POLITECNICO DI MILANO

MODULARITY AND FLEXIBILITY IN ARCHITECTURE: A PROTOTYPE FOR EMERGENCY SITUATIONS IN DEVELOPING COUNTRIES

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ABSTRACT
This paper study Mozambique as the background, first research is climate design and disaster prevention policy school design in Mozambique. And then from different developing countries perspective, choose some typical cases of school building develop status, policies, etc., to study the advantages of school design, and how they solve some thorny problems.

The focus is on the importance of modular design for the developing countries. There are two cases of a typical modular school design in two developing countries, extending to the idea of modular design in Mozambique. Modular design emphasis on total re-engineering of building materials, their manufacturing processes, construction and operation requires redesign, waste reduction and transformation into energy producing products and building. A sustainable future of architecture demands research into renewable, adaptive, recyclable and environmental building components. One of the primary intentions of revisiting modular building systems is to explore the past, discover possible patterns and solutions and reconsider what might be missing.

Key words: developing countries, education emergency policy, architecture design, modular and flexible design.

CHAPTER ONE - INTRODUCTION AND BACKGROUND
1.1 INTRODUCTION
This article is start to study Mozambique as a background, and study some different developing country examples to find a good way to solve the school architecture planning and design at those countries. How to build a low construction cost and how to use their local materials become a big issue, thus in this paper, it will find a good solution to solve it.

Relocatable buildings represent one of the most popular forms of 'modular' construction today. Yet, the processes by which such buildings are manufactured, is a far cry from applying present technological advancements. There are significant opportunities to advance the entire modular design, its structure, building materials and services technology. These opportunities require research at the pre-design as well as the prototype stages. This assignment is also in need of an organized research structure inclusive of economic, environmental, and social benefits of modular dwellings.

1.2 MOZAMBIQUE: COUNTRY OVERVIEW
Mozambique is located on the southeastern coast of Africa and is bordered by Tanzania to the North, South Africa and Swaziland to the South, Zimbabwe to the West and Zambia and Malawi to the northwest.

Mozambique is made up mainly of coastal lowlands, rising toward the west to a plateau ranging from 500 to 2,000 ft above sea level and on the western border to a higher plateau (6,000 to 8,000 ft), with mountains in the north reaching a height of over 8,000 ft. The highest mountains are Namuli (7,936 ft), Binga (7,992 ft) on the Zimbabwean border, and Serra Zuira (7,306 ft) in Sofala Province.

The most important rivers are the Zambezi flowing southeast across the center of Mozambique into the Indian Ocean, the Limpopo in the south, the Save in the middle and the Lugfenda in the north. The most important lake is the navigable Lake Niassa. In the river valleys and deltas, the soil is rich and fertile, but southern and central Mozambique have poor and sandy soil, and parts of the interior are dry.

Mozambique has continued to register high economic growth in the few past years. The Mozambican economy recorded a rate of economic growth of 8% between 1996 and 2006[39] and between 6–7% from 2006 to 2011 of the previous year (World Bank, 2013). Despite this, social problems, low levels of education for example, are still a constraint for the country’s development. According to the Mozambique Household Survey of 2012/2013, the adult literacy rate (population over 15 years) was 56% and the prevalence of poverty was 54%. The literature in economics of education emphasizes a strong relationship between low income and low levels of schooling. Therefore, one of the possible central reasons for low levels of education could be the high levels of poverty within the country or the other way around.

Rapid expansion in the future hinged on several major foreign investment projects, continued economic reform, and the revival of the agriculture, transportation, and tourism sectors. In 2013 about 80% of the population was employed in agriculture, the majority of whom were engaged in small-scale subsistence farming which still suffered from inadequate infrastructure, commercial networks, and investment. However, in 2012, more than 90% of Mozambique's arable land was still uncultivated.

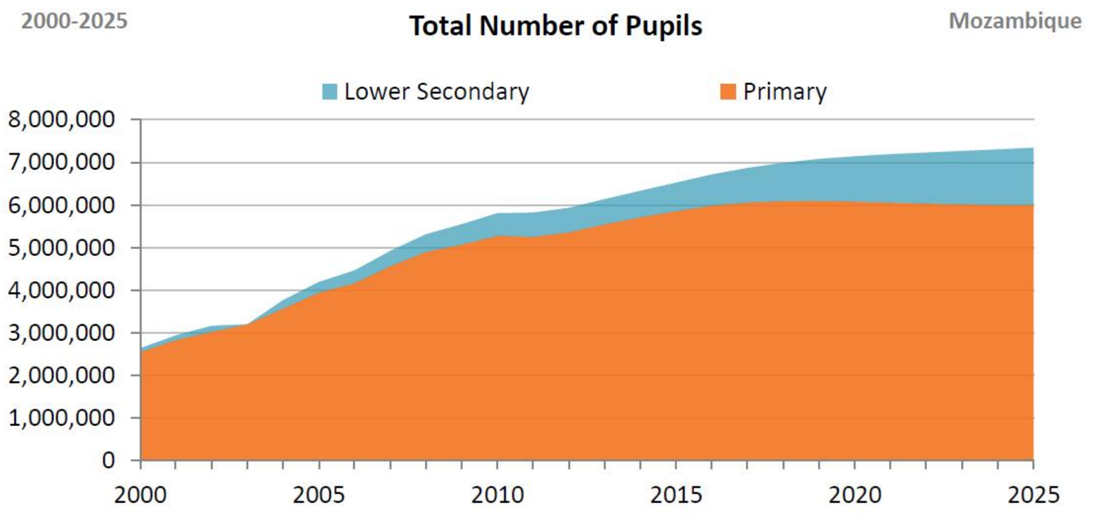
In 2013, a BBC article reported that, starting in 2009, Portuguese had been returning to Mozambique because of the growing economy in Mozambique and the poor economic situation in Portugal.

1.3 The education sector in Mozambique

1.3.1 Background

The decade of the 80s in Mozambique was characterized by political instability and the civil war. Consequently, a large proportion of the rural population moved to the major urban areas and it had a negative impact on the education system. The stagnation of the education system during 80s and early 90s was mainly explained by negative factors such as infrastructure destruction, social disintegration and the economic crisis.

As consequence of the war, the number of pupils decreased to fewer than 1,2 million (UNDP, 1990: 41). It is important to mention that the negative effects of the war had not been felt in a uniform way all over the country. The UNDP Report (1990: 41-42) demonstrated that Tete and Zambézia were the provinces which had seen most part of their education infrastructure destroyed or closed. In addition to the political crisis, the development of the education system was in this period also influenced by the implementation of the Structural Readjustment Program (PRE) from 1987. It resulted in a deep deterioration of the conditions of the education system because the program (PRE) did not give priority to education in its budget.



1.3.2 The Education System

The education system in Mozambique has slowly been rebuilt after the civil war, which destroyed at least 50% of primary schools. In 1990, private schooling was reintroduced. Education is compulsory for seven years, but in practice, most students do not study for the full compulsory period. Primary school covers these first seven years. This is followed by five years of general secondary education or five years of technical school. The academic year runs from August to June.

Primary school enrollment in 2013 was estimated at about 55% of age-eligible students. The same year, secondary school enrollment was about 12% of age-eligible students. It is estimated that about 52.4% of all students complete their primary education. The student-to-teacher ratio for primary school was at about 67:1 in 2013; the ratio for secondary school was about 27:1.

Eduardo Mondlane University is established at Maputo. The objective of the government is to promote the spread of education at all levels through democratization guided by the state. In 2013, about 1% of the tertiary age population were enrolled in some type of higher education program. The adult literacy rate for 2014 was estimated at about 46.5%, with 62.3% for men and 31.4% for women.

As of 2013, public expenditure on education was estimated at 2.4% of GDP, or 12.3% of total government expenditures.

1.4 BACKWARD EDUCATION SITUATION IN MOZAMBIQUE

Imagine if this were your classroom: Wind whistles through walls made from strips of coconut wood crudely lashed together, and the roof is a corrugated metal sheet. The floor is dirt that turns to mud when it rains. There is no furniture, let alone a library or a lab. There are neither toilets nor fresh water, putting children further at risk for disease. There is no electricity.

Inside the old-school buildings, children had to learn while sitting on a dirt floor. To get there, children must walk long distances along unsafe roads. Even so, classes are crowded and must be held in three shifts beginning at 6 a.m., because teachers are in short supply — one may be responsible for as many as 80 pupils. Many teachers are barely educated, themselves.

Come to the typical primary school in Mozambique's Zavala district, in a country where 70 percent of the population lives in poverty. Nearly 40 percent of its men are illiterate, and the rate for women is 70 percent, which is unsurprising in light of such difficult access to education.

Officials in Zavala's education department are concerned about the challenge. "We don't have enough educational opportunities," says one of them, Francisco Carlos. "The demand is high. Children get enrolled at school at an early age but drop out because of distance and other reasons." And when children drop out, they are more vulnerable to early pregnancy, child marriage, exploitative working conditions and abuse. Not long ago, ChildFund Mozambique's national director, Chege Ngugi, noted his excitement about ChildFund's incipient work in Zavala. "It is one of the very needy districts in Inhambane province," he said, "and to date there are no other [development organizations] working the area."

Part of ChildFund's work in Zavala is to improve access to educational opportunities there. To date, two schools have been built, and another two are under construction. Their walls are brick, the windows are glass, and the roofs are sturdy. Students sit on benches at desks. There are blackboards, reference books, basic supplies such as paper and pens and other equipment. In the few short months since the Mazivela Primary School opened in the Mazivela community, enrollment has climbed from 523 to 625, and similar growth is expected at the brand-new Nhaliveu Primary School in the Mavila-Nhacuonga community.

“Now we can practice writing well because we have beautiful classrooms with benches and nice blackboards,” says Flora, an 11-year-old girl in Mazivela Primary School's grade 6. “Before, it was difficult due to sitting on the sandy floor, and now we don't stay home when it is raining. Now the rain does not get into our beautiful classrooms.” “ChildFund is giving all its support to provide quality education and access to children in Zavala,” says Carlos. “ChildFund built better classrooms and provided furniture. Teachers are given training and follow-up.”

The distances are still long, and the roads still unsafe. But for the children of two (and soon four) communities in Zavala, their destination is a clean, comfortable place to learn.

CHAPTER TWO - LOCAL AND GLOBAL MODERN DEISIGN THINKING IN MOZAMBIQUE

It’s no accident that the most significant architectural achievements in Africa are to be found among educational buildings. The basic schooling of the African– as well as the education of his teachers–ranks before all economic, political, military, and other considerations. Elementary and technical schools, teacher’s colleges, and universities are thus the primary tasks of building in the new nations. - Udo Kultermann, 1969

2.1 DESIGNING WITH CLIMATE IN MOZAMBIQUE: SCHOOL BUILDINGS PRODUCTION

Modern movement architecture in former African Portuguese colonies, namely in Mozambique, was developed within the scope of African investment overseas conducted by the Estado Novo dictatorship (1926–1974). According to updated UNESCO policies (1951), the educational program was a main focus of investment initiatives, following the strategies of other African countries (Raedt, 2012).

Although high school buildings were initially designed in the metropolis (Lisbon) by professionals connected to the Board of Construction for Technical and Secondary Education (1934–1969)3 or later by the Ultramarine Urbanization Office4 (Tostões; Bonito, 2012), the role would soon shift to local offices. At the same time, two phenomena were of particular consequence: the wave of Portuguese architects’ emigration to African colonies after World War II and the increasing autonomy of these territories (Tostões; Oliveira, 2010). In Mozambique, it gave rise to the development of the Public Works Department (Ferreira, 2008), where a school trail– blazer concept was developed by Fernando Mesquita.5 Seeking for comfort in a tropical climate, a modus operandi was conceived and applied (Ferreira, 2012), varying according to the climate of each site. Establishing a methodological brand, an efficient and technical approach was achieved connecting design tools with school requirements.

2.1.1Thinking Global

The Fernando Mesquita concept arose from the need to construct educational buildings on a large scale and in a short period, throughout the whole of Mozambique and for several education levels. Emphasis was placed on fast execution at minimum cost. However, the education program in Mozambique was still in the process of being defined. Given the uncertainty of the program and of the school population, one of the key design requirements was "to ensure the school has the greatest possible flexibility in future use, alteration, extension or adaptation, in order to reduce the risk of obsolescence" (Mesquita, 1961).

Therefore, depending on age level and type of education, the concept was developed electing the classroom as the basic unit of spatial organization. More or less square in plan, the classroom is designed in a single compartment, always with at least 2 sides in contact with the outside, and flanked by a covered circulation gallery on 1 side. Initially designed for primary schools, based on the continued aggregation of rooms side by side, this model was later evolved in professional and secondary schools (technical, preparatory, commercial, industrial and high schools). Here, the basic unit of spatial organization is the grouping of classrooms, referred to as pavilions. These are distributed perpendicularly along a main covered circulation gallery. In some cases, the schools acquired 2 main circulation galleries, structured on a grid of orthogonal circulation, such as the Lourenço Marques Technical Elementary School (nowadays Estrela Vermelha High School) built in Maputo in 1961.

Acting as a backbone, the main gallery is assumed as the principal circulation channel, perpendicularly linked to the secondary access galleries, which give access to all the pavilions. With strict rationality and functionality, this system allows an economy of paths while ensuring shelter from the elements.6 In terms of functional organization, schools are divided between the school sector–aimed for teaching activities–the administrative sector and communal spaces. In the 60s, the sports sector also assumes a major role in high schools, with an independent pavilion for physical education. The school sector always assumes the major role. In primary schools, it is composed of a single floor of classrooms. In the professional and secondary schools, it is divided between classrooms–usually in 2 or 3 two–storey pavilions–and experimental teaching classrooms (workshops, crafts, design, etc.)–in 2 or 3 one–storey pavilions of more generous dimensions. The Portuguese Youth had as well a pavilion of its own, with the gym, such as the canteen and the choral, usually located in small spaces at the end of the main circulation gallery. In these schools, the administrative sector also acquires an independent pavilion, always adjacent to the school entrance. A backbone along which the programmatic blocks are judiciously articulated, Fernando Mesquita's system constitutes an archetype adaptable to different contexts. Almost based on a logic of mass production, his model projects were able to respond quickly and efficiently to the shortage of school buildings in the whole country.7 However, no two similar designs can be found in Mesquita's legacy of school buildings: he was beyond the simplistic logic that a model project could hide.

2.1.2 Thinking Local: Design with Climate

The climate of most of the case study sites–Maputo, Inhambane, Beira, Chimoio (former Vila Pery), Quelimane, Nampula, Pemba (former Porto Amélia) and Nacala–is characterized by average high temperatures of 22ºC in the hot season, combined with torrential rains bringing about high levels of moisture in the air. The main challenges for architectural design in tropical and subtropical regions lie in the optimization of solar gains and rain protection, while ensuring maximum ventilation to counter the effects of humidity.

To assure a positive environmental performance in these schools, the classroom was conceived as a single compartment between two opposing façades with a strong relationship with the exterior. What immediately caught the attention of Prof. Ana Tostões and Maria Manuel Oliveira during their missions to Mozambique (2010 and 2012), was the detached and non-aligned implantation of these structures in the urban context, suggestive of the importance of climatic considerations in the design. The buildings' implantation with respect to solar paths and wind directions would become the most representative principle of Mesquita's design with climate.

2.2 MOZAMBIQUE INITIATIVE AIMS TO BUILD SAFER SCHOOLS, PROTECT CHILDREN FROM DISASTERS

As schoolchildren sit quietly listening to their teacher or even gazing out the window, the furthest thing from their minds is the safety of their school building. They may be unaware that their school is located in a flood zone or that last year's cyclone has weakened the roof, which may be in danger of collapsing, but these are very real issues affecting schools in Mozambique due to the country's extreme exposure to natural disasters.

The Mozambique Ministry of Education is taking great strides to ensure schools remain resilient to the impacts of these disasters and provide safe and nurturing learning environments for children. A joint initiative has been developed with the aim of reducing the risk of damage to a school's infrastructure, protecting the children inside and ensuring education facilities remain functional.

Disasters have caused a disruption of education in Mozambique for quite some time. In 2012, Cyclone Funso and Tropical Storm Dando damaged 1,000 classrooms along the eastern coastline and in 2013, heavy flooding affected 250 classrooms in the Limpopo Basin. According to UN-Habitat, 60% of schools in the country are located in areas that can be exposed to one or more natural disasters and 200 to 1,000 classrooms are affected each year by cyclones and floods. The high impact is often due to issues such as poor structural design, use of subpar construction materials and ad hoc building practices.

Since July 2012, the World Bank's Africa Disaster Risk Management (DRM) Group, with financial support from the Global Facility for Disaster Reduction and Recovery (GFDRR), along with UN-Habitat and the Faculty of Architecture and Physical Planning (UEM-FAPF) at Eduardo Mondlane University, Maputo, have actively worked to produce effective strategies to help develop school safety guidelines for classroom facilities across the country. Additionally, the Government of Mozambique is benefitting from a stronger perception of the DRM procedures needed to revamp the schools' infrastructure network.

"The implementation of this project constitutes an enormous contribution to materialize government policy of school expansion, which is to enlarge more and more the national school network by providing conventional and safe classrooms to all the children of school age and at the same time, rationalizing permanently the investments made in this area" Luis noted.

Working together with relevant Ministries, the European Union (EU) and the Education Sector Support Fund (ESSF), a multilateral donor support channel, this joint initiative implements a phased approach by first undertaking risk assessments of schools and creating a catalog of hazard-resistant construction types and architectural models with adaptive measures for both traditional and conventional materials. For example, by assessing 637 classrooms in seven provinces of the country, officials were able to draw on their observations and realized that without proper planning, the technical execution required for building safer schools was lacking. Additionally, an outdated national building code and limited access to updated risk information added to the ongoing struggle. The assessments led to a cohesive strategic plan for building safer schools.

“The outcomes of the phased approach are certainly visible and the consensus among government partners regarding the importance of building resilient schools is the most remarkable,” said Sophie Naudeau, senior education specialist in the Bank’s Mozambique country office. “Add to this the sound risk analysis tools as well as guidelines on how to build similar schools across regions of Mozambique and one can really get a sense of the accomplishments to date. Now the challenge will lie in ensuring efficient implementation across provinces.

The next phases of the project will focus on school construction using dedicated national staff to strengthen both the policy and regulatory environment. The initiative will also aim to enhance the understanding of the types of disasters and climate issues affecting schools throughout the country. Additionally, the phased approach is linked to the GFDRR Safer Schools program. This program, which operates at both global and country levels, focuses on preventing disaster risks from affecting schools and also promotes an open source platform to share school safety guidelines.

Moving forward, the Bank, along with other donors, will continue to contribute to the ESSF with the goal to finance 800 increasingly newly resilient primary education classrooms and 150 rural secondary classrooms each year. Forty thousand classrooms are currently located in Mozambique, with the scheduled construction of almost 30,000 more.

“Over the last two years, a greater understanding of possible risks associated with hydro-meteorological events, such as floods, has led to a consensus on how to improve the state of schools in Mozambique to make them more resilient to natural disasters," said Mark Lunde

CHAPTER THREE - ARCHITECTURAL PLANNING AND DESIGN OF SCHOOLS IN DEVELOPING COUNTRIES

3.1 STANDARD VERSUS SITE SPECIFIC DESIGNS. THE JORDANIAN EXPERIENCE

Introduction

• In the 1950’s and 1960’s the Ministry of Municipalities was responsible for the schools in the Kingdom which were small scale, mainly classrooms and main facilities spaces.
• In the early seventies this responsibility was moved to the Ministry of Education and a new type of large scale schools was adopted (I-Shape , three storey building known as Hai Nazal school type).
• The Schools’ Programme started with several donors such as the World Bank, JAICA (Japan International Cooperation Agency) and the Social Security Corporation using different prototypes, known as ‘first type’ up to ‘seventh type',to construct the schools differing according to the school type, for example, academic or vocational. The final prototype used in the construction of school buildings was the sectoral type in 2000.
• The ministry started the educational reform in 2003 and one of its components focused on the school buildings. The design of schools had to be developed to adopt the needs and requirements of the ministry, so architectural design guidelines were prepared to describe the main educational spaces and specific facilities in the school.


Classroom type in the fifties I - Shape school (Hai Nazal type)

Standard Designs

When standard typical designs were used in school construction the same type of school buildings were constructed all over the Kingdom, for all geographical areas (mountains, Jordan valley and desert) and in both urban and rural situations. The same image is seen everywhere and therefore it is easy to recognise the school building from a distance.

Using prototypes in that period was useful for fixing the design procedure used by the consultant whose major role was the site plan design and the calculation of the sub-structure, since all the specifications and quantities for the super-structure were fixed. It also speeded up the construction period since the contractors were familiar with the construction components. It became a mass production of schools which also eased the follow up by the ministry.

However, using the methodology of the prototype, some deficiencies appeared that architects were not pleased with:

- Opening size was the same in all schools and for all areas since no consideration was given to the climatic conditions while designing (some cases showed the use of brise soleil in hot sunny areas).
- Improper outdoor and playground zoning areas were created due to the steep topography of some sites.
- The massing of the school prototypical building was changed depending on the size and shape of the land, by either enlarging the building when adding more modules or by squeezing it in.

Guidelines

There was a need to prepare guidelines as a reference for designers of schools and all those involved in the process of planning, designing and building new school structures (administrators, teachers, architects, engineers and contractors). Guidelines were to define the educational spaces needed such as classrooms, administrative areas, play-grounds and special activity rooms (laboratories, libraries, art rooms etc.) by type, size and specifications according to the international standards as well as MoE needs and requirements.

The first version of the guidelines was issued in 2003 for architectural requirements only. It was of great help in conducting the design phase of the ERfKE project. Therefore, the ministry decided to update and develop these architectural guidelines for the upcoming project (ERfKE 2) since new needs and educational requirements had risen during the previous five years. Meanwhile the guidelines were also developed to include all the engineering aspects that the designer should take care of, such as the structural, electrical and mechanical requirements.

Specific Site Design

Today a new generation of school types has been born. The ministry was lucky to launch this project a few years ago, when the KfW, EIB and USAID projects were showing changes and development in school design. The donors supported the ministry in that and now we can identify new schools that respect the following conceptual principles.

1. Creating visual balance while respecting the surrounding environment

(colors, materials, landscaping etc.).
2. Locating school buildings in the best position to derive maximum benefits from natural environmental factors (sun, wind, noise reduction, landscaping).
3. Using appropriate landscaping elements to define the boundaries of the school and to control access to the school grounds.
In the design of spaces, many concepts are applied:

1. Functionality and rationality of spaces
The design is to provide functionality and rationality of the spaces, taking into consideration the following points:
• Appropriate dimensioning of spaces
• Grouping of spaces according to their function
• Code requirements for circulation spaces
• Integration of needs so that equipped spaces satisfy other needs such as hygiene, lighting and acoustics.

2. Flexibility of the design
The design is to be adaptable to any changing needs that may arise in the future such as:
• Increases in the number of students
• New educational requirements

3. Architectural quality
• Harmony of building masses
• Respect of the surrounding environment and culture, taking into consideration colours, materials and landscaping to create visual balance
• Good choice of techniques and materials to ensure durability and ease of maintenance
• Appropriate compromise between cost and quality

4. Special requirements
The design is to take into consideration people with special needs:
• Movement of the physically disabled is facilitated with ramps, paved areas and easy access to the school site and buildings
• Appropriate facilities and equipment accessible to disabled people are provided (e.g. sanitary facilities, doors and drinking fountains,)
Construction cost
• It is to be noted that the following additions and changes to the design of schools were factors in increasing the cost of construction:
• Construction materials that were not implemented in the old schools such as double glazed windows and thermal insulation for all elements of the school building including floors, external walls and the roof.
• Computer network infrastructure for the whole school including classrooms and laboratories, plus the installation of central heating.

Ramps

Cost compromise

• Site landscaping (trees, shrubs and shaded areas) and the use of grey water for the irrigation of the vegetation.

• The new building forms that the contractors were unfamiliar with.

• The significant worldwide price increase of materials such as fuel, steel and cement over the last two years.

The unit cost increase is shown in the table:

Donor	Total Award Value (JD)	Total plan area of schools (m^2)	Square meter Cost/ m^2 (JD)	Total Number of Students	Cost per Student (JD)
EIB (2004 / 2005)	41,520,250	165,884	250	37,912	1,122
KfW (2005)	10,469,695	36,801	284	8,065	1,298
USAID (2007)*	5,500,000	14,365	382	3,240	1,697

* Consultant Estimated Cost

Maintenance

With respect to maintenance the ministry continues to have the following challenges:

• Insufficient budget allocations in relation to the needs.

• Lack of a proper maintenance system to rely on in spite of the simple database used.

Therefore, the ministry is still in an ongoing procedure to develop the system in collaboration with the World Bank and KfW through the Development Coordination Unit in the ministry.

However, from observation it is evident that through good design and the use of quality materials, fixtures and finishes, as well as the proper use of facilities it is possible to maintain a good school building for an increased period of time. There are three areas to concentrate on to achieve this:

• Users of the buildings (students, teachers and the community)

o Encouraging awareness amongst students about their schools in order to increase the perception of importance and therefore respect of the building, plants and furniture.
o Issuing the sponsorship and partnership principle between the school and its community.
o Promoting good relationships between the school and the community:
• Building material and fixtures:
o External walls could be clad in stone.
o A more durable material should be considered for the doorframe, the door and the kickplate.
o Door locks, hinges, sanitary units' water flush and water taps.
• Building systems:
o Alternative solutions for the heating and cooling systems (climatic design with efficient thermal insulation).
o Efficient drainage systems using rain water and grey water for irrigation.
o Using solar water heating systems and photovoltaics to power minor electrical applications

Conclusion

To sum up it is not possible to say that the ministry has obtained a different design for each school with its own character and individual educational spaces. The main reason is that certain standard facilities have to be provided and these are grouped in clusters due to the relation and importance of them, whether educational, administrative or recreational and to ensure proper use by the students. However, it is the opinion of the ministry that the track is right and there is an improvement in getting site specific design for each school.

It can be said that both standard and site specific designs have their place. The most important thing is to deal with the building on the three levels of designer, user and community in order to obtain a long life, proper, colorful, low maintenance building that is in harmony with its surroundings.

3.2 AN ON-GOING RESEARCH ON LEARNING AND SCHOOL BUILDINGS IN PALESTINE

Context

The aim of this research project is to investigate whether the special efforts that have been made regarding the architectural planning of new schools recently built in Palestine, notably with funding from KfW, have a particular influence on children's learning, self-esteem and representations.

The research project began in Fall 2007 and is currently under way, with the main bulk of data still to be collected toward the end of this school year. The analysis of data and conclusive report will be available only later, but as the project is close to the theme of this Architecture & Behaviour Colloquium, we present some of the first data and share some of our considerations.

1. General outline of the research project

The research project is investigating how children and teachers in 3 recently built new schools in different regions of West Bank (Nablous, Hebron and Ramallah areas) evaluate their school buildings, (the qualities and the shortcomings of the spatial layouts), and how they actually use the building spaces. These three schools have been chosen for this study because special care has been given to their site-specific spatial lay-out in the planning stage. These school-buildings have been in use only for one or two years. The evaluations by children are then completed with data on the children's scholarly performances, that are measured by tests in Arabic language and mathematics skills as well as self-esteem measures, in collaboration with the Assessment and Evaluation Centre, Ministry of education and Higher Education, Ramallah.

For comparison purposes, in addition to these three recently built schools, the study also investigates children from 3 elderly school buildings with more traditional spatial lay-outs. These schools have been chosen in areas close to the other schools, with children from a similar background. This means that we also study children from three elderly schools in Nablous, Hebron and Ramallah areas.

We are collecting data from 4th grade classes (children of about 9 years of age) as well as 10th grade classes (children of about 16 years of age) – from three "new" and three "standard" schools (that is, school-buildings).
A series of observational tools as well as questionnaire and interview forms have been defined and we are currently applying these to get data from the children and teachers in the six schools.

Once we have all the data it will be possible to compare scholarly performance data, self-esteem data, questionnaire data as well as other descriptive and observational data obtained from children and to some extent teachers in the different schools and look at correlations, with the different school buildings and lay-outs as one of the variables. The analysis will be done after the school year is over and a report will be produced.

2. Example of first research data.

We are now going to look at first data that we have collected from two of the schools that we are studying. The two schools are situated in the village periphery of Nablous (in the West Bank), all children walk to school, the walking distance being generally less than 15 minutes. Both schools are

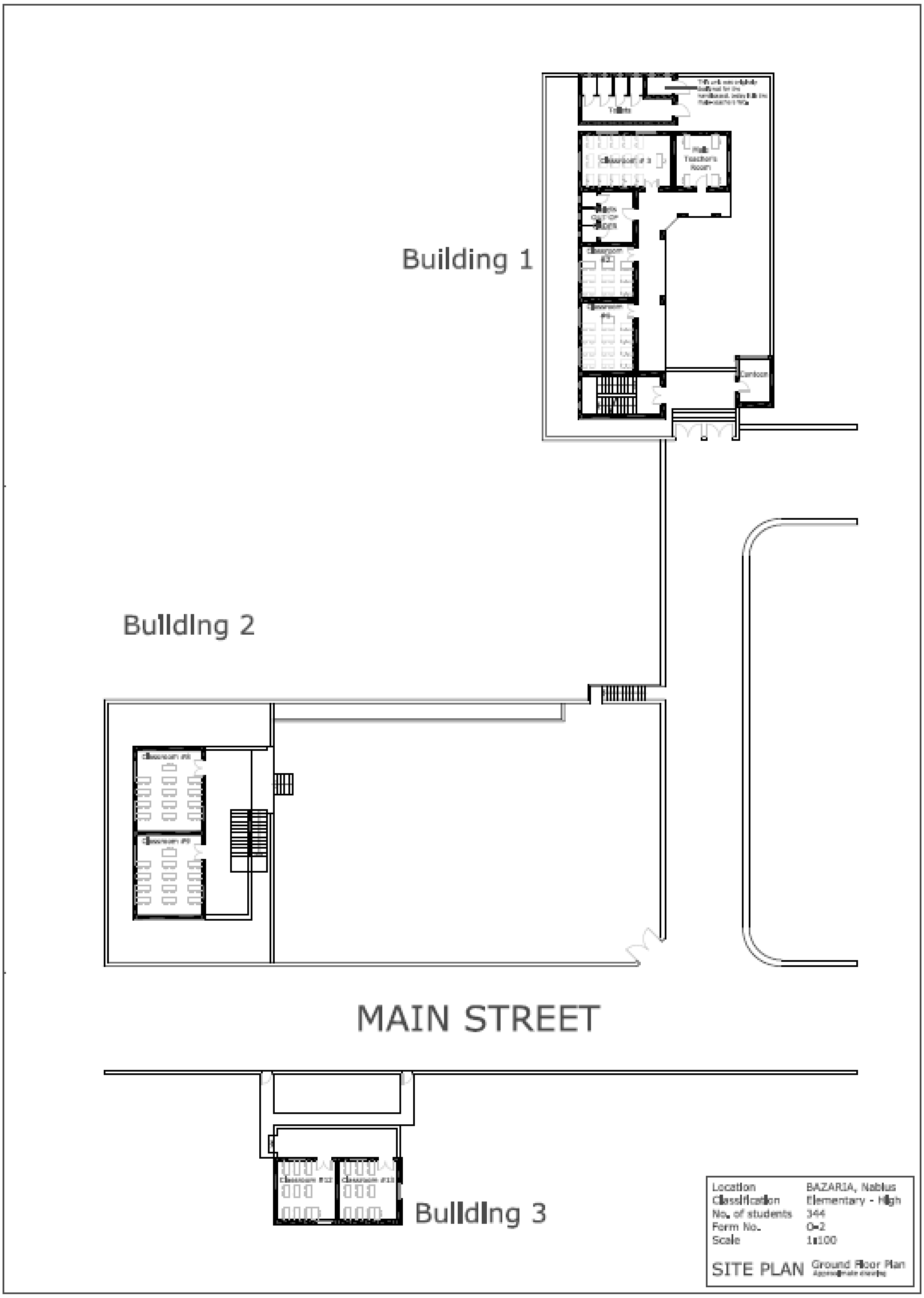
girls-schools and have a boys-school located close to them. Socio-economical level of the two school populations is comparable.
It was agreed with the teachers that we would have one hour at our disposal in the classes, and we asked the girls in 10th grade (about 16 years old), to answer a few simple questions about their school and to then make a drawing of their school with a set of colour pens that they then could keep as a gift.

We will contrast the results from the two classes and formulate some remarks whereby we try to relate these results to the two different school building environments. However, we insist on saying that these are preliminary findings and might be re-interpreted after we have more complete data.

Presentation of the 2 schools:
Bezzaria Girls' School.
The school consists of 3 buildings. The main building was originally constructed (in the 1950s) as a kindergarden and was in 1996 transformed, by adding floors, into a girls' school from grade 1 to 12, with today a total of 13 classes. A canteen, and toilets were added in year 2000 to the then existing buildings. 2 additional classes were obtained by renting two rooms from a close-by private house. There is a total of 344 students, with average class area of 21 m2 and 27 students per class. Outdoor space is limited to apprx. 470 sqm.


Bezzaria Girls' School

In summary, the general and spatial conditions in this school are not comfortable. We will not discuss this in detail here, but spaces in and outside the buildings are cramped and there is a general lack of equipment (for instance there are only 5 toilets for 344 students).



Deir Sharaf Girls’ School.

The school consists of two separate buildings. The old part was built in 1957 and the new part in 2005. When the new part was built the window and door frames, as well as the painting of the old building were also re-made. There is a total of 340 students, with average class area of 50 m2 and 30 students per class. Outdoor space is– apprx. 1000 sqm with gardens in addition.

(In this school, there are 10 toilets for 340 students).
The general and spatial conditions in this school are clearly different and more comfortable than in the Bezzaria School. Walls are colourful, the surroundings
are spacious, including a garden. Again, we will not discuss details here but a few pictures will show the classes and some of the equipment.

What can we expect on this basis?
The conditions for children in Deir Sharaf are clearly better than in Bezzaria (more space per children in the classroom, more outside space, more bathrooms, more light, etc.). Given this, what can we expect from the children's evaluations and their drawings?
We might suppose that Deir Sharaf children will express a more positive evaluation about their school and that their drawings will somehow reflect this.
Let us now have a look at the results.
First data.
Data from 10th grade students We asked all students to grade their school ("School" means here the building and the school area) and also to give a

mark to how much they like to go to school. The scale is 1-10, so 10 means “I like the school building very much” and 1 or 2 “I don’t like the school building very much or not at all”. As to the other question, 10 means “I like very much to go to school” and 1-2 “I don’t like to go to school”.

We present here the results in a table, with mean scores for both questions:

	School Building Mark (mean)	“How much I like to Go to school” Mark (mean)
10^{th} grade Bezzaria (N=30)	2,9	7,4
10^{th} grade Deir Sharaf (N=37)	8,3	7,0

These results are partially in line with what we expected. Generally speaking, children from Deir Sharaf like more their school (mean mark: 8,3) than children from Bezzaria (mean mark: 2,9).
At the same time the results don’t show a striking difference as to how much children in both schools like or don’t like to go to school (Bezzaria, mean mark: 7,4 and Deir Sharaf, mean mark: 7,0). We may conclude that, to like your school building and area is one thing, but to like to go to school is another.

In other words, school is the built environment (school-building and surroundings) but it is also friends, teachers, being-away-from home, learning new things and so on. These last-mentioned aspects are there irrespective of the built environment.




Drawings of Bezzaria school (left) and Deir Sharaf school (right)
As we mentioned earlier we then asked children to make a drawing of their school (the instruction said “Make a drawing of the school as you see it”).
Let us now look at some examples of drawings:
Without going here into systematic details, from a general analysis of these drawings we can summaries:
The drawings of the school-buildings by the children from the two schools are similar in their approach. When the drawings show the façades of the schools, the buildings can be recognized by some specific characteristics. (There might even be 1 or 2 future architects among the children in each school).

In other drawings from both classes the drawings of the school-buildings are more fantasy or home-inspired in their shapes and characteristics. So, although children from Deir Sharaf have a much more positive opinion about their school than those of Bezzaria, they don’t seem to express this difference in the drawing of the building itself.

However, in their drawings, children from Deir Sharaf give much more place to the surroundings, playground, nature, trees, open space, sun and also school-friends (= drawings of children in the courtyard) when compared to drawings from Bezzaria. This seems to us an interesting finding.
A table will show this:

	% of drawings containing surrounding details	% of surface in drawings given to Surrounding details (mean)
10th grade Bezzaria (N=30)	25%	20%
10th grade Deir Sharaf (N=37)	85%	70%

The drawings from Deir Sharaf show much more often “surrounding details” such as playground, nature, trees, open space, sun and also school-friends (in 85% of the drawings, compared to 25% from Bezzaria). In the drawings from Deir Sharaf more (relative) space (on the drawing sheets) is for the “surrounding details” (70% as opposed to 20%).

We suggest that this has to do with the fact that there is generally speaking more space and transparency in Deir Sharaf. Inside the building this is related to the size and light in the classrooms, the larger corridors, the view from the larger windows. The outside places are thus felt as being part of the school, the school spaces form a continuity from inside the building to outside the building. Thus, when children from Deir Sharaf say that they like their school this could mean the opening and transparency to the surroundings – that they consider that in their school there is a continuity from learning in the classroom to playing and talking with schoolmates. The school in Deir Sharaf somehow helps in expressing this continuity from inside to outside while the Bezzaria school is not suggestive in this respect.

This could then be a hypothesis for explaining the more positive evaluation that children of Deir Sharaf give about their school Conversely it would mean that although in Bezzaria the school is also a place for meeting friends, playing outdoors, being in contact with nature, it is so despite the built environment and surroundings and not with its help. In saying this, we are mainly referring to the poor evaluation mark given by the Bezzaria children to their school (2,9 as opposed to 8,3 for Deir Sharaf).

It remains to be seen, with data that we still should collect, how such considerations might correlate with scholarly performances and self-esteem of children from the 2 schools.

Let us add that when we asked teachers also to evaluate their school-buildings there was also a clear difference between Deir Sharaf and Bezzaria the teachers from Deir Sharaf were more positively inclined toward their building than the ones from Bezzaria. This can certainly also have an influence on children, but fore mostly as an opinion, not to represent the school building itself by a drawing.

3. Conclusion

We want to conclude this short presentation with two reflections.
We have here referred to drawings of children. A thorough analysis of drawings will require much more effort and may reveal differences that we are here overlooking. We are also considering only two classes in two schools, while we have got data from 12 classes and six schools, so these might open other perspectives. Yet, the few considerations that we have developed already seem to confirm that children do perceive and appreciate specific characteristics of their learning environment.

This research happens to be about girls. In many respects girls' education is different from boys', although perhaps more so because of the family than because of the school. One of the head-mistresses mentioned to us that she suspects that the generally not good scholarly performances of the elder girls in her school are caused by the clear concern of most families in the area (in Jalazoon) to get their daughters married as soon as possible, and not necessarily to go on studying at University or other trainings. Many (interesting) questions can be raised from here and we should probably try not to avoid them. For instance, given such a family context, what is or what should be the concern of the school, and more specifically the school programme and the teachers and even the school building? For instance, should some activities be favoured with respect to others and with what purpose for girls' education?

3.3 BASIC EDUCATION (GIRLS) PROJECT (BEGP) IN LAOS PEOPLE'S DEMOCRATIC REPUBLIC

1 general project information

The country

The population of the Lao People's Democratic Republic is 6.1 million, and growth is estimated at 3.1% per year. There are 47 ethnic minorities. With an estimated annual income of US$ 381 in 2000, the Laos PDR ranks among the least developed countries in the world. The country consists of 18 provinces, in which there are 135 districts and about 12,000 villages.

The regional perspective

The current five-year plan of the Ministry of Education emphasizes three key objectives: Equitable access, quality improvement, and improved relevance. There is limited access to primary education, especially for remote areas, with girls in areas of ethnic minorities suffering most. In 2001 it was estimated that there were about 8,000 schools of which 19% were regarded as being in good condition, and only 35% were offering the full five years of primary education. About 4000 villages, mostly in mountainous areas, had no schools at all. 58% of the schools are regarded as being temporary structures.

The need

At the time of project inception approximately 8,000 primary schools needed to be built, extended or refurbished. In terms of classrooms, it was estimated that a total of 30,000 classrooms were needed for primary education, and that only 10,000 will be available at the end of the current externally supported construction projects.

Furthermore, it is not enough to construct the buildings, they also need furniture, books, teaching materials, and of course, teachers. The schools need to be administered and the buildings maintained. So, school construction must be embedded into a national education development program. The building program must not be isolated from these other aspects.

The objective

The overall objective of concern here is universal primary education by 2015 - providing access to at least five years of education for all Laotian children. Education is a key step towards poverty reduction. The project objective of the construction component was the provision of adequate, technically realistic, affordable, and environmentally sound schools and district education offices in 52 districts.

The project components

The integrated project approach is flexible, which means that the project

impact and effects are continually assessed during the implementation, and lessons learned are applied to subsequent activities. The following components have been built into the project:
Component 1: Provide primary education facilities in 53 districts, and strengthen capacities at the central and provincial levels to plan, manage, and implement school construction and school development programs.
Component 2: Promote community participation in school management to increase the enrolment and retention of children in primary schools, particularly girls.
Component 3: Improve the relevance, quality and efficiency of primary education through supplementary materials and adapted curricula; in-service support for teachers and school principals in multi grade schools and schools in ethnic minority areas; professional supervision for teachers, and support for the recruitment and training of ethnic minority teachers.
Component 4: Strengthen management support systems at the Ministry of Education and educational capacities of the Ministry of Education, the Provincial Education Service and District Education Board.

The partners
In addition to the building programme of the National government, there have been several multilateral and bilateral partners, who have become involved in the construction of schools. The main external support agencies are the Asian Development Bank, the World Bank, and the governments of Japan and Australia. Non-governmental organizations also play a major role.

2 school construction implementation

Decentralized construction implementation approach
Planning, budgeting, bidding, supervision and monitoring of the project was done per specific terms of reference for specialized construction units established at central, provincial and district level. Construction of schools was generally undertaken by contractors selected through tender bidding. The availability and capacity of contractors sets a ceiling on the number of schools that can be constructed during the project implementation periods. Both national and international contractors were invited to bid for the construction of schools. Since the applied construction technology and building materials are well known in Laos, the schools were mainly built by local contractors from the village itself or the neighboring area thus creating ownership and stimulating the local economy.

Government and community contributions
The government contribution to civil works was fixed at a uniform level of 27% of the construction costs. The local communities were requested to make minimal contributions to the construction of their schools. The contributions required were typically the land for the site, the provision of water sources, the

construction of railings to fence in the site, an access road, and maintenance of the building. Involving the community in this way not only saved on costs, but also provided an important indicator of the commitment of the community to run and maintain the school, and it strengthens the sense of ownership.

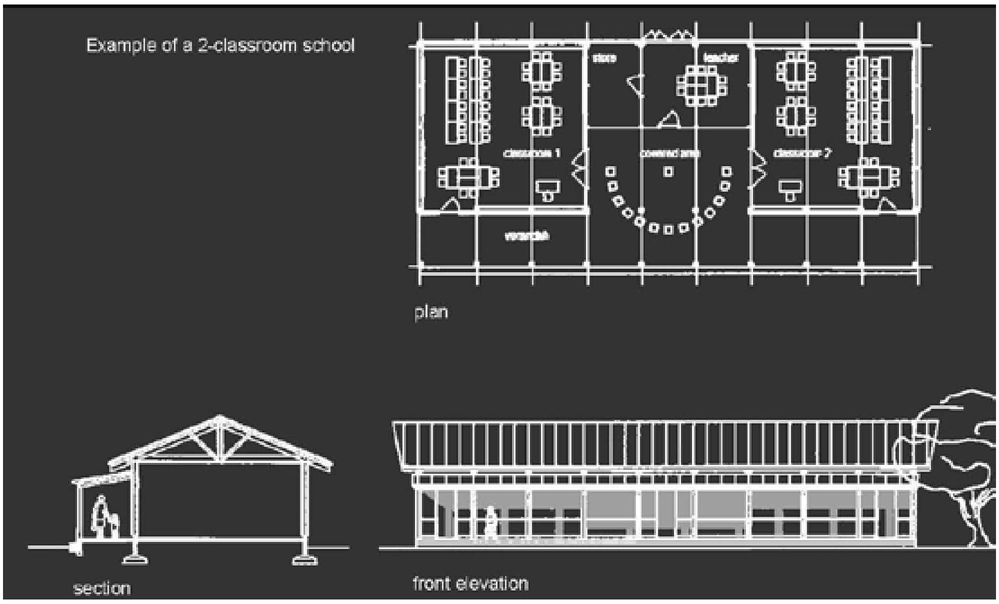
Site selection
Without clear site selection criteria and a determination to work according to the above criteria, the schools would be located close to major towns, in places served by good roads, and according to the directions and patronage of influential local leaders. Girls and ethnic minorities would continue to lack access. Therefore, in the overall interest of the nation, and keeping poverty reduction in mind, the ADB projects have defined their selection criteria. Selection also allowed the integration of project components such as ensuring the availability of teachers for the schools to be built.

Achievements
The project successfully implemented the construction of 512 schools and 43 district education offices, most of them built in areas known to be below the poverty line, thus enabling about 75000 children to gain access to modern primary education. The cost of one permanent classroom facility unit - including furniture and shared annex rooms - is approx. USD 6000.

3 unique features of the project
Multi grade teaching
The population of the target villages located in rural areas is often small with less than 100 pupils divided up into five grades. Tuition of the five grades takes place in two classrooms, which calls for a multi-grade teaching methodology that is new in Laos. Hence, the project had put much emphasis on facilitating tuition of two or three grades in one room. These efforts were underpinned by the decision to install blackboards that are movable all along the four walls of the classroom.
In addition to this, a working bench along the windows was built in, and specific furniture was designed to permit suitable arrangements for individual group work.

Architectural concept and characteristics
Layout: The architectural layout is simple, appropriate, and very cost-effective. It offers a wide range of options to communities and government, trying to consider their needs and the available financial and natural resources as much as possible. The building design seeks to maximize the reflection of local character, cultural traditions and preferences. The basic idea was to build a solid structural frame (floor, columns and roof). All the other building parts (walls ceilings, etc.) are not load bearing and are constructed in a way that they can be easily maintained, replaced or improved, e.g. from wood boarding

to plastered masonry.



Requirements: The classrooms for multi grade schools are based on a 7 by 7-meter square space allowing for optimal teaching in groups (instead for a 7 by 6 meter rectangular space as commonly used for single grade schools). Depending upon the size of the student enrolments the schools include either two or three such classrooms, a teachers’ room, a storeroom, a covered area that can be used as an additional classroom and an external water-flushed toilet.

Modular system: The school design is based on a module that meets a well-defined minimum standard. This minimum standard is specified by a clean and dry floor, a solid structural system, a ceiling and a solid roof, all of which will last a minimum of 25 years. The minimum standard can be further refined to determine 3 standards (minimum, medium and maximum). The proposal was to construct the minimum standard for the villages

included in all phases of the project. However, in most cases the medium standard was applied. In addition to the minimum standard, the medium standard includes permanent wooden walls and lockable doors. It allows villagers
or other investors to improve a school at a later stage (e.g. from wooden walls to whitewashed masonry) and at cheaper cost while still providing a space suitable for multi grade teaching.

Cost effectiveness: The rur a l multi-grade school buildings are utilized intensively during school hours. To give them even increased public importance in rural villages and to make them more economically viable, the schools built under the project are used for various other purposes such as:
Daily: Adult education (night school)
Periodically: Social work, community meetings
Occasionally: Natural disasters shelter, voting center, etc.


To meet this demand, a covered area was provided for each building. During the daytime teachers, can use it as an additional “outdoor classroom” for group-work typical in multi-grade teaching. After school villagers, may use it for social activities thus avoiding getting the classrooms dirty.

Water and sanitation
Each school was provided with a water supply and sanitation facilities. Very often, the school toilet is the first of its kind in the village. Teachers and students undergo a specific training in hygiene promotion including the use of toilets.

Maintenance
During the course of project implementation, a national maintenance concept was introduced, thus ensuring a friendly and motivating learning environment for pupils for decades. It contains a yearly maintenance budget (2% of the investment cost), training sessions, as well as tasks and responsibilities for all

stakeholders at national, provincial, district and village level.

4 project data
Function: Basic Education (Girls) Project
Location: Laos P. D. R.
Lender: Asian Development Bank
Project Consultant: OPCV / SKM Australia / Skat Consulting, Switzerland
Architects / Engineers: D. Schwitter, Skat Consulting, Switzerland / MoE Laos
Years of construction: 2001-2007

PROJECT SCOPE
No. of schools built: 512
No. of district education offices built: 43
No. of districts served: 52

BUILDING COST AND MATERIALS USED
Construction cost per m2: US$ 80. 00 (national average)
Overall costs of civil works: US$ 9.458 Mio
Overall costs of furniture: US$ 2.431 Mio
Foundations: Concrete
Walls: Concrete / wood / masonry
Roof: Wooden truss / corr. iron sheets / fibre cement sheets

3.4 PREPARATION OF LOW COST SOLUTIONS FOR THE SCHOOL CONSTRUCTION PROGRAM IN MOZAMBIQUE

Background
The Government of Mozambique approved the Strategic Plan Education and Culture (PEEC) in June 2006. The approval of the PEEC constituted a major milestone in the development of education in Mozambique and a tremendous achievement for the Ministry of Education and Culture (MEC). For the cooperating partners, including Germany, the PEEC represented a credible strategy for the achievement of Millennium Development Goals (MDG), based on expansion, improved efficiency and quality.

One of the objectives of PEEC is to promote access to primary education through expansion of the school network. Therefore, it is envisaged that approximately 6000 classrooms be built including teacher houses and related infrastructure per year until 2015.

This is a tremendous task and the scarce finances of the given financial envelope have to be employed in the most effective and cost efficient way in order to reach this target. Therefore, the cost of construction per classroom should be kept low. The major part of these classrooms was planned to be built as part of the Action Plan for Accelerated Construction of School Infrastructure, which has been developed and approved by the MEC in 2004. The Action Plan was guided by the Fast Track Initiative on Education for All (FTI, or EFA-FTI) that allowed approximately USD 10,000 per classroom. The FTI target of USD 10,000/classroom has meanwhile been removed from the international discussion due to strong variations in local and regional conditions.

Costs of conventional construction are high in Mozambique compared to international and regional standards. In 2001, the German and Mozambican governments agreed on a primary school construction program for the provinces of Inhambane, Manica and Sofala (Phase I) to be financed by funds from German Financial Cooperation. In 2005, Phase II of the program was agreed between both governments. In Phase I a total of 190 classrooms, teacher houses, boreholes for water supply, administration blocks and latrines were built and furnished. The quality of the buildings was good and to the satisfaction of the MEC. The average cost per classroom excluding furniture was USD 18,000. These costs resulted from a transparent procurement process with very good participation of construction companies operating in Mozambique.

Though the costs of Phase I were not considered to be extraordinarily high compared to other school construction programmes in Mozambique, it was obvious that the costs for the new Phase II had to be reduced in order to meet the FTI target and to use the available scare resources more efficiently. This had to be done without jeopardizing the quality of the buildings, guaranteeing security, full functionality and an acceptable life span of the buildings without an increased need for maintenance.

Therefore, under KfW financing, the MEC has employed the Architect Gerhard Graf and Engineer António Marrufo to develop concepts for feasible low-cost solutions for Phase II.

Methodology

To obtain an overall picture of the current situation of primary school construction in Mozambique Graf and Marrufo travelled to six provinces: Sofala, Manica, Inhambane, Gaza, Nampula and Cabo Delgado and visited thirty different schools and/or construction sites of the pilot programme under the Action Plan for Accelerated Construction of School Infrastructure (FTI). They analysed the construction preparation process, the planning, the tendering, awarding of contract, as well the execution of construction works from mobilisation at site to final acceptance of the building works and focussed on quality, duration and costs. Graf and Marrufo involved various planning specialists and administration within the MEC and especially its decentralised offices in the provinces' Provincial Directorate of Education and Culture

(DPECs).

Graf and Marrufo’s findings and analysis of the situation of primary school construction in Mozambique are further explained below. The FTI programme is described in more detail as well as programmes of other organisations: ADPESE, JICA and UDEBA Lab. This is followed by a discussion of low cost construction. As a result of the information obtained, an outline proposal for the organisation and implementation of Phase II of the school construction programme cofinanced by the German government had been established. The proposal respects the functional and quality requirements determined for primary school construction in Mozambique. During their research, Graf and Marrufo cooperated closely with MEC, with architects Rui Fonseca and Daniel Vasco and Heads of the FTI Department.

Current situation of primary school construction
According to the laws and regulations in Mozambique, responsibility for all public constructions works lies with the Ministry of Public Works and Housing (MOPH). Several years ago the Ministries of Education and Health created in-house construction departments in order to assist and relieve the MOPH with their immense workload of implementing construction projects. For school construction, the division of tasks was planned in a way that the implementation unit of MEC would be responsible for developing programme strategies and preparing the construction process from tendering to contract award. The responsibilities for execution of construction would remain with the MOPH and their authorities in the provinces and districts. In practice, there was an apparent lack of planning between the Ministries which was problematic. The Ministries have discussed reforms but decisions have not been made.

Activities planned between 2004 and 2007 and their estimated share in the total primary school construction in Mozambique. (Source: MEC)

Programmes	Stage of completion	Classrooms	Construction Volume estimated
FTI pilot phase	81%	618	71 %
FTI extension phase	0% Started end 06	1.467	
JICA Japanese Cooperation	0% Started end 06	65	2 %
Danish Cooperation ADPESE	85%	262	9 %
Portuguese Cooperation		134	6 %
German Cooperation conventional Phase I	97%	194	7 %
Others like World-Vision, Save the Children, Caritas, AAA and diverse religious org.	No data	200 *)	7 %
Total		2.940	100 %

Activities planned between 2004 and 2007 and their estimated share in the total primary school construction in Mozambique. (Source: MEC)

Presently, the average number of classrooms constructed is below 1000 per year. Major efforts are needed in order to reach the goal of 6000 classrooms per year.

THE FTI PROGRAMME

Because the FTI is presently the largest programme for construction of primary schools in Mozambique, it will be examined in more detail. Responding to the challenge of the MDG and on the initiative of the donor community, the MINED, a group of consultants was hired to initially develop a programme for accelerated construction of school infrastructure at low cost EFA-FTI. The group began their services in 2003, in order to reach the goal of constructing 6000 classrooms per year at an average cost of USD 10,000 per classroom. To achieve this goal, three different systems - contractor, community and NGO - were utilised. The decision as to which system would be adopted for a school was made at provincial level depending on local capacities.

The pilot phase of the FTI started its active construction works in November 2005 and aimed to achieve 618 classrooms nationwide within a one year construction period. By the end of 2006, 81% of the pilot phase was completed with very different results for each Province, for example the Province of Cabo Delgado achieved 42%, and others up to 100%. In September 2006, the extension phase of the FTI programme started, aiming to construct 1467 classrooms, nationwide, by the end of 2007. Further expansion of the FTI programme was planned for the construction of 3000 classrooms by the end of 2008 and 6000 classrooms by the end of 2009 (Source: MEC).

The following findings by Graf and Marrufo are selective and therefore may not be entirely representative of the nationwide programme. Nevertheless, the consultant is interested in identifying advantages as well as problems experienced, in view of feasible lower cost solutions for the benefit of the coming Phase II of the German co-financed school construction programme.

During December 2006 and January 2007 Graf and Marrufo inspected 30 school construction sites in 6 out of a total of 10 Provinces, covering approximately 15% of the total FTI pilot phase. A further 14 school sites of the new FTI extension phase were visited as well.

Findings in the FTI programme

Except for a few sites, the majority of schools visited which were constructed by FTI were executed on the basis of the design and specifications prepared by MEC. As a general design for nationwide application, it offered a general functional solution. Unfortunately, the majority of sites visited were found with alterations to the design - such as reduced quality, and reduced stability. Based on information from the DPEC´s, the main reason that changes were made was in order to keep within the cost limit. Nevertheless, design variations should not have been implemented to the detriment of quality, functionality and stability standards. There was a clear need for increased technical assistance at the provincial and district level. The pilot phase of the FTI programme did not allocate funds for supervision and resulted in a poor building quality. Installation of boreholes and hand pumps for water supply were not part of the FTI programme and were to be carried out under the responsibility of the MOPH. During the implementation of FTI school construction it was found that the development plans were not sufficiently coordinated to ensure water supply to all schools built.

Contract and Tender procedures in the FTI programme

Lump sum building contracts with a fixed price proved to be a good solution. These avoided later claims of additional costs and contributed to meeting the aimed cost ceiling.

Cost indicating Bank Guarantees for advance payments or contractor’s performance were not utilised. This financial risk (securities) was handled differently in the provinces visited. Some employers simply trusted the contractors while others released payments only on proof of expenses like mobilisation or delivery of equipment and materials, secured crossed cheques or pawns.

Raising the interest of contractors was found very difficult and sometimes impossible throughout all provinces. Only with active motivation from the MEC could contractors be convinced to participate in the programme. Therefore, a competitive tender and evaluation of bids in general was extremely difficult during the pilot phase of the FTI programme. The absence of contractors at Provincial and District level and the lack of understanding regarding low cost construction methods contributed to the problem. The few available contractors were only accustomed to conventional construction methods and then lost interest upon realising that their calculations did not fall within the fixed cost frame. Several contractors who submitted bids far above the cost ceiling were excluded from the programme.

Building construction in the FTI programme

Lack of technical assistance found at all provincial and district levels was the main constraint and a serious barrier for the long-term success of the ongoing FTI programme throughout all three systems: Community, NGO and Contractors. For example, communities were found to be working without plans and specifications. Contractors and NGO`s were not following design and quality specifications thereby resulting in dangerously unstable structures.

Supervision in the FTI programme

Learning from the deficiencies of the pilot phase, the extension phase of the FTI programme allocated funds for supervision, which resulted in an improvement in construction quality. However, the actual capacities such as the number of staff and the availability of transport for technical assistance on site at MEC levels were found to be insufficient in all provinces visited. Effective on-site technical assistance could avoid cost intensive consequences.

Several sites of the pilot phase were not completed, but works have stopped since the available funds have been used up. In some cases, the DPECs are now negotiating a later reduction of the construction volume in order to complete the contract.

Costs and accounts in the FTI programme

The frequently used parameter “USD per classroom” refers only to the “on site occurring construction costs” and does not include construction side costs such as: project preparation, selection and prior inspection of location, planning of implementation methods, architectural and structural design, establishing tender documents and tender procedures, awarding contracts, technical supervision for quality and time control and financial monitoring.

Observations in the FTI programme

The generalised design and specifications could allow more flexibility to adapt to the different local requirements and allow alternative construction methods. Technical construction details need improvement.

- The design could offer variations for different climatic conditions
- The roof overhang could be increased
- A damp proof course (DPC) should be standard
- Erosion protection should be foreseen

The main obstacle during construction was the lack of technical assistance. This problem was identified throughout all provinces as well as in regard to the different approaches of the programme. With additional technical assistance on site, most of the defects found could have been avoided without additional construction costs. Consequently, there ought to be measures to reinforce supervision in order to establish more efficient quality, time and cost control. In view of the planned increase in volume of the FTI construction in the coming years and especially in view of introduction of new low cost methods and materials, these measures should be realised urgently. A budget allocation of approximately 10% of the construction costs should be foreseen for site supervision during the construction period.

Findings in the ADPESE Danish Support to the Education Sector

Strategic Plan (Danida)
In the year 2004 ADPESE initiated a conventional school construction project with a total number of 62 classrooms for the Province Zambezia by employing the local consultant TECHNICA. The method and design was similar to Phase I of the German programme. The average costs were USD 20,000 per classroom without furniture.
Since the beginning of 2005 ADPESE has supported the Ministry of Education with a pilot low cost school project by employing a national NGO “AMDU” to facilitate the execution of 200 classrooms in 3 Provinces. No other NGOs were found suitable for the quantity and capacity required. The execution of the project is in coordination with the three DPECs. The project in the Province Tete started off well and in January 2007 the completion of 60 classrooms was expected. In the Provinces Cabo Delgado and Zambezia the provincial directors did not accept the design of “AMDU” and argued for example, that classrooms with simple wall openings instead of windows and doors, would not meet the minimum requirements on functionality for schooling purposes and security. The works were delayed until a compromise was reached with support from DIPLAC/MEC. The concept of the Danish low cost pilot project is 100% community based. The NGO “AMDU” provided only one technical assistant for construction and one social assistant for each province. The selection of sites has been carried out with approval of the DPEC´s. All construction is extensions to existing schools.

Promising results are being achieved from the separate tendering of a prefabricated steel roof structure in view of quality and cost insurance. The structure, with single foundations at the columns and coated iron roof sheets, is estimated by AMDU to have a 15-year minimum life span. The cost per classroom including technical assistance, furniture, water and sanitation is estimated at around USD 10,000. However, this is likely to increase due to the delay in completion and additional costs for transport and materials (doors and windows which were not included in the design). A final account has not been made since the project is not yet complete. The costs of labor were free due to contributions from the communities. ADPESE noticed an extreme lack of human resources for skilled laborer at province and district level. ADPESE considers the need for practical skills training courses to be a matter of urgency. Such courses would benefit both laborer and supervisors.

Findings and observations of the JICA Japan International Cooperation Agency

To date, the Japanese Cooperation has financed the construction of two primary schools in the province of Gaza. Each school contains 5 classrooms including furniture, 1 administration block and 2 latrines. Both schools were built for the total contract price of USD 109,076. Provision of water is not included. The construction started in December 2006. These 10 classrooms are part of a total of 65 classrooms to be financed within the years 2006 - 2008.

The construction works are contracted to the local NGO UDEBA-Lab. The method is 100% community based. UDEBA-Lab is administering the funds, purchasing the materials and providing storage for materials together with a representative from the community. UDEBA-Lab assigned one technical assistant for the works and reports weekly to JICA. Supervision is done by the DPEC with assistance from one member of the community. The JICA resident expert in Gaza is monitoring the works with visits twice a week. The Project Management Commission is formed from the school director and one member of the community. The community also provides one foreman for the works. The design, specifications and contract document used are the ones prepared by DCEE/DIPLAC for the FTI programme. Works have just started and JICA is worried about the quality of works possible with the limited budget of USD 10,000. In their opinion the cost ceiling should be reviewed considering the operation and maintenance costs and transport costs as well. Technical assistance and supervision at the district level was found to be weak.

UDEBA Lab grew out of and replaced UDEBA which was a former programme of the Mozambican Government which was financed by the Netherlands and founded in 1990.

Findings and observations of UDEBA Lab, Non-Government Organization

UDEBA Lab stands for Unit of Development and Basic Education. Lab has been in existence since Nov. 2005. At the moment, UDEBA Lab's activities are limited to the province of Gaza with a view to expanding country wide sometime in the future. The major goal is to train and guide basic education but the construction component is also a part of their work. Another mission is the training of the communities in basic administration. UDEBA has built about 100 classrooms for primary education. Other projects completed are: construction of bakeries, dispensaries and education boarding schools. UDEBA participated in the design and set up of the FTI programme which is now being implemented by MEC.

UDEBA Lab is a national NGO which depends on foreign funds for the implementation of its programmes. Each programme is led by an autonomic acting manager who reports monthly to his or her directors. The main objective in the community work is the training of community members to manage small projects independently. In the Province of Gaza, UDEBA Lab is presently constructing low cost primary schools financed and monitored by JICA. The life span of their low cost school buildings is indicated by UDEBA Lab to be 20 years. They have commented however that some of the local materials used - for example the roof sheets, have a life span of only 10 years.

Discussion of low-cost construction

How can designs for nationwide application in Mozambique, allow low cost solutions and at the same time consider other methods than conventional construction? How can designs be adapted to different local circumstances and at the same time ensure the required function and life span of the structures? The answer is to adopt a flexible standard design concept with a basic durable and simple structure, which allows design variations for different local requirements. A crucial element for the design, applicable for all variations, is to clearly state the minimum standards for its function as a school building. In so doing it is essential to ensure the quality of the construction as a shelter from rain, wind, and erosion. Furthermore, the design must:

- allow proper ventilation
- provide sufficient day light illumination
- offer basic health and hygiene facilities
- use environmentally friendly construction materials
- provide security and stability in its structure
- quarantine low operation and maintenance costs

The use of particular building materials should be restricted. The frequent use of field burned clay bricks, in some areas, is a disadvantage for low cost construction due to its negative environmental impact. Considering the low capacity of re-forestation in the country and the huge quantities of timber burned during the production of these bricks, the field burned clay bricks should be avoided where possible. The inefficient production process causes serious damage to the already limited natural resources. Similarly, the use of hardwood timber for roof structures should be reduced as well.

Proposal for phase II of the school construction programme co-financed by the German Government

In order to achieve low initial building costs and at the same time good quality with low operation and maintenance costs Graf and Marrufo recommend the implementation of Phase II of the school construction programme co-financed by the German government, taking into account the following main features:

- flexible architectural and structural concepts in order to adapt to the different local requirements, alternative low cost materials and methods
- awarding contracts for construction works to smaller companies (NGOs) while at the same time providing more technical assistance
- tender standardized parts of the structure separately, but in large quantities, in order for all schools to receive good quality at low costs
- consultant to provide additional accompanying services to enhance the low capacities of local contractors and to integrate the local community in anticipation of future maintenance of structures

Architectural Concept for phase II of the school construction programme co-financed by the German Government

The architectural design concept is founded on a basic classroom room type of a simple but durable quality structure and aimed at a minimum life span of 30 years. This basic type, which meets the minimum requirements on functionality for schooling purposes, is designed to allow adaptations at a minimum of additional costs. The proposed design packages offer flexible solutions for different buildings types and finishes.

The basic design of a classroom building, equipped with security grills at doors and windows only, can be adapted by adding proposed design variations, for example glass windows, mosquito netting and electrical illumination for evening classes. The buildings can be upgraded to a rural secondary school. The flexible design options cover the various climatic conditions within Mozambique: from a windy and hot sea climate in the province of Inhambane, to the fresh mountain climate in the province of Manica as well as being adaptable to the special problems of a low water table in Beira. The design also includes the option of rain water collection for locations with difficult geological conditions for boreholes. The architectural concept considers the use of locally available, low cost materials and offers solutions for sites with difficult access and environmental conditions.

Extract of significant, innovative design SOLUTIONS of the proposed architectural LOW COST concept, phase II:

TASK At several locations, hardcore is not available and has to be transported to the sites over long distances at high costs.

SOLUTION Replace hardcore with a double layer of DPM, gliding foils allow shrinking of the concrete slab and prevents capillary water rising.

TASK Cracks in the floor slab and screed.

SOLUTION Installation of monolithic concrete floor slabs without cement screed finishes separated from walls, proper curing and expansion joints, allow for shrinking.

TASK Wall finishes: Plasterwork and paint, high initial and maintenance costs.

SOLUTION Specify fair faced concrete bricks without plasterwork and paint.

TASK Cross ventilation in classrooms, cool room climate.

SOLUTION Single sloped roof structure allows permanent cross ventilation at the highest room level, underneath the roof cover, without disturbing the air at desk level.

TASK Erosion due to roof water, humid walls due to splash water.

SOLUTION Installation of simple but effective construction details to prevent erosion and protect the building.

Extract of significant, innovative design SOLUTIONS of the proposed

structural LOW COST concept, PHASE II:

TASK Complicated structures are often not understood on site and therefore create
the risk of defects during construction.

SOLUTION Simple, understandable load bearing structure applicable for all building types like classrooms, administration blocks and teacher houses.

TASK Weak footings endanger the stability of the entire structure, over designed
foundations are expensive.

SOLUTION Due to the limited loads for single storey buildings, the size and depths of foundations can be minimized. The proposed design calculates a solid foundation
at optimized costs. To reduce risks of differential settlement due to varying soil condition a cost effective and efficient solution was found by reinforcing strip foundations and the mortal layer of the foundation walls.

TASK Reinforced concrete columns are time and cost consuming; in some remote
areas shuttering materials are not available.

SOLUTION Load bearing walls without columns.

TASK Roof structure, the most expensive detail of low cost structures, yet the most important part of a building in view of functionality and life span, was found with extreme quality deficits and very different, sometimes unstable details.

SOLUTION Design a simple and unique roof structure applicable for all buildings. Main requirements are lightweight and suitably sized members to allow transport to
sites with difficult access conditions, an easy system for assembling and erecting on site and a system to allow prefabrication to ensure quality and low costs with bulk orders.

Tasks recommended for Phase II of the school construction program
co-financed by the German Government

- cooperate with MEC as Project Executing Agency
- examination of construction sites
- preparation of site plans, existing situation
- project preparation
- pre-qualification or assist in short listing of contractors
- detailed design, bill of quantities, specifications
- establishment of tender documents according to the national procurement procedures
- preparation of tender documents
- assisting during tender process
- evaluation of bids
- proposal of award of contracts

- supervision of construction
- assistance in supply of basic furniture for classrooms, offices and staff houses
- financial monitoring of the program
- acceptance of works after completion
- reporting quarterly to MEC and KfW
- Establish and coordinate for all three provinces the several separate tenders for civil construction works on provincial level, the material supply on national and international level
- Organize and synchronize the timing for delivery of diverse separate contracted materials and services
- Maintenance system should be applied for phase II of the project integrating the community during construction to increase technical understanding in view of future maintenance
- Motivate the sub-contractors and NGOs to involve the communities, from setting out of buildings to participating in assembly of the prefabricated roof, in view of future maintenance
- Establish simple contract conditions appropriate for provincial use
- Establish simple supervision systems appropriate for provincial use
- Set up an accounting and disbursement system appropriate for provincial use

Preliminary time estimation

For the Project preparation stage, we are estimating 10 calendar months for the consultant's services to cover:
- Verification and inspection of sites
- Surveying and preparation of site maps and contour plans of existing situation
- Detailed working drawings varying to different local requirement in the 3 provinces
- Specification and description of works (Scope or BOQ)
- Pre-qualification of contractors, shortlist of contractors
- Preparation of tender and contract documents

The tender procedures as an ongoing process are estimated to last about 12 months for:
- Invitation to tender
- Pricing and submission
- Analysing of bids and contract awards have to be carried out simultaneously at intervals according to the construction volume possible and the limited capacities of the provincial contractors

The construction period for one school with 5 classrooms, 2 teacher houses, one administration building and latrines is estimated between 6 to 8 calendar months depending on access conditions to the site.

CHAPTER FOUR- DISCUSSION ON MODULAR DESIGN OF ARCHITECTURAL DESIGN

4.1 WHAT IS THE MODULARITY OF ARCHITECTURAL DESIGN?

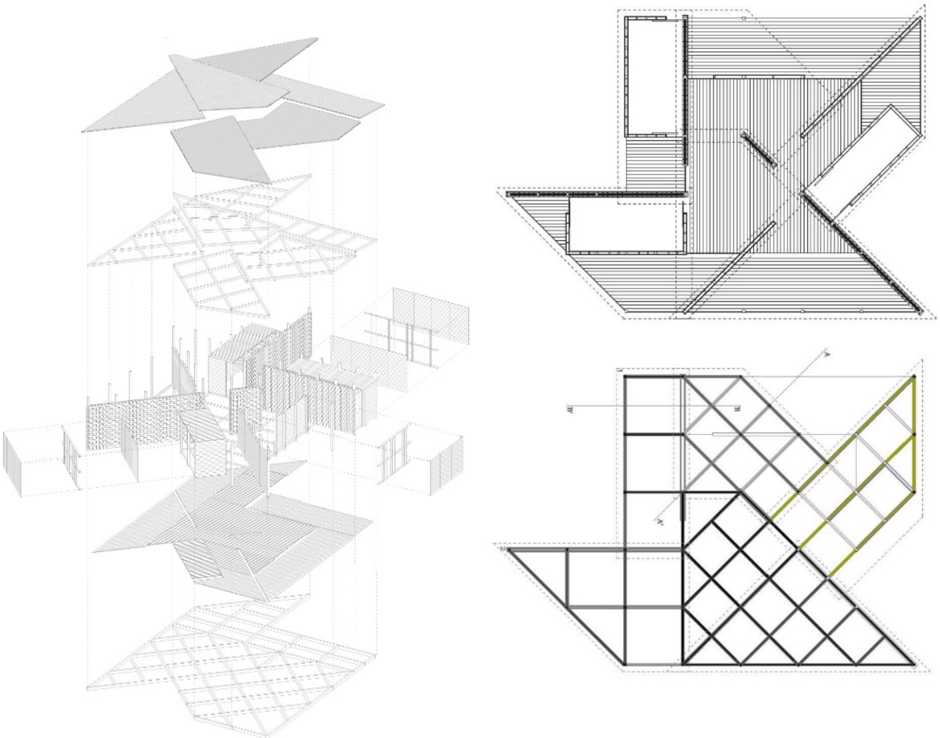
4.1.1 Definition of the modularity of architectural design

The so-called architectural design is a detailed analysis of the buildings we want to design, through the same terrain in the past, the same design purposes, the same architectural concept summarized. To re-build the same conditions when the building can be "used to do", that is, borrowing the previous experience and design, which can effectively form the structural system, architectural form, the overall space function. The so-called module is also a detailed decomposition of a whole work, will be designed to create a function of each module, and these modules for the specific use of the function of the refinement of the design of the time to use these modules and stitching, With the module can be re-formed a whole building. In the modularization of the time not only to refer to the original architectural design with the important thing is to do the following. If we can carry out the architectural design of the model so that in the conservation of land resources will have a prominent contribution. But even the exact same building cannot guarantee that the functionality used is the same. So, it should be carried out at the same time careful design, will be modeled and specific combination of each other. Only in this way can this modular design to achieve the effective use of resources to improve the overall progress of the project.

Modular design is based on the dimensions of a building component defining the 'module', used as a unit of measurement or standard which as a result determines the proportions of the remaining construction. The Japanese Tatami mat, for example is based on the proportions of the human body. All other dimensions of that building system evolved around the mat size, resulting in a systematic architecture, scaled and proportioned according to the unit of the human; one person lying or two people sitting.

The beginning of industrialized building can be dated to 1851 when Paxton created his Crystal Palace. The glass panel is the module of this building system. Everything else was designed according to its dimension. The innovations on the Crystal Palace were a huge step forward for the building industry which unfortunately did not maintain its momentum. If the building industry had developed and embraced technology as it did the aircraft or car industry, for example, we would all live in highly technologically sophisticated houses today. However, there is actually a huge discrepancy in the development between building and other industries. (Horden, 2001).

As Richard Horden states "change in building construction technologies, in most countries, is generally slow and rarely noticeable. When people think of a house, they are influenced by what already exists. The sense of familiarity is greater than the desire of experiment. Most people are looking for a home which is not the same as a product They haven't accepted the idea of a home being modular or prefabricated. For an office block or an airport this concept is perhaps more acceptable". (Horden, 2001).



4.1.2 Modular research purpose and significance of architectural design
(1) research purposes. Sustainable development means that to resolve the contradiction between us and natural resources, the contradiction between the construction industry and nature is the contradiction between building and land resources. In this case, the modular design is pushed onto the historical stage of architectural development. It not only solves the problems of structural system, architectural form and overall space, but also conforms to the psychological aesthetic and physiological needs of social people today.

(2) the significance of the study. Architectural design modularity is a practical architectural technology, with distinctive characteristics of the times, can effectively solve the contradictions between man and nature, but also can save the cost of time and the role of capital costs. ① high space flexibility. This can be effectively avoided and has greater flexibility when we can make "take" the building design, that is, the effective use of the rest of the building design in this area. Through this "take" can be fixed on the space to determine the design space within the column spacing, equipment conditions, layers of

design factors, for different space design can be a different modular design, and therefore also have diversity. ② save space. Modular design of the building can be different terrain and weather and weather conditions for effective use, with the original module design for detailed details of the design work, which can effectively reduce the waste of excess space structure. ③ simplified construction. In the architectural design of modular construction, due to the previous experience and design for reference, and because of modular design with diversity and flexibility. In the construction of the time when the module can be refined within the work. Small screws to the module within the housing, the higher the level can be simplified construction, which can effectively save time and reduce cost costs. ④ is conducive to expansion and growth. Building modular design is the most suitable for the construction of the project, so that the funds can be effectively raised and to achieve progressive investment, so that the interests of the stage to maximize.

4.2 Factors that influence the modularity of architectural design

(1) Functional factors.
The starting point of all our buildings is based on practicality, so we should follow the three elements when we are designed to be solid, practical and beautiful. In the design of the time to consider the purpose of the building to be designed, if it is a residential need to have a home function, if it is for commercial use should consider the overall business needs or office needs. If it is a hospital, you should consider the dual needs of life and business.

(2) Structural factors.
The building structure is also one of the main factors that affect the design of the module. In the design of the building structure, it is not only necessary to carry out the local optimization by means of modularity, but also to improve the use of the building to be built, cannot blindly copy the use of photos. In the design of the time to fully divide the space, indicating that the channel, space partition and so on. In the process of modular design should also pay attention to the connectivity between the modules, which for a building will play a very critical role.

(3) The impact of the environment.
The environment of the building is a key factor in the process of building design. In the design, it is not only necessary to refer to it. The same kind of building needs to be carefully examined and measured. The so-called investigation is not only about the topography of the study, or the surrounding

living environment and social environment for an effective study, in the external design of the time with the surrounding environment with each other, cannot be with the sex.

4.3 Module architecture design follow the principles

1. Functional independence

The base module is considered a dimension that can be used to realize the characteristics of architectural composition, the relationship and the proportional elements of all project.
This module must be characterized by a certain functional indefiniteness, but it should not produce impersonal houses, but rather residences that can be personalized and then recognizable, modifiable to allow a real compliance with some specific lifestyles.
This prototype must increase, and must have a changeable arrangement that is thought as a correlated union of base units, that can work independently.
The principle of functional flexibility is specific to the function of module, optimization work.
Let living personnel or commercial use is more reasonable and practical.

2. Flexibility and modularity

Designing modules with a great flexibility means guaranteeing their adaptability to meet the requirements of different users. Then, it must be able to adapt through revisions and new arrangements of space, dimension, structure and finishing that could be realized also by the users directly, with a precise range of possible solutions.

This research aims to analyses some elements that enable to modify the configuration of the structural plan, with an improvement or a decrease in spaces, to allow flexibility over time.

3. Transportation facility

The criterion of assembly and transport arrangements are elements that affect the structure materials and therefore the shape of the prototype (size limitations, weight, materials, etc.), and these are directly related to the transport system.

The structure of this prototype tries to contain the lowest possible number of different elements to favour various connection modalities that can be realized without specific tools or equipment such as bolts and joints.

This project probably must choose a modality of dry assembling. This is the most important characteristic for all structures of emergency houses because, most of the times, the construction of these units is realized on-site by qualified but not specialized staff.

4. Disposition and aggregation

This research is also a thought about temporary houses that can be study for a limited period, with a certain mobility of users; they can change their location and, subsequently, increase the mobility of the architectural product.

Space unit is realized like a spatial system with different environmental and functional characteristics that can be used for different needs every time. These systems are opened and they can be integrated, in order to interact with the hope of defining complex spatial structures.

In so doing, it is possible to pass traditional housing systems for emergency situations, in favor of integrated experimental systems composed of a combination of functional units, morphologically and technologically different.

5. Productive economy

The assembly facility of structure elements allows a partial self- building, that is furthermore important for environmental, economic, social and psychological reasons. The portability and the usability of the space should be compatible, as well as the lightness with stability and the compactness with expandability.

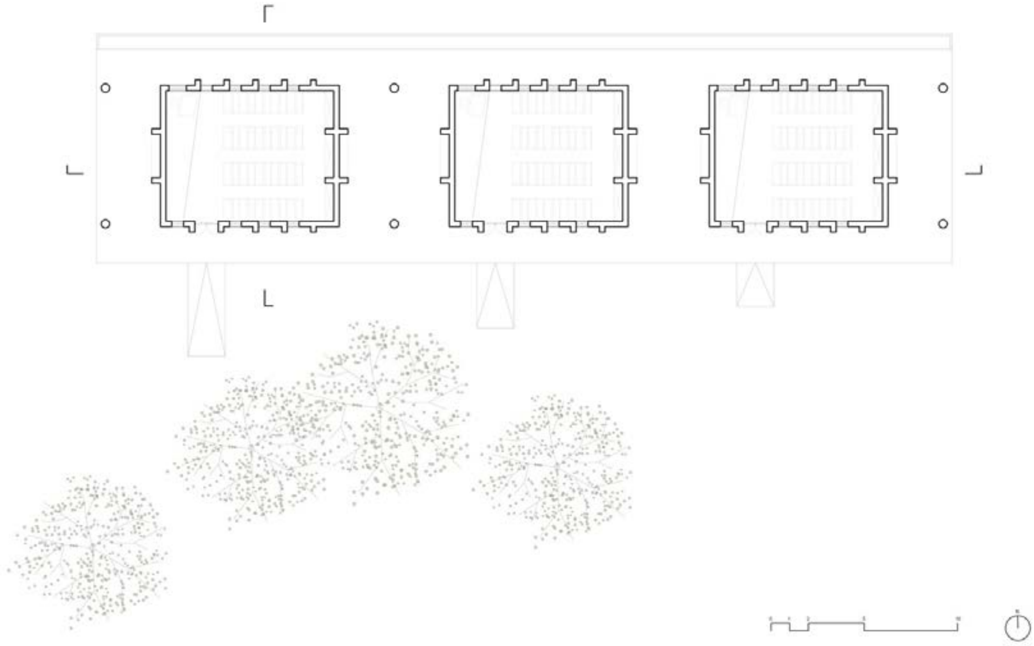
Flexibility, lightness, and mobility are the innovative components characterizing the contemporary architecture and adapting the typological characters to the new requirements.

the principle of space is mainly on the land resources and space saving, only in this way can realize the sustainable development, not the pursuit of quantity is big, but should be the pursuit of practical, beautiful, the second is to improve the overall utilization of the space, full use of the limited space, realize the perfection of the function of the area.

4.4 SCHOOL EXAMPLES OF MODULAR DESIGN IN DEVELOPING COUNTRIES

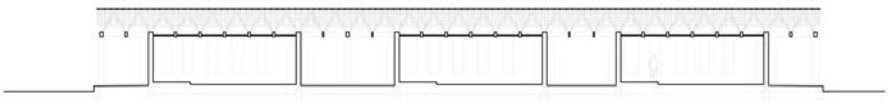
4.4.1 Primary School in Gando / Kéré Architecture

From the architect. As a native of Burkina Faso, Francis Kere grew up with many challenges and few resources. When he was a child, he travelled nearly 40 kilometers to the next village in order to attend a school with poor lighting and ventilation. The experience of trying to learn in this oppressive environment affected him so much that when he began to study architecture in Europe, he decided to reinvest his knowledge towards building a new school in his home village. With the support of his community and funds raised through his foundation, Schulbausteine fuer Gando (Bricks for Gando,) Francis began construction of the Primary School, his very first building.



The design for the Primary School evolved from a lengthy list of parameters including cost, climate, resource availability, and construction feasibility. The success of the project relied on both embracing and negating these constraints. In order to maximize results with the minimal resources available, a clay/mud hybrid construction was primarily used. Clay is abundantly available in the region, and is traditionally used in the construction of housing. These traditional clay-building techniques were modified and modernized in order to create a more structurally robust construction in the form of bricks. The clay bricks have the added advantage of being cheap, easy to produce, and also providing thermal protection against the hot climate. Despite their durability, however, the walls must still be protected from damaging rains with a large overhanging tin roof. Many houses in Burkina Faso have corrugated metal roofs which absorb the heat from the sun, making the interior living space intolerably hot.

The roof of the Primary School was pulled away from the learning space of the interior though, and a perforated clay ceiling with ample ventilation was introduced. This dry-stacked brick ceiling allows for maximum ventilation, pulling cool air in from the interior windows and releasing hot air out through the perforated ceiling. In turn, the ecological footprint of the school is vastly reduced by alleviating the need for air-conditioning.



Although the plans for the Primary School were drawn by Francis Kere, the success of the project can be attributed to the close involvement of the local villagers. Traditionally, members of a whole village community work together to build and repair homes in rural Burkina Faso. In keeping with this cultural practice, low-tech and sustainable techniques were developed and improved so that the Gando villagers could participate in the process. Children gathered stones for the school foundation and women brought water for the brick manufacturing. In this way, traditional building techniques were utilized alongside modern engineering methods in order to produce the best quality building solution while simplifying construction and maintenance for the workers.

The Primary School was completed in 2001 and received the Aga Khan Award for Architecture in 2004. More importantly, however, the Primary School became a landmark of community pride and collectivity. As the collective knowledge of construction began to spread and inspire Gando, new cultural and educational projects have since been introduced to further support sustainable development in the village.

4.4.2 Makoko Floating School / NLE Architects

Unpredictable climate changes along the world's most vulnerable coastal communities, have produced some fascinating design solutions that test the resiliency of architectural possibilities and the need for adaptation that will produce these changes. The coastal community of Makoko, a slum neighborhood, off the Lagos Lagoon in Lagos, Nigeria is receiving an upgrade to its current solution, which is building homes supported on stilts within the lagoon's waters. NLE Architects, with sponsoring from United Nations Development Programme (UNDP) and Heinrich Boell Foundation from Germany, designed the Makoko Floating School, phase one of a three-phase development that will become a floating community of interlocked and floating residences. Construction on the project began in October 2012 and was completed just last month with grand appraisal from the community and UN visitors.

The Makoko Floating School and the total planned projects makes use of local materials and resources to produce architecture that applies to the needs of people and reflects the culture of the community. Wood is used as the main material as the structure, support and finishing for the completed school. The overall composition of the design is a triangular A-Frame section. The classrooms are located on the second tier. They are partially enclosed with adjustable louvered slats. The classrooms are surrounded by public green space, there is a playground below, and the roof contains an additional open air classroom. NLE has also employed strategies to make the floating architecture sustainable by applying PV cells to the roof and incorporating a rainwater catchment system. The structure is also naturally ventilated and aerated.

Adeyemi's claim to fame is his widely covered floating school in the Makoko district of Lagos. Makoko, built over the lagoon that gave the city it's Portuguese name, effectively became a self-governing settlement due to the lack of government presence in the area. As Nigeria booms - recently overtaking South Africa as Africa's largest economy - Makoko has come under pressure from the government as a well-known and distinctive informal settlement in the heart of Nigeria's largest city. Although neither sought nor approved by the government (but built with the aid of NGOs and the UN),the school utilizes traditional Nigerian forms in a modern way and is uniquely suited to the situation in Makoko. Although only one building, the project proved easy to build and low cost, and indicates a different and desirable trajectory for Lagos rather than the current pressure to level Makoko - including the school, which is technically illegally built.

Despite this, Adeyemi is drawing on his considerable academic skills to expand the Makoko floating school into a proposal for multiple floating residential and commercial buildings - part of his proposal for MoMA's Uneven Growth exhibition - in what he considers a solution for the estimated 250,000 people living in Makoko, but also to future challenges brought by Lagos' vulnerability to climate change. The buildings, shaped to mimic local forms and take advantage of solar panels, would be perfectly suited to exploiting water based transport and heavily resistant to problematic storm and ocean surge flooding.

Outside the floating town project, Adeyemi is known for his context-specific urban planning on an academic level, and his residential proposals that continue these themes. For example, the modular Yaba Prototype is a well-designed yet low cost, efficient scheme which could be developed as a new form of urban housing for Nigeria's middle class, which is estimated to grow by 7.6 million in the next 16 years. This growth will put enormous pressure on existing housing stock in Nigeria, which despite increased investment is still heavily polarized between luxury housing and informal settlement in the highly unequal country. Additionally, with Nigeria's fertility rate long overdue for a significant drop - it has held steady around 6 for the past 40 years, while other countries such as Kenya have seen their fertility rate half over the same period - and therefore a potentially volatile housing market on the horizon as family sizes change, the modular nature of the Yaba Prototype allows for easy internal reconfiguration to create apartments with more or less bedrooms as required. Widespread rollout of the Yaba would not only provide space in Nigeria for a new lower and middle class, but also ease the stress of demographic changes that could easily render large swathes of new housing in Nigeria irrelevant.

4.4.3 Palestinian territories primary school

INTRODUCTION

The Abu Hindi Primary School is a rehabilitation project of a primary school in the Bedouin camp of Wadi Abu Hindi in Occupied Palestinian Territory, less than 10km east of Jerusalem. The geographic and socio-politic context is similar of the one of Al Khan Al Ahmar primary school, with the Israeli authorities prohibiting permanent settlements. The challenge of this project is to deal with the scarce resource in a zone of political tension in addition to addressing local climate and land policy constraints.

Building in this sensitive context, it is inevitable to work with velocity and simple construction methods, with a minimum cost and unskilled manpower. The rehabilitation had to face restrictions imposed by the Israeli military authority, which makes it impossible to change the volume of the existing school building.

The Abu Hindi Primary School is an international cooperation project led by Vento di Terra NGO, an organization working in Palestine for children's fundamental rights to education and health care. Here Bedouins live in very critical environmental conditions, due to the air and ground pollution and to the serious water scarcity of the area.

CULTURAL AND SOCIAL CONTEXT

The Bedouin community of Wadi Abu Hindi is a part of Al Jahalin Tribe, one of the biggest refugee tribe in the West Bank today, with more than 2700 people dispatched yet in 31 different areas. Natives from the Tel Arad district of Al-Negev desert, they had to leave from their environment and take refuge in the West Bank after the establishment of the state of Israel in 1948. This context makes life very difficult, particularly for the weakest inhabitants of these villages in the desert: children. The parents can't no more convey their traditional Bedouin nomadic culture, and further there is no place to give their children proper education.

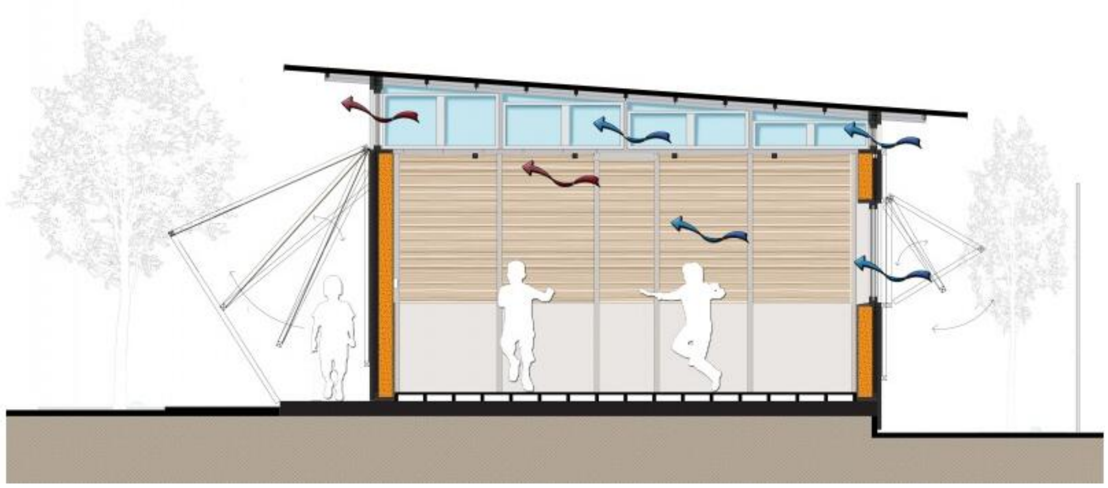
The Valley of Abu Hindi is situated in the desert between Jerusalem and Jericho, in a place now classified in the Area C territories1, which are parts of the West Bank under an administrative and military control by the Israeli Authorities. There, the Bedouins are subjected to many prohibitions in particular to build permanent settlements. In Wadi Abu Hindi there's no connection with the electricity or communication nets, they use a hire gas oil generators, which is insufficient for the local needs and cannot work in a continuous way. Water supply is realized with a service rubber pipe of 2 cm diameter, often damaged with infiltrations. Moreover, the camp is downstream of the biggest dumping ground in the area, which is used both by Jerusalem city and Israeli nearby colonies.

MATERIALS AND BUILDING TECHNIQUES

Having ruled out concrete or ceramic bricks for any structural part, ARCò looked for an easily available material, like those with biospheric origin, like soil, straw and bamboo, better if taken from the large number of junkyards, standing by the sides of the highway between Jerusalem and Jericho. Bedouins have a renowned recycling culture. All their houses and structures are realized in metal sheets and wooden trusses gathered in the building yards where they work or simply in the dumps. Unfortunately, these kind of materials are not appropriate during the hot summers and cold winters, since their insulating power is near zero.

Technical and architectural decisions, taken by ARCò team, had the purpose of retrofitting the existing building and transforming it in a new one, which is climatically comfortable and energetically sustainable. That’s why we worked on two main themes, which are acoustic and thermal insulation and natural ventilation.

From the initial building, new partitions between the classrooms were made for a best acoustic insulation. The existing metal sheet was substituted with stabilised soil bricks, produced by local artisans in the Jordan Valley, finally covered with a white lime plastering.



The exterior walls were isolated with the technique of “pisè” adapted to the local needs. The final result in the school is a wall around 30 cm thick including a first lime plastering, then a bamboo formworks with inside a soil and straw compacted layer using the method of pisé, following by the existing external metal sheet, an air cavity and a final external shading bamboo panel. Thermal insulation was also improved by placing a new wooden floor.

The existing roof were raised and inclined to allow the natural ventilation. New openings of 60 cm high on the Northern side and 60 cm high on the Southern side were placed in a way that can be open with sliding plexiglass panels. The creation of new openings led us to rethink the whole steel structure. The existing metal sheets which formed the roof were substituted with sandwich panels, improving then the whole building thermal insulation.

Except this part of the roof which use materials came from a specialized building company, all the constituents came from an environment close of the site. The Bamboo panels are nothing more than shades panels produced by an local artisan re-used by ARCò as formworks for the external pisé wall, favouring the local production and facilitating the transport and the implementation.

All works were realized in two months, six days per week, eight workers a day, all workers coming from the village. Thus works took place only during the summer school vacation, working hard in July, since August 2010 corresponded to Ramadan period.


EARTH AND CLIMATE

The walls were built using Pisé wall and adobe bricks which are methods using compacted mix of straw, sand and clay and the different plastering was also made out of earth. The choice of the material came from a deep analysis of the specific location of the project, with its geographical and socio-political conditions.

As said before, the school is located in a Bedouin camp in the desert, what nowadays is the area C of the West Bank, which means that no permanent building is allowed to be built there, so no conventional construction company is allowed to supply materials or to work in that place. Then the only manpower available was the Bedouins from the camp themselves, and the only material available from their nearest environment was earth, very much used in the past by the local population of the same area.

The techniques of Pisé and Adobe bricks are fast and simple to set up, easy to learn by the workers, using materials available on the site and allowing the construction to start under a very low budget allowing also a new climatic comfort. Indeed, raw earth is known for his high quality of thermal inertia, which allows to keep the freshness during the hot days and the heat during the wintry season. Thus, the school won around 10°C of difference perceived from the outside to the inside.

Use of renewable ressources - low tech
natural cross ventilation, use of high thermal mass, others

Renewable, recycled, recyclable and innovative materials
Bamboo (500 m2), Straw (3000 kg), Lime plastering (325 m2), Soil (20 m3), Sandwich panels (314 m2), Wooden pavement (180 m2), Steel structure 5x5 (810 m), Stabilised straw and mud bricks (120 m3 per 15600 kg)

Key Sustainability aspects
solar building integration, vernacular building strategies, accessability for disabled, renewable building materials, recycling and reuse, ecological building materials, integrated planning process, participation of users in planning process, low cost design, use of innovative design tools

Social and ethical responsibility
Abu Hindi primary school project was born from a strict cooperation and exchange of ideas and information about needs and desires between the Jerusalem Bedouin Committee Anata, the promoter Vento di Terra NGO and ARCò team. This building refurbishment answers to children need for a safe, clean and performing school and to the need for an identity collective place of the whole Bedouin community. Local inhabitants are employed as workers in a process of complete and transparent participation.

Ressource efficiency and environmental impact
Refurbishment activity is a highly efficient use of land, moreover of basic importance in a country with land scarcity as Palestine. We use low tech materials, easily available and recyclable, with minimum environmental impact; off-grid energy for illumination, that will be generated by a PV roof plant; passive mechanisms for thermal energy balance, offered by the bamboo shading panels, ventilated air cavity of the external walls, transpiring walls made of straw and mud, ventilated roof.

Economic lifecycle perfomance
The financing of this project comes from voluntary funding raised by Vento di Terra NGO. The building activity, carried on as auto construction by Bedouin workers with the supervision of ARCò team, brings improvement of their professionalism and possibility of new highly qualified job. Low cost and easy availability on site of materials used make local communities independent from any scarcity, commercial embargo or inflation. All the materials have low environmental impact in their Life Cycle Assessment, and can be reused in the future.

Contextual performance and impact
ARCò uses simple cheap materials to reach high performance and architectural quality. The colour and texture of bamboo panels, naturally changing with sunshine and time passing is in harmony with desert landscape. The creation of strip windows on top of external perimeter walls, together with classrooms internal white plastering, creates a warm and beautiful natural light inside the building. The restoration of the building brings a great positive impact on children perception of their everyday school-life and on the whole community.

4.5 MODULE DESIGN THINKING LINKING TO SCHOOL BUILDINGS

Background

Modular design is not new. The 1920's to the early 60's were full of inventors and innovations for modular construction and its on-site delivery. The 'Turning Point of Building' (Wachsmann, 1961) was an indication that such constructs would be the predecessor over conventional building processes as we know them today. Relocatable school buildings represent one of the most popular forms of 'modular' construction today. Yet, the processes by which such buildings are manufactured, is a far cry from applying present technological advancements. There are significant opportunities to advance the entire modular design, its structure, building materials and services technology. These opportunities require research at the pre-design as well as the prototype stages. This assignment is also in need of an organized research structure inclusive of economic, environmental, and social benefits of modular dwellings.

In order to obtain a better sense of what prefabricated buildings can offer, in the context of our present global situation, it is best to provide a review of the past. The objective is to acknowledge the established principles of prefabrication in the context of modularity. Many pioneers considered 'modularity' as a key component of prefabrication. Le Corbusier, Jean Prouve', Konrad Wachsmann, Fritz Haller, all embraced various principles and interpretations of modular design. The modular or 'prefab revival' is indebted to its past and must overcome several of its established phobias in order to advance and gain acceptance in today marketplace.

Modular Construction Benefits

Prefabricated design can be applied to both on site as well as modular construction methods; however, modular prefabrication is the preferred and more efficient method as it takes on similar principles of repetition and standardisation. The advantages of modular prefabricated construction methods are:

-Low Cost
-Easy and Compact Shipping Methods
-Time Efficiency in Product Delivery
-Increase of quality control through organized machine-based manufacturing
-Increased standard of OH&S (Occupational Health & Safety) manufacturing
-Reduction of Unforeseen Risks
-Easy Assembling of Parts
-Predictable Environmental Conditions and Services
-Tremendous material waste reduction

Failures in modular building have resulted from a vicious co-dependency on public acceptance, volume production, and distribution infrastructure. None of these attributes can successfully exist without the presence of the others. The public was looking for cost reduction and availability, while such reductions, in turn, depended upon mass production, and high public demand, offering little flexibility. Today the robotic and pre-programmed processes of building can offer 'one-offs' and unique diversity (Bock, 2006). While modularity remains a key component of such building systems, the limits of 'modules' have been redefined and the aspect of pre-fabrication is an economic advantage.

Evaluating modular design systems

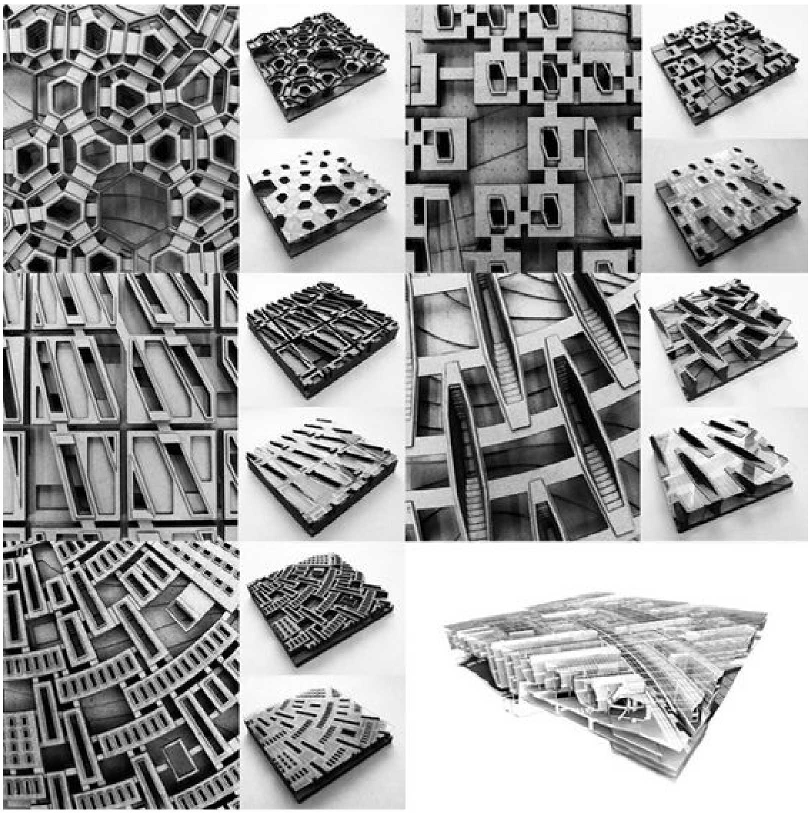
Solutions to modular and pre-fabrication need to be considered and approached as design problems. Modular and pre-fabrication design should consider:

-Systems that are composed of separate components (modules) that can be connected or integrated together.

-Systems that allow components to be added or replaced without affecting the rest of the system.

-Systems that can create spaces of differing scale through repetition of components.

A "modular architecture" easily allows the addition or subtraction of components and can enhance the flexibility of usage and maintenance of a built structure.



Modular Categories

At first, we consider that a modular system can be prefabricated or constructed on site. Since we are engaged in the paradigm of pre-fabricated construction we might explore whether pre-fabrication it-self can be categorized into particular types. In our analysis, a panel/skin, skeletal or cellular type of modular unit is determined to be a distinctive category of prefabricated building. These prefabricated systems are units that can be constructed by one or more modular systems. In this case, elements or components, a kit-of-parts, a fill-in or an assembled complete unit constitute modular design systems. Next, we define the possible construction stages and how modular pre-fabricated systems can become or are a part of this in their design. These construction stages are categorized as: foundation, sub-floor, envelope, roof, services and energy sources. The last two stages, 'service' and 'energy source' are intended as independent stages or products that could be delivered as pre-fabricated units or become a part of the other building stages.

The boundaries between the 'of modular building categories', and the 'modular design systems' are quite flexible such that, as shown in the following two examples, a panel as well as a skeletal type of modular unit can be part of a design system such as a kit of parts.

A panel system is defined here as:

- the construction based on a single integrated unit.
- external cladding, structure, insulation, internal lining, fenestration and design for ventilation may be included in the unit, making it diverse and unique.
- a system which may span floor to ceiling (wall panel) or floor or roof panel.
- a system which can minimize the building elements as well as provide an integrated structural stability.

Panels can comprise the entire envelope and structure (see Figure 1) such as in the Tropical House by Jean Prouve. Prouve designed the Tropical House as a prototype for inexpensive, readily assembled housing that could be easily transported to France's African colonies. Fabricated in Prouve's French workshops, the components were completed and flown disassembled to Africa in the cargo hold of an airplane. The house sits on a simple one-meter grid system with fork-shaped portico support of bent steel. All but the largest structural elements are aluminium. No piece is longer than 13 feet, which corresponds to the capacity of the rolling machine, or heavier than 220 pounds, for easy handling by two men.

The house volume is defined as multiples of the basic modular component the "wall pane!' which integrates a full prefabricated envelope system; structure, external cladding, internal lining, solar penetration, ventilation and insulation. The lightweight (aluminium and insulation) panels may act as a secondary element to the main structure or as doors, walls and windows.

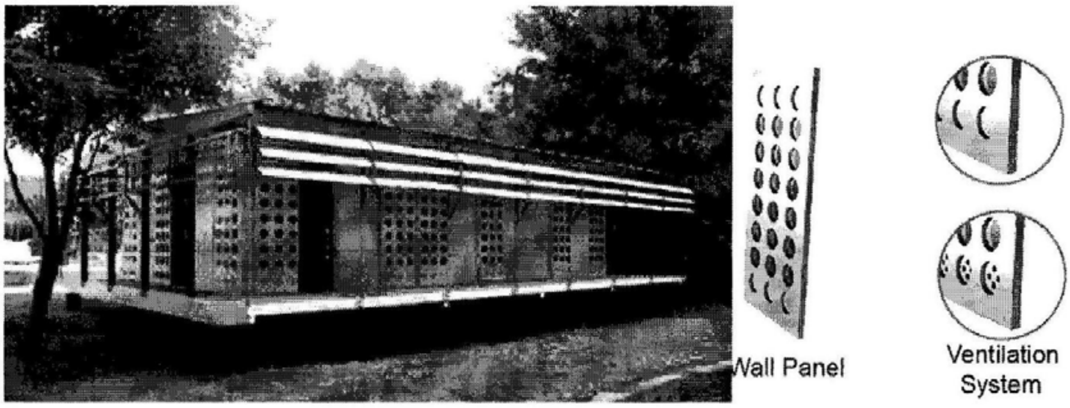


Figure 1: The Tropical House by Jean Prouve

A skeletal system is defined as:

- individual components assembled to provide a structural frame, foundation or structural system.
- a system which acts as an independent element to which envelope elements are attached.

Inter-connection or integration can occur between the skeletal system and other mechanical services.

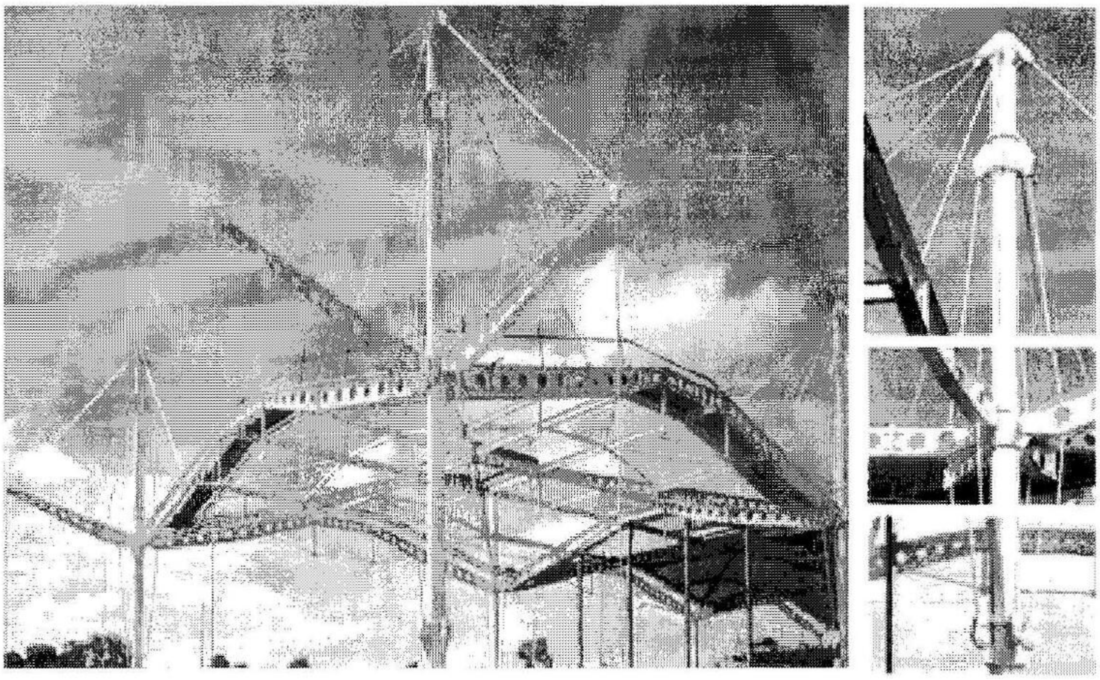


Figure 2: The Renault Centre (1982) - Norman Foster

Built in 1980 - 1982 in Swindon England, the Renault Centre by Foster Associates stands as an example of modular system building (Figure 2). The concept uses an umbrella structure as a "modular unit"to span the required distance (a bay dimension of 24 meters). The system consists of self-sustaining modules capable of grouping in a variety of configurations and responds to the demand of the site and its internal use, to requirements of flexibility, speed of construction and low cost. This allows incremental bi-directional growth for future change or expansion with minimum interruption to the current function of building.

A cellular system is defined as:
• Components which form entire singular spaces, that combine together, create a building or are prefabricated as an entire cellular building.
• Envelope, interior, mechanical and structural systems can be incorporated within a single unit. Delivered to the site as one unit (see Figure 3).

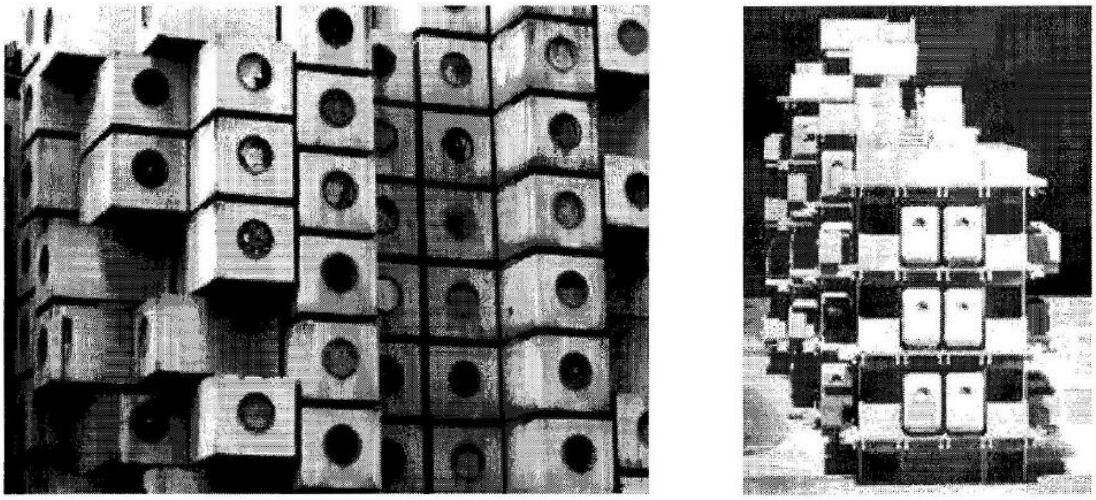


Figure 3: Nagakin Capsule Building - Kisho Kurokava, 1970-72

Modular Design Systems
These describe the manner in which the modular building unit is constructed
An element or component system is:
• based on a single modular component
• can be easily constructed or assembled into a system
• can produce a skeletal or panel building typology

A 'kit-of-parts'system is:
• a set of variable components packed together which make up a building.
• can be assembled on-site or delivered as a pre-fabricated system.
The problem with this particular 'design system' may be that only one solution of assembly exists. A 'kit of parts' should benefit by offering flexibility in modular components. The Toyota Motor Corporation is offering prefabricated housing where consumers can assemble their 'dream home' from over 350,000 single parts. Computer-aided design and manufacturing will produce around 2,000 components which in turn make approximately 300 functional modules (Bock, 2006).
Figure 4 below is an example of a cellular type of modular unit, based on a "Kit of Parts" design system.

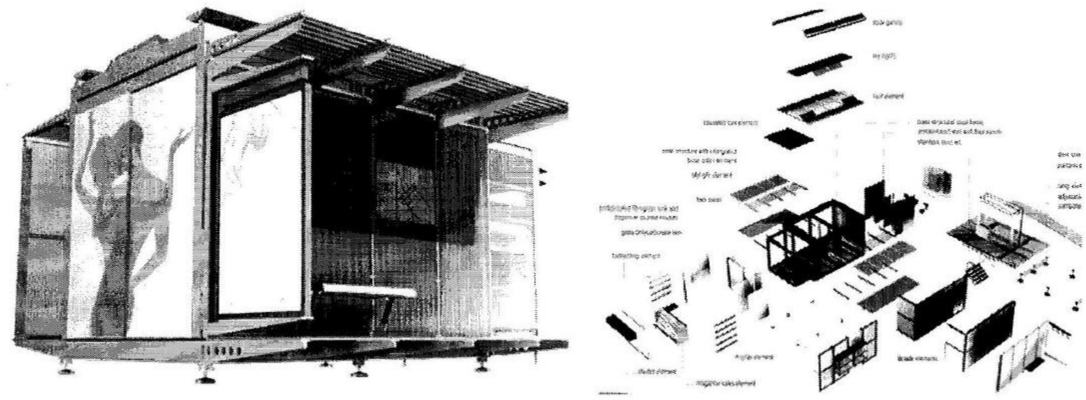


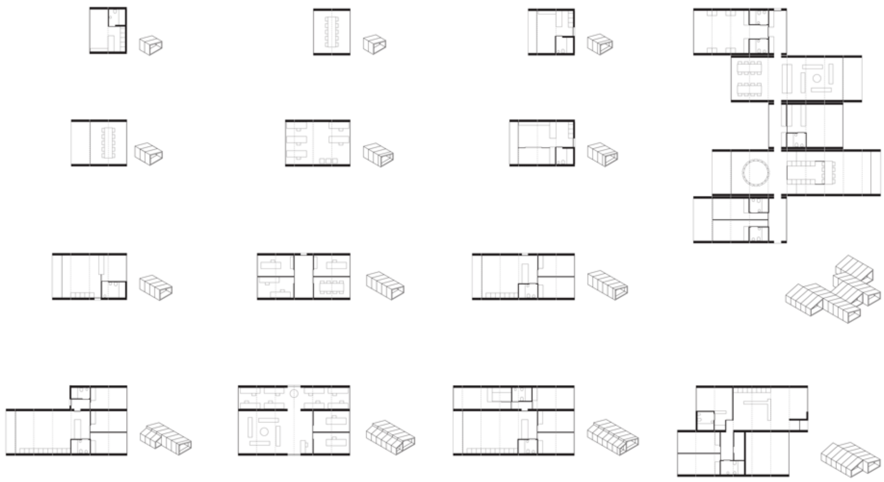
Figure 4: Modular Mobile Sanitary Facility

A 'fill-in' system could be defined as:

- one spanning between two structurally complete units.
- a combination of modular pre-fabricated systems: panel, skeletal or cellular units
- simply a 'fill-in' to make up the void or open space.

The next modular prefabricated systems in Mozambique: a solution

We need to rethink the way we design schools in Mozambique. A total re-engineering of building materials, their manufacturing processes, construction and operation requires redesign, waste reduction and transformation into energy producing products and building. A sustainable future of architecture demands research into renewable, adaptive, recyclable and environmental building components. This design needs to offer the composition of modular flexible space and versatility. Our next architecture will require innovative engineering of building services together with progressive design, applying the knowledge of material chemical composition, detailed construction assembly and the implementation of renewable energy and water systems.



Modular prefabricated building requires a new paradigm to make it work and coexist with present demands of affordability and reassuring sustainability. This paper is only a small step in trying to revisit and convince the designer that there may be a future in architecture with modular systems and that we need to be open minded about what they can offer.

One of the primary intentions of revisiting modular building systems is to explore the past, discover possible patterns and solutions and reconsider what might be missing. Within this context, we might consider a new approach or purpose for prefabricated modular building and what it could offer. Focuses on modular school structures, and this approach is extended into the building life and transportability of the unit. Depicting the permanent, temporary and transient conditions of the modular prefabricated unit directly relates to its construction category or type, its application of modular systems, its material selection, and construction method.

It is therefore useful to perform an analytical diagnosis of modular designs in an attempt to find opportunities to improve them. One of the major opportunities for modular designs is their application of RARE (renewable, adaptive, recyclable, and environmental) architecture principals integrated into the design. As stated by (Luther Altomonte & Coulson 2006), "it could be expected that our buildings become energy resources, instead of energy consumers". Modular often translates to individual units, allowing easier integration of services (Le. heating and cooling) control in comparison with conventional building. Prefabricated design provides a good opportunity to take on the RARE. principles because it supports the idea of integrated design at all stages in a project and offers the possibility to combine multiple systems and services. The focus is on flexibility, of design, of adaptation, of space and aesthetics. By identifying and classifying modular design we open up a larger playing field and therefore more variations. Modular design has not been as accessible in the past due to high costs and code restrictions. However today modular designs are becoming more intelligent as our sophistication of materials, energy systems and building services improve. The new paradigm for modular design is to understand its classifications, taking onboard our developed technologies, using renewable and adaptive principals to rectify livable space and through testing, combining and refining modular architecture it can be readdressed within a new light, one that may be more successful than the past.

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