ventilation based on demand calculations done through the ventilation demand calculation spread sheet. Dimensions of these elements are not determined by these calculations alone, but as a result of an iteration process between this calculation tool and daylight simulations in Velux Daylight Visualizer.

Three design proposals for the openings and expressions are shown below in illustration 5.3. The initial ventilation system (A) consisted of long, narrow inlet and outlet vents of the same dimensions and the ventilation system in the second proposal (B) consisted of small vents which were a result of removing bricks to create inlet and outlets. In the second proposal the sum of area for the inlets was less than that of the outlets. Finally, a system of equally dimensioned vents is chosen (C). In this proposal, the principle of fewer inlets than outlets is preserved. Since the vents contain insect protection and lamellas, the area of the openings are reduced to half size in the calculations to correspond to this disturbance of airflow. In this calculation all vents and one window on inlet side and one on the outlet side is included for the classroom to achieve good ventilation.

Although the initial suggestion gave possibility for higher air change rate (see table 5.1), it was not satisfactory for the aesthetic, architectural expression and for the flexibility of choice regarding ventilation amount. Through the final proposal an air change rate above the dimensioning air change rate figured from the demand calculation is achieved both for classroom and baby centre (see appendix G).

Velux Daylight Vizualizer

In order to see if we achieve the desired daylight factor, the daylight simulation tool Velux Daylight Visualizer is used. A model of the classroom and a model of the baby centre are imported to the software and daylight is simulated based on location, time and material finishes. Through this software the placement of the windows are also determined based on daylight. Regarding the window placement it is seen that elements placed closer to each other have better effect in spreading daylight into the room than elements placed separately. The classroom module is modelled with consideration of the overhanging roof and gallery to get an idea of how high daylight factor we could possibly get even with these shadow casting elements.

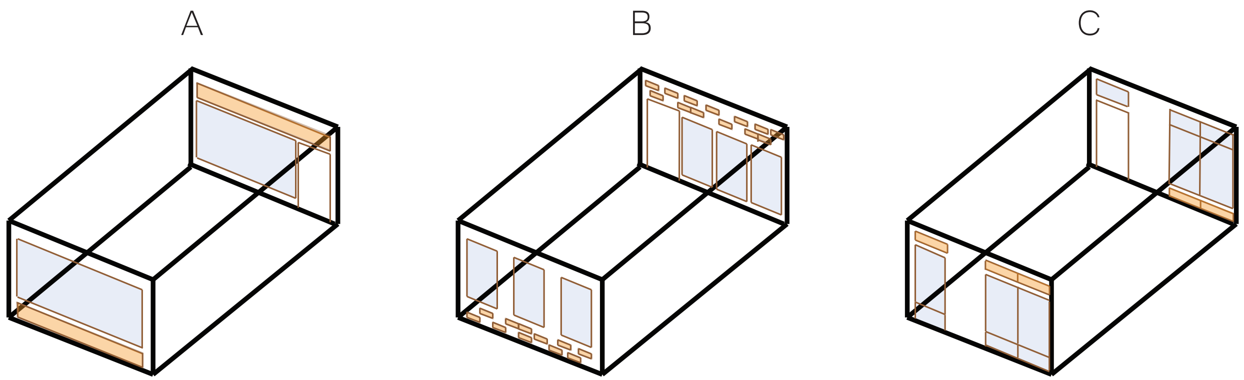
Proposal	Inlet area[m2]	Outlet area [m2]	Air change rate
A	2,15	2,15	30,40
B	0,33	0,45	2,30
C	2,30	2,55	24,37

Table 5.1 Comparison of possible achieved air change rate through the three illustrated proposals (Ill. 5.3).

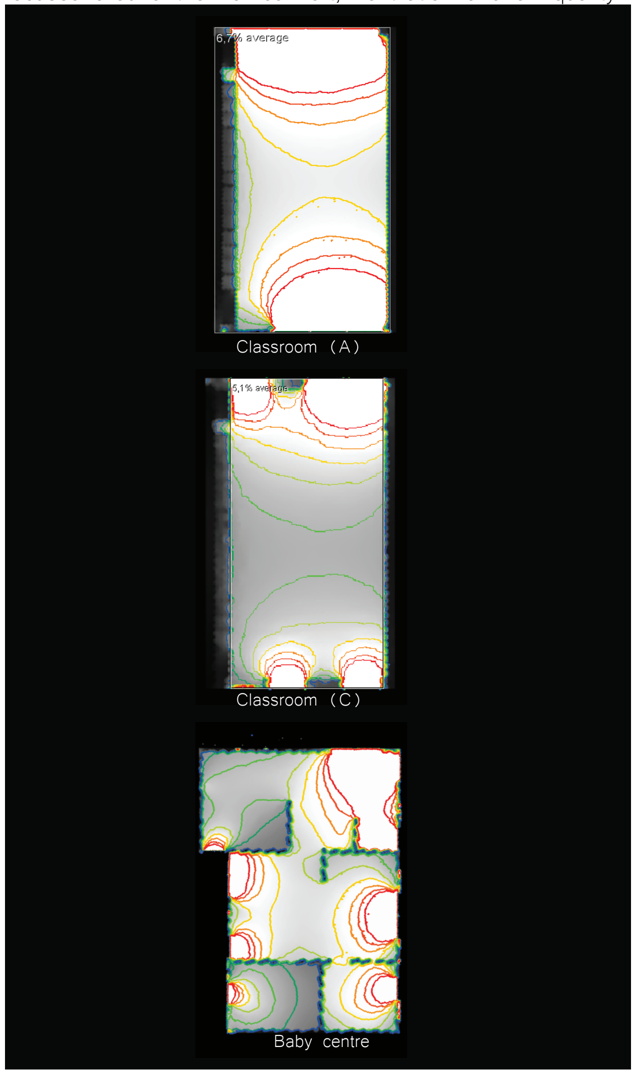
Through the simulation it is seen that the desired average daylight factor (minimum 2 % and preferably 5 % or more) is achieved (see ill. 5.4). In the classrooms it is just above 5 % and in the baby centre it is seen to be above 2 % for most areas and 5 % or more in major parts of the space. The quiet room is intended to have less light to create an appropriate environment for sleeping.

BSim

BSim is building simulation software that can simulate the indoor environment of a building based on a selected climate. This software is used in this project as a tool to see if the set indoor requirements were met or if major changes have to be made to at least achieve an acceptable indoor environment. The simulations are focused around thermal comfort, ventilation and air quality.



Ill. 5.3. Illustration of the mentioned proposals. Light brown indicates open vents and light blue indicates glazed windows



Ill. 5.4 Daylight factor of proposal C in June at 12:00 on an overcast day in December

As proposal C did not satisfy desired ventilation demand, it was not modelled in BSim. The remaining proposals were simulated as they are illustrated and with a few modifications to test the effect of varying the design.

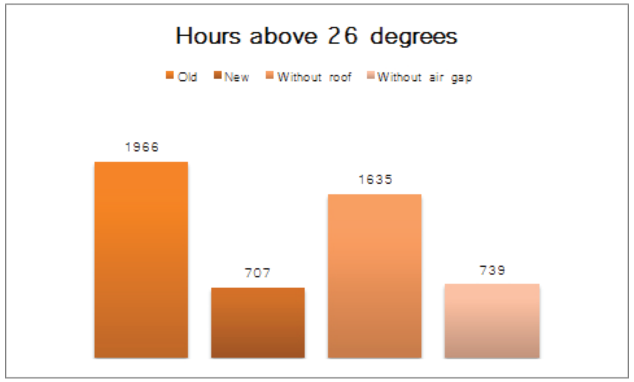
As a reference for the simulation, a classroom module in the ground floor with a neighbour classroom and a classroom on top is chosen to see the impact of a worst case scenario. This classroom will have fewer surfaces to lose heat through transmission and will be exposed to more solar radiance. The ventilation openings are reduced to half size to consider the disturbance in air flow as it was in the Natural Ventilation spread sheet and the air change rate is taken from the demand calculation. Further, the simulations are based on a classroom with 30 pupils and 1 teacher and on the daily schedule observed at the Miles2Smiles centre.

Mainly, two different models of the classroom are analysed: proposal A and C (final proposal). Proposal C was first simulated with a wall construction without air gap between the brickwork and to enhance the performance of the building envelope the air gap was added and the indoor environment was simulated again. To see the effect of the double roof construction, proposal C was also simulated without this element.

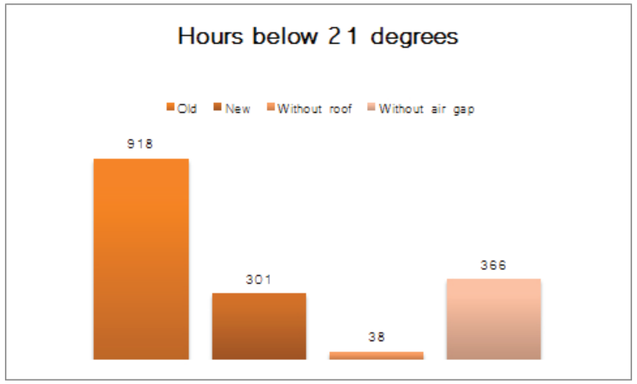
Results

As the results in illustration 5.5 and 5.6 show, the double roof construction has significant benefit for the thermal comfort indoors and the air gap in the wall construction enhances the thermal comfort further. The hours below the lower limit for thermal comfort in the final design (C) are not hours where occupants will be freezing as the lowest temperature is seen to be 19 °C indoors when the outdoor temperature is around 14°C. This, however, happens outside day-care hours according to results from the BSim simulation (see appendix E). As shown in ill. 5.10, the temperature indoor satisfies the temperature interval defined for thermal comfort in this project (between 21 and 26 °C).

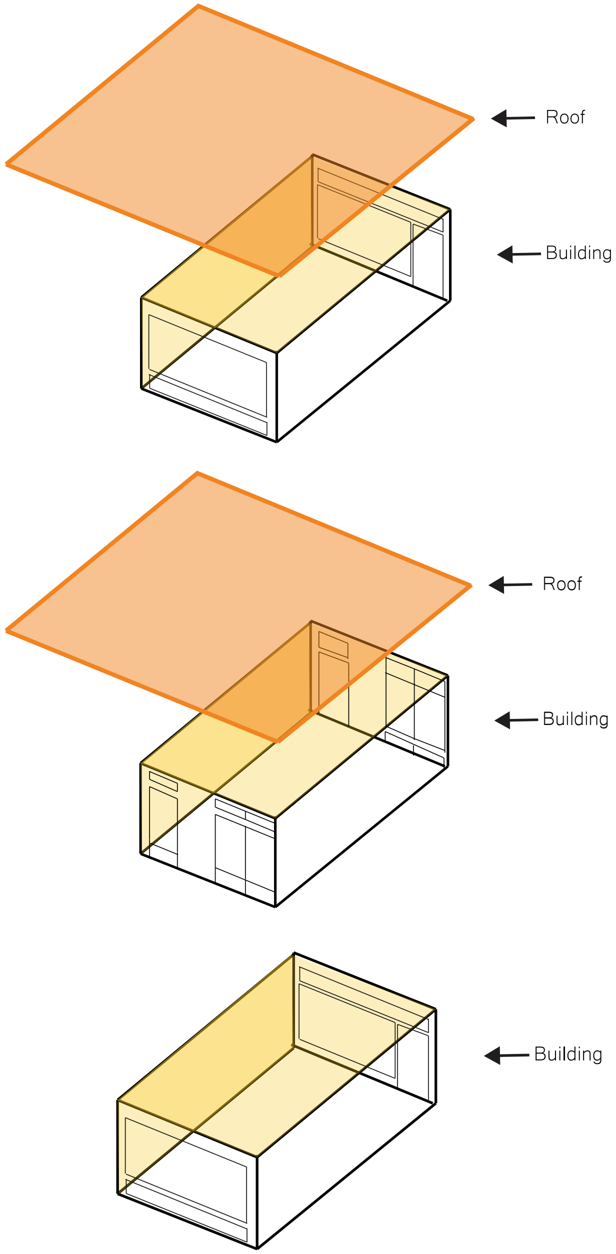
The air quality is good as the CO_2 level does not exceed the set limit derived from indoor environment category II (see ill. 5.9). This is due to a sufficient air change rate and the fact that the CO_2 particles do not get time to accumulate to peak load before the breaks between classes. During the breaks the CO_2 level indoors drops, because the occupants who produce it have left the room and the room is then ventilated and refreshed before the occupants arrive again for the next lesson.



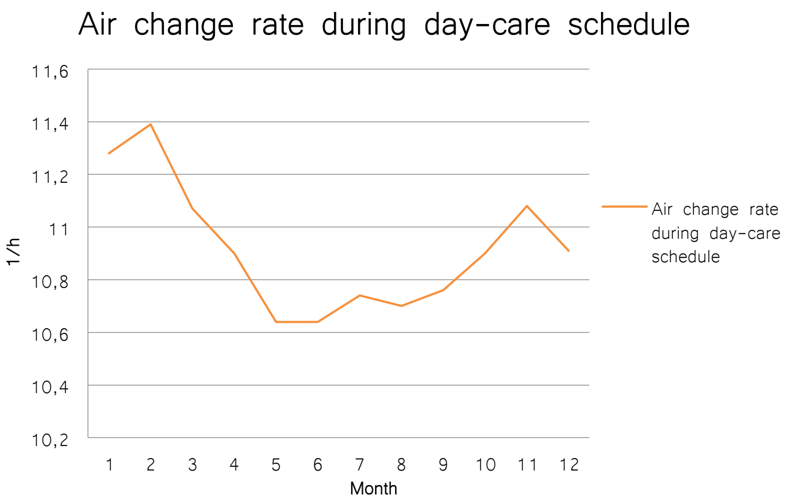
Ill. 5.5 Result from BSim: Hours above 26 degrees on annual basis



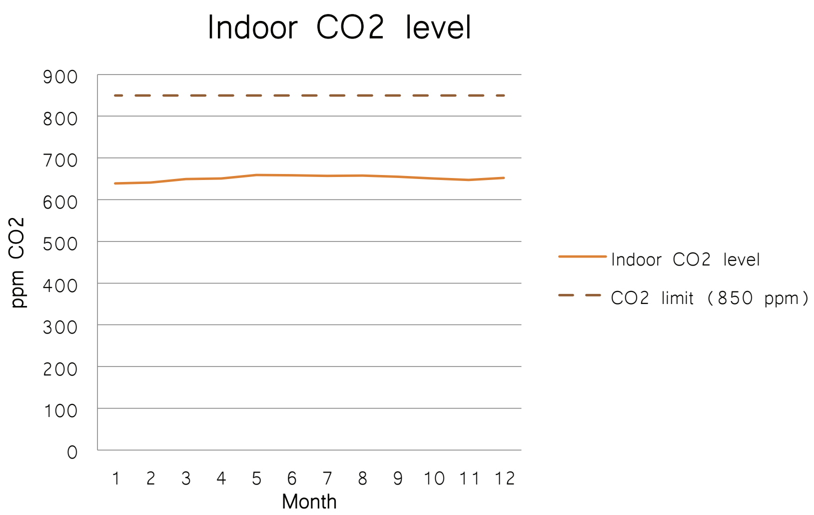
Ill. 5.6 Result from BSim: Hours below 21 degrees on annual basis



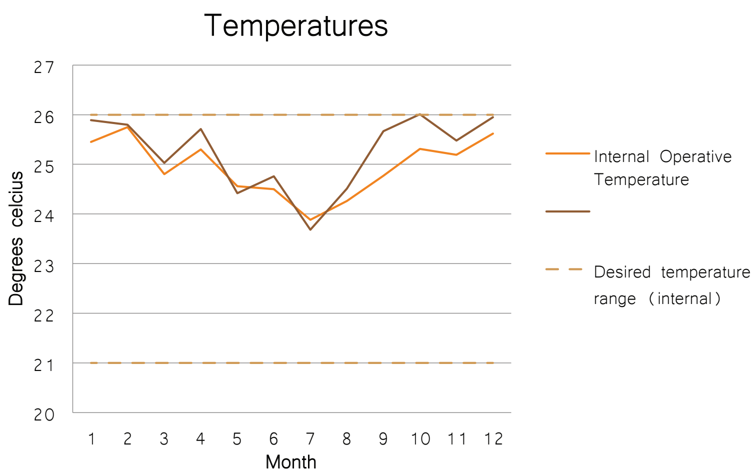
Ill. 5.7 Illustration of main models in BSim



Ill. 5.8 Result from BSim: Mean monthly air change rate (1/h)



Ill. 5.9 Result from BSim: Mean monthly CO2 level indoors



Ill. 5.10 Result from BSim: Mean monthly temperature variation and illustration of how indoor temperature follows outdoor temperature.

RAINWATER HARVESTING SYSTEM

Access to water is in general limited in most developing countries, and a great potential lies in the collecting of rain water and water filtration. The fact that Kampala experience a lot of rain annually, the total need for water can be covered by rain water harvesting, leaving the center self-sustainable and ensuring a low-cost solution for the future running of the center. Rainwater should cover the total water need for sanitation, cooking and washing and the grey water should be re-used for flushing the toilets. Besides the obvious environmental sustainable profit, the implementation of a rainwater harvesting system also contribute to the ethical sustainable, as the local community can learn about how to collect and filtrate rainwater to supply themselves.

The daily water usage per person for the new M2S center includes water for washing, toilet flushing, laundry, cleaning and cooking. This adds up to a total daily water usage of approximately 2100 litres (2,1 m3). The annual harvesting potential for the two sheets of roof area angled to collect rainwater (293,4 m2) is 332,7 m3.

This is calculated with an annual rainfall of 2100 mm (see appendix I).

The location of the main water tank is close to the collection point of the rainwater from the roof and close to the demand point (sinks, wash area and WC), elevated on top of the toilet house (Ill. 5.11). This location reduce the distance the water is conveyed to a minimum. This tank can hold up to 12,6 m3, and this volume can be expanded by adding a secondary water reservoir tank on ground level. The tank is shaded from direct sunlight due to its location close up under the outer roof, and will have to be fully enclosed to eliminate the risk of mosquito breeding. The height of the location enables the sink and tap outlets to rely on gravity force only, eliminating the need for energy demanding pump. Another water tank is located in direct relation to the kitchen and staff area and can potentially hold up to 500 l (0,5 m3), and will supply water for cooking (boiled), dishwashing and laundry.

Water harvesting system

Coarse filter: catches leaves and dirt collected on the roof before the rainwater is let down the conveyer system.

First flush diverter: allows the runoff from the first spell of each rainfall to be flushed away to avoid the relatively large amount of pollutants from the first spell of rain and from the roof area (see ill. 5.12).

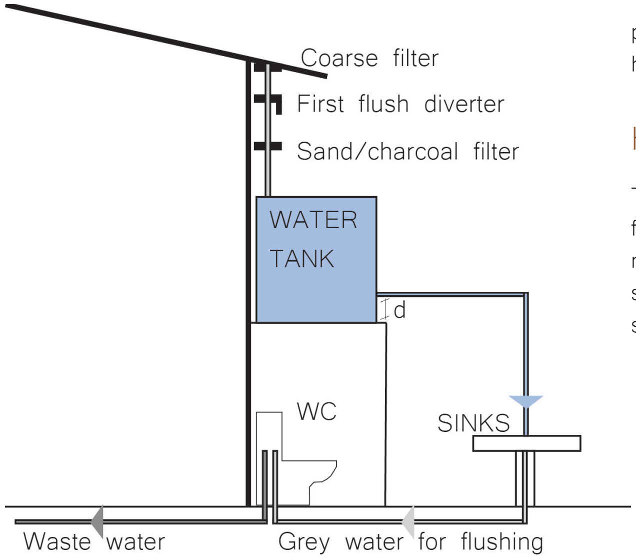
Filter: removes dirt and particles from the water before reaching the storage tank. The filter can consist of sand and gravel, or combined with charcoal, all which are materials that are easily available in the local context of Kampala. A filter consisting of sand, gravel and charcoal can remove turbidity (suspended particles like silt and clay), color and microorganisms from the water. This type of filter is a simple and inexpensive solution, and can be made in an earthen pot or a drum (Centre for Science & Environment, n.d.)

Ill. 5.11 Illustration of water collecting roof elements, pipelines and location of water tanks (orange) (Seen from west)

Purifying rainwater for drinking

To purify rainwater for drinking, the water has to be filtered and then purified/disinfected. Methods of disinfection include chloronization, ionization, UV or membrane filtration. All of these methods represent complex techniques which can cost both time and money in order to properly install and maintain. Although, such systems should be considered by the end user (Centre for Science & Environment, n.d.).

For purifying small portions of drinking water, a separate device for water-distillation can be used. Impurities are separated from the water through the process of heating the water to condensation, and then collecting the purified condensated water (Ill. 5.14). This technique utilize solar radiation, is inexpensive and simple to convey. The method may work best in small scale systems, and because of this the community can easily adopt it. By providing the center with a number of these devices the children can learn the process by being allowed to purify the water themselves. In this way, this solution represents both environmental and ethical sustainable strength (Architecure for Humanity, 2012).



Ill. 5.12 Water filtration and supply system

Another way to purify rainwater is ceramic water filters made from fired clay (ill. 5.13). The tiny pores in the ceramics are small enough to remove virtually all bacteria. The method can utilizes gravity to facilitate the filtration process, which can result in a flow rate of 1-3 liters per hour (Inhabitat 2011).

Hot water

The roof also provides possibility of utilizing solar radiation for hot water. This can be done through installing black rubber tubes on the roof, which gets heated up by direct solar radiation and then utilize gravity for supplying the sinks with hot water.

Ill. 5.13 Water filtration with ceramic filter

Ill. 5.14 Water filtration thorugh condenstaion

RENEWABLE ENERGY PRODUCTION

Potential and benefit of Photovoltaic Panels (PV)

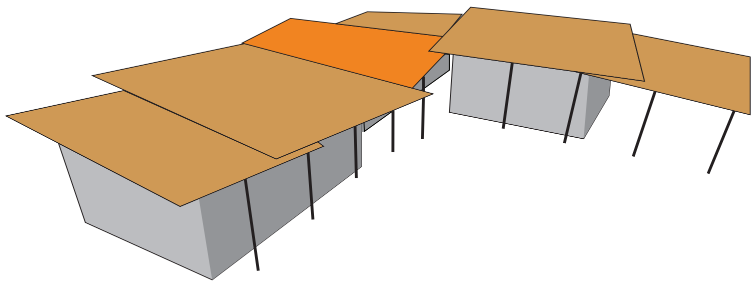
Roof mounted PV panels are a suggestion to active, renewable means of producing energy. The New Miles2Smiles Center is designed to have minimum energy demand because of the implemented passive techniques (e.g. shading). As Uganda lies by the Equator it has great solar potential that can be used to create energy. This will be a sustainable technique that can reduce environmental issues and reduce cost of energy during the building's use. It will reduce the load on the energy grid and make the building more self-sufficient. As a back-up, when there is not enough sun to produce the energy, a connection to the grid can be considered and/or a method of storing the excess energy production can be implemented. Such storing is possible through batteries. One example of a battery that has been used in power systems is the deep cycle battery which is similar to those found in electrical vehicles.

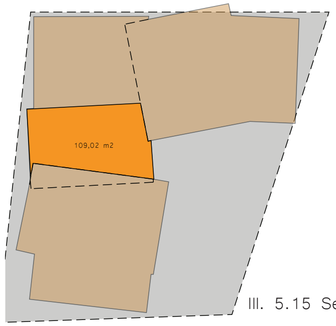
Placement and amount

The electricity use in the centre is mainly thought to be through the use of a number of fans and light-bulbs in the different spaces and this means that the amount of solar panels can be reduced to cover one roof element. As the sun exposure on the roof is present most days of the year, it is practical and great potential in placing the PV panels here. The energy can then be used immediately or stored to use during evenings, nights and overcast days. The storage unit is considered to be placed by/in the resource room.

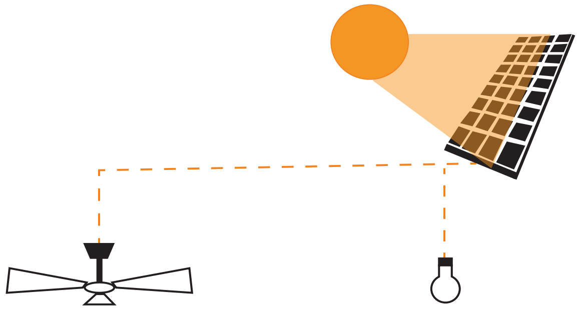
The panels can be mounted as freestanding panels on one of the south-facing roofs to utilize full potential of the sun as an energy source. In order to integrate the panels in the rest of the expression, hey follow the angle of the roof. According to calculations based on method from a lecture about renewable technologies at AAU in the 2.semester, an annual production of 14121 kWh is potentially possible if the unshaded parts of the roof element above the transition towards the bathroom are covered in panels (109 m^2) (see Appendix J). In this calculation the cumulative annual solar radiance is used without considering the roof's slope which is between 2-5 degrees and spaces between panels are not considered. Generally, the angle has an effect on the efficiency of the panels and an optimum angle should be found to calculate maximum potential.

To put the mentioned number in perspective: One fan or one light bulb uses about 400 Wh if it is on continuously for 8 hours. In a year this would be 146 kWh/year.
If the building all in all includes 10 fans and 23 bulbs running constantly for 8 hours all days in the year, distributed in the classrooms, baby space and offices, it would take about 37-38 m^2 of roof-mounted PV panels to cover this demand. The calculation is done for only an 8 hour period of one day and this means that outside service hours and during weekends the PV panels can produce more energy that can be stored for later use. Storing of energy is thought to be covered by battery





Ill. 5.15 Sected roof for PV panels

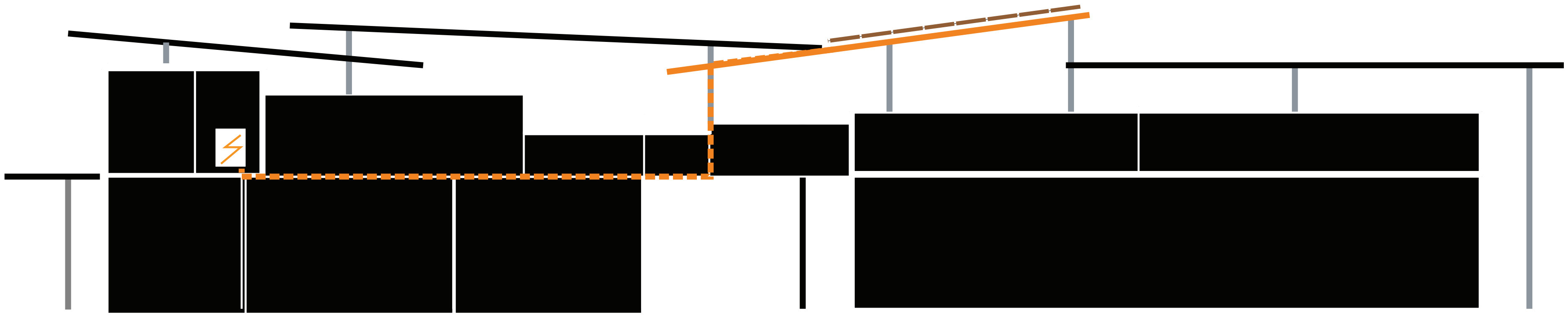


Ill. 5.16 Use of produced energy

elements placed in the resource room in the first floor.

During day-time light bulbs are not considered to be used unless the quality of indoor natural light becomes poor and the fans are to be used where less wind or too hot temperatures make the natural ventilation insufficient. This means that the above calculated number is a more extreme than day-to-day situation. In addition to this, the panels produce energy even when the lighting, fans and building is not in use. Even if the calculations did not consider the angling of the panels and distance between them, it shows that we have more than enough roof surface to incorporate into renewable energy production with consideration to the angle and distance between.

As seen in the mentioned numbers, the solar power potential is great within the project and the electricity demand of the building can easily be covered.



Ill. 5.17 Location of PV panels and battery (seen from east)

CONCLUSION

The New Miles2Smiles center is built upon a foundation where ethical and environmental sustainability are the main components.

The ethical sustainability is represented through the center`s function and purpose of providing a place for education and inspiration. Through daycare and pre-school the children have a safe environment where they can develop through learning, play and creativity. Simultaneously, the mothers can attend to work and provide for their child. The center is also a place where the adults are provided with education programs in nutrition, health and finance. This results in a highly multifunctional center for the whole community.

The design is kept, simple and honest to create readable architecture to further emphasize the ethical purpose of educating through architecture. This way the architecture will function as a mean of educating the locals in sustainable climate adaptive building design, and increase their awareness of the possibilities of good, non-expensive and healthy building design. By enabling the local community to participate in all aspects of the construction, the locals can gain experience for future job opportunities, which further proves the long-term effect on the community and the educational potential architecture beholds.

The architecture is based on environmental friendly principles though materiality, construction methods, organization and layout. Environmental sustainability is manifested in the design through low-tech passive solutions integrated with local building culture based on available resources and tools. Through introducing recycled materials like old car tires and glass bottles we rethink the potential of waste materials to create interesting elements in architecture.

The New Miles2Smiles center has become a symbol of community development and hope to break the poverty cycle and improve the living conditions of the locals. The sculptural roofs define a distinctive profile in the skyline of the area and articulates the importance of the building as a community center. The New Miles2Smiles center is first and foremost a place where the child is in focus. The architecture provides stimulating environment for all moods and activities through the presence of different elements that let the children use their body and mind actively or in a more relaxed manner.

Concept

The concept of the Protected and the Protective is readable though the physical and visual separation of the two elements. The Protected and the Protected create a clear contrast through the materiality. The protected building volumes are made out of local earth bricks and through the use of local building techniques, but is designed with new interpretation in shape and aesthetics, and represents a new perception of the old. The aesthetics of the building volumes are made possible because of the presence of the outer protective roof, which indicates that the old needs the new to improve and develop in a fast growing society.

The protective outer roof represent a poetic concept of “the new protecting the old”, and also serves the function of protecting the building volumes from the harsh sun and rain and enables use of the rooftop spaces. The roof is made of metal which represents the new and modern, while providing climatic properties like high reflectivity of solar radiation and surface for rain water harvesting. The building volumes are made of earth which represents the old and traditional, while contributing to regulating the indoor environment through its properties of thermal capacity. This represents the duality of the concept; representing both the poetic and the functional in one unifying concept.

Designing for children

Because the different age groups have different outlooks and ways of learning, this is reflected in the design. The pre-schoolers learn by focusing and observing. The grouprooms are therefore designed with simplicity in mind with minimal distractions. A logical use of color-contrast towards the blackboard help guide their focus, and creates a more intriguing interior. The infants learn by doing and experiencing, and therefore their territory includes more physical elements to encourage exploring the environment and developing their own set of skills.

- A stimulating environment for children is created through a continuous focus on the 4 environmental needs of children (motion, comfort, competence and control) stated in the analysis chapter 2.1.

The outdoor area provides the children with space to move freely and play actively. The interior of the baby center also support various movement through different elements like mezzanine, slide and stairs.

The design provides comfortable environments through accommodating for the child`s various mindset and physical comfort, through different types of spaces and the tactility of the floors of the interior.

In order to make the child feel competent, elements are designed to fit the scale of the child. Through this, the architecture empowers the child`s independence and confidence. All parts of the complex (excluding the staff functions) are made accessible for the child so that they can be in charge of their own environment. The smallest children are given the same possibilities in a safe environment adjusted to this specific user group.

The child is given a sense of control by minimalizing odd and confusing shapes and spaces, and provide visual overview throughout the site through windows, from the rooftop spaces or through gaps between the building volumes.

The creative use of elements like lightplay through bottlewall, screenwall, walls in contrasting tones in color, different tactility and use of natural elements create a holistic experience, which is the child`s way of experiencing architecture. The architecture stimulates the children`s imagination and inspire them to further exploring and learning. The environment is made the greatest curriculum in how to deal with the world.

- In addition to the 4 needs mentioned above, the stimulating environment is also based on 6 contrasts (as stated in the analysis chapter 2.1), each with their own hierarchy.

The contrast In/Out is found in the relation between the protective indoors and exposed outdoors, but also in the introvert semi-enclosed areas like in-between spaces and the rooftop space.

Light/Dark is created between the shaded spaces and the areas exposed to sunlight. The outer roof enhances this contrast on a large scale on top of the hierarchy, and a second level of shade is created in the in-between spaces underneath. These different levels of shade is also found indoors in the semi-private and private areas of the baby center.

Order/Mystery is found at the highest level in the main horizontal and vertical order of the architectural concept. This consists of the fluctuating roof mirrored in the ground slab, and the strict lines of the building volumes. The extruding walls surrounding the rooftop spaces break the horizontal order while conserving the vertical. The use of contrasting color-tones on both the exterior and interior walls create a mystery in the order and articulates a different function. In the baby center this contrast is found in the openings in the partition walls where some of them function as peepholes while other function as doors.

Exposed/Tempered relates to physical properties connected to climate, and is found in the highest level between the protective roof and the exposed outdoor spaces. The next level is found between the indoors and the outdoors.

Something/Nothing is a contrast between presence and absence, and is found in the occasional presence of the glassbottle elements, the movable furniture, the integrated seating in some facades and the wooden screen window elements in the rooftop spaces

Up/Down is found between the rooftop spaces and the ground level, between the access gallery and the shaded walkways and entrance area underneath, between the mezzanine and the floor in the baby center, and between the elevated stairs of the amphi-theatre and the ground slab. Different heights allows the child to perceive different types of spatiality.

Indoor environment

A good indoor environment is achieved through the use of passive techniques only. However the indoor temperature exceeds the comfort range during some hours of the year, but since we are designing in a tropical climate, a higher comfort range can be accepted. The building is self-sustained through the use of PV-panels that can relieve the users during these periods, meaning that the indoor environment will always be good.

When designing in cold climates, it is often expensive and challenging to achieve a high or sufficient ventilation rate through natural ventilation and considering energy efficiency. In this context, however, the outdoor temperature and desire for much ventilation to reduce the discomfort regarding heat issues allows sufficient ventilation through natural systems. A fresh air need of 7 l/s (CR1725) is therefore easier to achieve through natural ventilation in an African context compared to a European context.

REFLECTION

We have learned the importance of a good integrated design process when designing climate adaptive architecture. It has provided us with the possibility to test and adapt the building to perform its best regarding indoor environment throughout the whole process.

The challenges we met during the design process were mainly related to designing in a new and different climate and social environment from what we are used to. This required thorough studies and adaptation of knowledge. We experienced that our European mindset would not be suited in an African context.

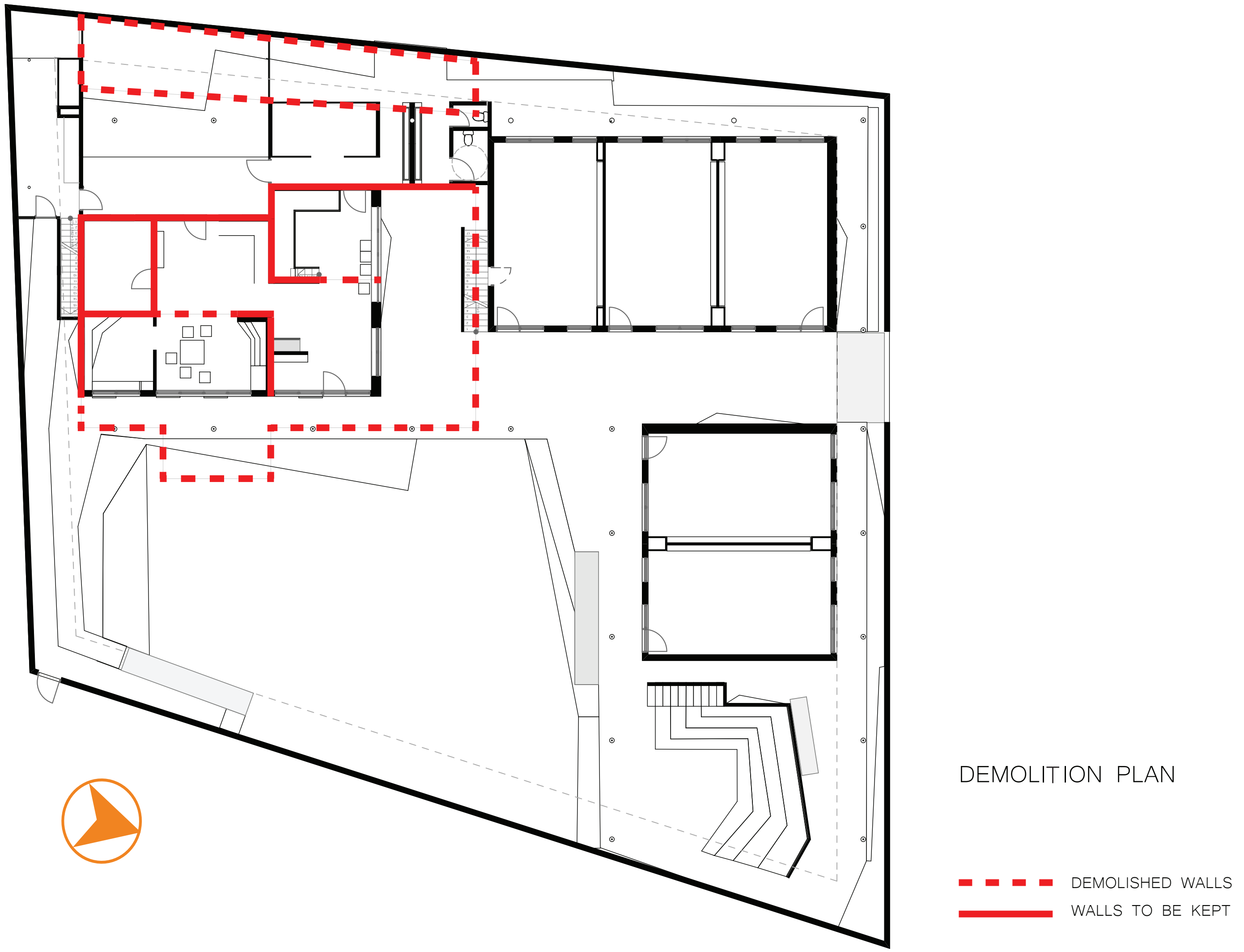
Our trip to Kampala gave us valuable insight in the situation of the users and the climatic conditions we designed for. The result of the project would have been quite different if the trip to Uganda was not conducted. The initial outlines and frames of the project we set before visiting Kampala and the existing Miles2Smiles center were very different from the ones we obtained after, especially regarding area use which we found to be extremely dense. This resulted in a higher tolerance regarding minimum area per child and we realized that the European standards were not applicable for this project.

We feel the New Miles2Smiles center reflects our vision of designing architecture that is both functional, aesthetic and provides a good and stimulating environment for the users.

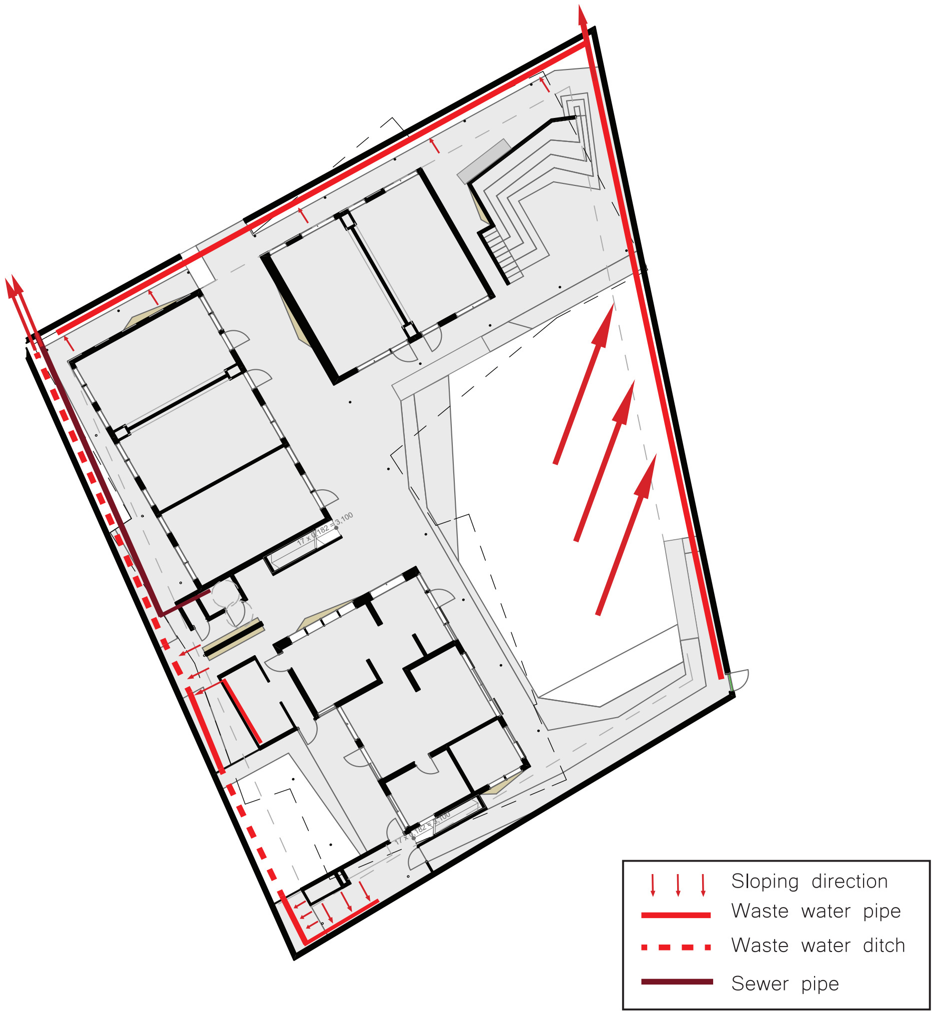
The architecture is honest and through its simplicity symbolizes the aesthetical potential of low-tech architecture. The concept of the protected and the protective is clearly articulated in the simplicity of the design, where these two are separated elements in a holistic design.

APPENDIX

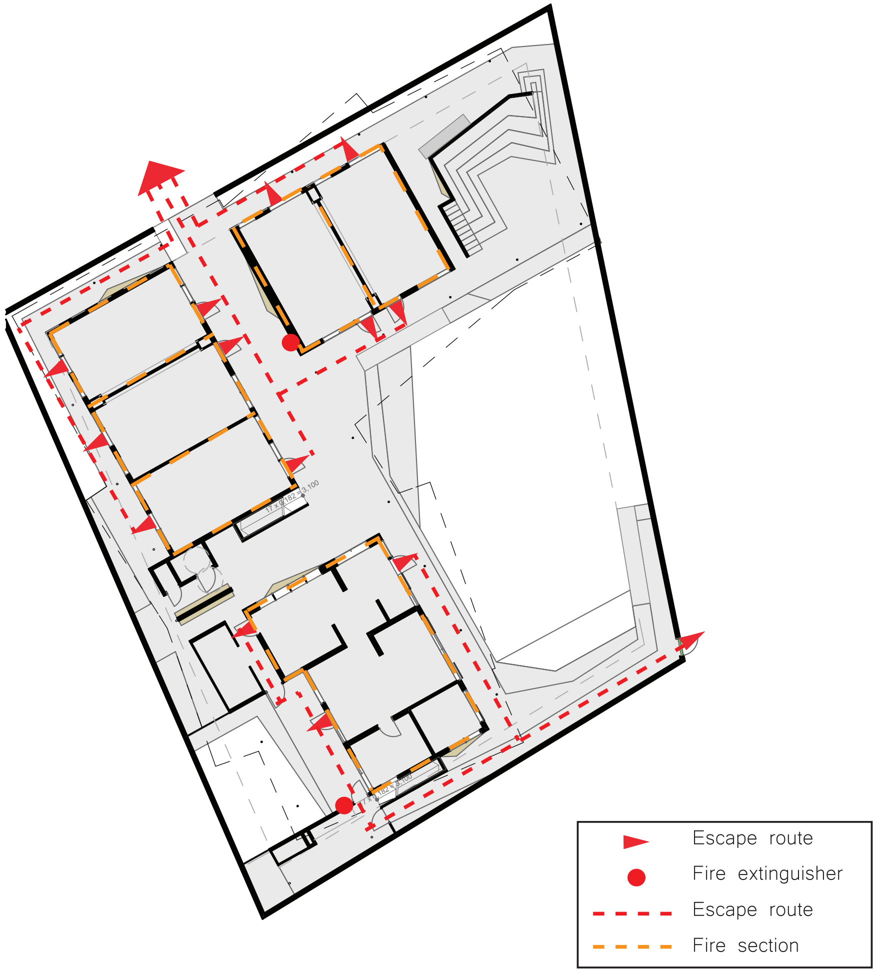
A: DEMOLITION PLAN



B: DRAINAGE & WATER PLAN



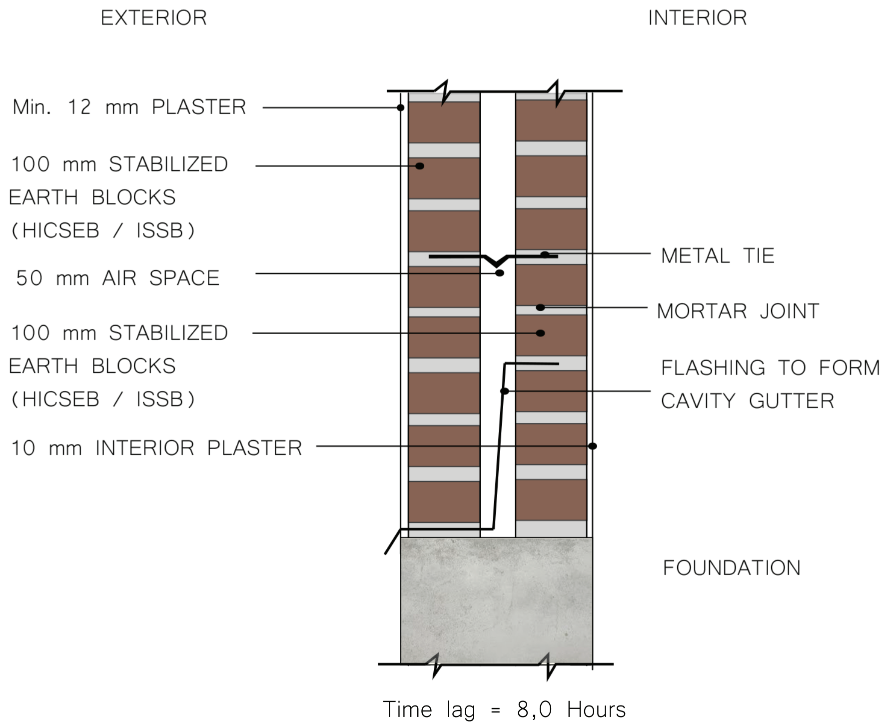
C: FIRE PLANS


Escape route
Fire extinguisher
Escape route
Fire section

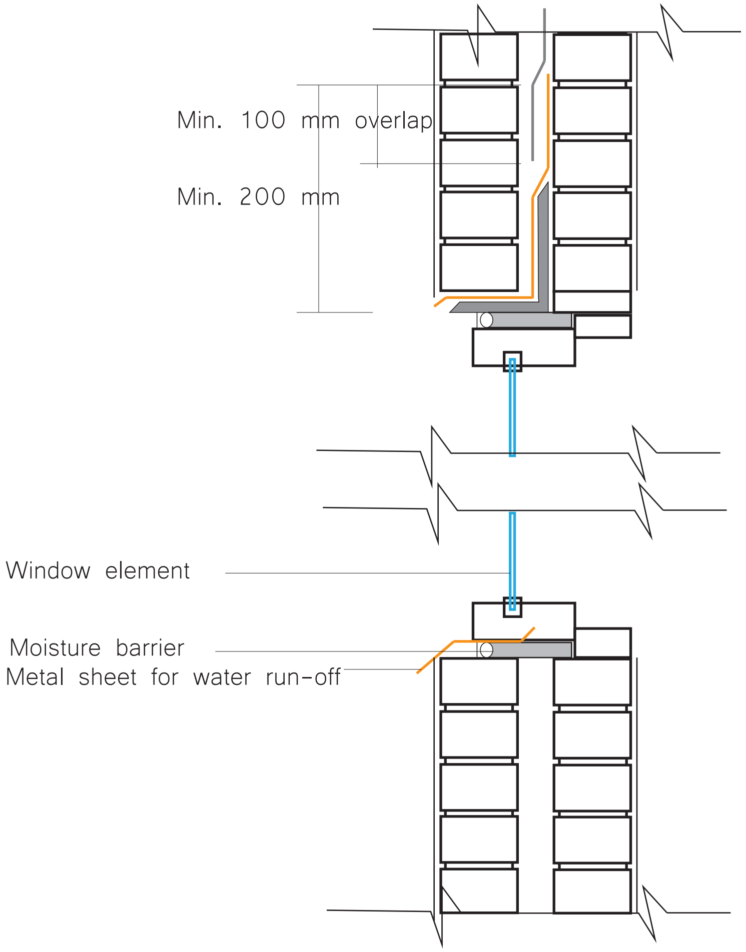

1.
Story
1:300
Escape route
Fire extinguisher
Escape route
Fire section

D: DETAILS

1:10



1:10 EARTH BRICK WALL COMPOSITE



1:10 WINDOW DETAIL

E: BSim SIMULATION

BSim is developed by the Danish Building Research Institute. In this project, version 7.13.10.1 is used and simulations are set to year 2002.

In order to conduct the analysis, relevant a relevant weather data file was obtained through http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm

For weather files in Africa, Uganda was not available, so its neighbour country Kenya was chosen. Within Kenya, the region was chosen to be Kisumu that also lies close to Lake Victoria.

As the surrounding settings are quite dense, location was selected to be in the city for simulating wind disturbances.

The selected time step for the simulation is set to 8. The option of simulating moisture is deselected, because it stops the simulation unless a higher number of time steps are chosen. A focus on the monthly and total results was held during the simulation and analysis of the results.

Modelling

The materials or constructions in the material database did not always match what we had in mind, so we had to customize the material layers for walls, roof and slabs and choose the windows with less performance based on energy.

The protecting roof was modelled as a separate, thin building that hovered 6 meters above the building. Adjacent rooms (thermal zones) were attached towards the ceiling and one side.

The model is oriented 75 degrees from north to match placement on site.

Not modelled for baby space, but if sufficuent for classrooms and it = 3 modules it should be enough. Even without walls it is the space gaining most solar radiance (probably) and therefore a higher ventilation is only beneficial

Systems

The only relevant systems were people load, venting and infiltration. No use of electricity is considered and ventilation is purely natural cross ventilation from vents and, if necessary, windows.

BSim is programmed to simulate that natural ventilation through windows happens when they are opened (venting). For this, all the windows have to be supplied with information of amount of area that can be opened in the model. In the software, 0,7 parts of the windows are simulated to open if set criteria's are exceeded. For CO_2 the criteria is 850 ppm and for temperature 26°C. The main ventilation through vents is therefore set as infiltration. The air change rate made possible through the design of the vents was gathered from the Natural Ventilation spread sheet (see appendix G).

Temperature

The simulation results show that the temperature in-doors does not exceed the desired range (21 - 26 degrees) during the day care hours (Figure 1), but on the overall results it shows that there are 301 hours beneath 21 degrees (Figure 2). This graph includes hours outside day-care hours. Thus, as seen in Figure 3, the lowest temperature of 19 degrees is outside day-care hours (when selecting "Always" as schedule instead of the "M2S Children" as shown in Figure 4). Through these functions in the software, it was seen that the hours beneath 21 degrees are when the children are not present, probably during evenings and nights.

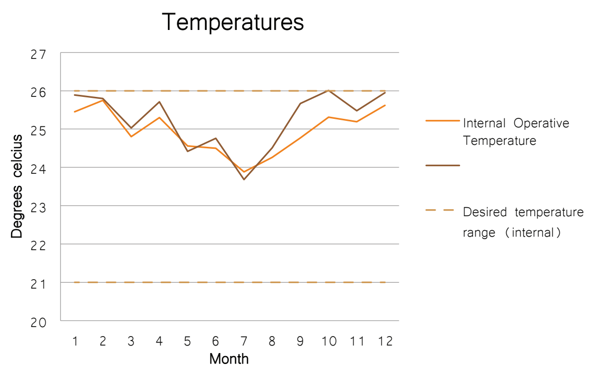


Figure 1

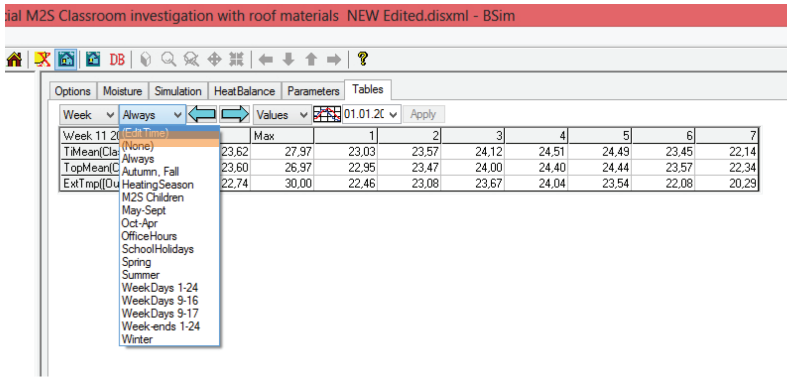


Figure 4

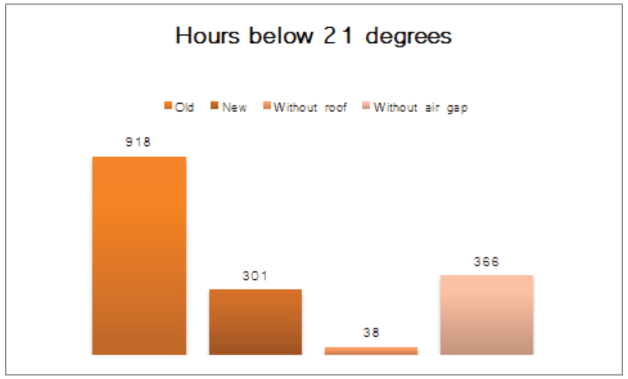


Figure 2

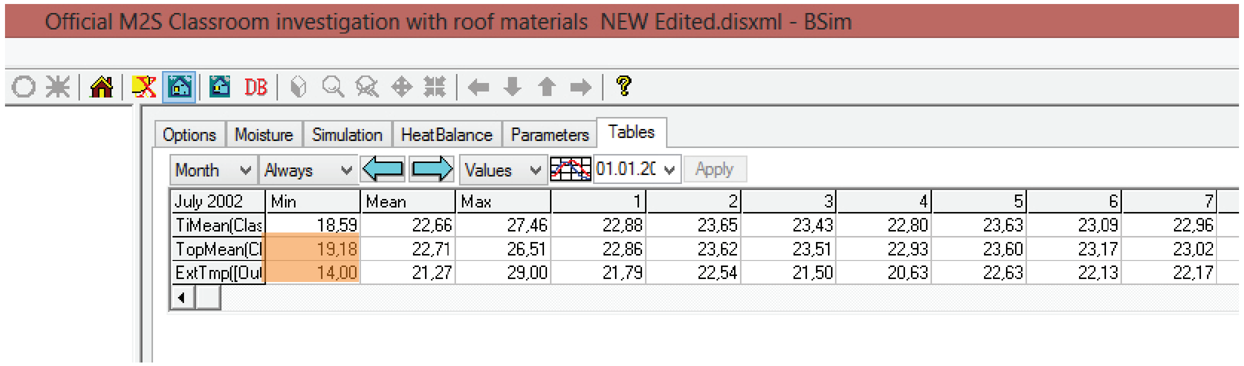


Figure 3

F: VENTILATION DEMAND CALCULATION

Since the project desires to achieve indoor environment category II, most values are taken from the DS EN 15251 and CR 1752 regarding educational buildings and children. Some values for adults are also used in consideration of the staff. The remaining information is extracted from the design and and the users' schedules.

For the calculations an average occupancy of 68,75 % is used as the rooms are not occupied during all the 8 hours of the average school day, but only during 5,5 hours.

In the calculation based on CO_2 level, the outdoor CO_2 level is defined as 350 ppm according to climate data extracted from the climate data file implemented in BSim. The calculation is based on the formula extracted from point A.3.7 in CR 1752

The calculation or demand based on sensory pollution is based on odour production from humans and building, Calculation is based on the formula extracted from point A.3.7 in CR 1752.

The fresh air need per person is set to be 7 l/s per person in category II. This multiplied by the number of occupants considering the average occupancy will give the total fresh air need for the occupants in the space.

Following these calculations, the air change rates are compared in a table and in a graph to see which criteria give the highest ventilation demands and what the minimum air change rate will become.

CO_2 Calculation	Children	Adults
Number of occupants	30,00	1,00
Average occupancy [68,75 %]	21,31	
Pollution load of chemical [l/h•person]	18,00	19,00
Allowed Co_2-level difference [ppm]	500,00	
Effectiveness [-]	0,70	
Floor area [m²]	35,00	
Air change volume for CO_2 [l/s•m²]		8,71
Air change ratio [1/h]		11,20

CO_2 Calculation	
Total pollution load	10,98
Allowance in time	1,80
Pollution per m²	0,61
Classroom volume [m³]	98,00
Classroom volume [l]	98000,00
Air change volume [l/h]	1098035,71

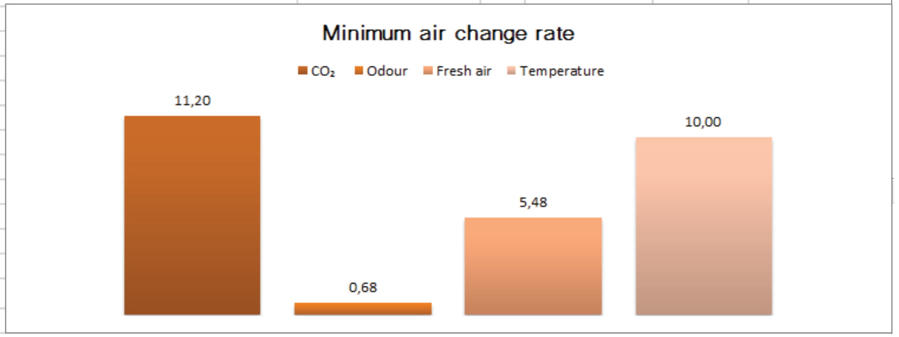
Percentage for pollution	
Children	0,97
Adults	0,03

Odour calculation	Children	Adult
Number of occupants	30,00	1,00
Average occupancy [68,75 %]	21,31	
Person pollution [olf/person]	1,20	1,00
Building pollution [olf•m²]	0,40	
Desired air quality	1,40	
Perceived outdoor air-quality	0,10	
Effectiveness	0,70	
Floor area	35,00	
Constant	10,00	
Air change volume for odour [l/s•m²]		0,53
Air change ratio [1/h]		0,68

Odour calculation	
People pollution for area [olf/m²]	1,34
Sum of pollution for area [olf/m²]	0,05
Air change volume [l/h]	66461,54

Fresh air need calculation		
Number of occupants on average	21,31	
Fresh air need for 1 person [l/s]	7,00	
Fresh air need for a classroom [l/s]	149,19	
Air change volume for fresh air [l/s•m²]		4,26
Air change rate [1/h]		5,48

Regarding temperature	
Air change rate [1/h]	10,00



Overall air change rate	
CO_2	11,20
Odour	0,68
Fresh air	5,48
Temperature	10,00

Highest air-change rate	11,20

Classroom

Calculations are based on the design, DSEN15251 and CR1752

CO_2 Calculation	Children	Adult
Number of occupants	55,00	5,00
Average occupancy [68,75%]	41,25	
Pollution load of chemical [l/h•person]	18,00	19,00
Allowed CO_2-level difference [ppm]	500,00	
Effectiveness [-]	0,70	
Floor area [m²]	87,00	
Air change volume for CO_2 [l/s•m²]		**6,80**
Air change ratio [1/h]		**8,75**

CO_2 Calculation	
Total pollution load	8,57
Allowance in time	1,80
Pollution per m²	0,47
Baby centre volume [m³]	243,60
Baby centre volume [l]	243600,00
Air change volume [l/h]	2131250,00

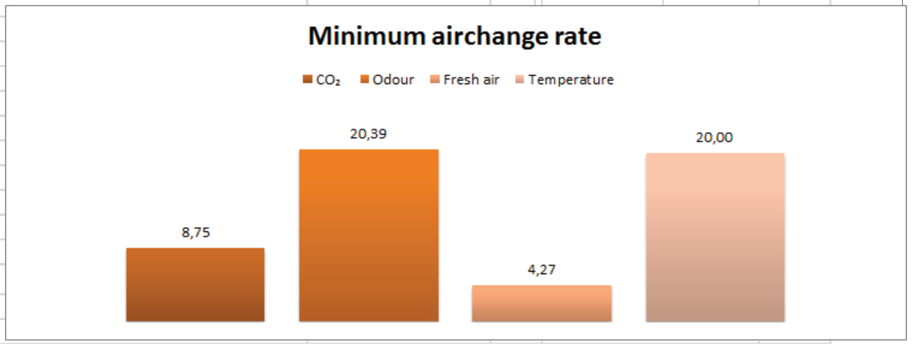
Percentage for pollution	
Children	0,92
Adults	0,08

Odour calculation	Children	Adult
Number of occupants	55,00	5,00
Average occupancy [68,75 %]	41,25	
Person pollution [olf/person]	1,20	1,00
Building pollution [olf•m²]	0,40	
Desired air quality	1,40	
Perceived outdoor air-quality	0,10	
Effectiveness	0,70	
Floor area	87,00	
Constant	10,00	
Air change volume for odour [l/s•m²]		**15,86**
Air change ratio [1/h]		**20,39**

Odour calculation	
People pollution for area [olf/m²]	1,04
Sum of pollution for area [olf/m²]	1,44
Air change volume [l/h]	4966813,19

Fresh air need calculation		
Number of occupants on average	41,25	
Fresh air need for 1 person [l/s]	7,00	
Fresh air need for baby centre [l/s]	288,75	
Air change volume for fresh air [l/s•m²]		**3,32**
Airchange rate [1/h]		**4,27**

Regarding temperature	
Air change rate [1/h]	**20,00**
Air change rate [1/h]	10,00



Overall air-change volumes	
CO_2	8,75
Odour	20,39
Fresh air	4,27
Temperature	20,00

Highest air-change volume	20,39

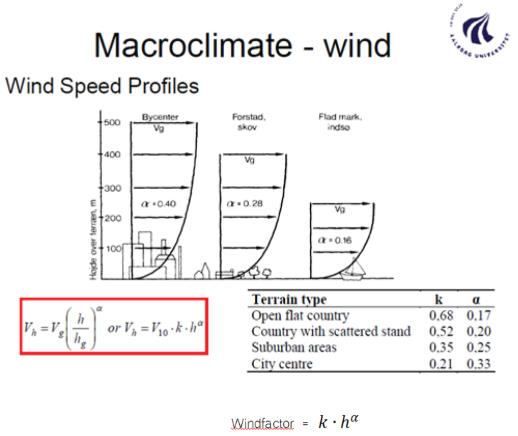
Baby centre

Calculations are based on the design, DSEN15251 and CR1752

G: AIR CHANGE CALCULATION

When using this sheet there are some certain input values that have to be found: information about climate and location and about wind pressure on windward and leeward side. Information from the design is also necessary, especially size and location of openings and windows used for ventilation. Some of these values are found in a lecture about Modelling of Natural and Hybrid Ventilation from the Architectural Zero Energy Concepts course at AAU (Lecture by Pomianowska, 2013), which is the same course where the spread sheet was obtained. Wind pressure coefficients are determined through figure 3.3 (i) and figure 3.3 (ii) from the Air Infiltration and Ventilation Center's document AIC-TN44: "Numerical Data for Air Infiltration & Natural Ventilation Calculations" for facades. The classroom that is chosen for calculation is one that lies with inlets towards south and outlets towards north. For this classrooms the table with wind direction of 45° is used (3.3 (ii)). Although the wind direction hits a classroom façade without openings or windows perpendicularly from east, the surrounding area is quite dense except towards east façade and it is estimated that the wind fluctuates between the neighbouring buildings. Therefore the wind is thought to hit the inlet façade with an angle of about 45°. The positioning of the baby centre is optimal for ventilation as the wind hits the façade perpendicularly and thus figure 3.3 (ii) is used.

In order to calculate the wind factor, a figure from a lecture in the Architectural Zero Energy Course (Lecture by Pomianowska, 2013) is used to determine factors regarding terrain (see figure on this page). Since our plot is not too far from the city centre and since the urban structure in the area is quite dense, factors corresponding to city centre were chosen (see figure below). To determine the meteorological wind speed, the annual wind diagram from the Energy Plus Weather file for Kisumu in Kenya obtained from the website of the U.S Department of Energy is used. The most frequent wind comes from the north-east or east and has a velocity between 10 and 20 km/h. From this, the meteorological wind speed was chosen to be 15 km/h which corresponds to about 4,17 m/s. To calculate the wind factor we chose our location to correspond to a location in the city centre where there are many obstructions for the wind (because of the surroundings and boundary wall). These numbers were then used as input to calculate the reference wind speed at a height from the ground and up to the middle of the openings or windows, which is 1,4 m (mid height of one story).



Inlets and outlets

The area of vents is reduced to half because of wooden lamellas crossing the openings and insect protection. One vent is therefore reduced from 0,5 m^2 to 0,25 m^2. The long window elements can be opened and have an area of 1,8 m^2 each, while the slightly shorter windows on the west façade of the baby centre are 1,5 m^2 each. The windows that can be opened are not covered in lamellas and are not fitted with insect protection and thus the whole area is inserted in the spreadsheet. The spreadsheet then calculates the effective area, which is the part of the areas that can be opened as it regards part of the openings to be frames.

Classroom			
Inlet	Quantity	Area per unit [m2]	Total [m2]
Vents	2,00	0,25	0,50
Windows	1,00	1,80	1,80
Total area [m2]			2,30
Outlet	Quantity	Area per unit [m2]	Total [m2]
Vents	3,00	0,25	0,75
Windows	1,00	1,80	1,80
Total area [m2]			2,55
Baby centre			
Inlet	Quantity	Area per unit [m2]	Total [m2]
Vents	9,00	0,25	2,25
Windows	4,00	1,80	7,20
Total area [m2]			9,45
Outlet	Quantity	Area per unit [m2]	Total [m2]
Vents	6,00	0,25	1,50
Windows	1,00	1,80	1,80
Smaller windows	2,00	1,50	3,00
Total area [m2]			6,30

Classroom

Pressure Coefficient		Windfactor	0,23	Pwind	0,60 pa
Windward	0,22	Vmeteo	4,17 m/s	Pmin	-0,36 pa
Leeward	-0,41	Vref	0,98 m/s	Pmax	0,13 pa
Roof	-0,60				
Location of neutral plan, Ho	1,81 m			Buildingvol.	98,00 m3
Outdoor temperature	28,00 C			Volume	m3/section/floor
Zone temperature	26,00 C				
Discharge coefficient	0,70			Internal pressure, Pi (pa)	-0,55
Air density	1,25 kg/m3				

	Area m2	Eff. Area m2	Height m	Thermal Buoyancy pa	AFR (thermal) m3/s	Pres Coefficient	Wind pressure pa	AFR Wind) m3/s	Win
Inlet	2,30	1,61	0,25	-0,13	-0,73	0,22	0,68	1,68	
Outlet	2,55	1,79	2,50	0,06	0,54	-0,41	0,31	1,25	
				Massebalance	-0,19		Massebalance	2,93	

VI (m³/h)	2387,93
ACR= AFR/Volume	24,37

Baby centre

Pressure Coefficient		Windfactor	0,19	Pwind	0,39 pa
Windward	0,44	Vmeteo	4,17 m/s	Pmin	-0,24 pa
Leeward	-0,28	Vref	0,79 m/s	Pmax	0,17 pa
Roof	-0,60				
Location of neutral plan, Ho	1,81 m			Buildingvol.	243,60 m3
Outdoor temperature	28,00 C			Volume	m3/section/floor
Zone temperature	26,00 C				
Discharge coefficient	0,70			Internal pressure, Pi (pa)	-0,55
Air density	1,25 kg/m3				0,01

	Area m2	Eff. Area m2	Height m	Thermal Buoyancy pa	AFR (thermal) m3/s	Pres Coefficient	Wind pressure pa	AFR Wind) m3/s	Wind pressure pa	AFR total m3/s
Inlet	9,45	6,62	0,25	-0,13	-3,00	0,44	0,72	7,12	0,16	1,45
Outlet	6,30	4,41	2,50	0,06	1,33	-0,28	0,44	3,71	-0,12	-1,45
				Massebalance	-1,67		Massebalance	10,82		0,00

VI (m³/h)	5225,26
ACR= AFR/Volume	21,45

Spread sheet obtained during the Architectural Zero Energy Concepts course at Aalborg University during the 2.semester of Masters in Architecture and Design study (2013)

H: U-VALUE CALCULATION

	Layer	Thickness [m]	Conductivity [W/mK]	Resistance [m2K/W]	U-value {W/m2K]
Wall		0,25			
	Indoor resistance			0,13	
	Plaster	0,01	0,43	0,02	
	Brick	0,09	0,711	0,13	
	Air gap	0,05	5,56	0,01	
	Brick	0,09	0,711	0,13	
	Render	0,01	0,43	0,02	
	Outdoor resistance			0,04	
	Sum	0,25		0,48	
	U-value				2,09
Roof		0,1			
	Resistance over roof			0,04	
	Aluminium	0,01	230	0,00	
	Ventilated air gap	0,05	5,56	0,01	
	Rubber (sliced tyres)	0,03	0,17	0,18	
	Aluminium	0,01	230	0,00	
	Resistance under roof			0,10	
	Sum			0,33	
	U-value				3,07
Ceiling slab	Outdoor resistance			0,04	
	Concrete	0,25	0,75	0,33	
	Indoor resistance			0,10	
	Sum			0,47	
	U-value				2,11

Values obtained from SINTEF Byggforsk Kunnskapssystemer (http://bks.byggforsk.no/) and the software Ecotect analysis.

I: RAIN WATER HARVESTING

Calculations based on formula from http://www.yougen.co.uk/energy-saving/Rain+Harvesting/

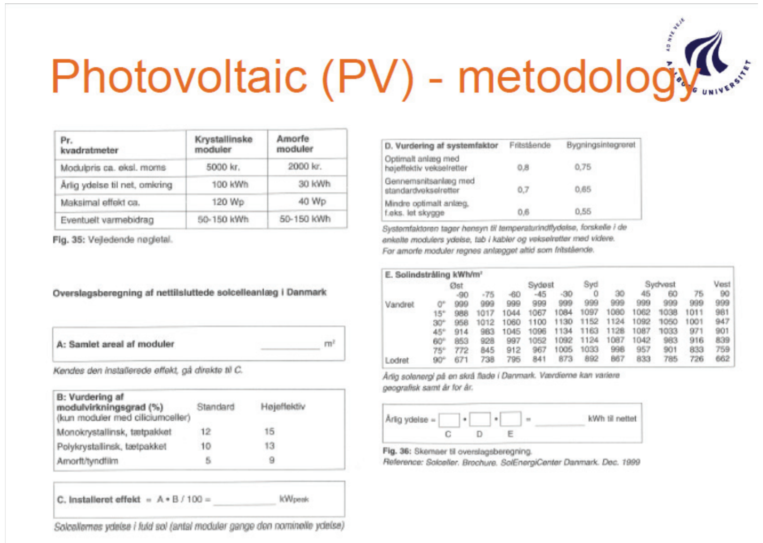
Rain water harvesting for main tank				
Harvesting potential		[l]	[l]	per day
		332715,60	332,72	911,55
	Roof area [m2]	293,40		
	Drainage area []	0,60		
	Filter efficiency [-]	0,90		
	Annual rainfall [mm]	2100,00		
Optimum sized tank		[l]	[l]	per day
		16635,78	16,64	45,58
	Annual harvesting potential	332715,60	332,72	
	0,05	0,05		
Tap water usage [l/day]		[l]	[m3]	per year [l]
		1300,00	1,30	339300,00
	Persons	260,00		
	Water use per person [l/day*pers]	5,00		
Toilet flush [l/day]				
		1560,00		
	Per flush [l]	3,00		
	Number of flushes per person per day	2,00		
	Persons	260,00		
Sum of water use [l/day]		2860,00		
Tank room size [m3]		[m3]	[l]	
		12,56	12562,50	

Rain water harvesting for Kitchen				
Harvesting potential		[l]	[m3]	per day
		79380,00	79,38	217,48
	Roof area [m2]	70,00		
	Drainage area []	0,60		
	Filter efficiency [-]	0,90		
	Annual rainfall [mm]	2100,00		
Optimum sized tank		[l]	[m3]	per day
		3969,00	3,97	10,87
	Annual harvesting potential	79380,00	79,38	
	0,05	0,05		

Kitchen tank size		[m3]	[l]
	Area	0,20	
	Volume	0,50	500,00

J: PV-PANELS CALCULATION

Potential production from PV panels on a roof	
Manufacturer/Model	Lumeta
System factor	0,80 Free standning
kWp	0,44
Module efficiency	15,00 High, monocryst
Solar radiance	1072,70 kWh/m2
Panel area	2,90 m2
Production pr panel	373,30 kWh
Productionpr m2	128,72 kWh/m2
Available	109,70 m2
Our production	14121,02 kWh/year
	Roof



Comparison:	W	kWh/year (8 hours use per day)		W	kWh/year (8 hours use per day)
One fan uses	50,00	146,00	One bulb uses	50,00	146,00
Number of fans that can be powered by PV		96,72	Number of bulbs that can be powered by PV		96,72
10 fans [kWh]	1460,00		23 bulbs [kWh]		3358,00
Needed number of panels	3,91		Needed number of panels	9,00	
m2 of panels needed	11,34		m2 of panels needed	26,09	

Total need (both fan and bulbs)	
Total needed number of panels	12,91
m2 of panels needed	37,43

Calculation based on lecture (Renewable Technologies) in the Architectural Zero Energuy Concepts course at the 2.semester at Aalborg University (2013)

K: GROSS AREA CALCULATION

Function	m2	Note
Totalt Tomteareal	1100	
Grouprooms (35x5) (210)	175	
Babyroom + quiet room (100/55)	87	
Storage (integrert) 1,9 x 6	11,4	In
Bathroom1 (potty, diaper)	8,9	In/out
Bathroom2 (wash)	10	In/out
Toilets x2	4,8	In
2nd floor:		
Reading space	76,6	
Creative play area	129,8	
Slide area	6	
Office x3	17	In
Staff area	10	In/out
Resource room	4,1	In
Grouproom3 (35x2) (100/60)	70	In
Outdoor:		
Reception	32,8	Shaded
Kitchen	12	Out, shaded
Food storage	2	In
Laundry	6	Out

Total footprint of building	275,7	
Total playarea on ground level	804,3	
Total built area on 1st floor	91,1	
Total playarea on 1st floor	212,4	
Total used area	1403,5	
Total primary area indoor	320,6	
Total primary outdoor	1016,7	
Total primary area	1337,3	
	265 barn	Area used
Total area per child in grouproom	1	30
Total primary area per child ind.	1,20981132	320,6
Total primary area per child outd.	3,83660377	1016,7
Total area per child in average	5,04641509	1337,3

L: PROPERTIES OF MATERIALS

This chapter will investigate the different building materials with regards to their properties, suitability and performance in the Tropics. When choosing materials it is also important to study and understand the physics that lies behind the different material`s performance, therefore basic material physics is presented initially.

Thermal radiation

Heat travels between two surfaces facing each other, from a warmer to a cooler, leaving the cooler surface warmer and the warm surface cooler (balancing each other). This process depends on the warm surface´s material emissivity, and the temperature difference between the surfaces, and also the angle of the surface.

The main thermal properties of materials to be considered are:

- Absorption of radiant heat
- Re-emission of stored heat
- Reflection of radiant heat

Absorption of radiant heat

The surfaces´ properties, absorption and reflectance, decide whether the energy received by the cooler surface gets absorbed or reflected (white = high reflectance (r), while black surfaces have a high absorbance (a) (ill. 2)

A + R = 1

Heat transmission

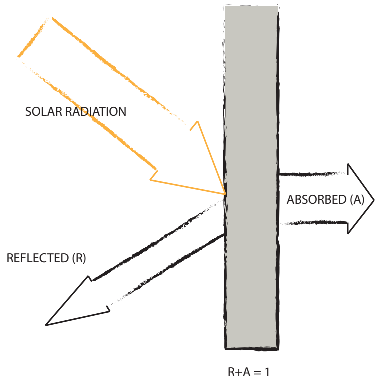
Heat transmission through a material (from high to low temperature) depends on the material´s conductivity and thickness, the surface´s conductance and temperature difference (inside/outside). A material´s conductivity (k (Lamda) = W/m2K) is the rate of heat flow through a unit area of unit thickness by a unit temperature difference between the two sides (Gut and Akernecht 1993). The lower the conductivity, the better the material works as insulation to obstruct heat transfer.

A material`s heat resistance (R) defines how much heat is prevented from travelling through a section of the material, and depends on the material`s thickness and conductivity:

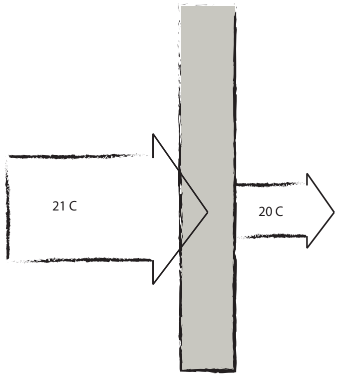
R= thickness/Lamda = 1/U

The total heat transmitted through a composite construction by a temperature difference of 1^{O}C is called the U-value of the composite.

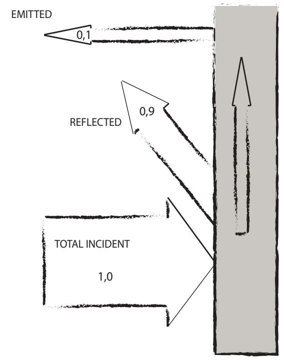
Total heat transmission= U x (ti-to) x (W/m2)U= 1/R



Ill. 1 Reflection of radiant heat



Ill. 2 Absorption of radiant heat



Ill. 3 Re-emission of radiant heat

Re-emission of stored heat

Heat emission at night is also important. It takes place only towards cooler surfaces, that is, mainly, towards the clear night sky (Ill. 3). There is no radiant heat emission towards other buildings and surfaces that have the same surface temperature. Where re-emission of heat at nighttime is desired, the surface materials should be porous, meaning that plaster and brick are more efficient for re-emission than metallic surfaces. The higher the emissivity of a surface, the better the building cools down at night.

Reflection of radiant heat

Much of the heat received by a building is through radiation, mainly solar radiation. The treatment of the outer surface is therefore important, to ensure that as much solar radiation as possible is reflected (Ill. 1). If a material has a high reflectivity, the surface receives less heat load by radiation, and the interior will thus recieve less heat loads through transmission through the material (Gut and Ackernecht, 1993). Lightweight constructions should always possess high reflective surfaces. Where radiant heat loss is possible, for example to the sky, a white surface allows less net gain. Where opposing surfaces are warm, there is no radiant loss, and aluminium is preferred. (white = high reflectance (r), while black surfaces have a high absorbance (a).

With regard to reflectivity, the property of the roof surface is of the greatest importance because it receives a far greater amount of radiant heat than any vertical surface, and can also re-emit more than other surfaces. Hence, it has to be carefully selected. If an absorbent surface is used, the time lag should usually be at least 8 hours. Lightweight roofs should have reflective surfaces combined with thermal insulation or a ventilated ceiling.

When selecting the building materials, their thermal properties should be analysed so that materials suitable to the local climatic conditions can be chosen. When considering exposure to solar radiation, the solar heatgain factor (SHF) is an important criterion to be taken into account, especially in the case of the roof. It is more important than the U-value.

Heat storage and Time lag

A material`s time lag, O (h) is the time heat need to pass through a material. More specific it can be defined as the time difference between when the outside surface temperature and the inside surface temperature of the material reaches its peak.

In a temperate climate such as Kampala, a compromise is necessary; too little storage capacity will result in overheating during the warmer periods, while too much heat storage capacity will make the building difficult to heat during the cooler periods

Specific heat (Wh/kgK) is the amount of energy required for a unit temperature increase in a unit mass of material (Gut and Ackernecht 1993). The higher the specific heat, the more heat the material will absorb.

Heat capacity, Q (Wh/m2K) is the amount of heat energy required for a unit temperature to increase in a unit of area (Gut and Ackernecht 1993.

Q= thickness x specific mass x specific heat

(The values for time lag, reflectivity, emissivity, specific heat gain factor, specific heat and thermal conductivity are studied in Climate responsive buildings: appropriate building construction in tropical and subtropical regions by Paul Gut & Dieter Ackerknecht)

M: CASE STUDIES

Olifantsvlei Primary School

Theme: Children and architecture

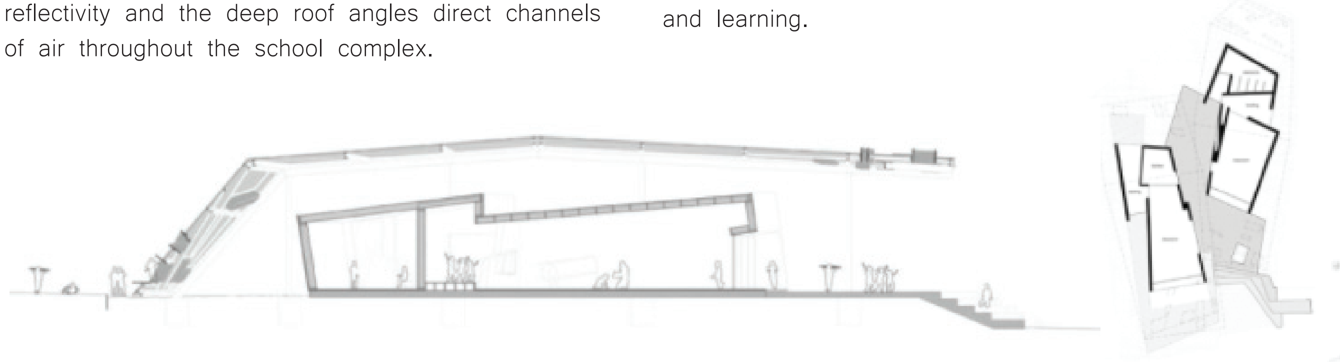
Location: Johannesburg, South-Africa

When the new Olifantsvlei Primary School was to be designed, a group of architecture students wanted to create a school that associated learning with fun. The playground is integrated into the architecture through colourful geometric shapes and openings in the tin shell that functions as both roof and sloping walls to shelter the whole complex from the sun.

The school, housing 80 students, consists of two classrooms, a kitchen, restrooms and an outdoor play area. A separate roof structure that folds and continues down to the ground creates a wing-like shading structure. The different functions are organized in different volumes placed under the roof canopy and all benefit from the shade. The roof is made out of white wrinkled tin sheeting with high reflectivity and the deep roof angles direct channels of air throughout the school complex.

This primary school represents a new learning style: making the students learn together. The shaded areas under the canopy are used for breaks as well as for learning and function as outdoor classrooms. The element that makes this project interesting is the way the separate roof construction has multiple functions such as shading, ventilation control and being part of the physical playing environment. The roof ties the whole complex together and simultaneously it creates interesting semi-outdoor spaces used for both playing and learning.

Ill. M.2-4



Ill. M.1 Section and plan

Gando primary school

Location: Gando Village, Burkina Faso, Africa

Architect: Diébédo Francis Kéré

The building is a standing example of an architectural project that educated the local community in building effectively with what is available for them. It was erected by the use of local materials and workers. The local community participated in all aspects of the construction and a local government agency was enlisted to provide training in brick-making and they were also taught to use a handsaw and small wending machines. Despite the challenge in explaining non-literate locals about the design and its drawings, the community gained much out of the project. After the building was finished the local workers who were trained during the construction of the school were offered to build other public projects using the same techniques. This proves the long-term effect on the community and the educational potential architecture beholds.

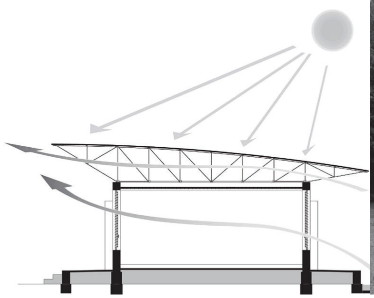
Form, layout and material were largely controlled by the local climate. The building consists of earthen brick classroom structures gathered under a large, soaring roof of corrugated metal that is held up by a lightweight steel truss system welded together by smaller handleable pieces of rebar. It is a double roof structure that provides passive techniques for shading, cooling and ventilation through the design itself. The soaring roof allows cool air to flow freely between it and the classroom ceilings and, simultaneously, it constitutes a large overhang that shades the façades.

The form of the roof is also a product of practical considerations. Difficulties and economic issues were seen in transporting larger elements to the site from further away destinations and in using heavier machinery like cranes. This made way for construction of the corrugated metal sheeting that rests on steel bars that create lightweight trusses.

Classroom volumes are arranged linearly with semi-outdoor spaces between them. These semi-outdoor spaces are shaded thanks to the soaring roof and they can be used in situations of play and educating without feeling discomfort under the sun. Walls and ceilings of these units are built of compressed and stabilized earthen bricks that give them load-bearing strength and moderates room temperature through its heat storing abilities. Across the width of the ceiling there are concrete beams crossed by steel bars.

Climatic comfort was achieved through low-cost methods by utilizing the potential of local materials and the local community at the same time as using minimal and adapted industrialized technology.

Later an extention unit (completed 2008) and a library (completed 2012) were also added to the school. These buildings follow the same basic principles of the primary school. In the extention has curved ceilings of the same bricks instead of linear ones. The library lies between the primary unit and extention and creates a protection from dust-carrying windsfrom east for the school-yard. An innovative solution for light and ventilation is displayed here by the use traditional and locally made clay pots. They were cut so that there was hole both at top and bottom and casted in the concrete ceiling. Since the library also is covered by a soaring, corrugated metal roof, the air circulation potential through these holes are enhanced as the metal heats up so that the air from the library is drawn up towards it. In addition to these traits, the area around the library are shaded by eucalyptus coloumns. Usually eucalyptus is considered as weed in the village and is used as firewood since it dries soil and shades less, but they are also termite resistant.



Ill. M.5: Section

Ill. M.6: ventilation strategy

"Without education, development is a dream." - Diebedo Francis Kere

Tromsø Kindergarten

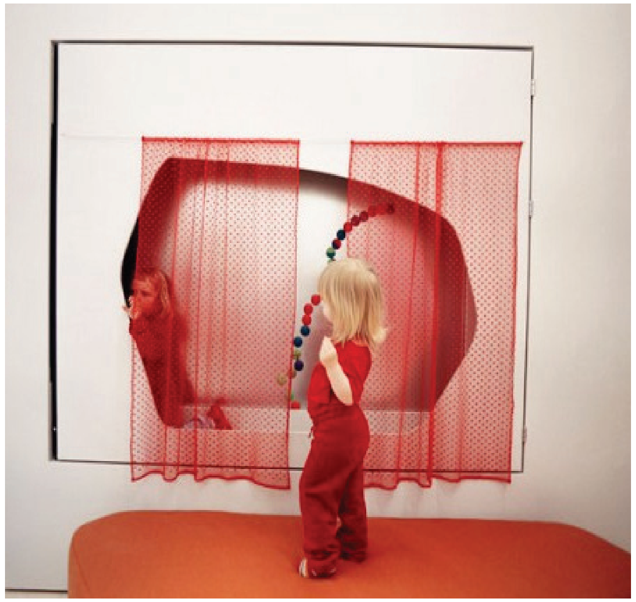
Architect: 70oN arkitektur

Location: Tromsø, Norway

What makes Tromsø kindergarten so special, is the way the walls are used as an active part of the playful interior design. The interior space, designed by 70oN arkitektur, is divided by wall segments that create spaces within the large space. The walls have holes and openings in different sizes and provide for a variety of functions and areas for creative play; as partition walls, creating miniature space sto be used as part of the children`s play, as spaces in which to withdraw from the action, elements to climb, stage for a puppetshow, a shop, etc. The ways in which the walls can be used are many, and the walls are creating a number of different experiences within one larger space.

By moving the elements of play up from the floor in a vertical manner, a larger area of the room can be utilized for play. Storage is also integrated into the walls, freeing even more floor-area.

The play-walls are all in different colors, and the openings are in contrasting colors to highlight their appearance and create a very child-friendly and aesthetically stimulating interior design.



Ill. M 7-9: Interior

Fuji Kindergarten

Architect: Tezuka Architects

Location:Tachikawa, Tokyo, Japan

Ill. M 10

Fuji Kindergarten is designed to maximize a limited plot in a sub-urban area for 500 children. The built volume is planned so that as much as possible of the ground is left for the children to use in their play and in addition they are given access to an open play-space on the roof of this 1-story, oval shaped building. The children have access to these spaces and can move around in and between them to use for their play and development. The rooftop expansion of outdoor play-area is connected to the ground floor through stairs and a slide outdoors and indoors it is made accessible through climbable elements which drop down from skylights and into the classrooms. Three large trees in the plot are preserved for the children's play that includes climbing as they simultaneously provide shading for parts of the play area. Where the tree penetrates the roof decking a net secures the children from falling down and is also used for seating and climbing.

The oval shape creates a courtyard and connects the different sides of the building to each other physically and visually. It gives an overview for both the children and the caregivers. It also creates a rooftop play-space without dead ends. By assemblies and gatherings, the centre of the courtyard functions as a focus point or stage while the circular form becomes the spectators arrangement around it both on ground level and on the rooftop.

The building has an oval shape that frames an inner courtyard. The roof of the building slopes toward this courtyard so that the caregivers can have an overview of the children up on the roof from the ground.

The playground is equipped with taps for the children to use for play or washing and since the ground by the taps is covered by wood that absorbs the water they are made aware of the effect water has on the wood.

Ill. M 11

Ill. M 12

N: VERNACULAR ARCHITECTURE

A good way to understand the background or history of building culture and principles is to look back in time and look at the architecture made in early times and in a daily-life situation. Such architecture can be referred to as vernacular. A lesson on vernacular architecture can help us look back in history of our building culture and techniques to see that the same principles, maybe modified, can be useful in today's building culture as well. It is a lesson of built, architectural tectonics. Although we have modern technology, materials and broader experiences than long time ago, some principles are and have always been fundamental in building and designing. These principles of vernacular architecture can help enhance the project in its simplicity, readability and sustainable aspects.

Vernacular architecture can, as John May mentions in Buildings without Architects, be seen as the architecture designed and built by communities or owners using traditional techniques and available local materials and tools – an architecture of the people. According to the Atlas of Vernacular Architecture of the World by Paul Oliver and Marcel Velinga, it is estimated that the number of existing buildings in the world is above a billion and 80 % out of these are thought to be vernacular (May, 2010).

In the rapidly developing western world technological development has introduced new materials and techniques in the building industry and traditions, knowledge and skills of ancestors are diminishing. Africa, Asia and Latin America have preserved many of these abilities and much of the knowledge of traditional building techniques through having a close connection to their vernacular architecture. These continents are also undergoing increasing development and this calls for a greater focus on how to better preserve the vernacular traditions and perhaps adapt them to an architecture that suits the changing situations.

Vernacular architecture is, first of all, practical – it's adapted to climate and place and the basic needs, culture and traditions of the people who created it. It contains valuable principles for sustainable, climate and geographically adapted building and traces of culture, belief and expression. As time passed, modern architecture with developed technology, more expressive purpose and new materials made vernacular architecture be categorized as "primitive", but today, many architects, builders and engineers look back to this architecture to find incorporated and adapted sustainable solutions in a world with growing demands. Vernacular architecture can give inspiration to "hand-made" architecture with innovative solutions.

African Architecture from indigenous times

As this project is to be built in the Africa, it could be useful to look into the older, vernacular building culture and principles within the continent to seek for relevant information on how to build in these lands and with which materials and principles. This will also reveal some tectonic aspects of African architecture.

Africa's climate and landscape varies from dry savannah landscapes to well-watered lands of lush vegetation and rainforests. These variations lead to diverse architecture across the continent. In addition to this, culture and traditions of the many ethnic groups also affect the layout and expressions of their homes. As the basic to all architecture, early African architecture is also about creating a shelter for man to protect himself from the surroundings.

The landscape and climate does not only define how these shelters are formed to protect the users, but also by what they are made of – the available materials. In the dry areas earthen materials are primary in the indigenous building culture because of its accessibility. Where there were grasslands or bush vegetation there were chances of making thatched roofs to these buildings as well. In inland areas with savannah climate one also needed to shelter from the desert winds. High diurnal temperature changes made the architecture seek for solutions that could shelter from biting cold winds and hot middays. Buildings in these landscapes often had a more spherical form because of the material's flexibility and its abilities of strength in such shapes. The earthen construction's ability to store heat during the day and release it in evenings was also a highly appreciated aspect of the material. The form also helped to radiate heat towards the center of the space within. To preserve strength and shade from intense light and harsh winds, and utilize the earth's heat storage ability to the most, openings were kept to a minimum. In the most northern regions where the lands become drier one had to dig deeper for suitable earth consistency and access to adhesives and hardening medium like dung and vegetal juice are less. Here one would tend to use more stone material, but the available tools would not always be the best to process the stone. This resulted in constructions with rubble masonry resting on beds of earthen mortar. In regions by the river it was not uncommon to use fishbones and shells as hardening agents in mortars.

In rainforest areas where vegetal material like bamboo and palm was available, it was easier to build in rectangular shapes because of the materials' straight form and this was also more suitable for cross ventilation. The high temperatures and low temperature variations demanded well ventilated buildings to preserve comfort, thus more openings were preferred. Coastal buildings were equipped with louvered or natural openings, raised floors on platforms to catch ocean breeze, bamboo screens and were often rectangular due to the climatic conditions. The forest vegetation would filter light and give shading naturally in most of these areas.

In regions between the forest and savannah vegetal material and earthen material were combined in the structure. Because of rain, pure earthen constructions were in risk of being washed away or weakened and therefore earth needs to be combined with vegetal reinforcement. In such regions wattle and daub constructions were preferred, where the vertical wattle consists of bamboo or palm frond tied together horizontally and the daub, packed within, consists of earthen material.

The local culture, traditions and occupations of the communities also had influence on how their shelters were formed. Expression of culture, hierarchy, family structure and spiritual and cosmological beliefs affected floor plans and ornamentation. Tools used in their daily life in their home, during hunting or in agricultural activities were the same used when building. In this sense, the architecture of the local communities was not only shelters for them, but also an expression of their identity.

An example

One of the most famous vernacular buildings in Africa is located in Mali and it is also the largest mud-brick building in the world: the Great Mosque of Djenné. This was the first mosque in the area in the 13th century, but it has been demolished and rebuilt a few times. Mali is known for its use of earth in architecture. The walls are 41-61 cm thick and vary in height. They consist of sun-baked mud bricks, ferey, coated with mud plaster. The plaster enables a smooth sculptural expression. Since the constructions are thick and made of earthen material, they have the ability to collect warmth from the sun during the day and release it to the interior during the night. Palm branches and ceramic pipes are incorporated in the walls of this building. The palm branches reduce cracking of the mud plaster that may occur from drastic changes in humidity and temperature, while the ceramic pipes function as drainage of the water from the roof before it affects the walls. Another function of the palm branches is that they act as scaffolding to step on for maintenance during the spring festival, crepissage. The whole community takes part in re-plastering the building during the festival (May, 2010).

Ill. N.1

Lesson Learned:

After discovering the background of vernacular and indigenous architecture of Africa it is visible that the architecture can tell more than a human being's need for shelter. Lessons of culture, beliefs and roles the various members of a family or society had is also embedded into their buildings. The hand-built architecture is, of nature, tectonic. It is simple, readable and honest – it includes function and aesthetics. As seen in the Great Mosque of Djenné, the architecture also included some integrated, multi-functional elements. The palm branches in the walls reduce cracking of the mud plaster, but they also provide scaffolding to make maintenance easier.

In the savannah and drier areas earthen materials were most used due to its accessibility. This material can help design in flexible forms and they are endurable in the relevant climate. It is this type of indigenous architecture that might be most relevant to study since Kampala's climate and placement relates to this earthen-vernacular building traditions.

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List of Illustrations