

**ATTE KIIANEN**

MASTER'S THESIS AT CHALMERS ARCHITECTURE | DESIGN FOR SUSTAINABLE DEVELOPMENT

# Mobile schools for tribal villages

A conceptual study for transportable structures in rural Odisha, India

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**CHALMERS**  
UNIVERSITY OF TECHNOLOGY



MASTER'S THESIS

# **Mobile schools for tribal villages**

## **A conceptual study for transportable structures in rural Odisha, India**

ATTE KIIANEN

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EXAMINER: SOLVEIG SCHULZ



**CHALMERS**  
UNIVERSITY OF TECHNOLOGY

Master's thesis at Chalmers Architecture (Design for Sustainable Development):

**ATTE KIIANEN**

**“Mobile schools for tribal villages. A conceptual study for transportable structures in rural Odisha, India.”**

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Chalmers University of Technology

Gothenburg 2016

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# Abstract

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India is known as a country of high ethnic, linguistic and cultural diversity, including a high density of tribal communities. The tribals belong to the poorest segments of the society, who due to their relative socio-cultural isolation have not been able or have not considered necessary to adapt to the requirements of the surrounding society. Due to their inferior position, many of them are subject to segregation and exploitation.

Education is generally seen a key area of improving their level of development and literacy, and through these indicators, improving their rate of integration to the society. However, drop-out rates of tribal children remain high, even though plenty of schools may be available in some regions. Limited physical access to schools is considered one of the important factors contributing to low level of education and literacy.

This thesis is an attempt to develop a concept of a modular school, which can be quickly established in desired location, disassembled and re-established in other locations. The design research is done by studying literature, built projects of similar kind, and by interviews and consultations in Sweden and in India, with the assessment of mobility, accessibility and sustainability factors in the Indian context. The result is a contemporary fusion of prefabricated elements and vernacular building techniques.

**Keywords:** India, school, modular, mobile architecture, bamboo, experimental



# About the author

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Photo: Talvikki Tenhunen

## **Atte Kiianen | Born on April 6, 1982 in Lappeenranta, Finland**

I have accomplished my previous degree in architecture at Tampere University of Technology, Finland. During those studies I specialised on architectural history and historical cities. After having ended up as a city planner for a few years upon graduation, I felt I had to take a move towards a different direction, awakened by the undesirable actuality of global problems, importance of sustainable development

and the innovative power and responsibility of an architect; An increasing proportion of the World's population are subject to discrimination and oppression for the economic profit of others, while our planet is being depleted of its resources. Sometimes human rights become a privilege of the few.

I applied for the master program 'Design for Sustainable Development' at Chalmers, and now whilst taking the final steps, I consider it having been a challenging, but worthy choice. Courses dealing with cultural viewpoints foreign to myself, namely Design and Planning for Social Inclusion, and Reality Studio, the former situated in Swedish multi-cultural context and the latter in Kenya – have helped me to perceive a better picture of the diverse nature of humanity, and challenges in communication and development.

I wish to increase – through my creations – the total amount of happiness and mutual understanding among people on our planet. To understand myself, I must look outside the context I'm familiar with.

# Foreword and acknowledgements

---

The motivation for this study lies in the internationally agreed recognition of education as an essential instrument for sustainable development and empowerment of the socially disadvantaged people. Moreover, it is a humble attempt to get a grasp of a context that was previously unknown to me. It is a context that has its cultural roots in some of the oldest known high civilizations on our planet.

I realise the coexistence of parallel cultural paradigms, where the Western view is merely one among the others, but it is nevertheless the one that defines my personal identity and the way I conceive the World. Full understanding of things from an alien perspective is a nearly impossible task, but in order to arrive at a state of mutual agreement, intercultural approaches must be made.

The initial momentum for the project was a talk with Emelie Mahanandia von Schedvin from Kalinga Institute of Social Sciences, a pioneering NGO for tribal education in India. Throughout its existence of 22 years, KISS has expanded its capacity at an aggressive rate – a situation requiring constant

design, planning and construction of new facilities. That appeared as a potentially fruitful area of investigation for an architectural master's thesis.

I decided to look into it, however no task for a possible thesis was specified from KISS. Thus, I had both the pleasure and the challenge of defining one through my own exploration. Having had no previous first-hand experience of India whatsoever, it turned out to be a challenge indeed.

I spent a field study period of eight weeks in Bhubaneswar. A major setback was that my chances to visit tribal locations during the field study were restricted due to security risks. In order to acquire understanding of tribal livelihood, I had to rely on other sources.

Our world is an orderly system and a chaotic organism at the same time, undergoing a constant transformation. We cannot predict the future, not even our own actions to a very large extent. Therefore we must prepare to adapt. The ideas of modularity, versatility and universality in design have fascinated



me for a long time, and they constitute an important part of my conception of sustainable design; the ability to use a single element in various ways, to create different environments depending on time, place and situation. Upon this thought I built my thesis, with an explorative approach to fit it into the chosen context.

Due to various reasons, the journey has been more difficult than I imagined it to be in the first place, even painful at times; There has been loneliness and frustration, but also adventure, insight, joy and satisfaction. The process has convinced me that difficulty is ultimately the best teacher.

\* \* \*

I would like to express my gratitude for the valuable comments, support and assistance I have received, to all who have provided such, to any degree. Of these, I would like to mention the following:

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**Swapna Sarita Swain** from KIIT School of Architecture and Planning, **Krishna Kumar** from National Mission for Bamboo Applications (NMBA) in New Delhi, for technical consultations;

The library of **Scheduled Castes and Scheduled Tribes Research and Training Institute** (SCSTRTI) in Bhubaneswar, for granting me access to their collections;

**Swedish International Development Cooperation Agency** (Sida), for financial support (MFS scholarship);

**Nihar, Shiva, Sudhamay, Pratik, Sanjaya, Jemima, Sambhav, Pedro** and other friends, for your hospitality and taking care of me during my stay in India.

Thank you.

in Gothenburg, December 2015





Special thanks:

**Emílio**

for most constructive feedback,  
advice and optimism.

**Talvikki**

for the love and understanding.

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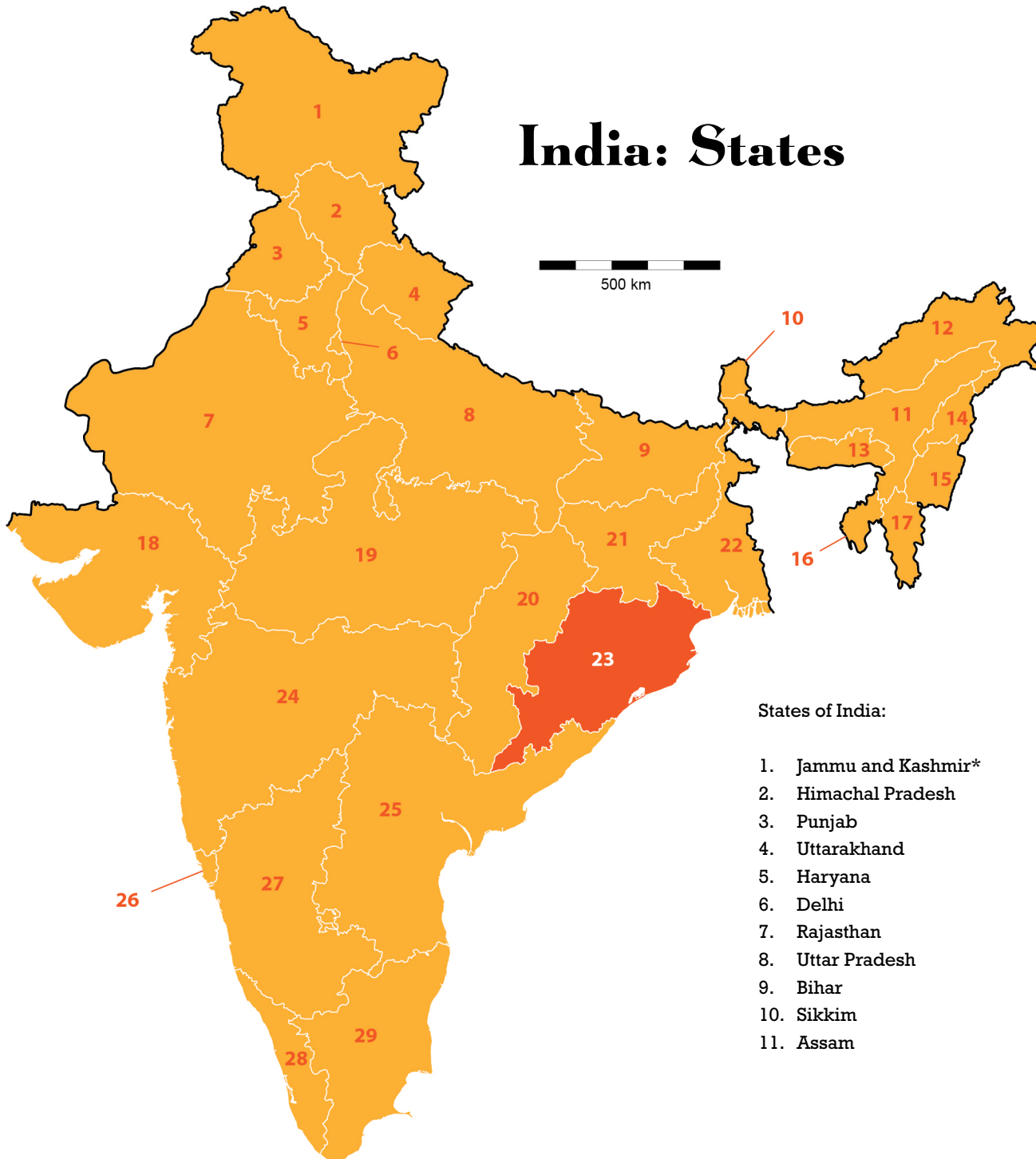
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# India: States



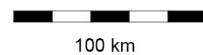
## States of India:

1. Jammu and Kashmir\*
2. Himachal Pradesh
3. Punjab
4. Uttarakhand
5. Haryana
6. Delhi
7. Rajasthan
8. Uttar Pradesh
9. Bihar
10. Sikkim
11. Assam

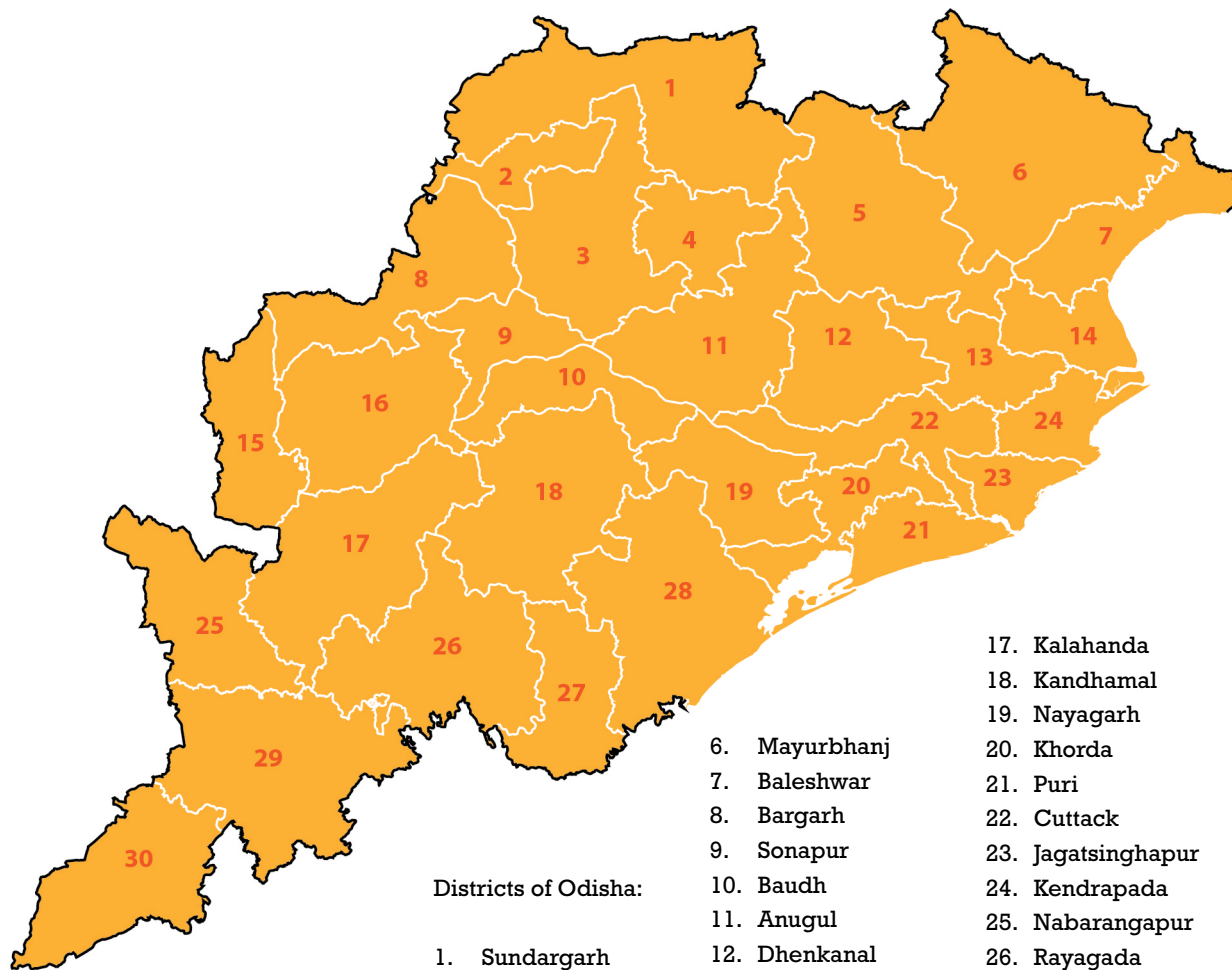
12. Arunachal Pradesh
13. Meghalaya
14. Nagaland
15. Manipur
16. Tripura
17. Mizoram
18. Gujarat
19. Madhya Pradesh
20. Chhattisgarh
21. Jharkhand
22. West Bengal
23. Odisha
24. Maharashtra
25. Telangana
26. Goa
27. Karnataka
28. Kerala
29. Tamil Nadu

\* Borders of Jammu and Kashmir depicted here represent the interpretation of the Government of India. The region is subject to a territorial dispute between India, Pakistan and China.





# Odisha: Districts



## Districts of Odisha:

- |               |               |                    |
|---------------|---------------|--------------------|
| 1. Sundargarh | 10. Baudh     | 17. Kalahanda      |
| 2. Jharsuguda | 11. Anugul    | 18. Kandhamal      |
| 3. Sambalpur  | 12. Dhenkanal | 19. Nayagarh       |
| 4. Debagarh   | 13. Jajapur   | 20. Khorda         |
| 5. Kendujhar  | 14. Bhadrak   | 21. Puri           |
|               | 15. Nuapada   | 22. Cuttack        |
|               | 16. Balangir  | 23. Jagatsinghapur |
|               |               | 24. Kendrapada     |
|               |               | 25. Nabarangapur   |
|               |               | 26. Rayagada       |
|               |               | 27. Gajapati       |
|               |               | 28. Ganjam         |
|               |               | 29. Koraput        |
|               |               | 30. Malkangiri     |

## Basic facts of Odisha:

Population:	41 947 358
Population growth:	13.97 % (2001-2011) (India: 17,64 %)
Avg. pop. density:	296 persons/km <sup>2</sup> (India: 382 persons/km <sup>2</sup> )
Major language:	Odia (Oriya) <sup>1</sup>
Capital city:	Bhubaneswar (pop. 880 000)
Other major cities:	Cuttack, Brahmapur, Puri, Balasore, Rourkela, and Sambalpur.

(Census 2011)

---

<sup>1</sup> In 2011, the official spelling of the state name was changed from Orissa to Odisha, and the name of the Oriya language to Odia, respectively. Odia is one of the 22 official languages of India.

References with either name Orissa or Odisha are used in this work. To avoid confusion, please note that the state in question is the same.



# 1. Introduction



# 1. Introduction

## 1.1. PURPOSE

---

The purpose of this thesis is to study the context and propose an architectural approach for extending the availability of education among tribal minorities in Odisha, India, by investigating technical possibilities to establish temporary schools in the vicinity of remote tribal settlements, thus minimising the distances between schools and settlements.

Potentially, the proposed model could contribute in social inclusion of all age groups of tribal communities, directly or indirectly increasing literacy rates among them. Literal skills enable communication and a way to exchange cultural knowledge with surrounding 'mainstream' society.

Access to adequate education is among the greatest factors to advance sustainable development. It helps indigenous people to acknowledge their

rights, retain or improve their livelihoods and keep control over the crucial natural resources of their environment.

## 1.2. SUBJECT AND SCOPE OF STUDY

---

The subject of this thesis is the conceptual study of the elements comprising a prefabricated modular school unit for rural village areas of Odisha. The unit would provide a facility for preparatory education in varying rural environments.

The context is very wide and complex, and due to difficulties in the acquisition of information on everyday situations, the study focuses on the material and structural properties of a modular architectural concept.

The study is essentially conceptual and provides a crude model for a prototype. Further stages are

acknowledged as essential areas of study, but their deeper investigations are excluded from this thesis.

### 1.3. THEORETICAL FRAMEWORK

---

#### IMPROVEMENT OF SOCIAL EQUALITY IN INDIA

Indigenous peoples (in India categorised as Scheduled Tribes, ST) generally constitute the most disadvantaged section of India's population. (Senapati, 2015). They are excluded from the development processes taking place in their surrounding society, due to their physical isolation, absence of common means of communication, detachment from political or economic mechanisms, or incapability to recognize their rights as citizens of the society. Many tribals have unjustly been displaced from their productive assets and homes, which has distorted their social organization and led to further problems (Sahoo, 2005). They are often made dependent on subsidies from government or other party having a greater economic potency, who then take it as their right and responsibility to determine the needs of the

subject, which obviously results in authoritarianism and increased social inequality (Sen, 2013).

United Nations Declaration for the Rights of Indigenous Peoples was adopted in 2007, India being among the countries in favour of the declaration. The declaration makes important statements regarding the equal position of indigenous peoples in the society and their fundamental right to their cultural identity, calling for the states to take responsibility in their social inclusion (UN General Assembly, 2007; see p. 22).

However, the Indian government has not been able to provide a school network that would successfully reach the children of tribal communities. A more specific approach should be taken in this regard, focusing on the factors behind high drop-out rates among certain groups (Sahu, 2014). It is obvious that inability to communicate in the prevalent majority language is one of these factors, and given the high number of linguistic minorities of Odisha, most of whom are indigenous, inclusion of all groups is extremely challenging.

Efforts to address the issue have been made by NGO's such as Kalinga Institute of Social Sciences

## ARTICLE 14

1. INDIGENOUS PEOPLES HAVE THE RIGHT TO ESTABLISH AND CONTROL THEIR EDUCATIONAL SYSTEMS AND INSTITUTIONS PROVIDING EDUCATION IN THEIR OWN LANGUAGES, IN A MANNER APPROPRIATE TO THEIR CULTURAL METHODS OF TEACHING AND LEARNING.
2. INDIGENOUS INDIVIDUALS, PARTICULARLY CHILDREN, HAVE THE RIGHT TO ALL LEVELS AND FORMS OF EDUCATION OF THE STATE WITHOUT DISCRIMINATION.
3. STATES SHALL, IN CONJUNCTION WITH INDIGENOUS PEOPLES, TAKE EFFECTIVE MEASURES, IN ORDER FOR INDIGENOUS INDIVIDUALS, PARTICULARLY CHILDREN, INCLUDING THOSE LIVING OUTSIDE THEIR COMMUNITIES, TO HAVE ACCESS, WHEN POSSIBLE, TO AN EDUCATION IN THEIR OWN CULTURE AND PROVIDED IN THEIR OWN LANGUAGE.

United Nations Declaration on the Rights of Indigenous Peoples  
(UN General Assembly, 2007)

(KISS) (Senapati, 2015). Based in Bhubaneswar, KISS provides a holistic education program for tribal children. For teaching younger children, KISS uses a specific learning method, where basic communication skills are taught in multilingual scheme, including the mother tongue of the pupils. This prepares children from various language groups to successfully attend the formal education program provided in Odia language (KISS, 2014).

Despite its rapid expansion over the past two decades, having increased the student capacity of Bhubaneswar campus from a few hundreds to over 22 000, only a small fraction of tribal children can attend their program. Being an important trailblazer for tribal education in India, their holistic approach does not provide a direct solution for educating the rural masses.

## **MOBILE FACILITIES FOR INCREASED ACCESS**

Accessible, free and compulsory elementary education is noted as everyone's right in the article 26 of The Universal Declaration of Human Rights (UN General Assembly, 1948).

Ensuring the social inclusion of people who willingly or unwillingly live in a situation in which their access to education or other public services is restricted, requires special arrangements.

The most obvious obstacle restricting access to schools is a long distance to be travelled or other physical barriers preventing their attendance at schools (Sahu, 2014), when means of transport are also insufficient or nonexistent. The remote groups are often more disadvantaged in the first place, and low economic priority of the maintenance of transport infrastructure can lead to their further exclusion. In areas affected by ongoing armed conflict, civilian movement may be restricted or civilian groups may be displaced into remote or otherwise less accessible location.

Another type of restriction is economic responsibility imposed by community. The management and

continuity of a livelihood requires everyone's participation, thus children are discouraged to leave their village to attend school (Sahu, 2014).

Effective provision of education in these situations would require sheltered facilities to be established at convenient distances from the settlements. As human workforce, heavy machinery or construction materials are difficult to transport, semi-prefabricated architectural solutions with simple assemblage capability and lightweight materials would turn appropriate.

## **MATERIAL SUSTAINABILITY**

As the social proportion of the matter is wide and implies a serial production of any proposed construct developed, the environmental sustainability is important. Use of locally produced, renewable raw material for the main components of the structure contributes - among other impacts - to the mitigation of carbon emissions and global warming, whereas certain phases of the process would require a mechanised industrial process resulting in more emissions, but potentially more durable product.

## 1.4. RESEARCH QUESTIONS AND METHODOLOGY

---

### RESEARCH QUESTIONS

The research questions are as follows:

- *How can the education be made more accessible in rural areas by transportable design?*
- *What design features are required for the appropriate performance of a transportable structure in the context-specific conditions?*
- *What factors contribute to the environmental impact of the concept?*

### METHODOLOGY AND DELIMITATIONS

A study trip to Odisha (Bhubaneswar) was made in February-April 2015, to gain a basic understanding of the conditions in Odisha. The period of the study trip was the relatively dry and hot pre-monsoon season, and was concluded before the annual maximum temperatures and the eventual arrival of the monsoon. Personal experience of the climatic severities is limited in that regard.

A primary intention was collaboration with KISS, to figure out a framework for the study with a relevant stakeholder. I had predefined two directions for my approach: A proposal integrated to the current agenda of KISS, or a distinct proposal exploring further ways of development, yet relevant to the field;

Said integration would have required a more comprehensive understanding of the context and related practices and mechanisms, than what was actually possible to achieve during this relatively short study period, also considering my lack of previous experience of the concept of an all-inclusive residential school and the cultural context in



general. I therefore decided to reject the option of direct integration and contribute by exploring an alternative way for further expansion – for potential integration in the future.

Interviews and discussions with KISS teachers and students were carried out to understand their background and situation at their home villages. Due to security risks, restrictions to physically enter tribal locations were applied. Government census reports and other statistical data on demographics, as well as local collections of tribe-related literature were studied instead, to understand the socio-cultural context.

Technical knowledge of bamboo and other construction materials was acquired from Indian government agencies, research papers and international publications. Built projects with similar contextual approach were studied for their design features and approaches.

KISS was generally an important source of contextual information. In spite of that, towards the end of the process of contextual investigation, it became evident that they were not ready to take a proper stakeholder position in the process, however they

were informed that the study would be essentially visionary in character, not entailing financial responsibilities or any compromise of their current programme. The original intention of providing a proposal with practical approach with cooperative functional planning was considered unattainable due to the lack of stakeholder support. Therefore a lesser focus was given to the functional content of the proposal.

A stronger emphasis was then given to the study of modular properties and construction techniques enabling mobility.



## **2. Contextual background**



## 2. Contextual background

### 2.1. GEOGRAPHY AND NATURAL RESOURCES

---

Odisha is bounded by the states of West Bengal and Jharkhand in the North, Chhattisgarh in the West and Andhra Pradesh in the South. The state has a coastline of 480 kilometres to the Bay of Bengal. Odisha covers a land area of 155 707 km<sup>2</sup>.

Odisha can be divided into four major topographical regions: The middle mountainous region, the rolling uplands, river valleys, central plateaus and the coastal plains (Fig. 2)(Government of Odisha, 2014). The mountainous region constitutes approximately three quarters of Odisha's area. Generally the topography is undulating, with the exception of the high plateaus and coastal plain areas.

The soil is abundant with mineral resources, such

as coal, iron ore, manganese ore, bauxite, chromite, dolomite, limestone and graphite.

Odisha's forest coverage is about 32% of the state's total area (Forest Survey of India, 2013, 17), and it's most abundant in the middle mountainous region (Figs. 2-3). Diverse forest produce constitutes an important part of economy, as grass and timber varieties are used as raw material in paper and furniture industries, firewood or construction material. Agriculture provides direct or indirect employment to 65% of the total work force (Government of Odisha, 2014)

There are four meteorological seasons in Odisha:

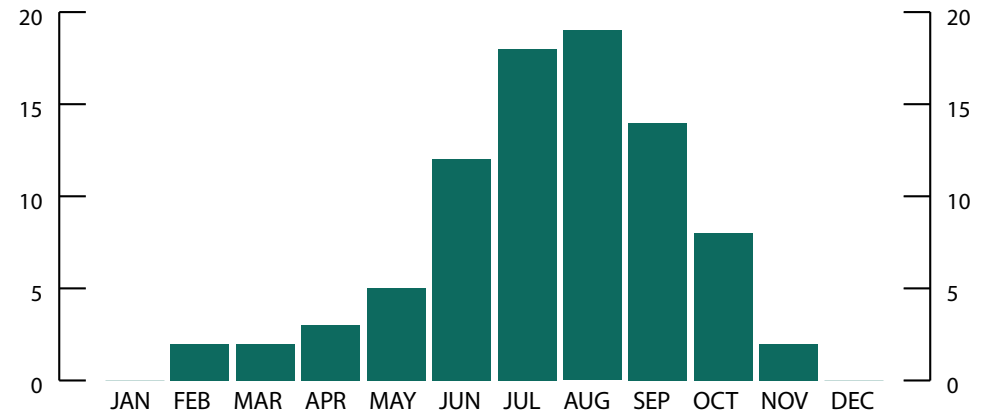
- *Winter season (January-February)*
- *Pre-monsoon season (March-May)*
- *South-west monsoon season (June-September)*
- *Post monsoon or north east monsoon season (October-December)* (Know India, 2015)

Rainfall is the main source of water in Odisha, annually varying between 1200...1700 mm. Odisha receives about 78% of its rainfall between June and September, and the remaining throughout the year (Fig. 1). The rain has a crucial role for agriculture, which is the principal source of livelihood of the rural population. (Government of Odisha, 2014)

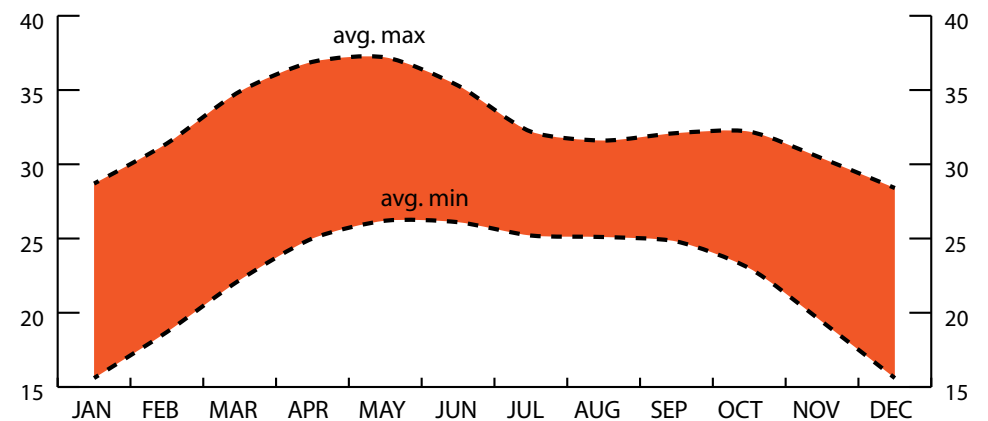
## 2.2. TRIBAL COMMUNITIES AND THEIR SOCIAL CHALLENGES

Of all states of India, Odisha is home to the greatest number (62) of distinct tribal groups. The Scheduled tribes (ST) population of 9,6 million comprises 22,8 % of Odisha's total population and 9,2 % of India's total ST population, and ranks third highest among the states in the whole country.

Indigenous peoples are referred to as the original settlers of a certain territory, who have retained their social, cultural and economic traditions, despite having been reduced into a minority under an alien government. (Debnath, 2013, 2-3)



Average days with precipitation (prec. > 1 mm/day) per month



Average daily max. and min. temperature per month (°C)

Fig.1 Diagrams of long-term average days with precipitation and daily extreme temperatures in Bhubaneswar from the mean period 1961-1990. (Data source: Yr.no, 2015)

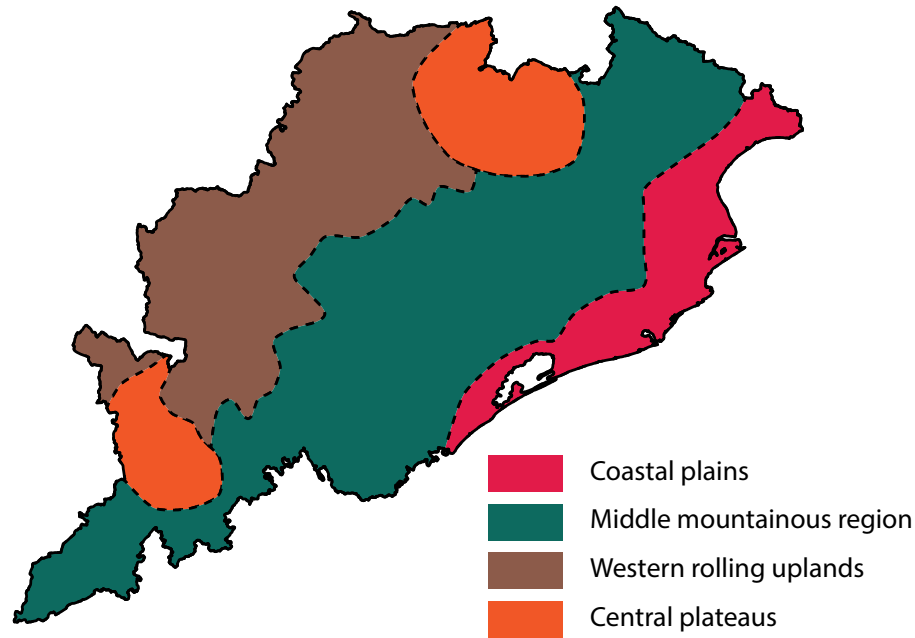


Fig.2 Geographic regions of Odisha (Data source: Government of Odisha, 2014, p. 8)

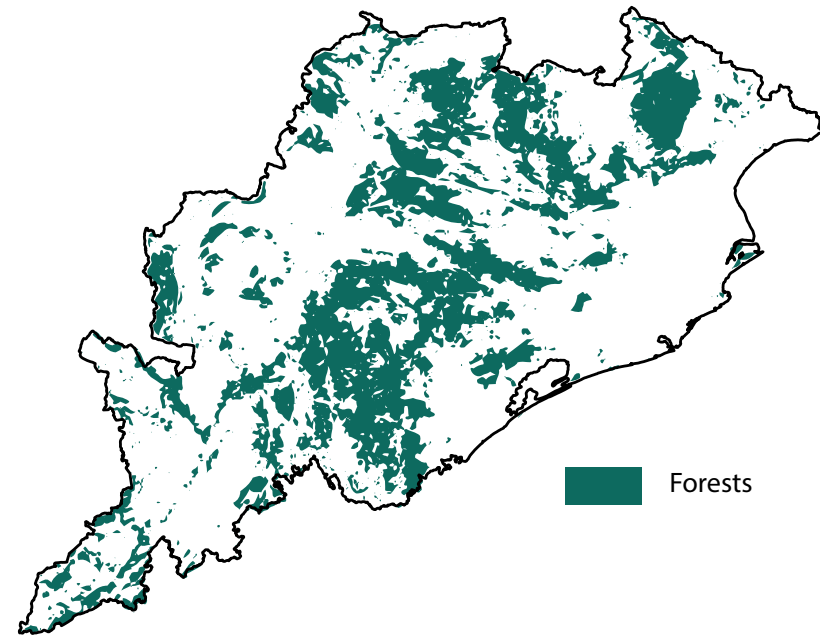


Fig.3 Forest coverage of Odisha (Data source: Mapsofindia.com, 2013)

## TRIBAL CULTURES AND INDIGENOUS KNOWLEDGE

Tribal groups represent cultural development to a varied degree. Typically they have a strong group identity and emphasis on tradition and group self-sufficiency. Their world view can be restricted and limited and lacking historical depth, due to geographical and cultural isolation. Religion has a

strong presence, the natural and the supernatural are merging, resulting in the blending of the sacred and the secular (Patnaik 2005, 1-2)

The livelihoods of indigenous peoples are essentially dependent on resources provided by the natural environment, with which they have a close relationship; environmental sustainability is a fundamental requirement for the survival of their community. Over

**a long succession of generations, they have come to possess valuable knowledge on natural elements and phenomena. This knowledge survives in their languages and traditional beliefs.**

*“Indigenous people often possess a broad knowledge base of the behaviour of complex ecological systems in their own localities which has been accumulated through a long series of observations transmitted from generation to generation. The indigenous people have depended for a long period of time on local environment for the provision of a variety of resources; they have developed a stake in conserving, and in some cases, enhancing biodiversity. They are aware that the biological diversity is a crucial factor for generating the ecological services and natural resources on which they are dependent.”*  
(Debnath, 2013, 7)

**Traditional non-scientific knowledge systems, such as the Ayurvedic medicine, have often provided hypothetical impetus to proper scientific research and discoveries. If the survival of tribal cultures is threatened, valuable knowledge becomes endangered, which may have disadvantageous effect on sustainable development, as is agreed by Debnath (2013, 11):**

*“It is not wise to belittle the importance of traditional knowledge system considering it useless or irrelevant in our contemporary societies. The real wisdom lies in learning from the primitives and thereby saving our resources from fast depleting.”*

## **SOCIO-ECONOMIC STATUS OF TRIBAL GROUPS**

**Hereditary social stratification based on the caste system originating from Hindu culture is actual reality in India. Parallel traditional and official systems exist, comprising numerous categories and appearing very complex. Most people of tribal origin are considered a class of ‘Scheduled tribes’ (ST), sometimes also referred to as ‘Adivasi’. ST is among the strata of lowest social value, along with ‘Scheduled castes’ (SC) and ‘Other backward class’ (OBC). The stratification system has been widely criticized for being segregative and maintaining inequality in the society.**

**Odisha’s rich natural resources make the state attractive to industrial corporations. The state government has supported the capitalistic development by imposing new laws and policies that have forced the indigenous peoples to leave their traditional rights of community resources, which have become legal**



Fig. 4 Women and children of Kondh tribe in Niyamgiri, Odisha (Photo: peasantautonomy.org).

property of the state. Large-scale industrial and infrastructural projects have led to forced evictions and displacement of vast numbers of indigenous people from their traditional sources of sustenance. The forced evictions have created large socio-economic problems. Many risks of further impoverishment are met by involuntarily displaced persons. These include, but are not limited to landlessness or homelessness, unemployment, marginalization and social discrimination, food insecurity, loss of access

to common property and community services, loss of educational opportunities (Sahoo, 2005).

### LIVELIHOODS AND CONDITIONS IN TRIBAL VILLAGES

Generally, the adult population in tribal villages are occupied with various livelihood-related tasks and are thus unable to attend education. The management of an agricultural economy is a continuous process with changing activities throughout the year. Agricultural tasks are labour-intensive, due to rarity or lack of agricultural machinery. In May-June, when the cultivation is done and the monsoon has not yet arrived, life can be less busy.

The political situation is tense. Organised insurgency calling themselves Communist Party of India (Maoist)<sup>1</sup> has since 2005 carried out one-sided armed violence against the government. The group views themselves as defendants of the oppressed people. The CPI (Maoist) has used a variety of

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<sup>1</sup> CPI (Maoist) is not to be confused with other Communist groups; Communist Party of India and Communist Party of India (Marxist), abbreviated CPI and CPI(M) respectively, who are both represented in the Indian Parliament.



## INTERVIEW: MASTER STUDENTS AT KISS

Eight master level students from KISS, from the fields of sociology, social work and philosophy were interviewed through a written questionnaire regarding livelihoods, environment and level of development in tribal villages (for questionnaire, see Appendix: 2.). Assisted by an interpreting person speaking Odia, an oral introduction was given to clarify the intentions related to each question.

### Outcome and reflection:

*The participants were somewhat capable of communicating in English, however, some obvious misunderstandings, incoherence or conciseness can be spotted from the written answers.*

*The purpose of the questionnaire was to form a rough understanding of the diversity of conditions in the villages, to support the published material on the topic. The number of answerers being only a few, no statistical conclusions were intended or even possible.*

*It is apparent that the concept of a community house is familiar with some communities, whereas some communities use open space for social occasions, sometimes with temporary shelters, like a tent, depending on the situation.*

*Several answers mention marriage ceremony as a specific cultural tradition. Marriage in India is an event of great importance to not only the married couple, but their entire families. Marriage is a near inevitable event in the life of an Indian person, thus ceremonies occur frequently, combining religious and local traditions. Other traditions mentioned relate to tribal beliefs, folklore and performance arts.*



Fig.5 An outdoor kitchen of a rural homestead in Puri district, Odisha. (Photo: AK)

tactics, including raids against villages, kidnappings, planting of land mines and targeted assassinations. Odisha and its adjacent states Maharashtra, Chattisgarh and Jharkand are among the most affected areas of the Maoist-related violence. The conflict has resulted in estimated annual fatalities from 40 up to over 350, between 2005 and 2014 (ucdp.uu.se, 2015).

For the above reason, the state government has imposed travel restrictions to tribal areas. The situation is inconstantly changing and is monitored by local authorities, who apply restrictions accordingly. Restrictions apply not only to research and tourism activities, but sometimes they also complicate the movement of local inhabitants, including the interaction of KISS and the tribal communities.

## 2.3. TRIBAL EDUCATION

---

Literacy rates are relatively low in India. This is especially true among the rural population, a large part of which is comprised by the tribals (Fig. 11). Literacy in Odisha is 73,45%, which is slightly below the Indian

average of 74,04% (censusindia.gov.in, n.d.)<sup>2</sup>. Literacy is seen as an important indicator of development in the society, as it makes possible the recording and more accurate transmission of knowledge. However, many tribal languages have not developed into a written form. Thus, there are entire communities where the concept of literacy doesn't even exist, which also greatly restricts communication with other societies.

The district-wise figures of tribal populations and literacy rates suggest some correlation between each other (Figs. 6-7); The districts in the Northern and Southern parts of the state are the ones with highest concentration of tribals and lowest rates of literacy.

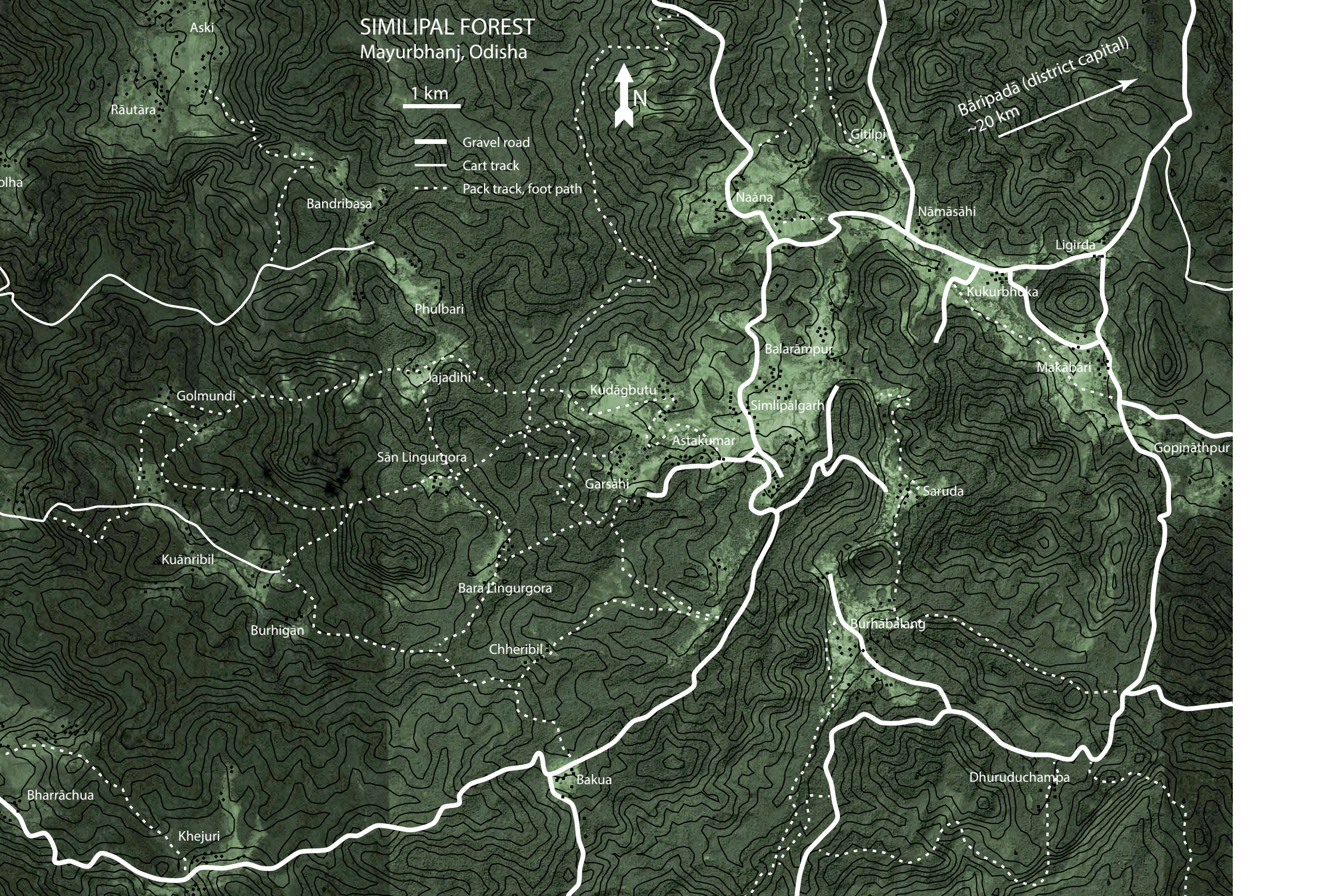
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<sup>2</sup> In the figures produced by Census of India, the following definition for a literate person have been used: "A person aged 7 years and above who can both read and write with understanding in any language is to be taken as a literate. A person who can only read but cannot write is not a literate. It is not necessary that to be treated as a literate, a person should have received any formal education or passed any minimum educational standard. Literacy would also have been achieved through adult literacy programmes or through any non-formal educational system. People who are blind and can read through Braille will also be treated as literates."



Fig.6 Replica of a traditional hut of Saora tribe. Photo: AK

# SIMILIPAL FOREST Mayurbhanj, Odisha



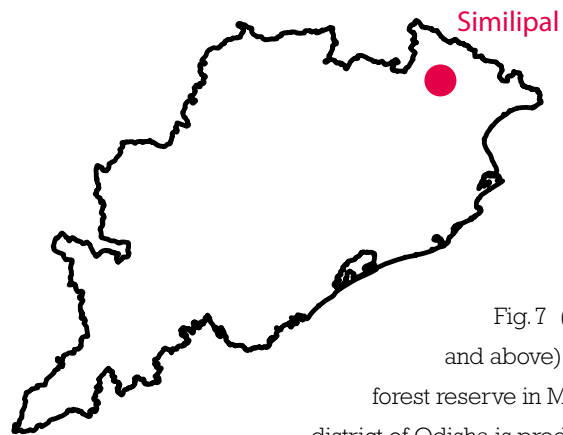


Fig.7 (Opposite page and above): The Similipal forest reserve in Mayurbhanj district of Odisha is predominantly inhabited by tribal communities. The transport network consists of few gravel roads and smaller tracks, sometimes with map descriptions like 'jeepable during dry season'. Forest described as 'dense mixed jungle' surrounds clearings where the villages are situated. Vehicle accessibility to some villages is poor or nonexistent, making these forest villages some of the most remote permanently inhabited locations in Odisha. The opposite map shows a cluster of villages in the Northern Similipal, West of the district capital Baripada. (Data sources: Survey of India, OpenStreetMaps, Google Maps)

Fig.8 (Right): Children of a remote village in Kandhamal district crossing a river on a tightrope to get to school, risking their lives. The decision to build the tightrope was taken at a village meeting, as the government project to provide a bridge has failed (Orissapost.com, 2015). Photo: Orissa Post, 2015.



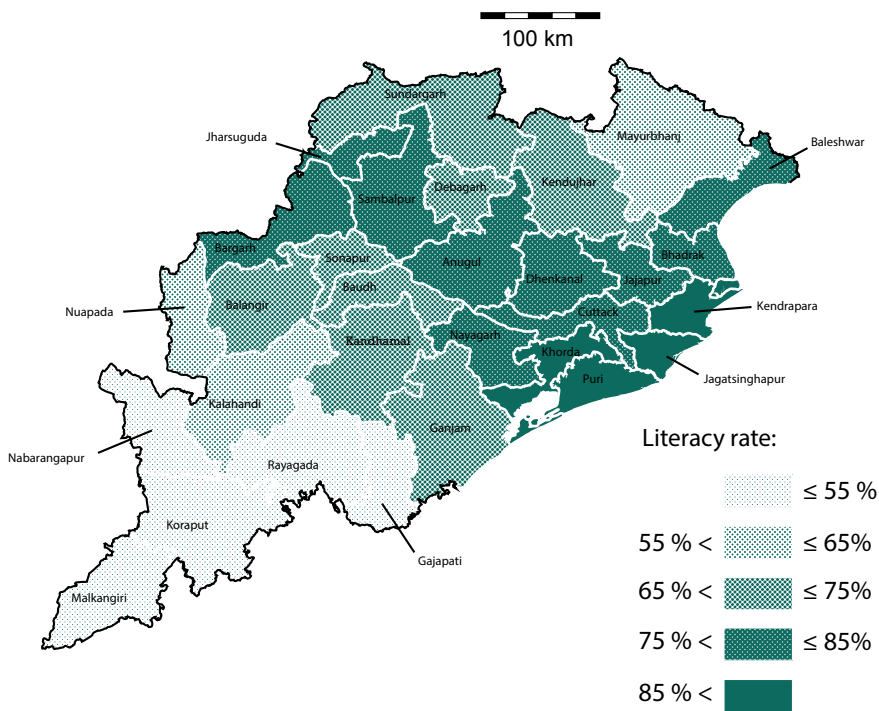


Fig.9 District-wise literacy rates in Odisha.  
(Data source: censusindia.gov.in)

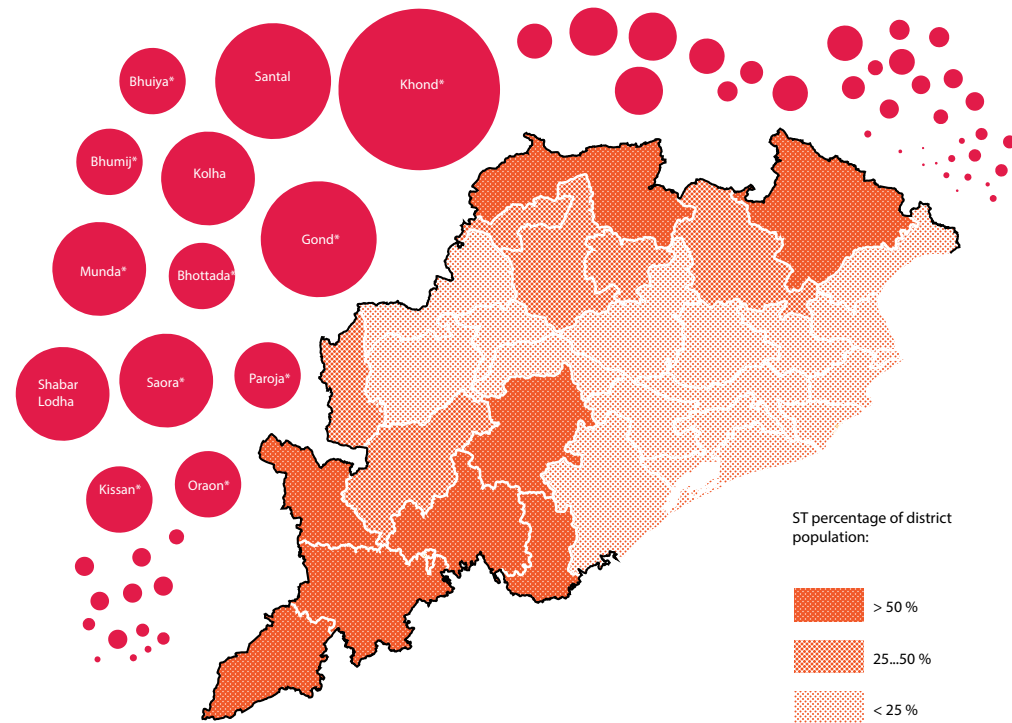


Fig.10 District-wise scheduled tribes (ST) percentage of total population in Odisha. Circles illustrate the relative size of the tribal populations of the State. See Appendix for full list. (Data source: censusindia.gov.in)

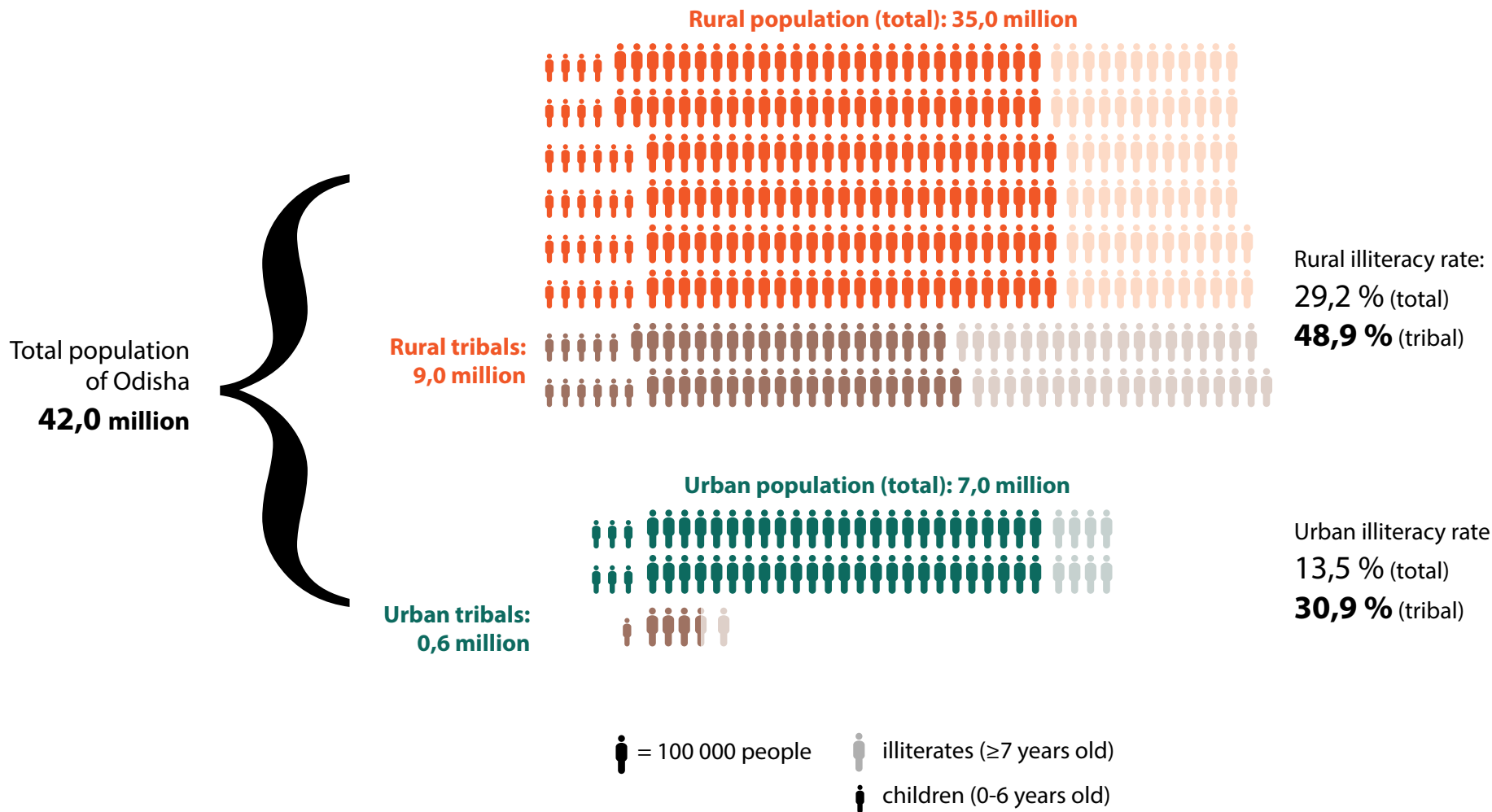


Fig.11 Distribution of total population into urban and rural habitats and literacy among the respective populations in Odisha. (Data source: censusindia.gov.in; Ministry of tribal affairs, n.d.)

*“The population of my village is around 370. The distance to nearest school is about 3 km. Part of the year the village is surrounded by a river, during that time another route must be used and the distance grows to 8 km.”*

**(Comments from graduate teachers at KISS)**

*“For small children, three kilometres is definitely too long distance for walking to school. One kilometre would be appropriate.”*

## **DEVELOPMENT STRATEGIES**

Certain recognised critical factors have contributed to low level of education in tribal areas:

- *Remote physical location of villages*
- *Restricted economic conditions*
- *Negative attitudes of parents*
- *Availability of qualified teachers*

(Sahu, 2014)

As the result of discussions with tribal people in tribal-dominated areas of Mayurbhanj district, Sahu lists the following among other strategies to improve the situation:

- *Use of mother tongue as a primary medium of instruction in early stages of education.*
- *Appointment of local teachers should be preferred, for their understanding or familiarity with local culture and language; this helps the teachers to gain acceptance by the community, which would have an effect on rates of participation.*
- *Tribe specific learning arrangements that make full use of tribal culture and traditions, should be developed.*
- *More residential schools specifically directed for tribal students should be established, as they have shown to have a positive impact.*

(Sahu 2014)





Fig. 12 Students in front of main building of KISS campus in Bhubaneswar. The chariots on the left are used for annual religious Ratha Yatra procession. Photo: AK.



Fig. 13 Rat figures created by children studying at KISS. Rat is a creature commonly known by everyone in rural areas, therefore an ideal object for multilingual learning. Photo: AK.

## KALINGA INSTITUTE OF SOCIAL SCIENCES (KISS)

Kalinga Institute of Social Sciences is a non-governmental educational institution founded by Dr. Achyuta Samanta in 1993. KISS is essentially an annex institute of Kalinga Institute of Industrial Technology (KIIT University). However, it has adopted a special mission of social inclusion of the tribal groups. Achyuta Samanta remains a central figure in all decision-making at KIIT and KISS.

Currently, KISS campus operates at Bhubaneswar, adjacent to KIIT university. The KISS campus has a capacity of approximately 22500 students. As of today, KISS has become a well established institution, who also utilise modern technological solutions that improve the overall energy and resource sustainability at the Bhubaneshwar campus.

The number of enrolled students has increased somewhat steeply since the beginning, at a rate of approximately 1000 students a year. Future development plan of the Institute is to establish new branch units in other districts. 20 branches are projected to be constructed with yet indefinite schedule in Odisha and a few other states.

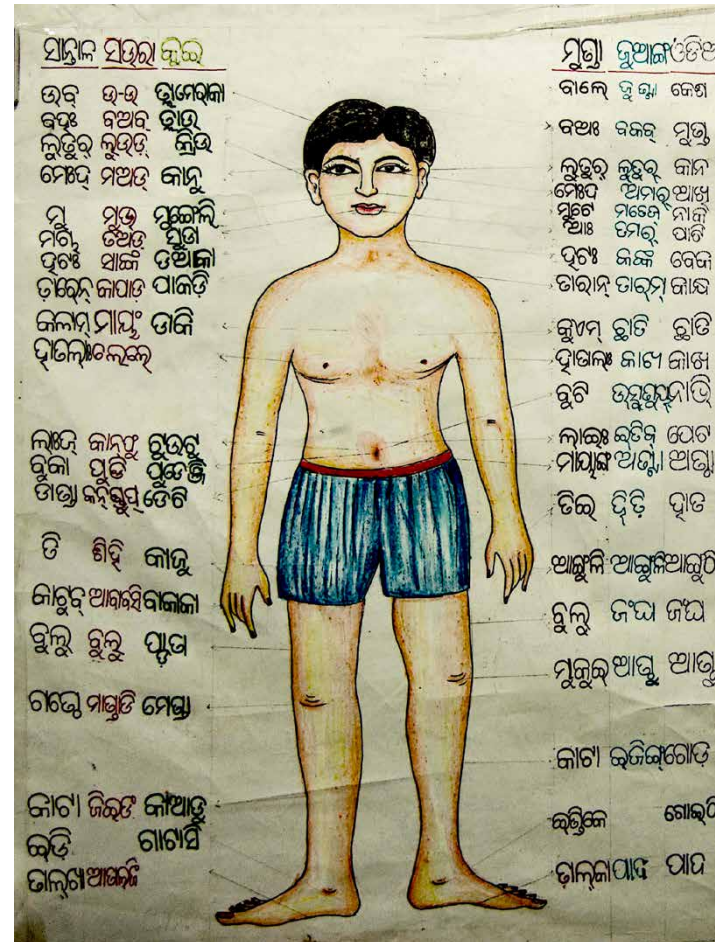


Fig. 14 Chart of human body parts in different languages transcribed into Odia script. Photo: AK.

KISS is a residential institute, where admitted students spend entire semesters and visit their home villages only briefly on an occasional basis. Student activities at KISS campus are organised and scheduled to a somewhat high degree; this is justifiable due to high number of people involved, to avoid the occurrence of general disorder. During extracurricular time, students roam about at campus or involve in games or other activities at nearby open yards.

Teaching at KISS premises is carried out in conventional classrooms, capable of accommodating approximately 40 students each. Classrooms are generally situated on upper floors, while ground floors are reserved for administrative offices and common services. Some classrooms are furnished with desks, some are minimally furnished, where students sit on the floor; The latter is not an unusual practice in Indian schools.

Given the fact that the capacity of the institute still meets only a fraction of the number of eligible children, the future demand for expansion appears infinite; This is why it would be important to look into new strategies at an early phase.

## **MOTHER TONGUE BASED MULTILINGUAL EDUCATION AT KISS**

The students who arrive at KISS represent all the tribes of Odisha, many of which solely use their own indigenous language. The languages prevalent in Odisha belong to Indo-European (Indo-Aryan), Austro-Asiatic and Dravidian language families. The languages belonging to different principal language families are fundamentally different from each other.

As a common language of instruction is vital to the educational pursuit, KISS has initiated an educational method to assimilate the children into the state mainstream language (Odia). As of 2015, the project benefits approximately 6700 children of 4-10 years of age (Kalinga Institute of Social sciences, 2015).

The method, called Mother tongue based multilingual early childhood education, begins by addressing the children by their native languages, gradually transiting to other languages, involving them in participatory and creative activities. The main objectives are the following:

- *To enable young children who come straight from their villages and do not know the state language, to feel comfortable and less likely to drop out from school*



Fig. 15 Teacher students at KISS language lab, learning about mother-tongue based learning method. Photo: AK.

- *To improve reading and learning outcomes including children's ability to learn other languages*
- *To develop mother-tongue based education reading materials for KISS students, as well as to train workers involved in relevant situations*

- *To encourage training, research and development in early childhood learning in tribal languages in the residential institution*

(Kalinga Institute of Social sciences, 2015, 18)

Being first-generation learners, the students admitted at KISS are prepared for further education through the mother-tongue based method. Mother-tongue based teaching has resulted in students feeling themselves more comfortable and able to communicate more effectively with teachers (Kalinga Institute of Social sciences, 2015, 19).

Students belonging to one language family are instructed together as a group. Through oral communication they find similarities in familiar words and expressions, which are then, with the teacher's assistance, merged into an artificial 'link language'. From the link language, transitions to Odia, and at later phases, also to English and to Hindi, are made.

The method of mother tongue based learning is being developed at KISS. The idea of incorporating a link language into the learning process is based on a naturally occurring social phenomenon in areas with high diversity of languages, such as Odisha. Such link language is created when people gather at market-places to trade their goods. In order to reach an agreement upon something, they first need to reach a common understanding about the matter. They must come up with an expression which everybody understands, but which doesn't necessarily belong to any recognised local language. It becomes a linguistic

expression valid for the specific occasion of trade; However, since it now has a meaning in at least two different languages, it can be used as a medium of translation between these languages or into another language.

An interesting dimension in this process is that it reveals the vast indigenous vocabulary and knowledge possessed by the children; they are able to name and recognise manifold kinds of natural objects and phenomena, plants, berries, animals, products prepared of them and their uses. The specific knowledge they possess often exceeds the knowledge on the respective field commonly possessed by the surrounding society. Using their mother tongue, they are able to convey what they have learnt from their parents, other members of their community and native livelihood. This information comprises of traditional stories, songs, riddles, games, practical everyday activities. Through the mother tongue based learning process, this traditional knowledge can be transmitted to other languages and documented appropriately. This can be called a true exchange of knowledge.

The method is relatively new, having been implemented in 2013. Currently there is only a single classroom dedicated for the purpose, intended to

be applied to other classrooms after further development. An essential feature of the language lab is the 'item library' it contains; various kinds of items, artefacts, paintings, models, drawings relating to different aspects of life and reality in the tribal villages, in the nature, in cities. The learning of different expressions associated with these objects, happens through the examination and observation of them, as well as through creative activity, poems, songs, visual arts, games and plays.

Since all expressions are documented, the method eventually enables the creation of a tremendous source of information for anthropologists, linguists and researchers of tribal cultures.



Fig. 16 Collage of tables with tribal scripts, artefacts, models and other objects used as learning material at KISS mother-tongue based program. (Photos: AK).





# **3. Concept development**



## 3. Concept development

### 3.1. INSPIRATIONAL REFERENCES

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The concept sought after is a type of a covered public space, whereof conceptual references can be found in both traditional and contemporary contexts.

The concept of a village dormitory has been popular among many Indian tribes. The dormitory represents a concept of internal tribal education, concerning matters directly relevant to the community. Its existence also indicates that at least some communities are familiar with non-private social activities taking place in dedicated permanent buildings, instead of open air.

*"It is a rest house and also considered a centre for cultural education. It is a sort of traditional youth club, developed from the communal houses. [...] It also functions as a social service centre and guest home. Generally the tribal youth spend their leisure time there, in playing, singing, and dancing.*

*Sometimes, they also sleep there during night times. It also helps to maintain cohesion, harmony, integrity among youth and develops community feeling among them."* (Subramanyam, 2008, 241)

### RECENT PROJECTS

The three school projects featured on pages 49-51 have had an inspirational value on the formation process of the concept. They are intended to function in challenging environments, to provide unprivileged people an easier access to education. Moreover, they have the optional function to be used as community houses. They comprise features and functionalities enabling their application in specific contexts, where conventional constructions are sometimes troublesome, impractical or impossible. Locally available traditional materials and crafting techniques are utilised in the projects; Local manufacturing reduces the costs and environmental impact of long distance transport.



Fig. 17 Makoko floating school. Photo: NLÉ (www.nleworks.com, 2015)

## MAKOKO FLOATING SCHOOL, NIGERIA

NLÉ (Kunlé Adeyemi), 2012.

Makoko is a densely built waterfront slum community in Lagos, Nigeria. An estimated 100 000 people reside in Makoko in housing units built on stilts. Yet the community has no roads, no land and no formal infrastructure to support its day-to-day survival.

Nigeria/Netherlands-based design practice NLÉ has developed a prototype floating structure that will serve primarily as a school, whilst being scalable and adaptable for other uses, such as a community hub, health clinic, market, entertainment center or housing. The building is a triangular A-frame structure on a 100 m<sup>2</sup> floating platform. The shape provides stability and balance even though the building has three floor levels. The building can be moved to desired location and anchored for more permanent use. The capacity is 100 people. Electricity is provided by solar panels and composting toilets are incorporated in the structure. (NLÉ, 2013)



Fig. 18 Mae Sot moving school. Photo: Building Trust International ([www.inhabitat.com](http://www.inhabitat.com))

### **MAE SOT SCHOOL, THAILAND/MYANMAR**

Dan La Rossa & Amadeo Bennetta/Building Trust International, 2012.

The design is the winning entry of a competition for a mobile, modular school for displaced community of Burmese refugees in Thai-Burmese border areas. The school is designed for easy transportability, assembly and disassembly.

The building frame is steel with bolt connections, whereas the wall panels, floor and sun blinds are made of bamboo, utilising various traditional techniques. The roof is made of fabric, which creates less rainfall noise than metal sheets and is more easily manageable. The structure allows for easy relocation of the building. (Architecture in Development, n.d.)

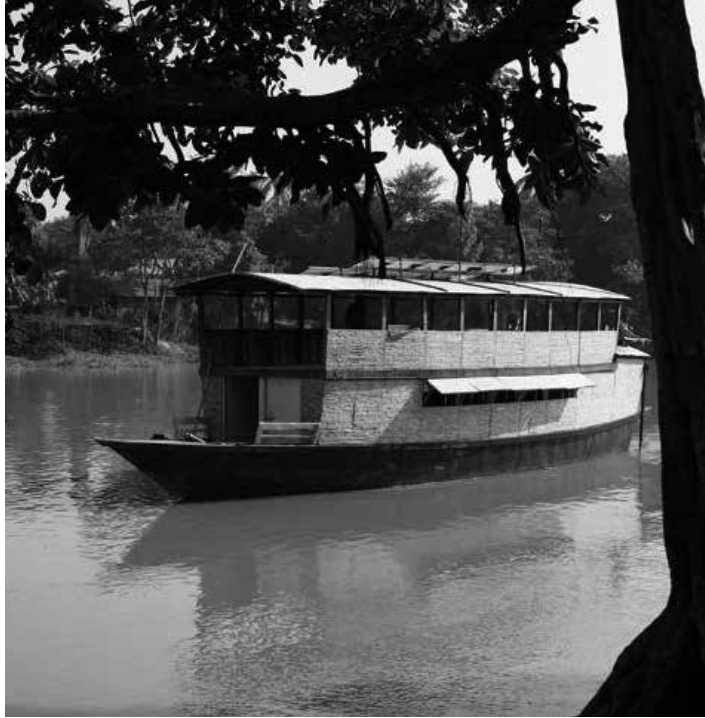


Fig.19 Solar-powered floating school (www.inhabitat.com, 2015)

Fig.20 Interior of a classroom (www.inhabitat.com, 2015)

## **SOLAR-POWERED FLOATING SCHOOLS, BANGLADESH**

Shidhulai Swanirwar Sangstha, 2012.

Being a low country situated at the world's largest river delta, Bangladesh is prone to severe flooding and river erosion caused by the monsoon and increasing flows of Himalayan melting water. The floods annually cover 1/3 to 2/3 of the land. Many rural areas already suffering from high population density, poverty and poor connections are the most vulnerable in this situation, where they are sometimes completely isolated from social services.

Shidhulai Swanirwar Sangstha is an NGO who operate a fleet of floating schools, libraries, health clinics and floating training centres with wireless internet access, serving close to 97 000 people in flood-prone areas. The boats are equipped with solar panels and rainwater harvesting system. Students are picked aboard as the school circulates from village to village. One classroom accommodates 30 students. Additionally, adult population is also taught about environmentally sustainable agriculture, climate change adaptation, and human rights. (Shidhulai.org, 2013)

## 3.2. DESIGN CRITERIA

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### TECHNICAL AND STRUCTURAL ADAPTABILITY

The design should be transportable to and from different locations, some of which can be remote or poorly accessible. Local human resources can be used for the assembly with mechanical assistance, but heavy machinery should not be required. The elements should be light enough to be handled and moved around by average people.

Infrastructural service networks (electricity, water, sewage) may not be available at intended locations, thus the design should be able to provide them to a degree of self-sufficiency.

The principles of the construction system should be simple enough for unskilled workers and planners to conceive. The school administration as operator should be capable of planning and producing different plan configurations, as well as varying sizes of units.

### LOW ENVIRONMENTAL IMPACT

The proposed concept should aim at minimal use of non-renewable or unrecyclable resources. The importance of this is proportional to production volume. The environmental criteria are partially compromised by technical and climatical requirements, thus the chosen solutions may represent the optimal choice.

When the structure is not intended to remain permanently on its site, physical intervention to the site is to be minimised.

### PROTECTION AGAINST CLIMATE

The design should be capable of withstanding and providing protection against changing natural circumstances typical to tropical climate, most prominently *intense solar heat* and *heavy rainfall*, which are common occurrences. A few regions of Odisha are prone to flooding and earthquakes.

The design criteria set for the proposal are:

- *Technical and structural adaptability*
- *Low environmental impact*
- *Protection against climate*

as described on page 54. The following paragraphs describe the approaches to the technical and environmental questions.

### 3.3. TECHNICAL ADAPTABILITY: WHY SHOULD DESIGN ADAPT?

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French architect and theorist Yona Friedman's idea of mobile architecture ('L'Architecture mobile') introduced already in late 1950's (Lebesque & van Vlissingen, 1999, 11) has influenced the thought process latently in the background.

Friedman has studied systems of prefabricated elements in different scales, although mostly in urban context. Friedman's systems are unlimited modular structures which the users can easily utilise and combine in various ways according to their needs. The user is empowered to determine the design of

their dwellings and other facilities. The reasoning behind the idea of adaptability is the difficulty or impossibility of predicting future situations, which is even more of a challenge to the architect whose familiarity with the context is often limited and superficial. In Friedman's philosophy, the architect, instead of having an autonomous point of view, rather takes the role of a technical advisor (Lebesque & van Vlissingen, 10) who leaves the freedom and responsibility of designed environment to the users.

In any design process there is always a factor of unpredictability, which supports the creation of generic space and the inclusion of specific features only to the minimal necessary degree.

Either the user, the designed object, or both, are expected to adapt to the other in one way or another. The unknown factor can be the different needs and behaviour of changing human occupants redetermining the function of architectural space; or, when the function and users are predetermined, it can be the changing number of occupants and their geographic location;

The latter is the case of a school in a rural environment. In a situation where distance learning is

not considered, students are supposed to physically arrive at the school facility, most usually on a daily basis. Therefore, accessibility is one of the primary requirements of a school, and distance is an important determining factor of accessibility. If accessibility is limited, the school's ability to fulfil its function and purpose is limited.

### **NEED FOR MOBILITY**

In India, it is generally the responsibility of students and their families to organise travels to schools. Means of transport are limited, unavailable or economically not a viable alternative. The distance between home and school is greatly limiting the accessibility of schools.

A new kind of mobile solution can possibly shorten distances and adapt to different capacity requirements. Another question is, when the distance to school is shortened through the introduction of a transportable concept capable of reaching a remote location, it implies reaching of several other remote locations, which requires capability to adapt to significantly different sizes of village populations it would enable to attend the education.

Local construction materials are necessarily not available to a sufficient degree. Gathering and preparing the material, as well as the actual construction can be slow and requires more work on site. Local materials and techniques can plausibly be used to reinforce the modular building once assembled.

## **3.4. ENVIRONMENTAL IMPACT: CONSTRUCTION MATERIALS**

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### **LOCAL CONSTRUCTION MATERIALS IN ODISHA**

Earth, mud and manure are typical wall materials of vernacular dwellings in Odisha. Blocks cut from local laterite stone are widely used. Timber and bamboo are used for secondary structures, scaffoldings and supports for thatch roofing. Thatch is prepared from the remaining parts of crop plants and collected into piles after harvest. Of industrially manufactured construction materials, concrete is obviously most popular. Despite the positive reputation of concrete due to its durability, it is





Fig. 21 (above) Rural hut with mud walls, thatch roof and palm leaf screens. Puri district, Odisha. Photo: AK.

Fig. 22 (right) Thatch is a by-product of agriculture, which is gathered in piles after harvest to supply roofing needs for the rest of the year.

Fig. 23 (below) Laterite blocks on a roadside. Odisha. Photo: AK.



noteworthy that concrete and cement industry is among the most energy-intensive manufacture industries, and therefore highly unsustainable. Utilisation of sustainable alternatives would be recommended.

As transportable elements can be easily removed from their sites, biodegradability is not a priority, although use of toxic chemicals is generally not preferable, if alternatives are available. Bamboo elements used for building are usually chemically treated for better climatic and vermin resistance. Resin compounds used in laminates or substances used for impregnation of the culms can be harmful to the natural environment, if inappropriately disposed of.

The notion of embodied energy refers to the total amount of energy used within the production process of any material. Transport between different phases often comprises a major part of the embodied energy. To lessen this impact, the choice of materials is based on their actual or potential production in Odisha, India, or nearby other countries. For example, India is among the most important cotton and cotton fabric producers in the World.

## **BAMBOO AS SUSTAINABLE CONSTRUCTION MATERIAL**

Bamboo is a generic name for the subfamily Bambusoideae of the family *Poaceae*. They are distributed in tropical and subtropical to mild temperate regions, with the heaviest concentration and largest number of species in East and Southeast Asia and on islands of the Indian and Pacific oceans ('bamboo', 2015). Approximately 1200 species are known, of which 750 in Asia and 450 in America (Minke, 2012, 9).

The growth and reproduction rate of bamboo is very high, which makes it an efficient carbon-sequestering and biomass-producing plant (Minke, 2012, 11). The culm of an American *Guadua angustifolia* species reaches its full length in six months of growth, and produces 1200-1350 canes per hectare per year (Minke, 15).

The process of lignification, where the bamboo tissue becomes hard, takes between four and six years, after which the lower and middle sections of the bamboo stalks can be used for construction (Minke, 15).

Presence of humidity and the starch content of bamboo can cause the material to deteriorate, due



Fig.24 Bamboo is used for the construction of temporary structures, like celebration tents for weddings, Odisha. Photo: AK

to attraction of parasitic organisms such as insects, fungi and lichen. Appropriate treatment is therefore important, before applying bamboo into structural or other uses (Minke, 17).

Primitive and more developed methods to protect bamboo against parasites, fire, ultraviolet radiation etc. are used, depending on the local resources. The methods require varying amounts of labour and energy, whereas they also contribute to the durability to a varying degree.

These include drying by air or microwaves, curing by smoke or earth, chemical impregnation by flooding, immersion, injection or pressure (Minke, 17-20).

Bamboo is a traditional construction material used at varying degrees of complexity in its native areas. In India, bamboo is traditionally used in construction of houses particularly in Northeastern regions (e.g. Nagaland, Assam, Bihar). In Odisha it is mainly used for handicrafts and woven applications, and secondary or temporary structures (e.g. sheds, scaffoldings and party tents (Fig. 24)). Short-term use does not require the chemical treatment of the material.

Commercially the most important bamboo species in Odisha region are *Bambusa bambos*, *Bambusa nutans*, *Bambusa tulda*, *Bambusa vulgaris*, and *Dendrocalamus strictus*<sup>1</sup>.

## **DIMENSIONS AND MECHANICAL PROPERTIES**

A bamboo cane has a high resistance to tension. The tensile strength of the outer layer is equivalent to that of steel (40 kN/cm<sup>2</sup>), but as it is only a small portion of the total transverse section of the cane, the tensile resistance of an entire cane is significantly lower.

Compression resistance is better along the direction of the fibres (i.e. lengthwise), and depends on the slenderness (length/thickness ratio) of the cane. Any internodes subjected to compressive forces perpendicular to the fibres are to be filled with cement mortar, to avoid splitting (Minke, 22). The structure of a bamboo culm is not homogeneous, for it is mostly hollow with solid nodes. The culms vary in size, diameter, wall thickness and distance between nodes, even more so between different bamboo species. Due to this irregularity the quality

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<sup>1</sup> Information acquired from Odisha Bamboo Development Agency (OBDA).

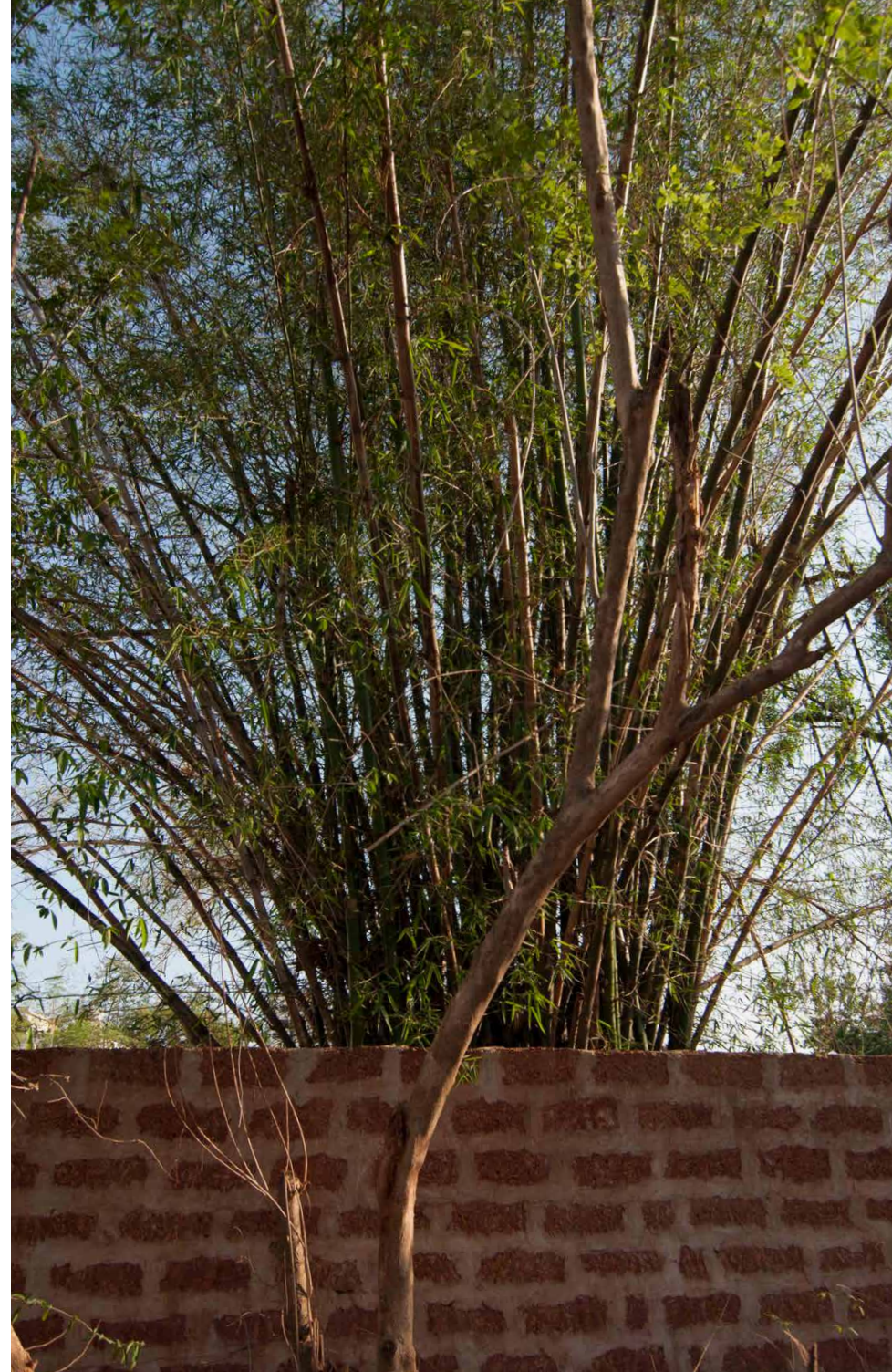
and suitable use of each culm must be carefully examined, to define how it will perform as intended when joined together with adjacent parts. For construction elements requiring compressive strength, such as posts and columns, lower parts of the bamboo culm are usually utilised, where inter-nodes are shorter and the wall thickness is greater.

Bamboo is flexible and highly resistant against forces in relation to its weight, making it an ideal material for earthquake-resistant structures. Structures built of or reinforced with bamboo are reported to have survived high-magnitude earthquakes without experiencing structural failures in several occasions (Minke, 26).

### LAMINATED BAMBOO

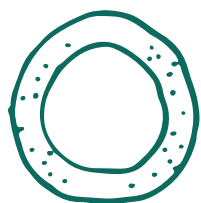
The natural structure of a bamboo culm limits its structural applications; Reliable joints and connections are difficult to create with tubular shapes, which are often non-uniform and prone to splitting. They are also unsuitable where flat surfaces are required. The interest to resolve these deficiencies has led to the research of

Fig. 27 Bamboo growing behind a laterite block wall.. Photo: AK.



## COMMERCIAL BAMBOO SPECIES PRODUCED IN ODISHA

*Dendrocalamus strictus*



Height: 15 m

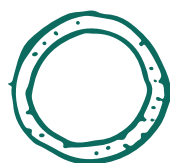
Diameter: 6-10 cm

Internodes: 35-45 cm

Wall thickness: 2-3 cm

Uses: Pulp and paper, construction, furniture, basketry, handicraft. The most common species used by pulp and paper industry.

*Bambusa vulgaris*



Height: 20 m

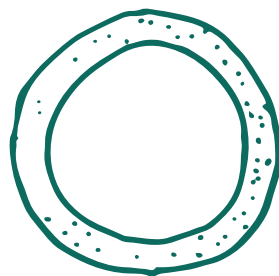
Diameter: 5-10 cm

Internodes: 30-45 cm

Wall thickness: 0,7-1,5 cm

Uses: Paper, handicraft, scaffolding and ladders. Starchy species, needs proper treatment before structural uses.

*Bambusa bambos*



Height: 25 m

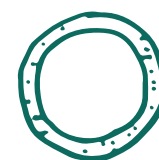
Diameter: 15-18 cm

Internodes: 30-45 cm

Wall thickness: 1,5-2,5 cm

Uses: Raw material for pulp and paper, panel products, handicrafts, thatching and roofing.

*Bambusa tulda*



Height: 25 m

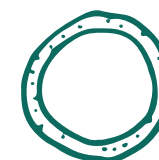
Diameter: 5-10 cm

Internodes: 40-70 cm

Wall thickness: 0,8-1,5 cm

Uses: Basketry, handicraft, structural purposes. Strong species, well suitable for mechanised processing e.g. manufacturing of composites.

*Bambusa nutans*



Height: 25 m

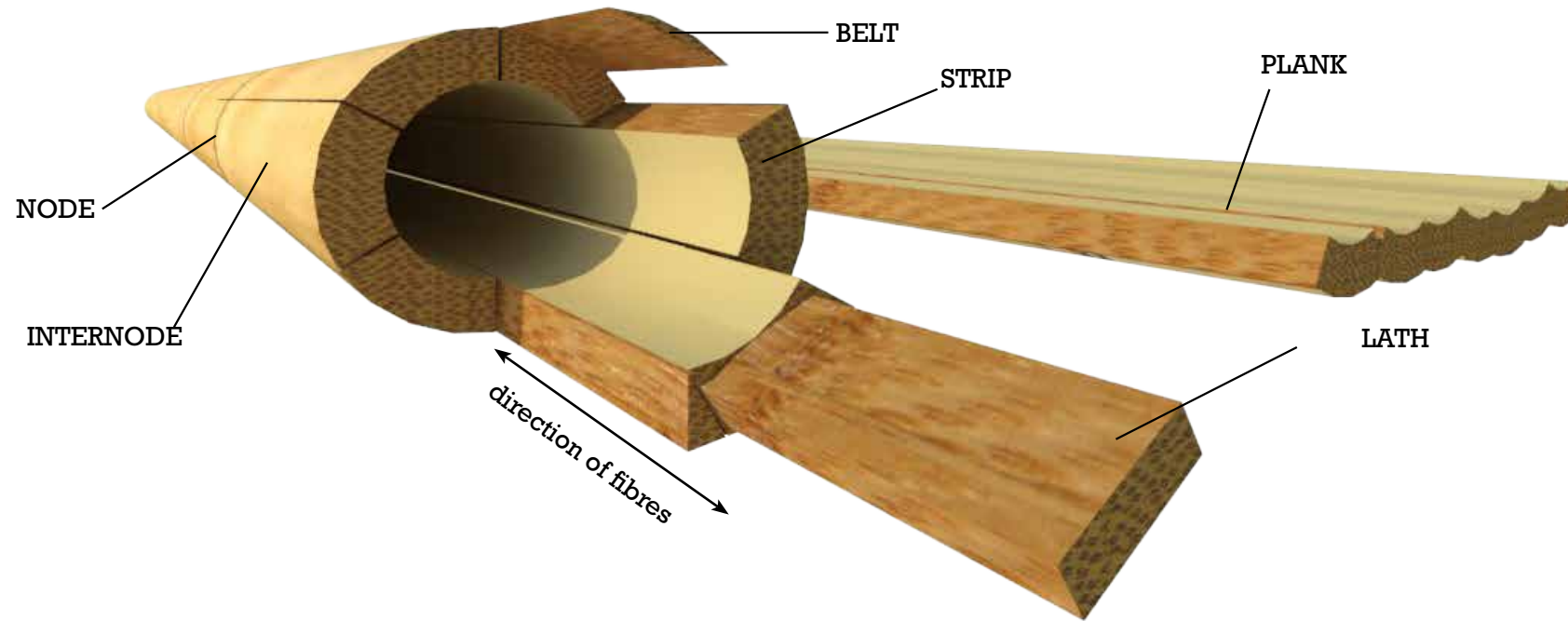
Diameter: 5-10 cm

Internodes: 25-45 cm

Wall thickness: 0,3-2,5 cm

Uses: Basketry, handicraft, occasionally house construction.

(NMBA, 2011, pp. 29-54)



### SEGMENTS OF A BAMBOO CANE

**STRIP** is a longitudinal segment of a cane, which is obtained by cutting the cane parallel to the fibres. A strip whose sides have been cut (planed) into a rectangular cross section, is called a **LATH**.

**BELT** is a longitudinal segment of the exterior part of the cane. Belts are used for woven works, like baskets and panels. Being strong and flexible, belts can be used to join several strips in parallel.

**PLANK** is a portion of a cane that has been opened into a flat surface by making longitudinal cuts at its nodes and removing the interior soft tissue with a spade.

**INTERNODE** is the hollow section between two **NODES**. In bamboo connections, where the cane is under compression perpendicular to the fibres, the respective internodes are filled with cement mortar to prevent cracking.

composite products combining the mechanical properties of bamboo, and the defined dimensions of commercial timber products, which would make it more suitable for conventional structural applications (Mahdavi et al. 2011). Laminated bamboo has been used as a material suitable for boards and flooring, but its structural potential has been studied only recently.

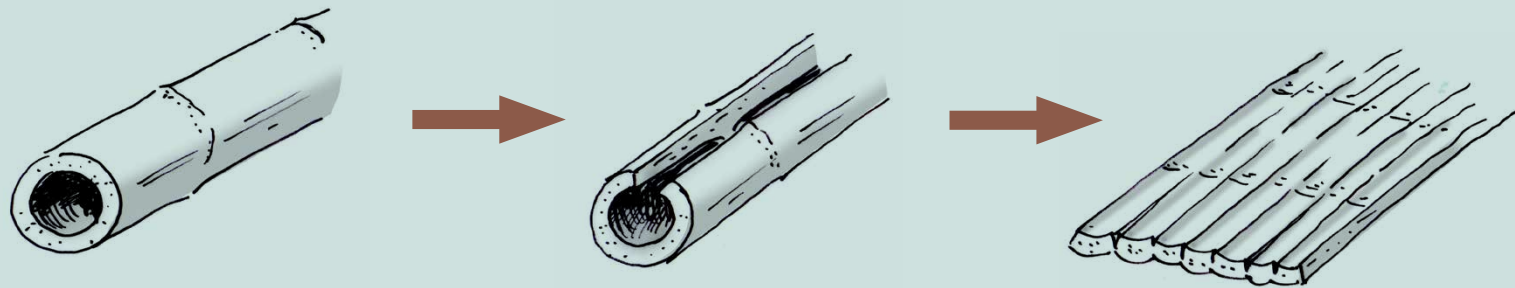
Laminated bamboo lumber (LBL) is fabricated by splitting tubular culms into strands, which are then driven through a planer to make them rectangular in cross section. The strands are glued together to form

larger rectangular elements of desired dimension.

A cost assessment for American markets suggests LBL to be relatively expensive, while it also mentions that much of the material is imported and transport constitutes a significant part of the cost. The manufacturing processes are still uncommercialised and further development would likely bring down the cost (Mahdavi et al. 2011). This implies that if LBL can be manufactured where bamboo is naturally abundant, competitive prices at local markets are achievable.

Industrial production of LBL typically requires sophisticated fabrication equipment and energy-intensive

Fig.28 (Below): Manual engineering method. Bamboo culms are opened lengthwise with a blade and crushed flat using a hammer. Remains of nodes are removed and the inside surface is smoothed. Resulting planks can be used to construct wall or floor panels, or, provisionally, laminated beams (Mahdavi et al., 2012). Illustration: AK.



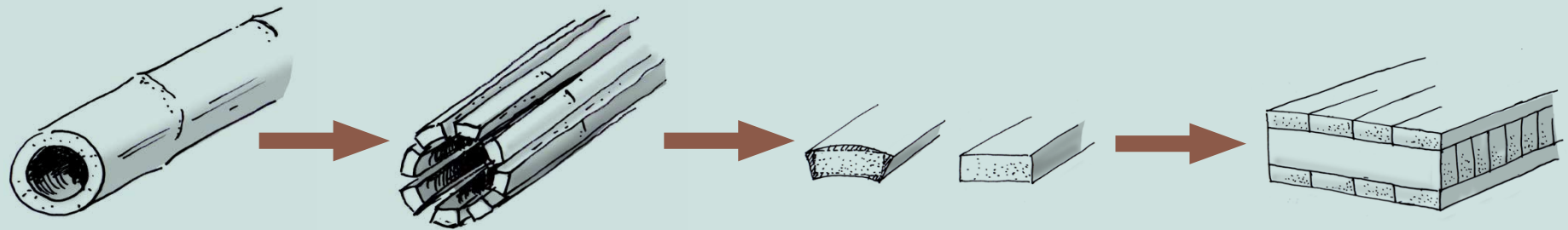


pressing processes, which is generally a limitation for local production, and also adds the cost and embodied energy of the final product. Experiments to find a low-technology approach for LBL fabrication have thus been carried out. Test results have been promising, indicating that LBL beams produced using only basic hand tools and a mechanical press perform with no significant difference to other similar products. This also suggests that a local, manual production of LBL would make it available for small-scale construction at a more affordable rate, while also reducing the embodied energy generated by transport (Mahdavi et al. 2012).

Phenol resorcinol or phenol formaldehyde based resin adhesives are typically used for gluing together LBL lamellas. The chemicals contained by the adhesives are generally toxic to humans, but the resins release less toxins when hardened. In LBL, the resin is exposed to the surface only at the very thin cross-sectional lines between lamellas.

Polyurethane based construction glues are environmentally safer option than formaldehyde adhesives. During the adhesion procedure or when handling unsolidified polyurethane, protection from fumes

Fig. 29 (Below): Mechanised engineering method. Bamboo culms are split into strips, which are machine-planed into uniform rectangular cross-section (laths). Laminated elements of desired proportions can then be produced out of the dimensioned strands (Mahdavi et al., 2011). Illustration: AK.



is appropriate. Polyurethane sticks well to various materials and makes a tight bond. If it ends up in the nature, it forms inert and unreactive, though unbiodegradable polyureas once solidified, whereas formaldehyde compounds are highly toxic to living organisms. It may be more harmful in aquatic ecosystems, where it disperses into tiny particles and gets ingested by animals. Polyurethane is combustible and can be incinerated for energy generation, or chemically processed for reuse. (American Chemistry Council, 2005)

Polyurethanes become stable in the environment and on disposal have no adverse impact on municipal waste handling processes, landfills or incineration, although landfill, being an unsustainable method of disposal, is not recommended.

Experiments with environmentally friendlier castor oil based polyurethane adhesive have been made with both glued laminated timber (Azambuja & Dias, 2006) and glued laminated bamboo (Cardoso Ventura et al., 2014) with conclusions suggesting the castor oil based adhesive to be a viable alternative to formaldehyde-based adhesives in these applications

## PUCCA AND KUTCHA

In India, any construction can be considered either pucca, semi-pucca or kutcha. This traditional categorisation roughly describes the overall resilience of the building, The evaluation is largely based on the materials used.

Typical pucca materials include:

- *burnt bricks*
- *cement bricks or stones, packed with lime or cement mortar*
- *cast concrete*
- *mechanically manufactured roof tiles*
- *cement tiles*
- *slate*
- *galvanised iron or asbestos sheets.*

Typical kutcha materials include:

- *unburnt bricks*
- *loosely packed stone*
- *mud, manure*
- *grass, reeds, leaves, thatch*
- *bamboo*

(Ministry of Home Affairs, n.d., 17).

In cases of structures being partly kutcha and partly pucca, the term semi-pucca is sometimes used.

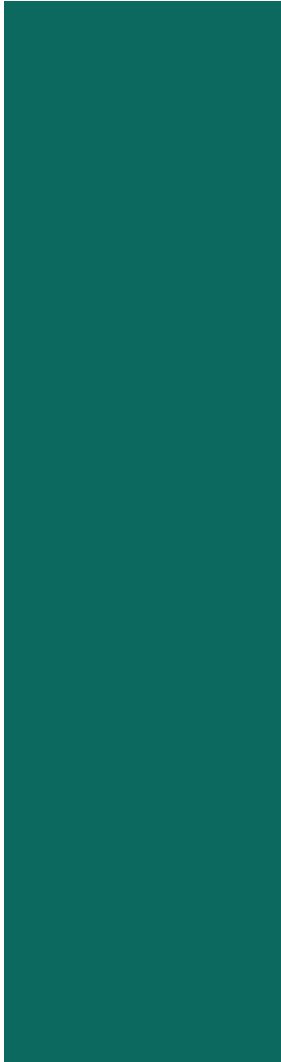
People belonging to lowest income segments are often unable to afford pucca housing, which increases their vulnerability against natural disasters. The government has sought for strategies to provide pucca housing to the poor. Also bamboo is generally considered kutcha, which has given it a reputation of a weak material. This is justifiable, since untreated bamboo is commonly used in non-permanent constructions where it quickly starts to degrade under normal conditions. However, properly constructed and engineered applications do not deserve the negative stigma. The laminated bamboo lumber demonstrates the pucca aspect of bamboo, an alternative that questions the popular sentiment.

Fig.30 Cross-section pattern of laminated bamboo laths.





## **4. Design proposal**



## 4. Design proposal

### 4.1. SHAPING THE IDEA

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Prefabricated transportable elements are essentially designed to fit into compact volumes. This puts more emphasis on the design of joints and connections between two or more elements. Many conventional types of elements are not necessarily usable and have to be redesigned to achieve better transportability. The proposal demonstrates an explorative attempt to do this with all elements.

The frame system that transforms into a transport container is the original approach to the problematic studied in the following proposal. The material of the frames is laminated bamboo, chosen because of its obvious strength and durability, as well as accurate dimensions, which are essential for interchangeable and modular elements. The material is manufactured and frames prefabricated entirely through industrial process.

The dimensions of the frame opening correspond the cross-section of a standard shipping container. 18 frames can be stacked into an open sided standard 20-foot container. The hollow inside space would be used to contain other material needed.

Another question was the space and its ability to respond to different needs. Teaching methods can involve instruction of the class as a whole group or divided into smaller subgroups. The instruction can be done the conventional teacher-to-student way or as a social interaction among the students, facilitated by the teacher. The classroom interior layout should enable these alternative configurations by partition elements. Also traditional media, like plays and performances, are used for teaching:

*“Traditional folk media are cultural resources that accumulate indigenous knowledge, experiences and expressions passed down from generation to generation. Woven into proverbs and poems,*

*songs and dances, puppet plays and stories, rhythms and beats, they are embedded with a strong sense of cultural identity which can be a potent force for development; in many cases, these media are the traditional conduits for indigenous knowledge, experience and culture."*  
(Subramanyan, 2008, p. 246)

The *Mother tongue based multilingual early childhood education* of KISS aims for creative ways of learning through linguistic and visual expression, bodily activity, social interaction, exploration, etc.

A predetermined environment may not be useful, for the users' needs and conceptions are not always known. This is particularly true when evoking interaction between people with inherently different cultural backgrounds.

The method aims at encouraging children to express themselves and learn to understand each other. The item library forms an essential part of the learning material. It requires an adequate space for storage and display of the items and it would take up a substantial portion of the floor area. The collection may vary in size.

To approach above requirements, a modular system of interior elements was considered, the elements

of which can be also used as storage shelves, chairs, audience stands for performances and building blocks for other creative uses.

## 4.2. PROGRAM

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The unit of 18 frames can be assembled to enclose approximately 80 square meters of floor area in two levels.

The area comprised of four basic modules is approximately 22 m<sup>2</sup>. This would be a sufficient area for a classroom for up to 20 children sitting on the floor. A preferred layout would enable combining of two or more classroom units into one, by moveable light partition walls. The classrooms are generally situated at the upper level and the library, storage and administrative functions at the lower level. This is because the system allows the construction of the upper level without vertical structures in the middle of the volume, which suits better for games and other group activities.

Examples of different floor plan configurations are displayed on pages 86-88.



Fig.31 Interior view from a classroom in use.



## 4.3. TRANSPORTABLE ELEMENTS

### SCREWPILE FOUNDATION

A ground screw or screwpile is usually made of galvanised steel. It is used as a foundation element for various types of structures. Ground screws are manufactured in various sizes and types, suitable for different types of soil and sizes of intended structures. Ground screw foundation is simple to install and no or little excavation is usually required, and upon removal, it leaves no trace but a hole in the ground. Certain types of screwpiles can be driven to ground by manual force or a portable electric or petrol-powered driver. (Krinner Schraubfundamente GmbH, n.d.; Paalupiste Oy, n.d.)

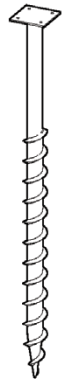
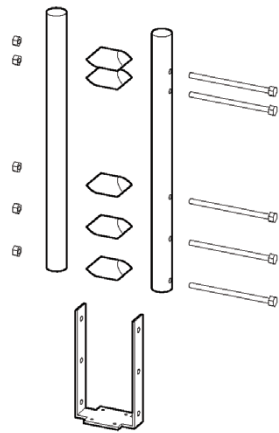


Fig. 33 (Above) Assembly principle of a stilt on a screwpile foundation.

Fig. 34 (Right) Smaller screwpiles can be manually driven into soil.

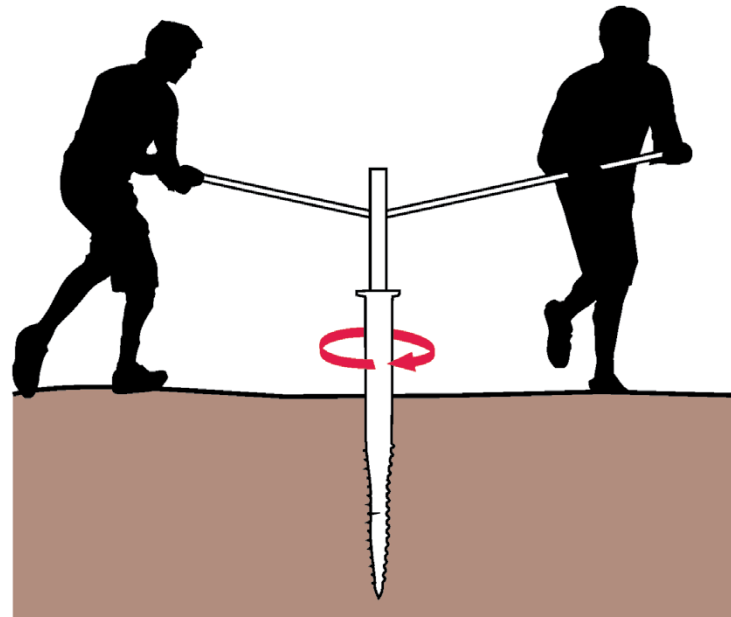


Fig. 32 (Above) Screw piles of different sizes, with different thread types and mounting plates are available on the international market.

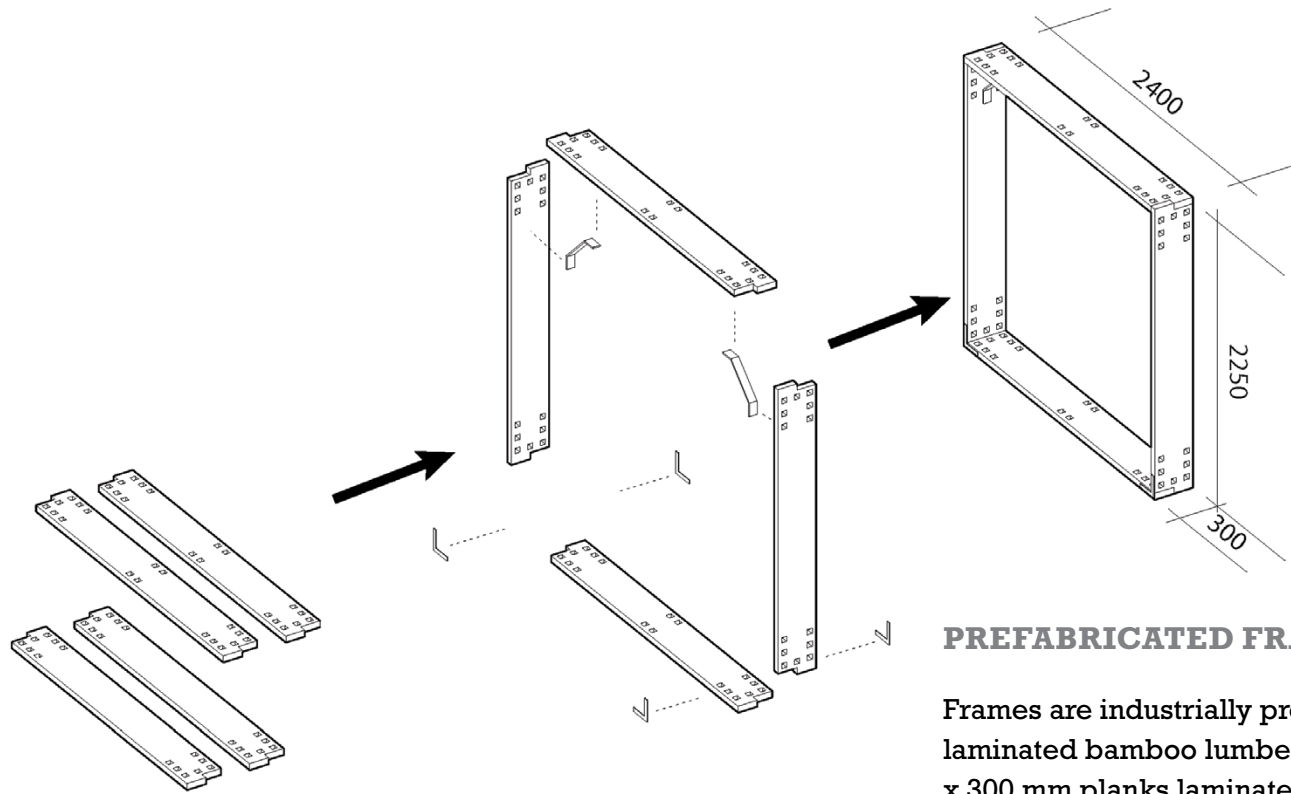
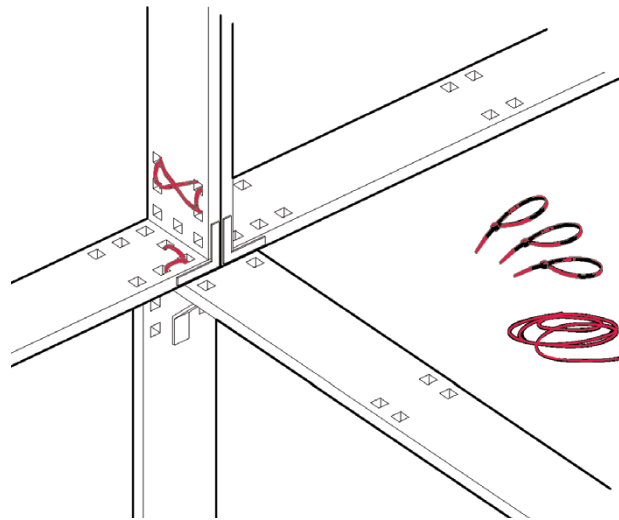


Fig.35 Prefabrication of the modular frame.

### PREFABRICATED FRAME ELEMENT

Frames are industrially prefabricated out of laminated bamboo lumber. The sub-elements are 50 x 300 mm planks laminated from bamboo laths, to which perforations and joint cuts are made. Joints are glued and reinforced with steel braces to form rigid corners with permanent connections (Fig. 35).

Frames are joined by fastening them tightly together, through the arrays of perforations in the corners. Binding can be done with various optional materials; heavy-duty plastic or metal cable ties, nylon rope or velcro straps, or even traditional coconut fibre rope. Amount of required binding material can be adjusted depending on how critical the connection is. Tied



re- interpreting traditional techniques (bound connections)

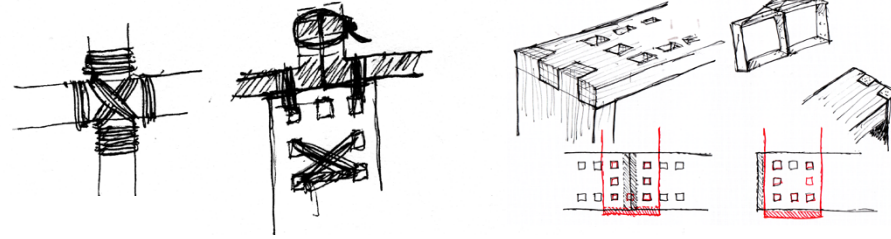
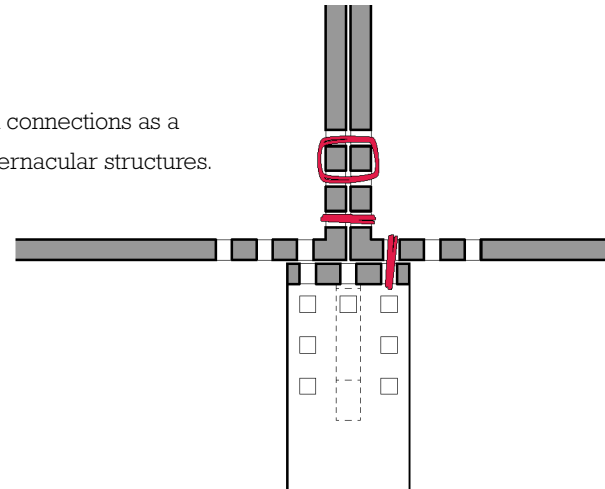


Fig.36 Bound connections as a reminiscent of vernacular structures.



connections are a traditional way of joining bamboo and other light materials (Fig.36), and they are easy to put together and dismantle again. Additional rigidity of the frame is achieved by bracing and wire rope anchoring, the modular frame system

The elements are intended to be moved, assembled and disassembled by manual force on construction site. Weighing approximately 80 to 100 kilograms each (density of laminated bamboo is approximately 700 kg (Minke, 35)), the frames are somewhat heavy, but manageable without heavy machinery. They could be moved around with the aid of support wheels and hoisted to upper level using slings and pulley mechanism.

A square space enclosed between two frames constitutes a basic modular unit, with an area of approximately 5,5 m<sup>2</sup>. The frames can be attached on top of or next to each other in parallel or stacked upon each other. The upper level is created by assembling upper frames perpendicular on top of the lower ones, making the vertical parts aligned. Spacing between two parallel frames at the lower level should correspond the frame width. This is the principle of the two-level modular system (Fig. 37).

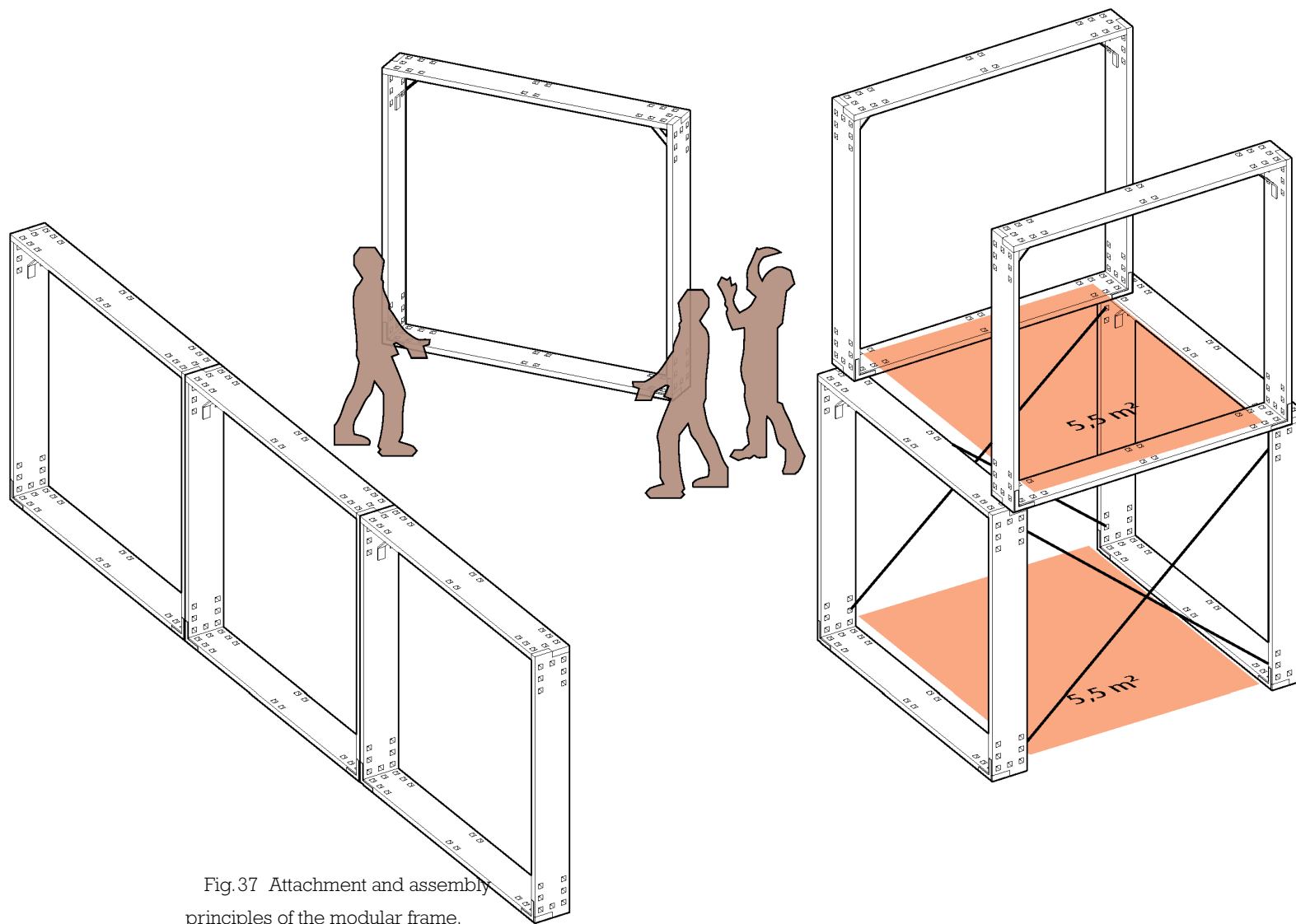


Fig.37 Attachment and assembly principles of the modular frame.

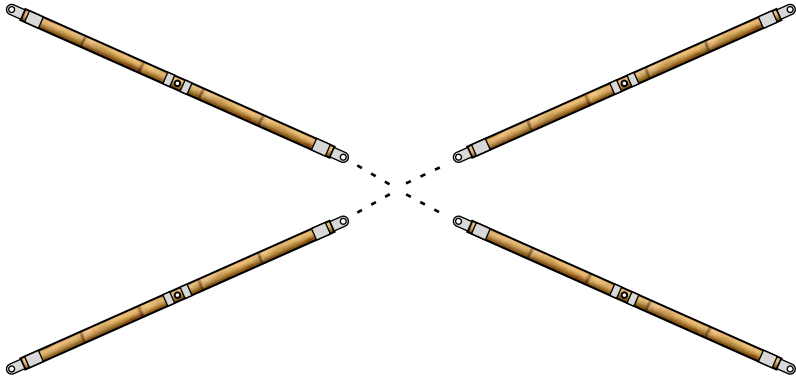
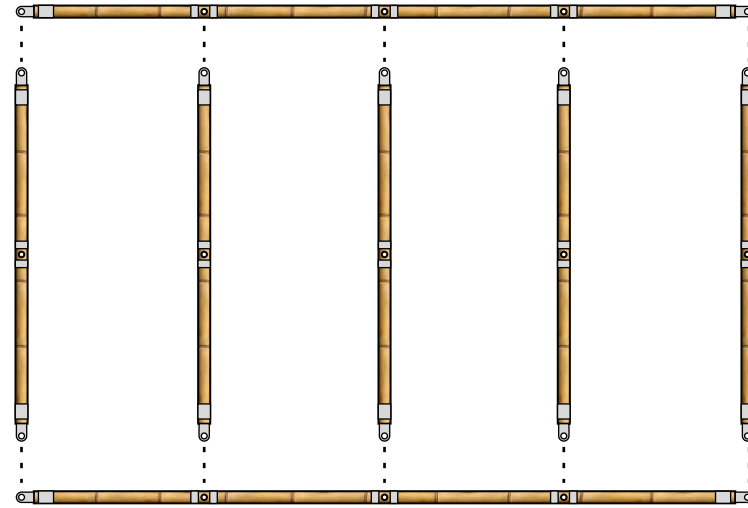
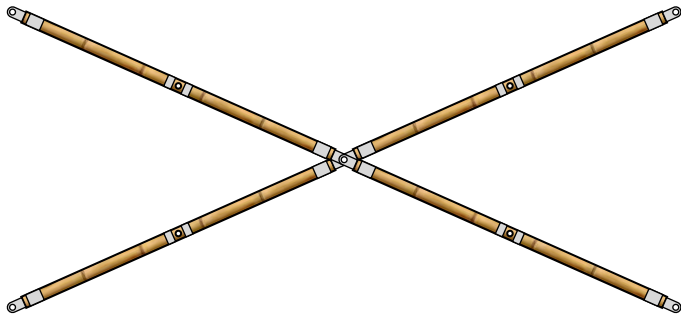


Fig.38 (Above/below left) Bamboo poles assembled into X-shaped bracing element.



### ATTACHMENT POLES

Prefabricated bamboo poles with reinforced attachment holes at even distances of 1200 mm, are used for the base of the roof support system, attachment of the screens and curtains, and as bracing elements of the frame (along with smaller steel braces).

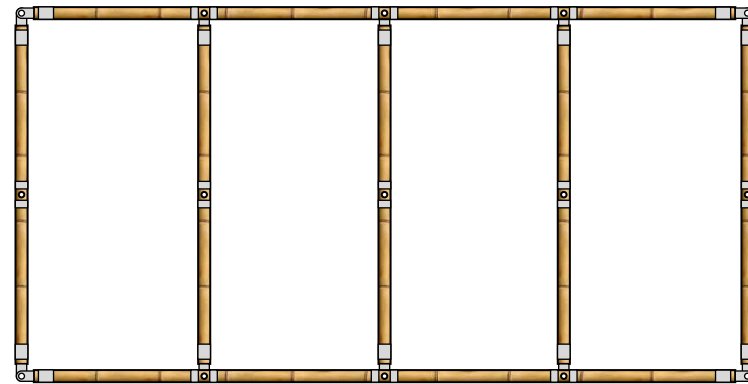
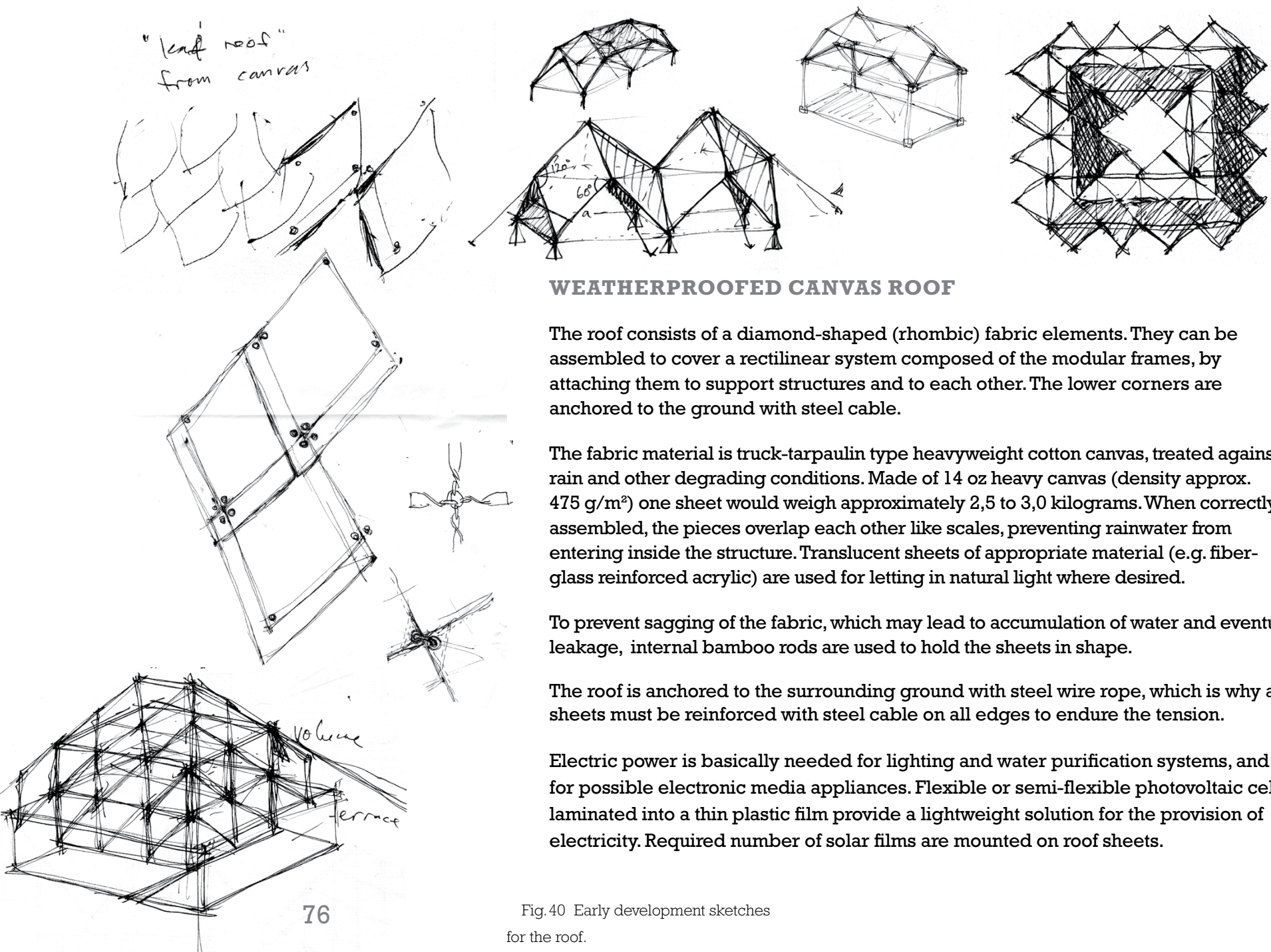


Fig.39 (Above/below right) Bamboo poles assembled into a roof support grid.



## WEATHERPROOFED CANVAS ROOF

The roof consists of a diamond-shaped (rhombic) fabric elements. They can be assembled to cover a rectilinear system composed of the modular frames, by attaching them to support structures and to each other. The lower corners are anchored to the ground with steel cable.

The fabric material is truck-tarpaulin type heavyweight cotton canvas, treated against rain and other degrading conditions. Made of 14 oz heavy canvas (density approx.  $475 \text{ g/m}^2$ ) one sheet would weigh approximately 2,5 to 3,0 kilograms. When correctly assembled, the pieces overlap each other like scales, preventing rainwater from entering inside the structure. Translucent sheets of appropriate material (e.g. fiberglass reinforced acrylic) are used for letting in natural light where desired.

To prevent sagging of the fabric, which may lead to accumulation of water and eventual leakage, internal bamboo rods are used to hold the sheets in shape.

The roof is anchored to the surrounding ground with steel wire rope, which is why all sheets must be reinforced with steel cable on all edges to endure the tension.

Electric power is basically needed for lighting and water purification systems, and for possible electronic media appliances. Flexible or semi-flexible photovoltaic cells laminated into a thin plastic film provide a lightweight solution for the provision of electricity. Required number of solar films are mounted on roof sheets.

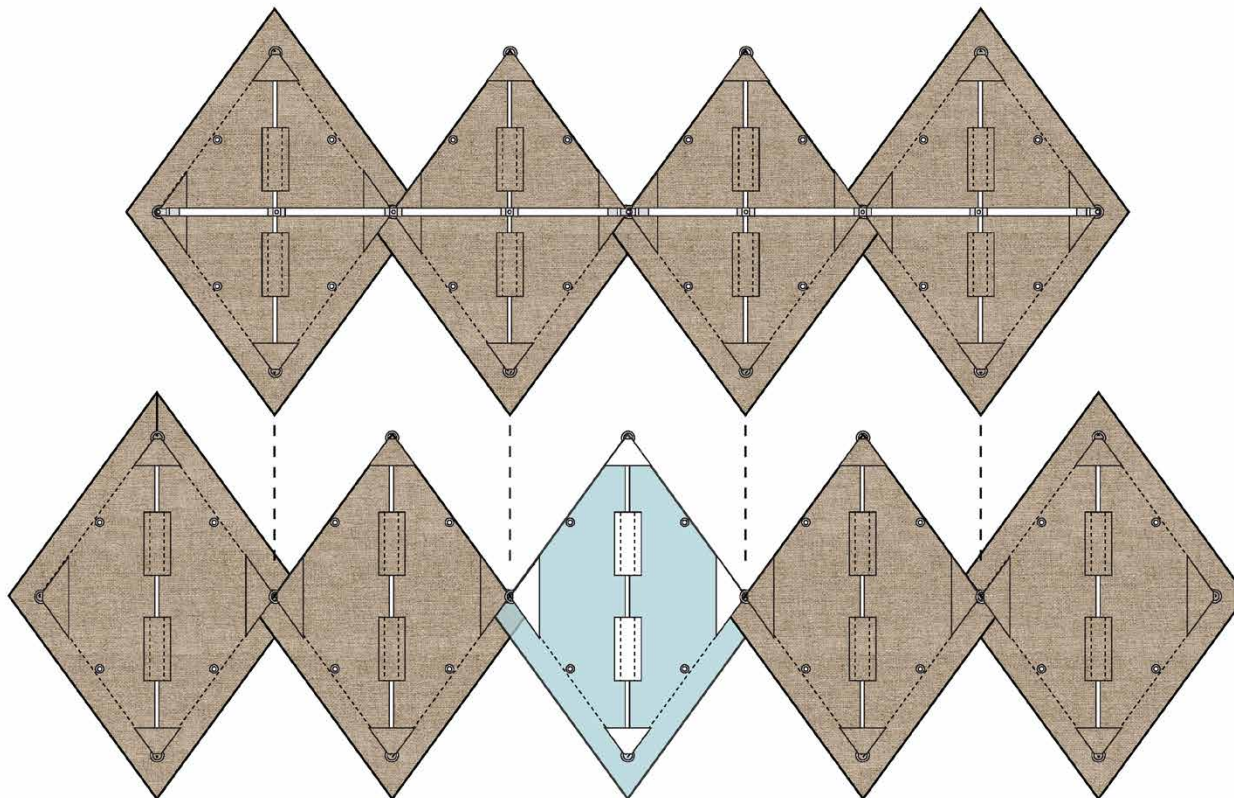
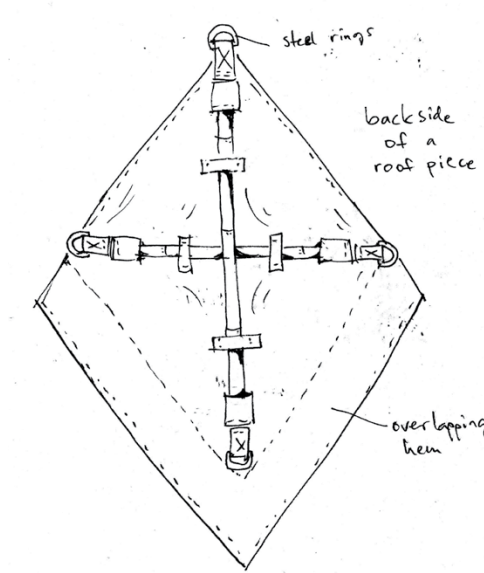
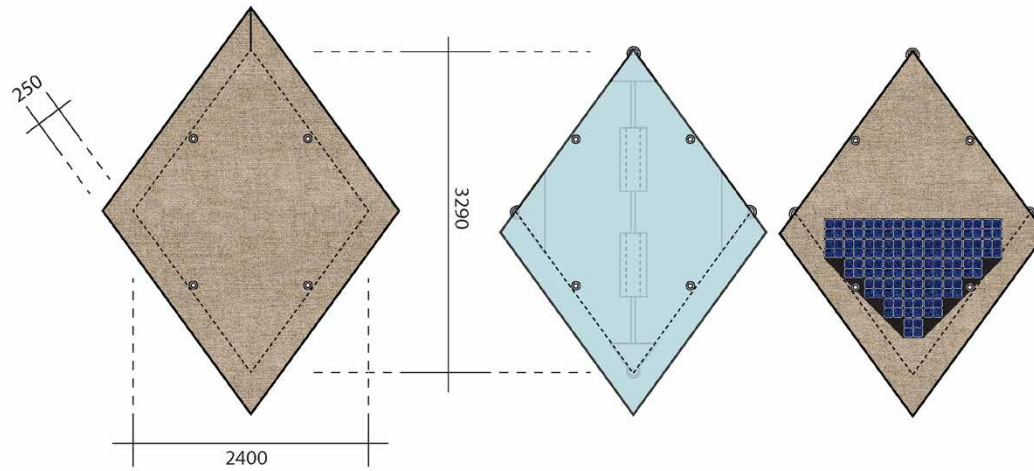
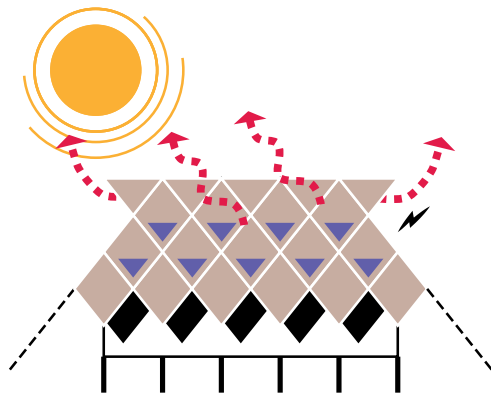


Fig.41 (Above) Sketch of the structure of a roof sheet.

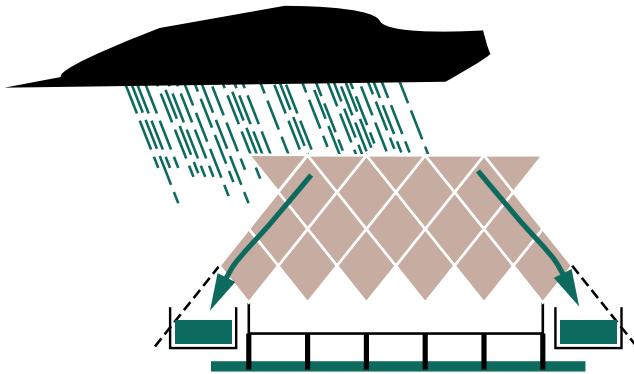
Fig.42 (Above left) Types of diamond-shaped roof sheets: Ridge sheet for top and corner ridges, daylight-permitting translucent sheet and basic sheet with optional solar cell film attached.

Fig.43 (Left).Interior side appearance of roof sheets attached together from their horizontal corners and onto a horizontal pole.

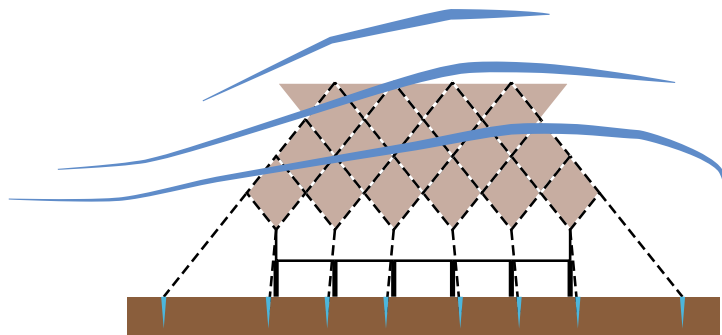
## CLIMATICAL FUNCTIONALITY



The roof provides effective shade during daytime, when the structure is occupied and the solar radiation is most intense. Thermal conductivity of cotton fabric is less than  $0,05 \text{ W/(mK)}$  that of low-carbon steel being over  $30 \text{ W/(mK)}$  (Engineeringtoolbox.com, 2015); Opposed to steel roofing, the fabric roof would have substantially smaller heat transmission through the roof, contributing to a better thermal comfort. Shade is also important for the protection of bamboo structures, which are vulnerable to degradation when exposed to ultraviolet radiation. The roof is equipped with solar cells, to provide electric power for necessary appliances. High-pitched roof with a 'breathing' scale-like structure and ventilation openings at the ridge lets warm air out, from the top, creating a cooling draft inside.



Heavy noise caused by rain hitting the roof sometimes prevents teaching and studying. During rainfall, the canvas roof creates less noise than more conventional roofing materials, such as iron sheets. The fabric is treated to be waterproof, and overlapping edges prevent water from entering inside. Rainwater can be collected at the outer tip of the fabric sheets.



Structure raised upon stilts separates it from the ground, which may be temporarily flooded during rain. However, in areas prone to severe flooding the stilts must be higher and the foundations would have to be driven deeper into the ground, which may restrict the applicability of this proposal in said areas. Steel base of foundations effectively prevents ground vermin, like termites, from entering the structures.

The roof sheets are reinforced with sewn-in steel cable on all edges. When assembled the cables form a large mesh, which is anchored to ground with screw anchors at several points. The roof becomes resistant against wind. The eaves can be extended downwards for added cover and better aerodynamic shape.



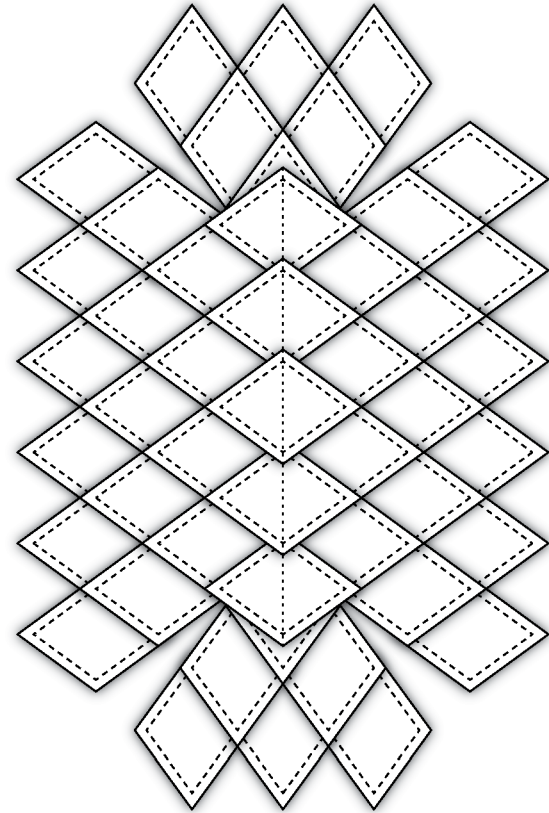
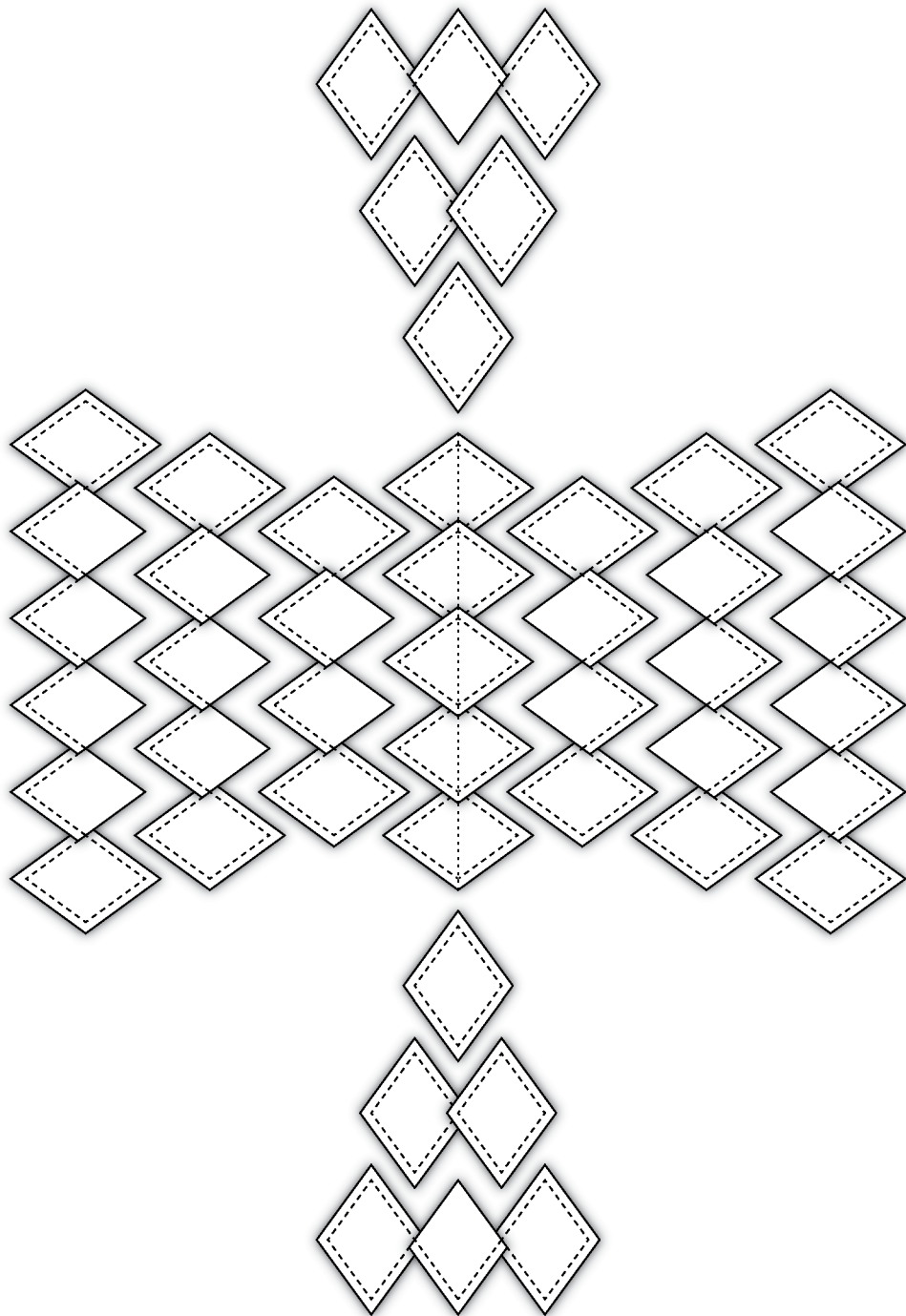


Fig. 44 Assembly of roof sheets for a two-storey volume of 2 x 5 modules (featured on pages 96-97). Sheets on the top ridge are folded in the middle.

## WALL PANELS AND CURTAINS

Woven screens and folding curtains are installed onto frames. The screens function as both outer and interior wall elements. Curtains can be used, where adjustable opening is appropriate for added daylight or ventilation. A folding curtain is operated vertically with a simple and reliable mechanism.

Some tribal communities have long traditions of decorative bamboo weaving. Locally handmade screens can possibly be used for partition panels, adding a touch of familiarity for the users. These elements can have educational value as cultural artifacts.

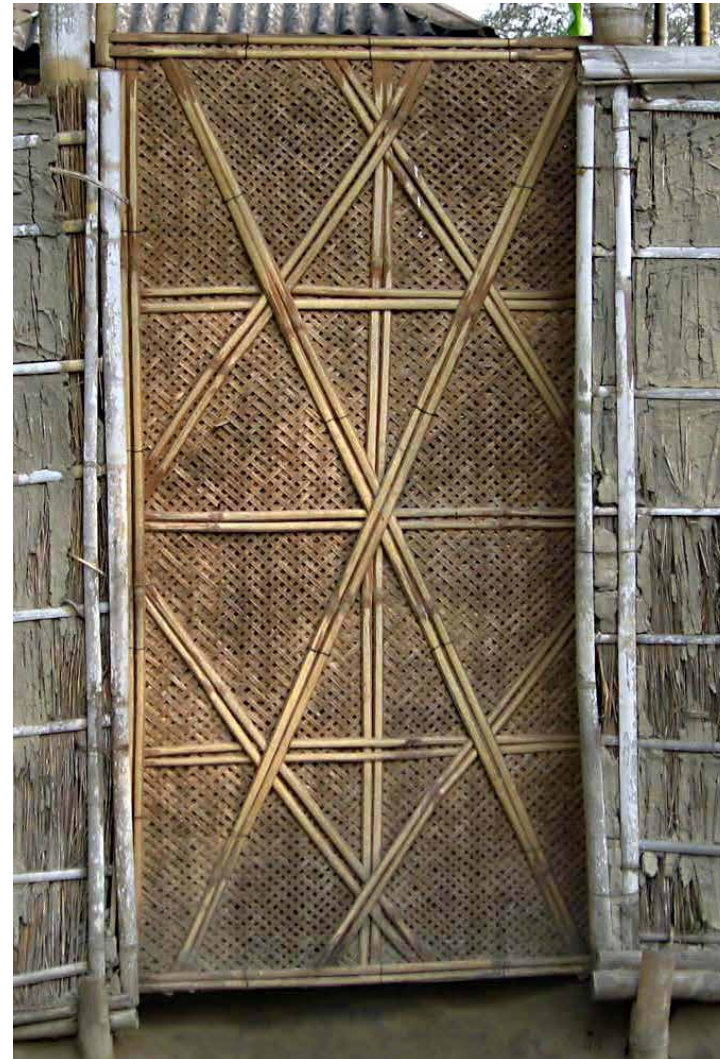


Fig. 45 A vernacular door from Assam (Northeastern India), made of woven bamboo screen. (Photo: peasantautonomy.org)

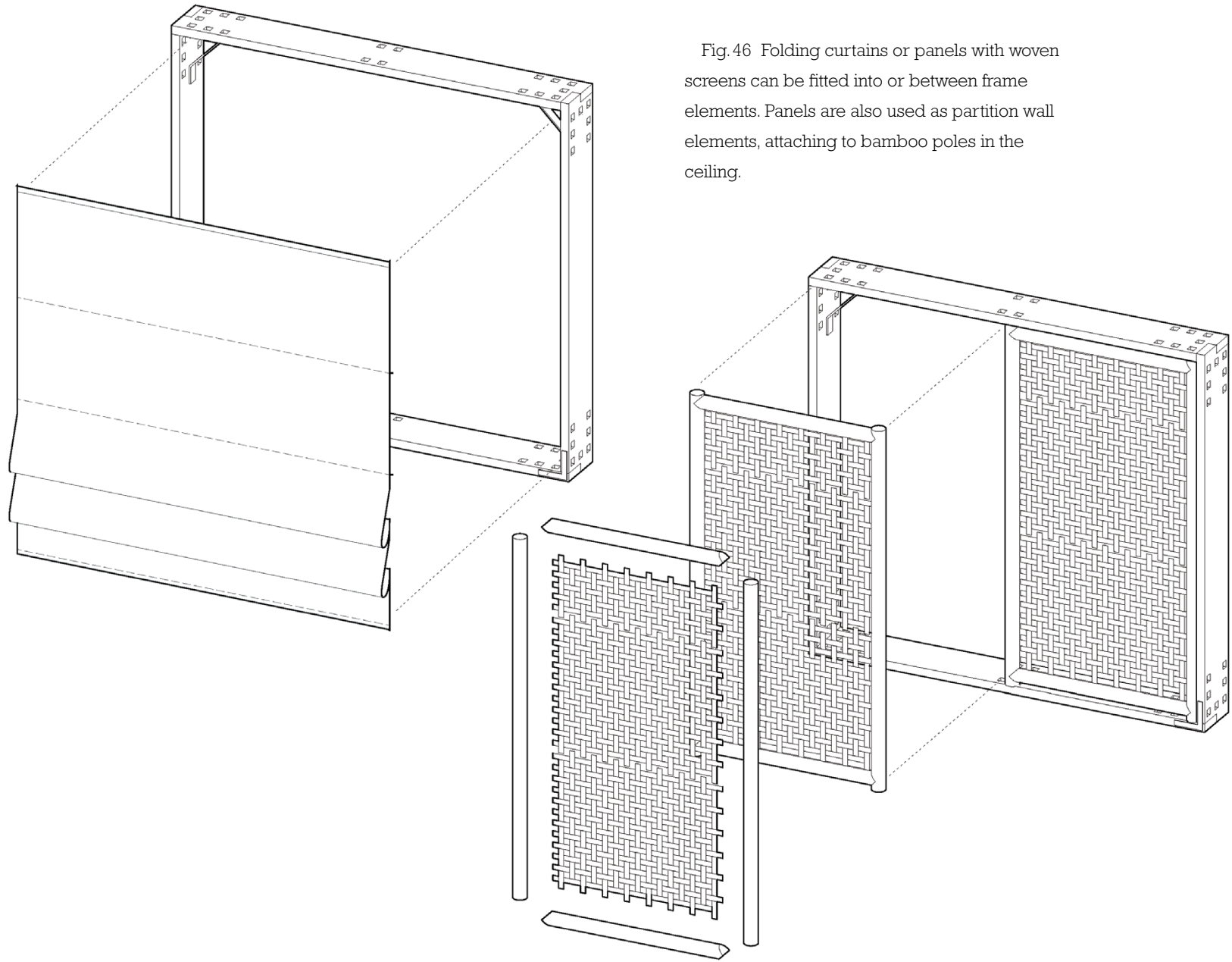


Fig. 46 Folding curtains or panels with woven screens can be fitted into or between frame elements. Panels are also used as partition wall elements, attaching to bamboo poles in the ceiling.

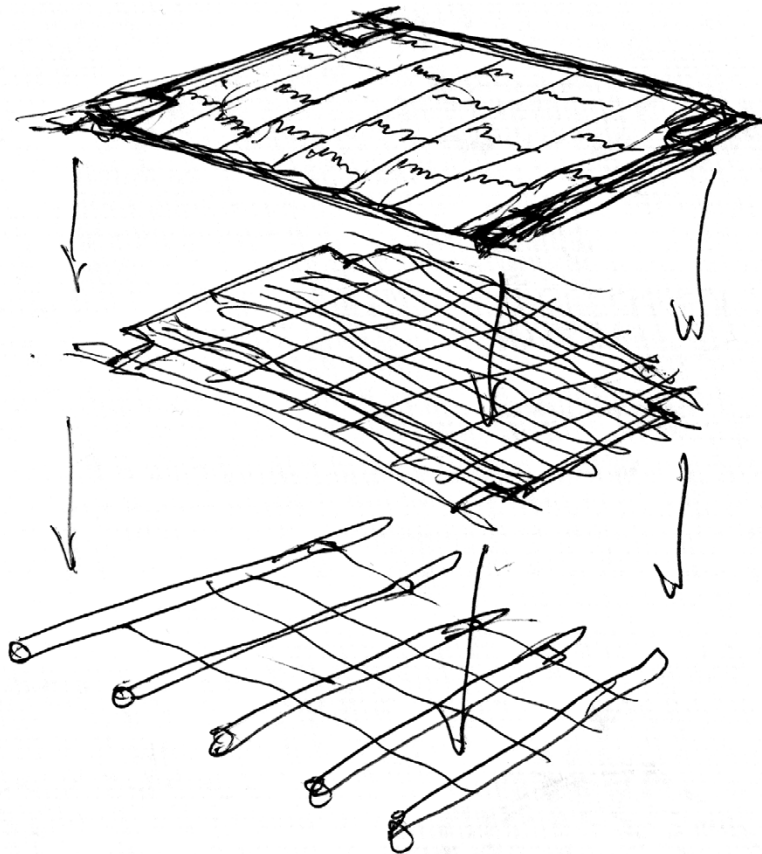


Fig. 47 Sketch drawing of the floor structure.

## FLOORS

Floor levels are composed of 'mats' of bamboo placed upon each other in perpendicular orientation; the mats can be rolled up for transport.

Primary layer:  $\varnothing$  60 mm canes, tied or attached to fabric strips with 350 mm spacing.

Secondary layer: Thick bamboo strips or  $\varnothing$  40 mm canes, with spacing 150 mm, tied or attached to fabric strips.

The primary and secondary layers are fastened to the frame as well as to each other, thus forming a rigid grid with sufficient loadbearing capacity for a floor. Bamboo plank tiles are used as the actual flooring layer.

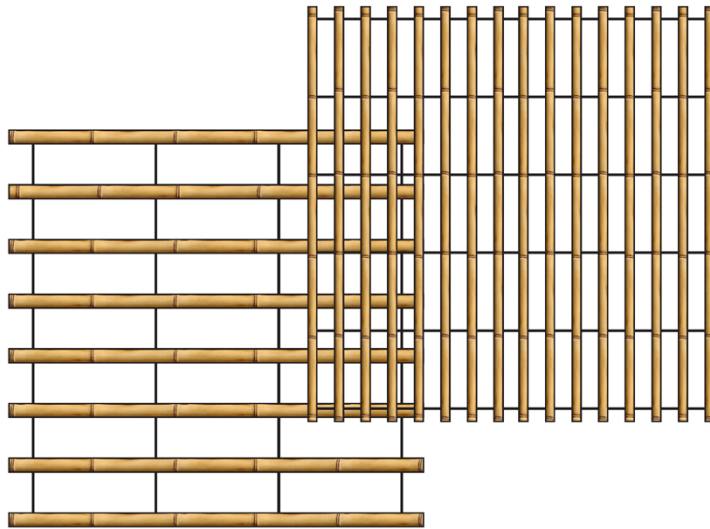


Fig. 48 (Left) Rollable bamboo cane mats, for floor support, covering a basic modular area of 2,4 x 2,4 metres when tied together.

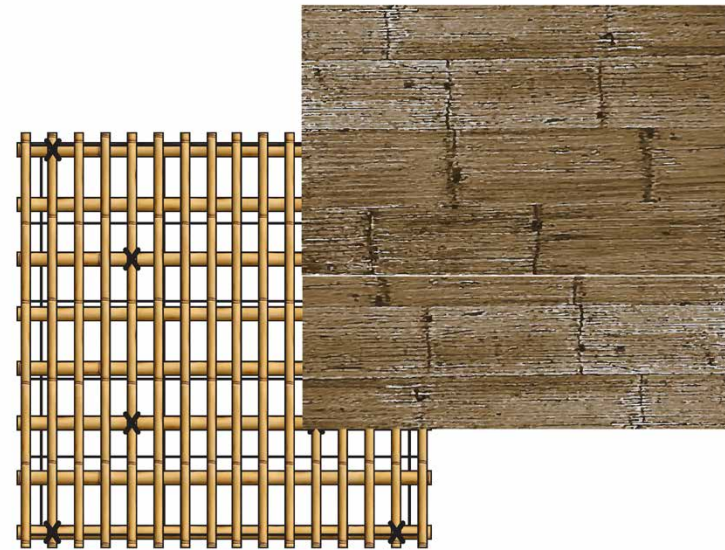


Fig. 49 (Right) Supporting mats assembled together with the top layer of bamboo plank flooring tiles.

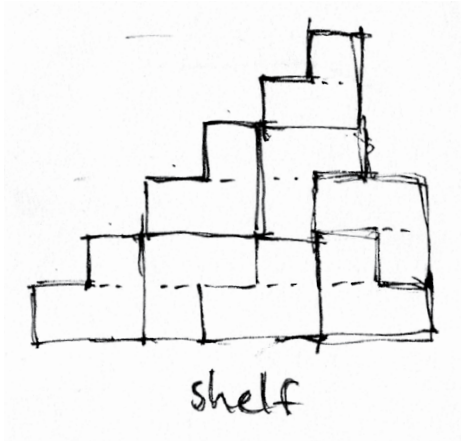
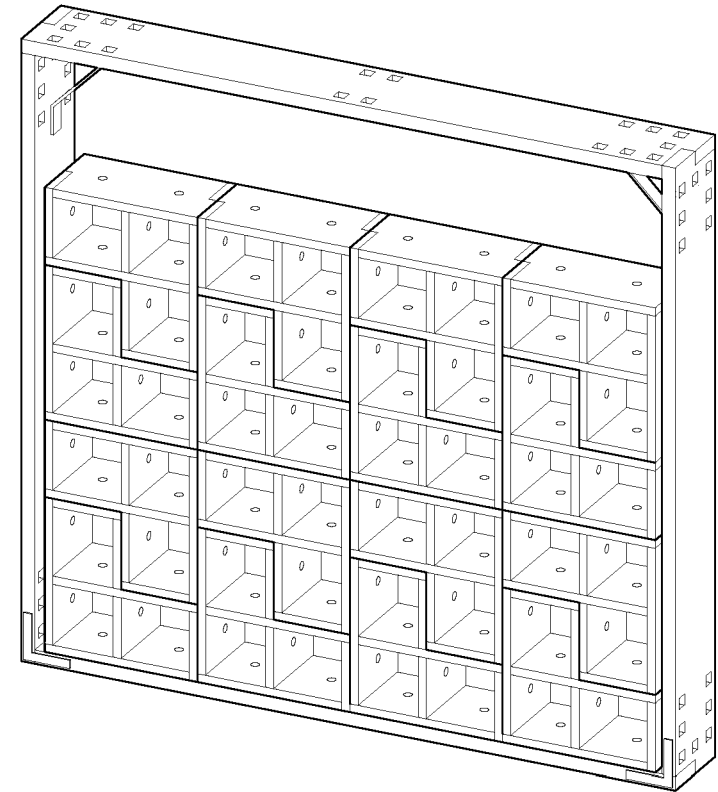
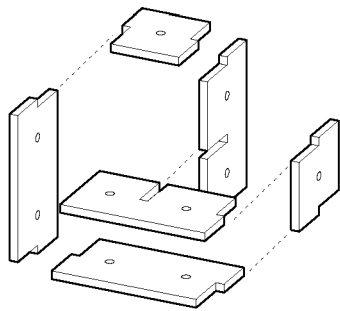
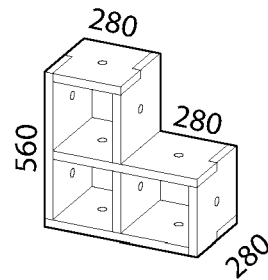
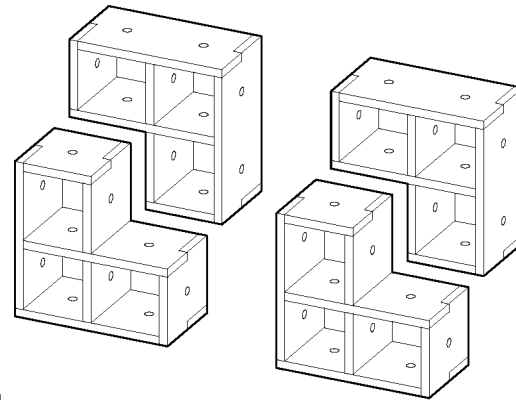


Fig.50 Prefabrication of the furniture block and principle of the shelf assembly.



## MODULAR FURNITURE

The furniture is a modular system within a larger one. A block made of laminated bamboo board can be used as a part of a shelf, a chair with two optional seat heights (28 and 56 cm), or other creative and playful constructions. The depth of a block fits inside that of a frame element and can be compactly stacked for transport. When assembled, the blocks are joined through the holes with wooden pins.

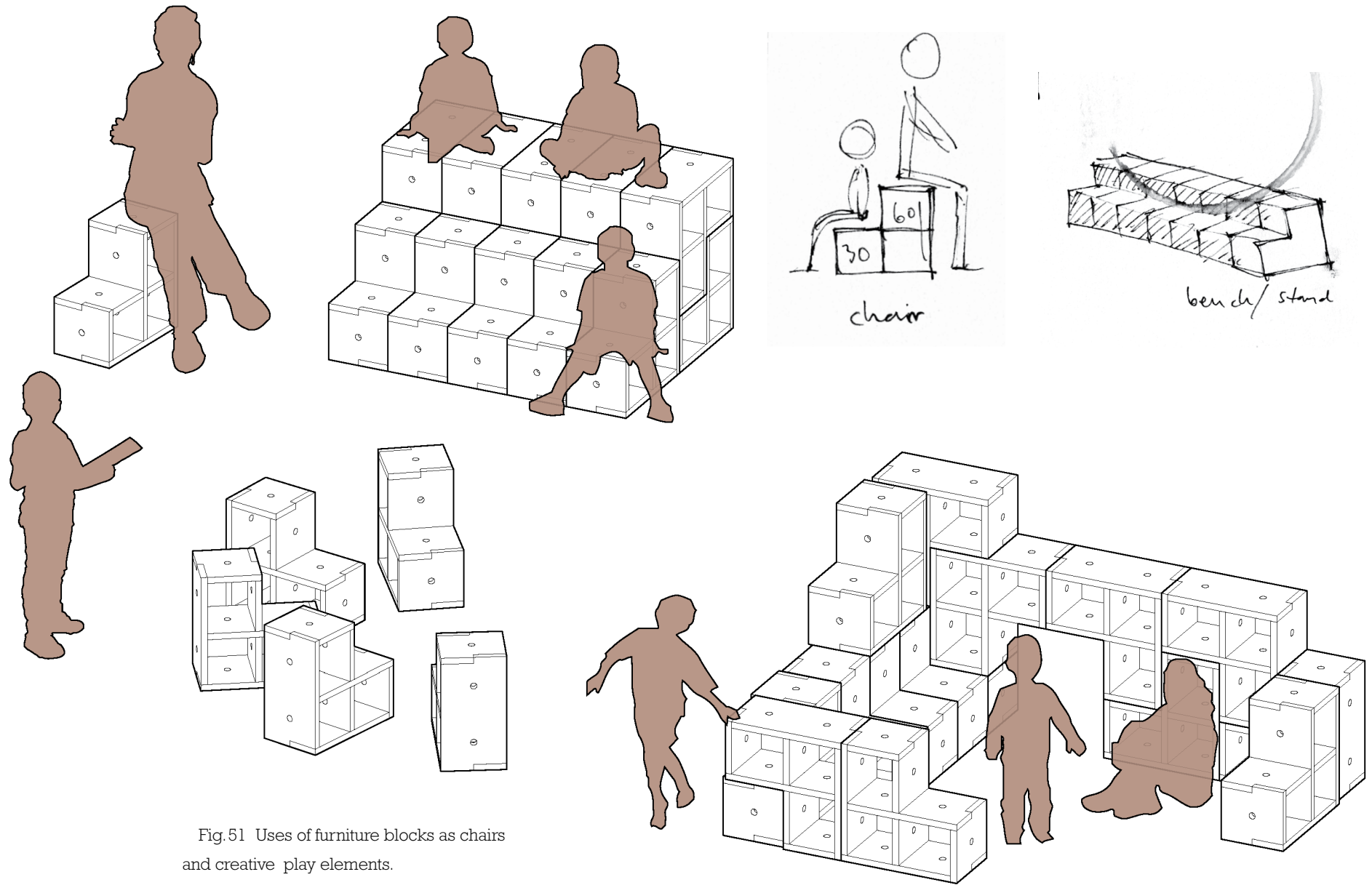
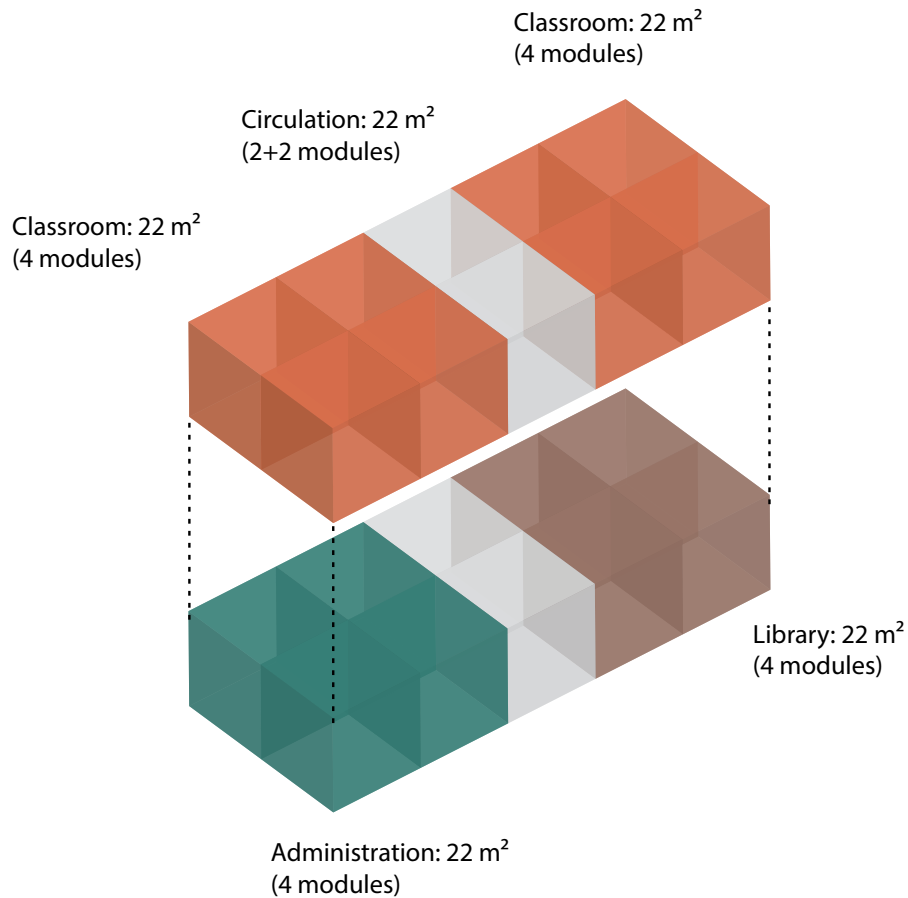
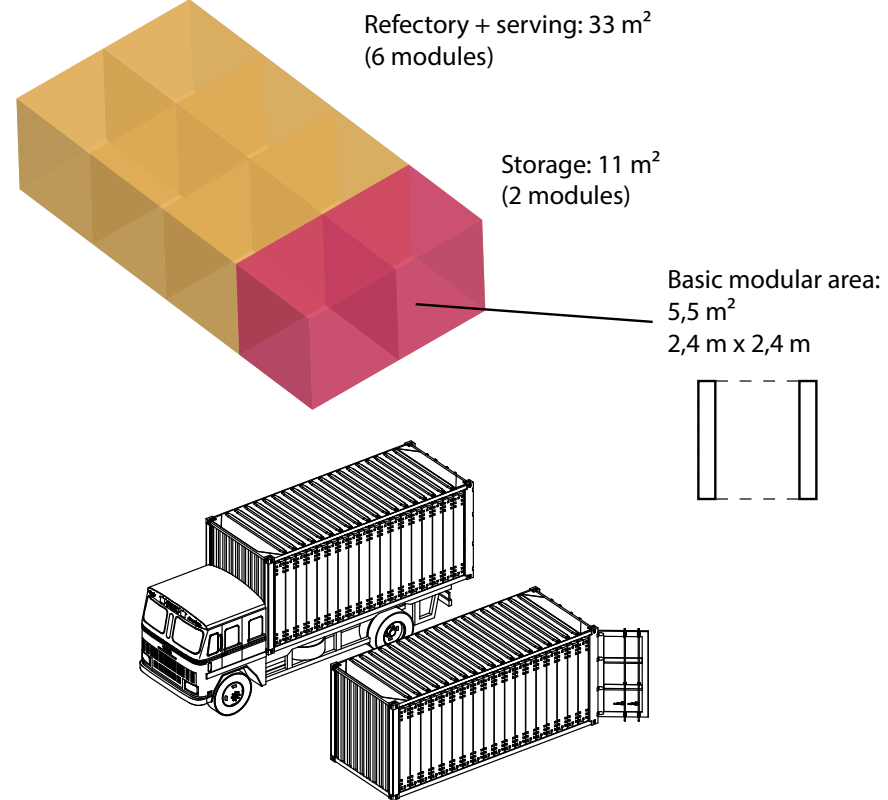


Fig. 51 Uses of furniture blocks as chairs and creative play elements.

## CLASSROOM UNIT (2 floors)



## REFECTORY UNIT (1 floor)

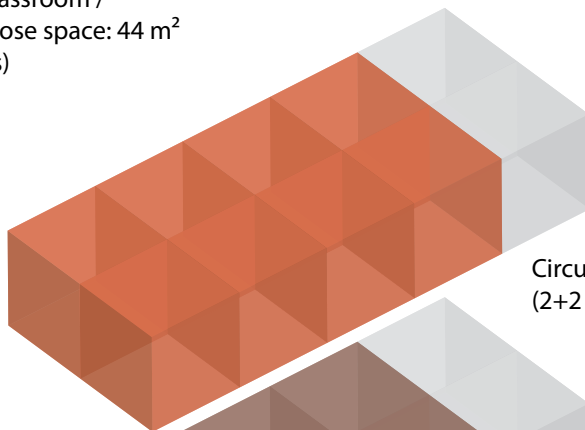


The system allows somewhat flexible configurations of spaces and divisions. However, two parallel rows of modules would be the optimal shape. The volume can consist of one or two levels and it can be extended lengthwise by steps of two modules. Displayed above and on opposite page are two examples of a minimum school setting, with spaces allocated for administrative and library functions. A separate unit is designated for food preparation and serving. Sanitary facilities are not included in the modular system and are to be built as independent units. Page 90 shows a suggestion for a larger school site.

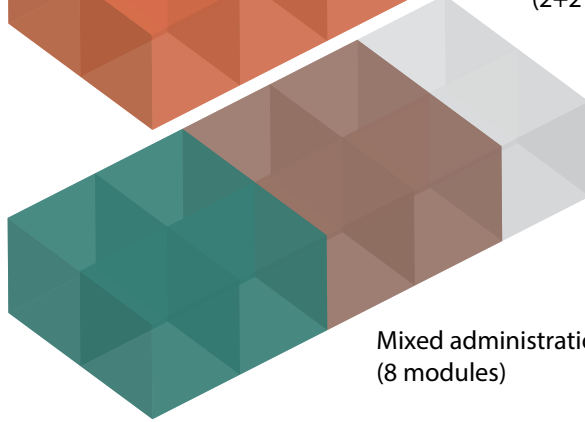


# CLASSROOM UNIT (2 floors)

Divisible classroom / multi-purpose space: 44 m<sup>2</sup> (8 modules)



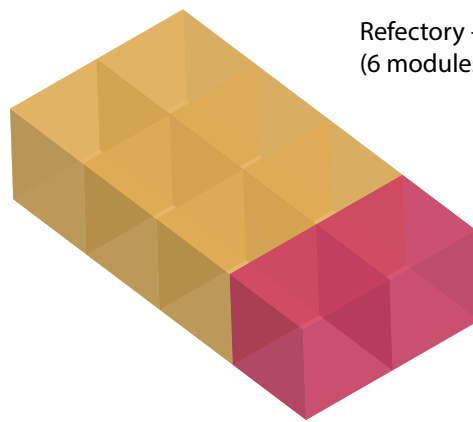
Circulation: 22 m<sup>2</sup> (2+2 modules)



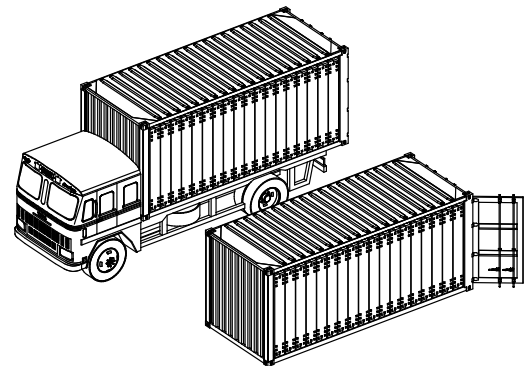
Mixed administration / library: 44 m<sup>2</sup> (8 modules)

# REFECTORY UNIT (1 floor)

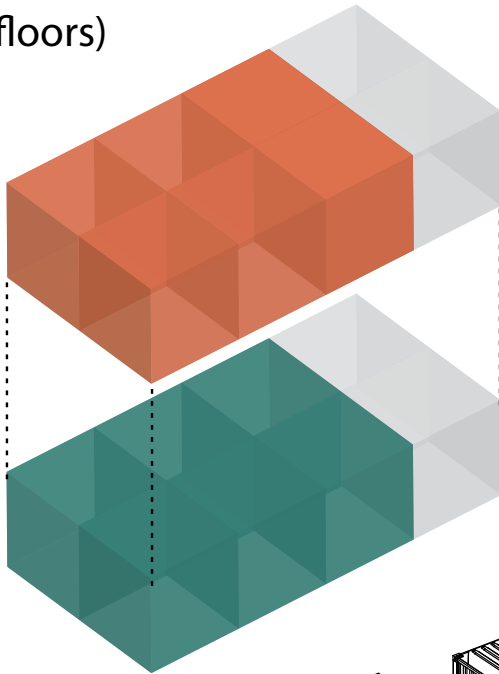
Refectory + serving: 33 m<sup>2</sup> (6 modules)



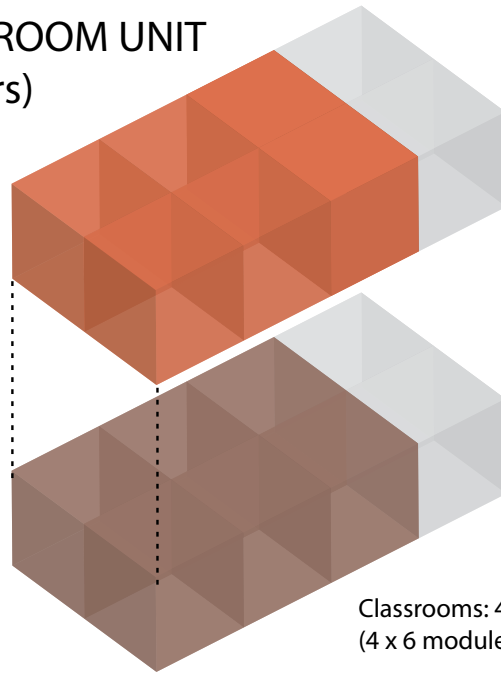
Storage: 11 m<sup>2</sup> (2 modules)



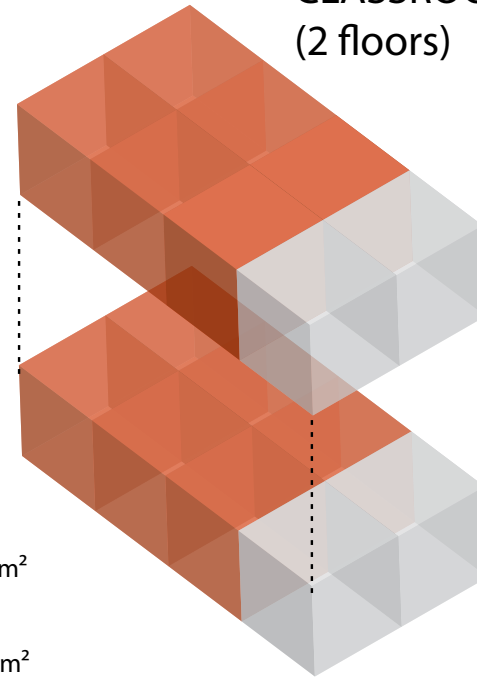
CLASSROOM UNIT  
(2 floors)



CLASSROOM UNIT  
(2 floors)



CLASSROOM UNIT  
(2 floors)



Classrooms: 4 x 33 m<sup>2</sup>  
(4 x 6 modules)

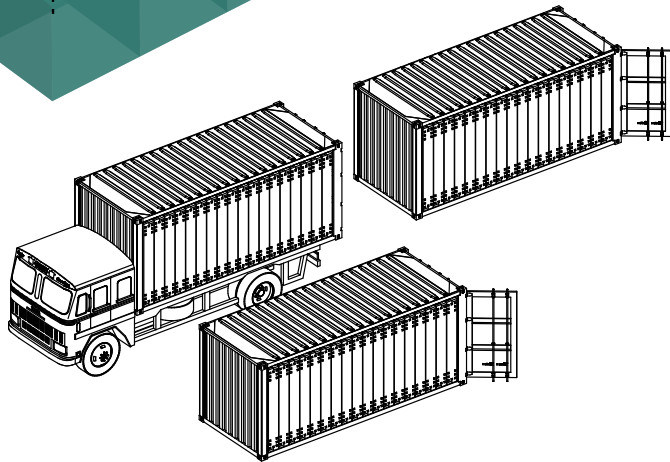
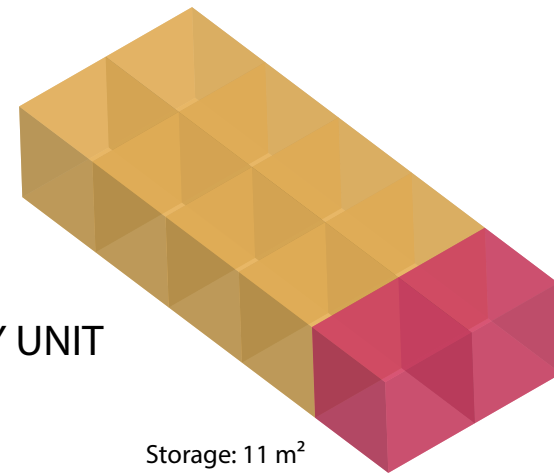
Administration: 33 m<sup>2</sup>  
(6 modules)

Library: 33 m<sup>2</sup>  
(6 modules)

Cooking + serving: 44 m<sup>2</sup>  
(8 modules)

REFECTORY UNIT  
(1 floor)

Storage: 11 m<sup>2</sup>  
(2 modules)



## 4.4. NEED FOR SANITATION

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Proper hygienic practices are necessary for the operation of the school, as well as an important area of health education. Open defecation is still fairly common in many areas, whereas toilets are sometimes considered expensive and therefore scarce. The introduction of a low-cost type of a permanent toilet might lead to more of them being built, thus contributing to healthier population. Inadequate sanitary conditions are sometimes preventing young girls from attending school, which has a long-term negative impact on gender equality.

The concept of sanitation has been qualitatively very well defined, but the transformation of sanitary conditions in rural India has been slow. due to poverty and historic cultural rigidity. The Government of India has identified the need of appropriate technologies, which are affordable and sustainable in regard of water and waste utilisation. Several types of latrines suitable for domestic and public environments, have been developed. (Reddi & Joglekar, 2005, 162-171).

The options being either (1) a septic tank or composting pit latrine or (2) a composting toilet with

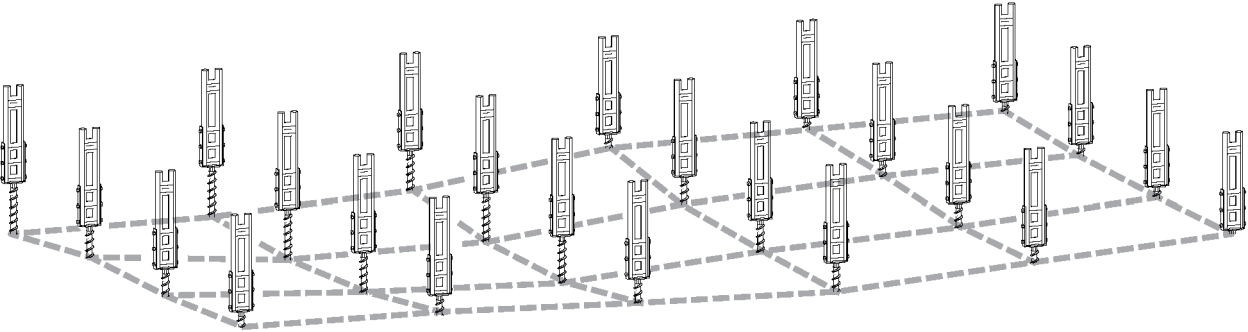
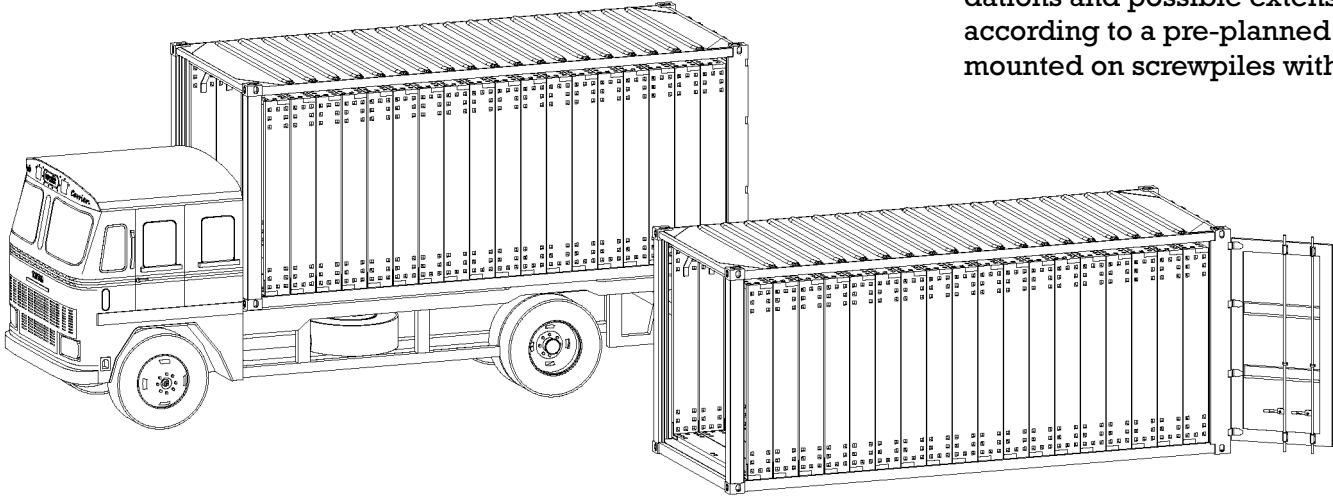
a transportable container led to the quick conclusion that both a long-term benefit and a sufficient capacity would be easier to achieve with option (1).

Requiring waterproofness and regular cleaning, the latrine should be constructed on concrete or brick plinth, while the compartment walls may be of lighter material. A transportable unit including a waste container, fitting to the modular frame system, would take up a considerable portion of the transportable volume, while its container capacity would remain relatively small.

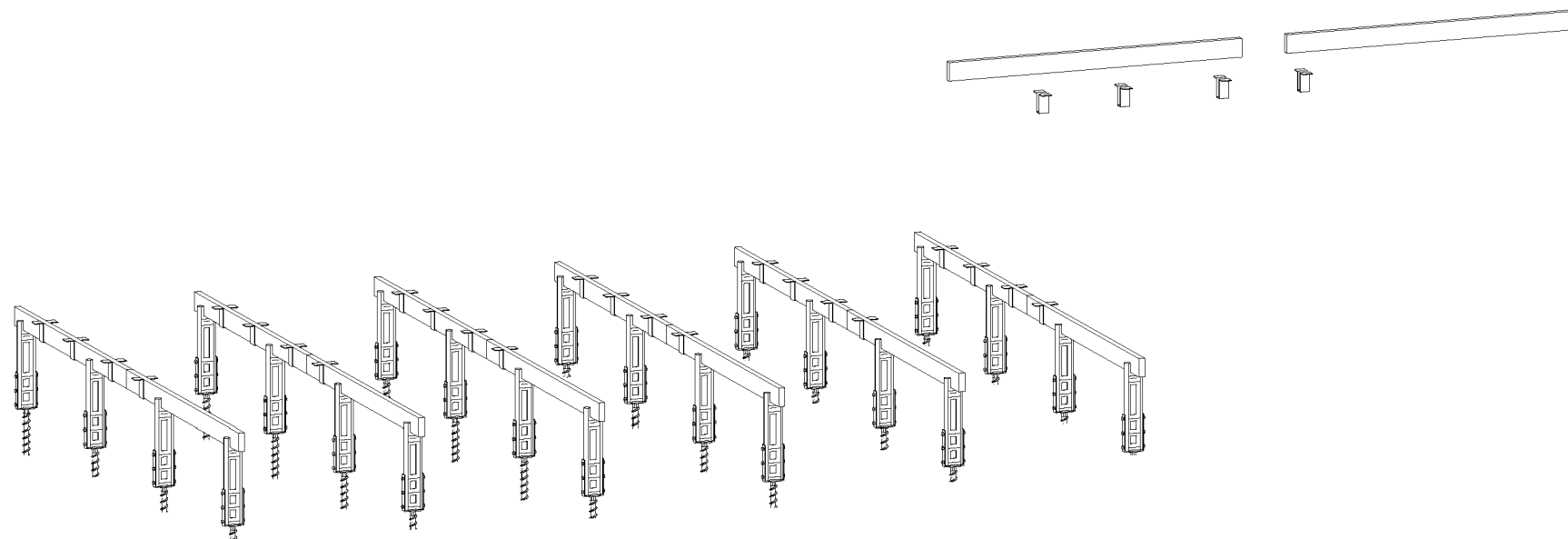
The challenge of the permanent latrine is the site intervention it requires to create the pit, and the site should be chosen in consideration of the future use of the toilet facility. Location near cultivated land would serve agricultural workers, and the composted waste produced could later be used as fertiliser.

The sanitary unit is an essential function of a school, but since the proposed solution is detached from the system and can be studied as an independent element, a detailed study is excluded from this thesis.

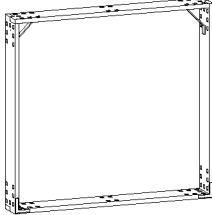
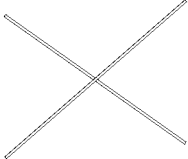
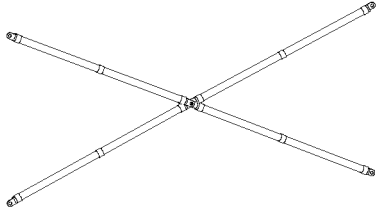
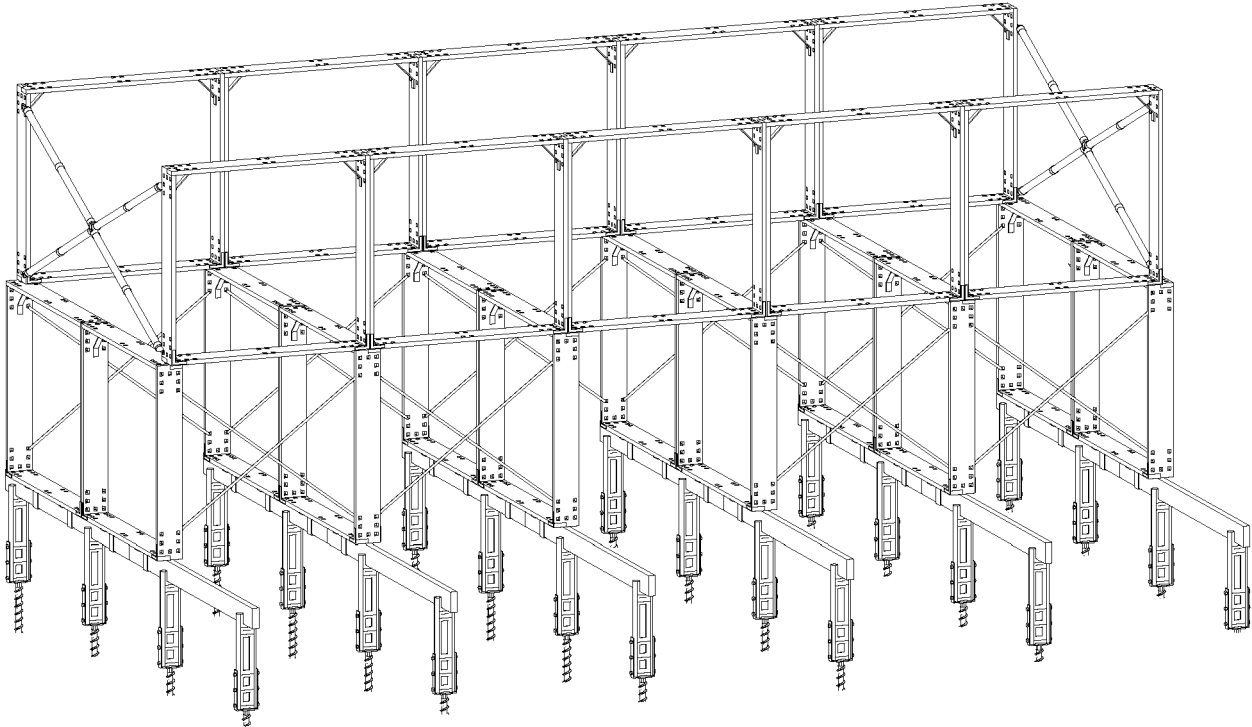
A required amount of construction elements arrive at or near the site by truck transport. Screwpile foundations and possible extension shafts are installed according to a pre-planned grid. Bamboo stilts are mounted on screw piles with steel fitting.



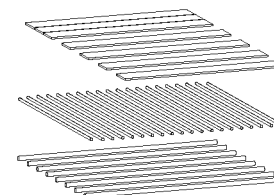
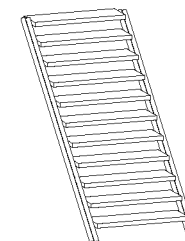
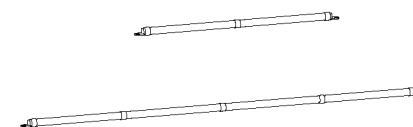
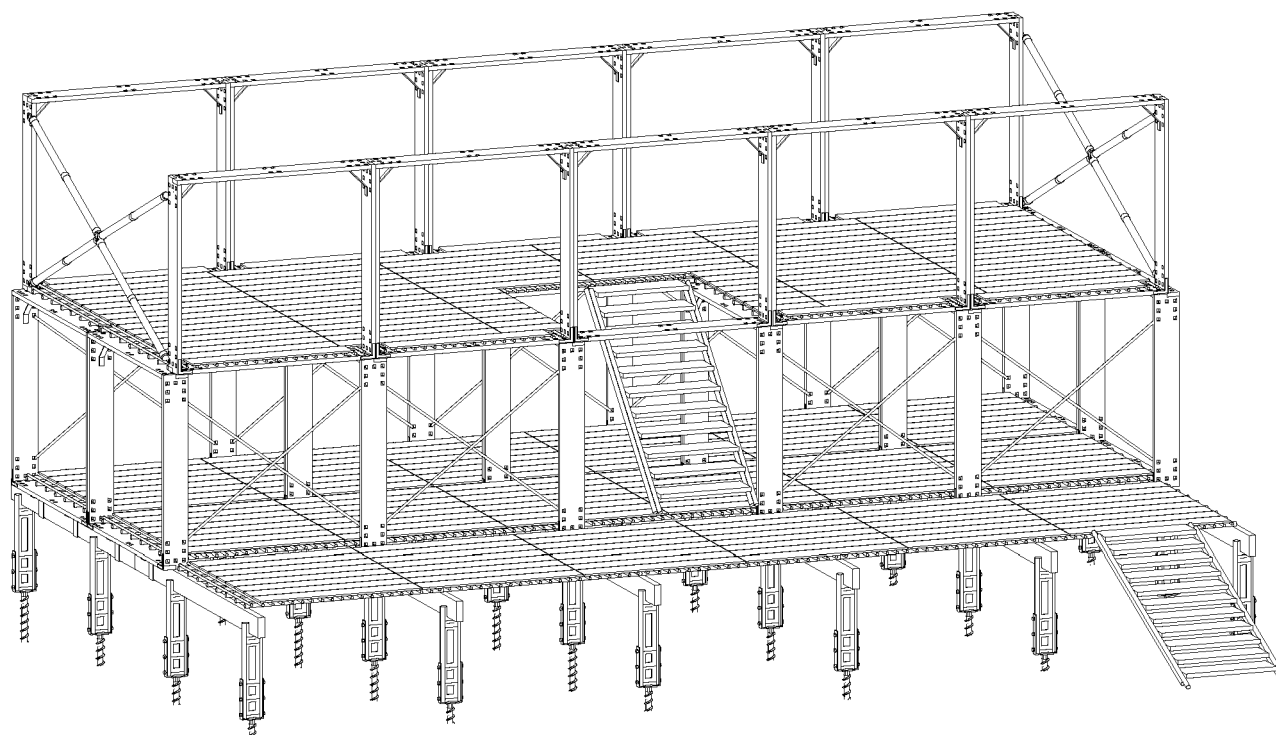
Bamboo plank laminated beams are assembled and mounted on the stilts, and the system is adjusted to level.



Frame system is assembled, tied together and secured with metal and bamboo braces.

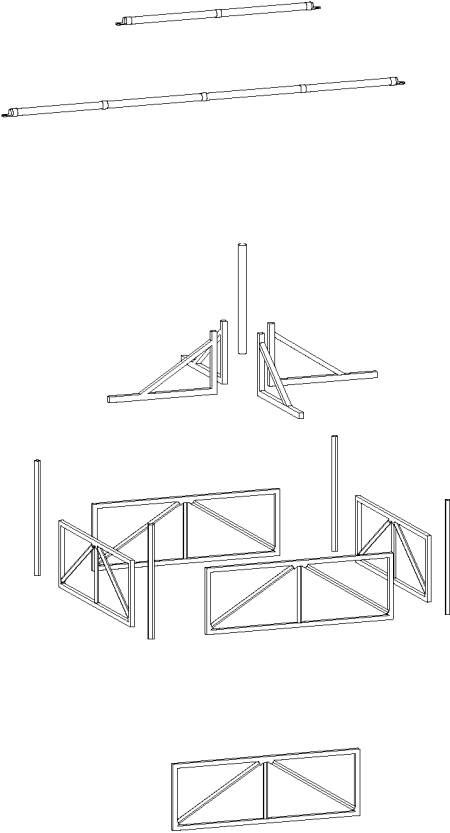
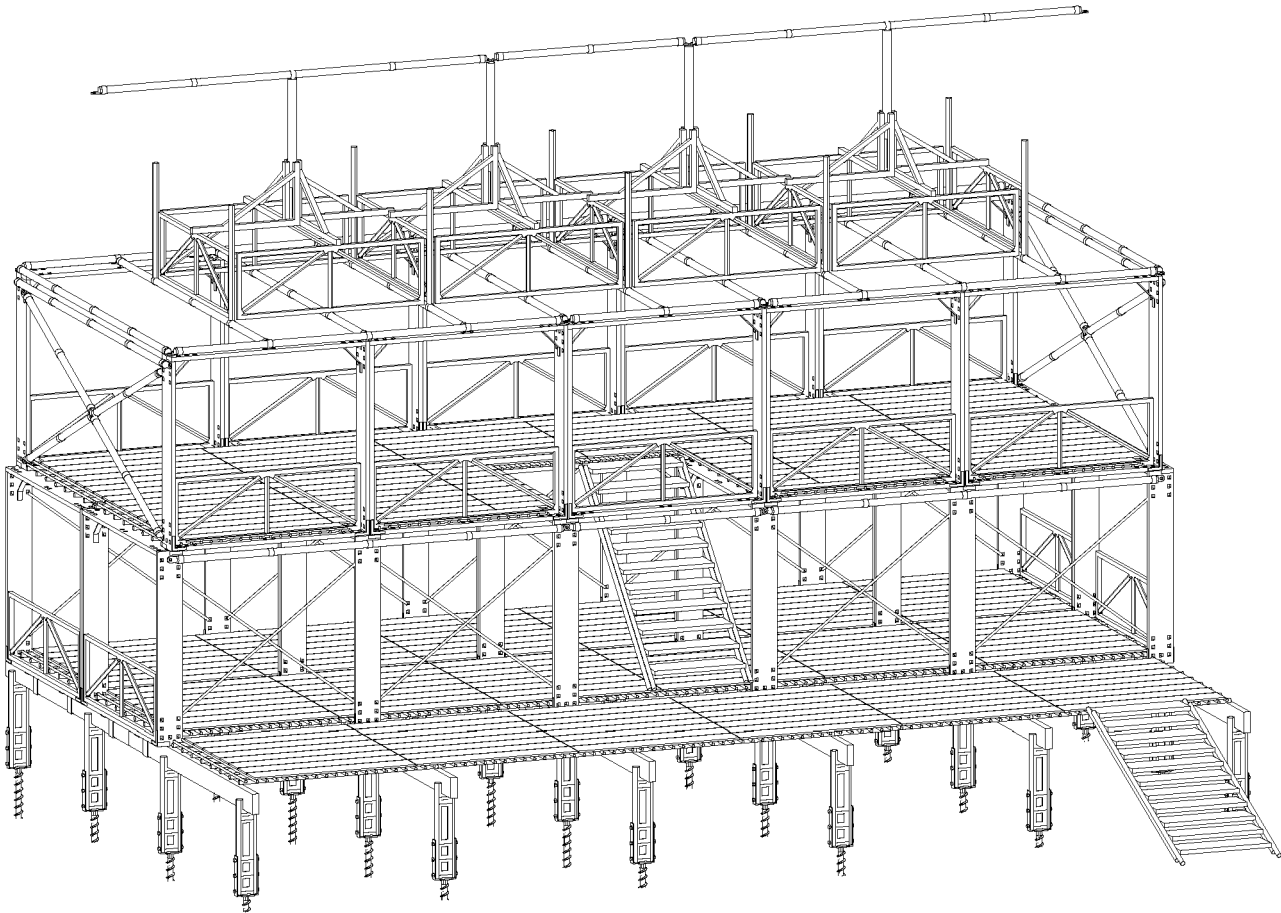


Floor supports, flooring, stairs and latrine equipments are set up.



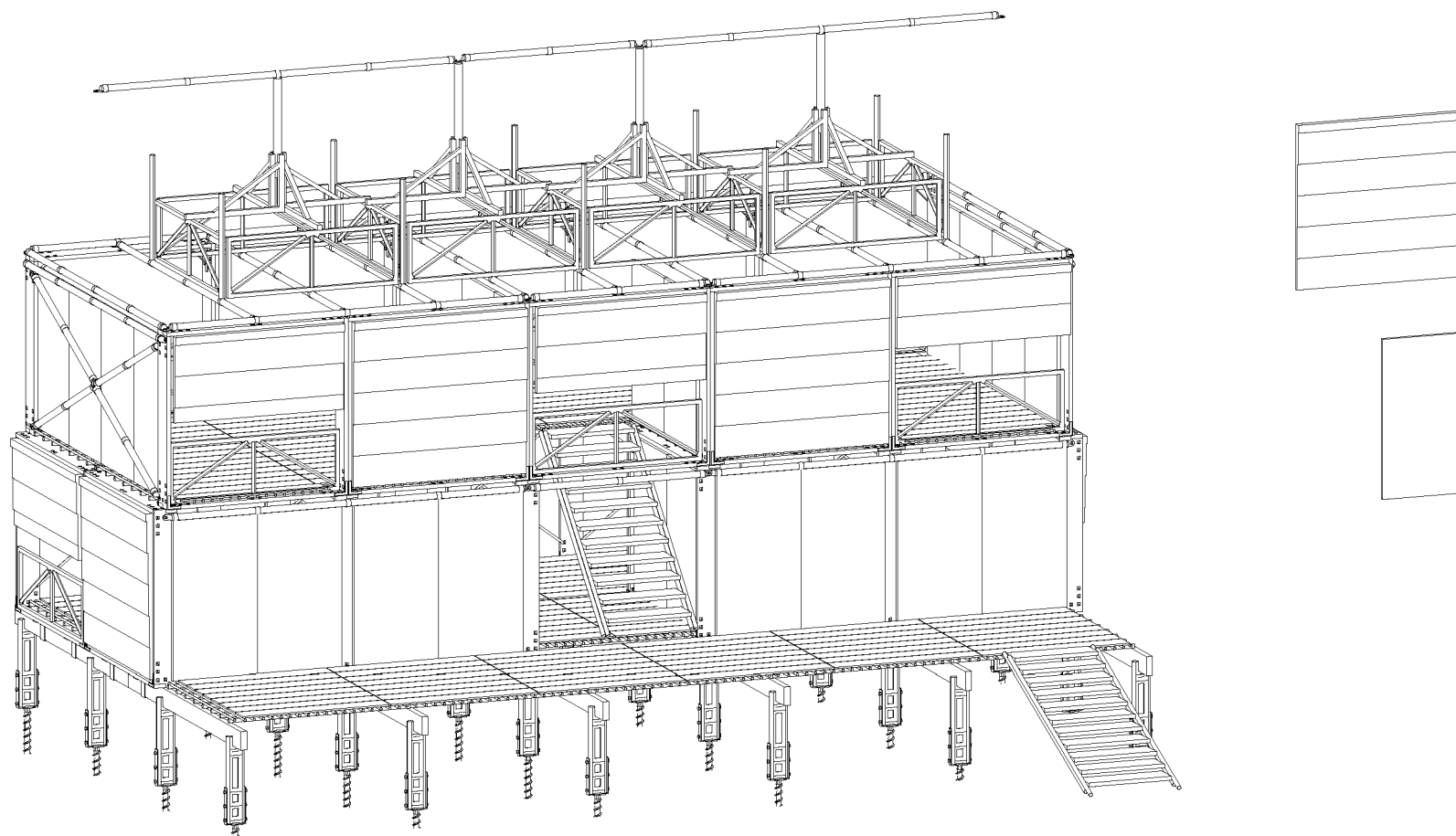
# ASSEMBLY

Support systems are pre-assembled from poles and roof support structures are placed on the top.





Bamboo screens and folding curtains are mounted to the frames and pole structures, to form outer and partition walls according to a desired configuration.



Fabric roof is assembled and anchored to surrounding ground with steel wire ropes.

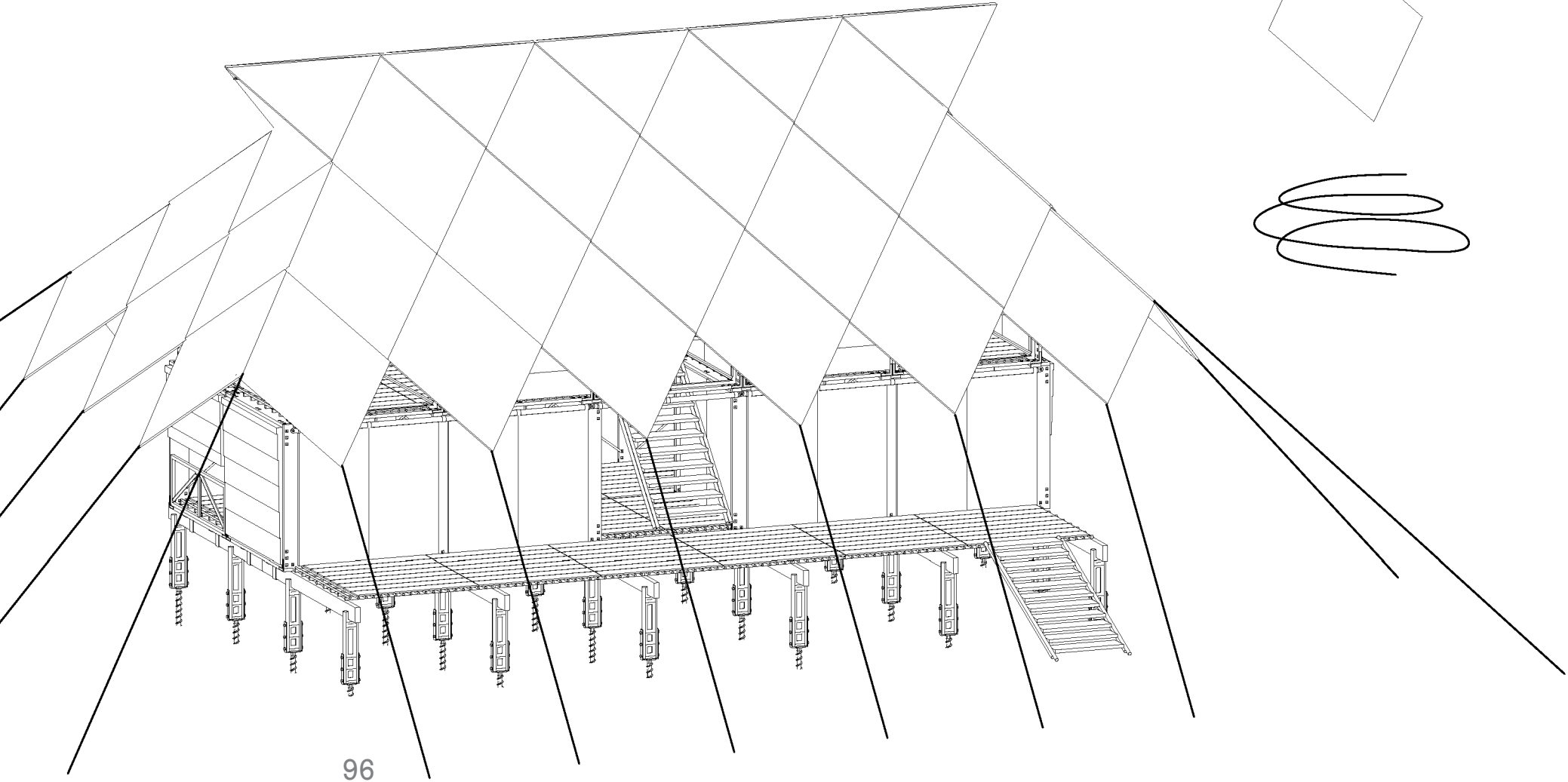
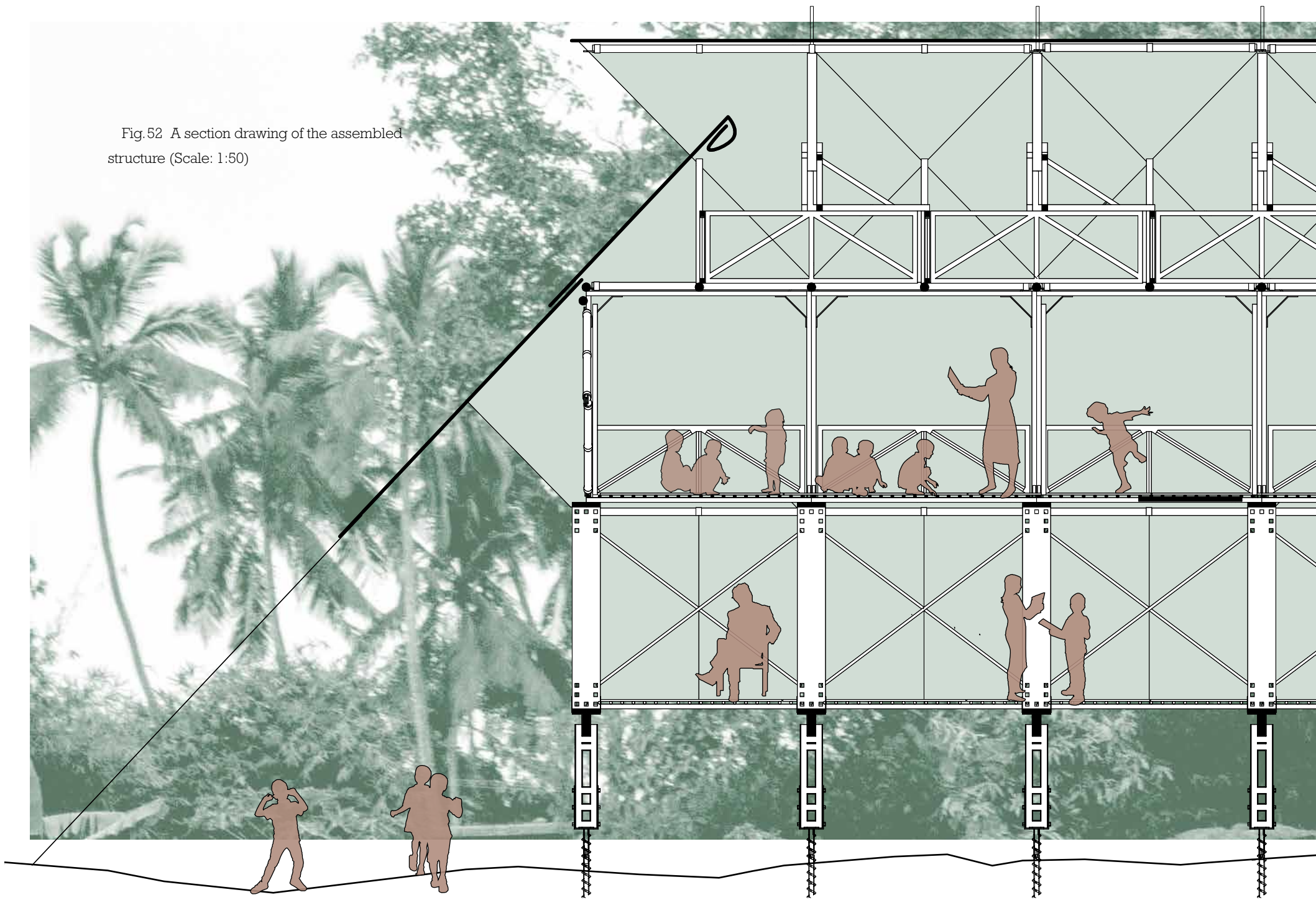
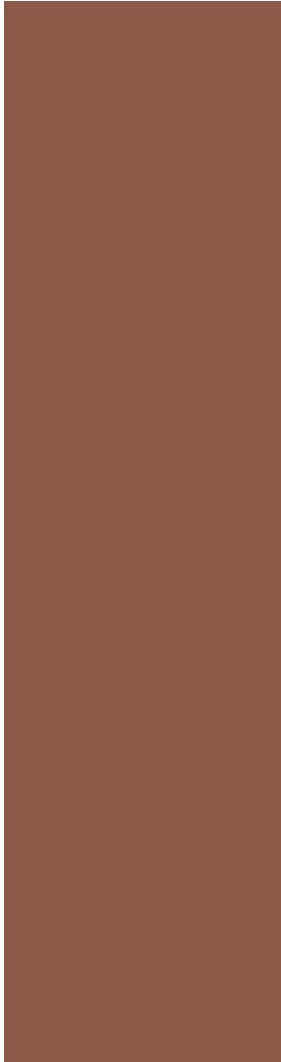


Fig.52 A section drawing of the assembled structure (Scale: 1:50)





## **5. Concluding remarks**



# 5. Concluding remarks

## 5.1. DISCUSSION

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### **CULTURAL AND HUMANITARIAN IMPACT**

Isolated tribal communities may not be familiar with the notion of universal human rights or the general concept of public education. Interference with tribal cultures can not be reasoned with the intention to preserve them, because inclusion of tribal children into institutionalised education system essentially contributes to the merging of original cultures into the mainstream. The negative stigma of certain social strata, however, can be alleviated by encouraging people to embrace their tribal identity within the larger society.

The more important aspect of bringing education to tribals is the humanitarian intention to make them

aware of their position in the society they legally belong to. Tribal livelihoods are dependent on forest or agricultural land, which they consider a common resource. Land ownership is a foreign concept to some tribes, which makes them vulnerable to legal abuse and exploitation by government and corporate powers.

### **COMMUNICATION WITH TRIBALS**

The approach suggests a potential value in combination with existing assets in tribal education; a question of managing staff would be obvious. KISS currently runs a teacher education program, where tribal teachers upon graduation return to educate their native communities, possessing the appropriate communication skills, cultural knowledge and professional skills; the familiar connection which is crucial. The teacher graduates from KISS could be ideally employed in the mobile schools.

Regular communication and consultation is maintained between tribal parents, village councils and KISS, for keeping updated on tribal matters and reaching the children; Due to its capability to be situated closer to the settlements, the mobile unit brings a potential of wider inclusion of people, by providing a temporary hub for meetings and information for all villagers, not only children.

### **BENEFITS OF MOBILITY**

Low-cost modular design can plausibly serve various purposes, particularly where access to machinery and/or site itself are limited. Lack of material may sometimes restrict the use of traditional construction techniques, in addition to being relatively slow. This is where the quickly deployable supply of prefabricated elements comes useful. Modular segmentation does not greatly affect the performance in tropical climate, compared to conventional lightweight structures. Allegedly, the performance can be slightly compromised under most extreme storm conditions.

### **ENVIRONMENTAL AND ECONOMIC ASPECTS**

Transport contributes to a greater negative environmental impact during the use of the product. Moreover, the implied scale of production of the concept requires the existence of a large-scale manufacturing industry. Mass production of the units would become essential, as the targeted populations are numerous and fairly large. Services directed to tribals often rely on donations or government subsidies; due to this limitation the costs of the unit would have to be lower than average.

The negative impacts can be alleviated by choosing sustainable materials. As of today, laminated bamboo lumber is not widely manufactured in India, but has a high potential to become a reasonable construction material, given that the raw material is abundantly available and Indian economy is rapidly developing. The fast renewal rate of bamboo makes it suitable for mass production, without the risk of resource depletion. Modular building elements can be maintained during storage and their condition can be continuously evaluated. They may also be replaced

during use, without need for a major refurbishment. The structure may be reinforced in case of a long-term need.

Costs may be difficult to assess with reasonable accuracy, since they greatly depend on variable factors, such as production volume.

### **FURTHER USES**

The concept can have uses in other contexts with similar needs and circumstances, for which it may turn out equally or even more suitable. Emergency settlements inhabited by refugees or other disaster victims require preparedness for quick expansion, including access to sufficient building supplies. The modular system can potentially be used for basic accommodation or larger facilities, like clinics, administrative premises — or schools.

## **5.2. REFLECTIONS ON THE PROCESS**

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The focal point of the thesis changed significantly throughout the working process, as the quality and quantity of available information was altogether different than was expected. Initial information from KISS was somewhat difficult to obtain. Partly to their apparent unfamiliarity with the participatory methods of user oriented design, the approached employees did not show great willingness to identify KISS as a stakeholder in the process of looking for alternative strategies; They were reluctant to identify challenges related to tribal education when requested; During the later stages of the process after the field trip, feedback based on draft proposal was requested from KISS and a few other relevant parties. Critical response was little, and the proposal was generally positively received.

There might have been unfamiliarity or cultural misconceptions regarding the participatory design process; Usually, the objective of architectural study is not only to interpret and make a statement regarding the status quo, but proceed to suggesting future actions and developments based on the statement, be it preservative or intervening.



A person coming from outside the stakeholder community, may be confronted with a lack of social authority to make convincing suggestions.

I consider the interaction a valuable experience that would be useful when pre-assessing and preparing for similar upcoming situations.

The contextual background is largely based on literature and research articles. As I was unable to form a proper understanding of the social issues, I decided to shift my focus towards material and structural properties of the design, instead of user-adaptive features.

I studied the use of bamboo as construction material. I had a latent interest on learning about bamboo design, but did not have the opportunity to use it on a project until now. During this process my knowledge on bamboo has essentially increased.

Having been a relatively unknown field to me, the study of questions and issues related to indigenous peoples, cultural diversity, however superficial, have invoked insight and philosophical thought during the process. It may have been partly irrelevant for the topic of this thesis, but more importantly, it has helped me to see certain things in a different light.

### 5.3. SUMMARY

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The design proposal is the outcome of an explorative and experimentative process, considering not only context-specific, but also universal potential.

The proposal is a conceptual study for a prototypical unit; An alternative approach implying expansion of the total capacity of education among rural populations, and shortening physical distance between schools and settlements. Several technical details and practical matters remain to be solved in a more precise manner, should it enter a further stage of development.

A substantial amount of research regarding alternative technologies exists. They possess the potential but have yet to enter cost-effective production. The design approach anticipates this, admitting that they are not readily available.

Site assessment and assembly plan must be carefully prepared for the foundation of each establishment. A usable set of optional assembly configurations can be pre-designed to make this easier.

Required sanitary systems may exceed the

transportable capacity. Permanent pit latrines would provide a more feasible alternative; once established in the vicinity of the school, they would continue benefitting the local community afterwards. The site should be chosen appropriately to ensure the future beneficial use of the latrines.

Accommodation of the teachers and other staff would become necessary in some situations, if none is available within a convenient distance. This would require a study of transformability into temporary accommodation, which is not included in this proposal.

Required resistance to climatic effects was acknowledged, but not properly assessed. The sufficiency of chosen solutions is largely based on assumptions and a greater focus on structural detail and anchoring would be needed for further development. Resistance to proper cyclonic winds is assumedly poor; this limits the establishment of the unit to locations, where natural protection, such as forest or topographic formations, can be taken advantage of.



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## PHOTOGRAPHY AND ILLUSTRATIONS

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Photographs and illustrations by Atte Kiianen (AK), unless otherwise indicated.

- Fig. 4 Peasantautonomy.org (n.d.). *Village life* [Online gallery]. Retrieved November 12, 2015 from: <http://www.peasantautonomy.org/odisha-village-life.html>
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- Fig. 17 NLÉ (2012). *Makoko floating school* [Online image]. Retrieved September 30, 2015 from: <http://www.nleworks.com/case/makoko-floating-school/>
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## FURTHER READING

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The further reading list of titles and websites contain sources that are not critical for the general understanding of the thesis and have not been cited in the text.

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# Appendices

## APPENDIX 1: LIST OF SCHEDULED TRIBES IN ODISHA

List of Scheduled Tribes notified (after addition/deletion) as per the Scheduled Castes and Scheduled Tribes Order, 1950 as amended by Modification Order, 1956, Amendment Act, 1976 and The Scheduled Castes and Scheduled Tribes Order (Amendment) Act 2002 No. 10 dated 8.1.2003 of Ministry of Law & Justice republished by the Notification No. 7799/ L dated 7.6.2003 of Law Deptt, Govt. of Orissa.

(ST & SC Development, Minorities & Backward Classes Welfare Department, Government of Odisha, 2015)

1. *Bagata, Bhakta*
2. *Baiga*
3. *Banjara, Banjari*
4. *Bathudi, Bathuri*
5. *Bhottada, Dhotada, Bhotra, Bhatra, Bhattara,*

- Bhotora, Bhatara*
6. *Bhuiya, Bhuyan*
7. *Bhumia*
8. *Bhumij, Teli Bhumij, Haladipokhria Bhumij, Haladi Pokharia Bhumija, Desi Bhumij, Desia Bhumij, Tamaria Bhumij*
9. *Bhunjia*
10. *Binjhal, Binjhar*
11. *Binjha, Binjhoa*
12. *Birhor*
13. *Bondo Paraja, Bonda Paroja, Banda Paroja*
14. *Chenchu*
15. *Dal*
16. *Desua Bhumij*
17. *Dharua, Dhuruba, Dhurva*
18. *Didayi, Didai Paroja, Didai*
19. *Gadaba, Bodo Gadaba, Gutob Gadaba, Kapu Gadaba, Ollara Gadaba, Parenga Gadaba, Sano Gadaba*
20. *Gandia*

21. Ghara  
22. Gond, Gondo, Rajgond, Maria Gond, Dhur Gond  
23. Ho  
24. Holva  
25. Jatapu  
26. Juang  
27. Kandha Gauda  
28. Kawar, Kanwar  
29. Kharia, Kharian, Berga Kharia, Dhelki Kharia,  
Dudh Kharia, Erenga Kharia, Munda Kharia,  
Oraon Kharia, Khadia, Pahari Kharia  
30. Kharwar  
31. Khond, Kond, Kandha, Nanguli Kandha, Sitha  
Kandha, Kondh, Kui, Buda Kondh, Bura Kandha,  
Desia Kandha, Dungaria Kondh, Kutia Kandha,  
Kandha Gauda, Muli Kondh, Malua Kondh,  
Pengo Kandha, Raja Kondh, Raj Khond  
32. Kissan, Nagesar, Nagesia  
33. Kol  
34. Kolah, Loharas, Kol Loharas  
35. Kolha  
36. Koli, Malhar  
37. Kondadora

38. Kora, Khaira, Khayara  
39. Korua  
40. Kotia  
41. Koya, Gumba Koya, Koitur Koya, Kamar Koya,  
Musara Koya  
42. Kulis  
43. Lodha, Nodh, Nodha, Lodh  
44. Madia  
45. Mahali  
46. Mankidi  
47. Mankirdia, Mankria, Mankidi  
48. Matya, Matia  
49. Mirdhas, Kuda, Koda  
50. Munda, Munda Lohara, Munda Mahalis,  
Nagabanshi Munda, Oriya Munda  
51. Mundari  
52. Omanatya, Omanatyo, Amanatya  
53. Oraon, Dhangar, Uran  
54. Parenga  
55. Paroja, Parja, Bodo Paroja, Barong Jhodia Paroja,  
Chhelia Paroja, Jhodia Paroja, Konda Paroja,  
Paraja, Ponga Paroja, Sodia Paroja, Sano Paroja,  
Solia Paroja

56. *Pentia*
57. *Rajuar*
58. *Santal*
59. *Saora, Savar, Saura, Sahara, Arsi Saora, Based Saora, Bhima Saora, Bhimma Saora, Chumura Saora, Jara Savar, Jadu Saora, Jati Saora, Juari Saora, Kampu Saora, Kampa Soura, Kapo Saora, Kindal Saora, Kumbi Kancher Saora, Kalapithia Saora, Kirat Saora, Lanjia Saora, Lamba Lanjia Saora, Luara Saora, Luar Saora, Laria Savar, Malia Saora, Malla Saora, Uriya Saora, Raika Saora, Sudda Saora, Sarda Saora, Tankala Saora, Patro Saora, Vesu Saora*
60. *Shabar Lodha*
61. *Sounti*
62. *Tharua, Tharua Bindhani*

## APPENDIX 2: QUESTIONNAIRE INTERVIEW OF MASTER STUDENTS

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Eight master level students from KISS, from the fields of sociology, social work and philosophy were interviewed through a written questionnaire regarding livelihoods, environment and level of development in tribal villages. Assisted by an interpreting person speaking Oriya, an oral introduction was given to clarify the intentions related to each question. The questions and transcriptions of returned answers (7/8) are found below.

### QUESTIONS

1. *Tribal group of student*
2. *Name of village, nearby town, district*
3. *Approximate population of village*
4. *Description of natural environment near your village*
5. *Description of built environment at your village*
6. *How are public gatherings organised in your village? What types of buildings are used? Is there a specific building for the purpose? Are buildings used at all? How are people*

*interacting?*

7. *Types of livelihood in your village (agriculture/trade/fishing/hunting/industry/etc.)*
8. *How isolated is your village? Are there connections or communication with other villages or tribes? Is the village accessible by car or other vehicle?*
9. *Technology commonly available in the village (electricity, sanitation, machinery/tools, industrial products imported from outside)? What technology is produced in the village?*
10. *Examples of traditional knowledge your tribe could be able to share with surrounding society?*

### **ANSWER 1**

1. *Gond*
2. *Paharsrigida, Attabira, Bargarh*
3. *5000*
4. *There is a canal or 3 ponds. This canal is providing water for agriculture near our village. Forest providing raw materials, like: life [leaf?], honey, wood, flower, fruit, bamboo, etc.*
5. *In our village, there is tubewells and wells etc.*

*In our village there is ANGEMWATI center and primary school, high school and college. There is PALLA road or facilities of health centre, one bank, RI centre, cooperative society.*

6. *In our village, there are many buildings of common gathering. In marriage ceremony people organised in their own house and any festivals gathering is done on opened place with making tent. [For] only a few people are buildings used and other people used of Kachha house. Bamboo house.*
7. *Our villagers depend on agriculture. Most of them are doing agriculture; paddy, wheat, vegetables, dal plant (lentil). Other people depend on fishing and hunting. 60% depend on agriculture, 10% of people on fishing/hunting, 20% on business, 10% on service.*
8. *Our village is 3km from other village and tribes. There is communication to go other village. People go to other villages by bicycles, [motor]bike or car, bus etc.*
9. *There are many technologies commonly available in the village. There is electricity, which is given by government only for all the BPL category people. There is no sanitation,*

most people are going or using open place but a few people are using bathroom.

10. *Though we are Gond tribe we have no specific dance and being a Gond marriage in the own house and temple. In our tribe marriage a proposal goes to the girls house by performing [to the] girls parents, brother, etc. Then the girl's parents allow to enter in to the house, then one day they come to see the girl, when the girl is agreed with the boy, then after the engagement both sides of the people gather to the girls house. Boy side only come 20-30 people but girl side uncountable people gather in the own house marriage. The boy wears a dress and the girl has the sharee. It is done by Brahmin and all are blessing husband and wife.*

## **ANSWER 2**

1. *Jara Savara*
2. *Barhmpu, Ganjam, Gajapati*
3. *3000*
4. *There is not any river but there is some canal, in which the sage and seers was meditating.*

*There is the forest which indicates spirituality, which is known "Mahindragiri".*

5. *In our village, there is [not] any government college. Also electricity not available, with the local internet all these are not facilities in our village. We all are suffering all these problems.*
6. *In our village, there is a common house which is known as " Sat Sangh " [= "sit together"]. That house is used each and every festival and ceremonies, such as Rama Navani, Holi, Purnima Dasahara (?), etc., but not in marriage time; otherwise other festival, special [occasion], worship of god and goddess, the building is used.*
7. *All our villages are agriculture. They have their own land to cultivate. Also there are some small industries. They all depend on the agriculture for their life; but now come to look some change to develop in the field of education, also agriculture.*
8. *Our area is not totally free from all conflict, problems. But there are some aspects to connections with other people, also the people are interacting with others through small business and through the way of education,*

*like: Some are educated, they interact with outside people. [The village] is accessible by bus, car etc.*

9. *In our village there is no technology which is available for people. Also no new product [or] machine in our village, through which our villages are get the benefit. But they are try to make or imported from outside.*
10. *[...] There is a story about our culture and society, which is based on this culture and tradition of Jara Savara, who at the beginning worshipped lord Ram, and lord Jagannatha; which is also described in the scripture of Sri Bhagavata Gita, in the Ramayana. All the epic give the vast knowledge about our tribe or our culture and traditions. The basic thing of the scripture [is that] all are one, there is no discrimination between caste, creed and religion. In really the early people [...] they had pure heart, open minded and innocent. Therefore, through these qualities the he is able to get the knowledge Brahman and to the God. It give our traditional scripture or culture.*

### **ANSWER 3**

1. *Santal*
2. *Bankadungri, Rairangpur, Mayurbhanj*
3. *300*
4. *-*
5. *-*
6. *Passing the information door to door by the mediator. Demohouse is used for gathering. Yes, there is a specific building, no buildings are used at all. People are interacting by diferent types of ceremony; in Nakara Sankaranti, Baha Parab, Raja Pasra, marriage ceremony and death anniversary.*
7. *Agriculture, fishing and hunting*
8. *Village is connected with main road. Yes, there are connection or communication with other villages or tribes. The village is accessible by car or other vehicle.*
9. *Electricity.*
10. *Dance of Baha, [...], Danta, Dhangela and Dasany.*

#### ANSWER 4

1. *Kondha*
2. *Kaliakana, Tikiri, Rayagada*
3. *400*
4. *Many natural resources, like forests, mountains, rivers etc.*
5. *-*
6. *Many people are gathering in a community house or place for discussing of special event. Cottage, pottery, AZWEST are used by tribal in our village. People are interacting in the following ways: tribal language, social issues and wedding ceremonies in the community.*
7. *Agriculture, fishing, hunting, industry.*
8. *Village is connected with the main road. There are connections and communications with some villages. Village is accessible by car.*
9. *Electricity, machinery, tools commonly available. No technology produced in the village.*
10. *Dhemsha tribal dance, gurmai dance, belief to nature like trees, special rocks etc.*

#### ANSWER 5

1. *Kisan*
2. *Goriamal, Rajgangpur, Sundargarh*
3. *15000*
4. *Near our village there is a river. It's providing water to the cement factory at Rajgangpur (Orissa Cement Ltd.). This river is providing water for agriculture near our village. There is no forest or hills area.*
5. *In our village there are tube wells and wells etc., there is aganwadi centre and primary school. There is Kacha [kutcha] road and no cement road. And no facilities of health care.*
6. *In our village there is no buildings for common gathering. In marriage ceremony people organised in their own house. And any festivals gathering is done under the tree on opened place with making a tent.*
7. *Our villagers depend on agriculture. Most of them are doing agriculture, like paddy, wheat, vegetables dal plant. Working in factory, it is 5 km far from our village.*
8. *Our village is 2 km far from other (nearest) villages and tribes. People go to others village*



*by bicycles and [motor]bike only.*

9. *In our village there is no any machinery, tools, industrial products and no technology is produced in the village. There is electricity that is given by the government only for all the BPL category people. There is no sanitation, most of the people are going or using open place.*
10. *Though we are Kisan tribe we have Kisan dance. And being Christians we get marriage in the church. Marriage is done as it is that, a proposal goes to the girl's house by performing [to the] girl's parents, brother etc. Then girl's parents allow to enter into their house, then one day they come to see the girl. When the girl is agreed with the boy then after do engagement. In engagement both side of the people gather to the girl's house, then openly showed to the girl. Boy side only come 10 to 12 people, but girl side uncountable people gather. In the church marriage the girl and boy wear white dress and also girl have the crown on head.*

## **ANSWER 6**

1. *Munda*
2. *Karanjei, Rairampur, Mayurbhanj*
3. *600*
4. *River, dam, forest*
5. *-*
6. *There is a person, who is given power to call villagers going door to door. Open place are used for building. There is no specific building, no buildings are used at all. People are interacting by their own vernacular language.*
7. *Agriculture.*
8. *Our village is isolated [\*situated] very close and near. There are connections with other villages and tribes. The village is accessible by car.*
9. *Electricity, sanitation, no technology produced in the village.*
10. *About our origin and development.*

## ANSWER 7

1. *Santal*
2. *Matiali, Rairampur, Mayurbhanj*
3. *400*
4. *Forest, river, stream, agriculture field.*
5. *-*
6. *Common gatherings are organised by calling door to door by a person. There is a particular place is used, no building is used at all. People are interacting respectfully each other.*
7. *Agriculture, fishing.*
8. *Our village is isolated [\*situated] very close. There are connection with other villages. The village is accessible by car.*
9. *Electricity, sanitation, machinery. No technology is produced in the village.*
10. *Sharing different type of songs, dances, of its importance and purpose, and rites and rituals.*

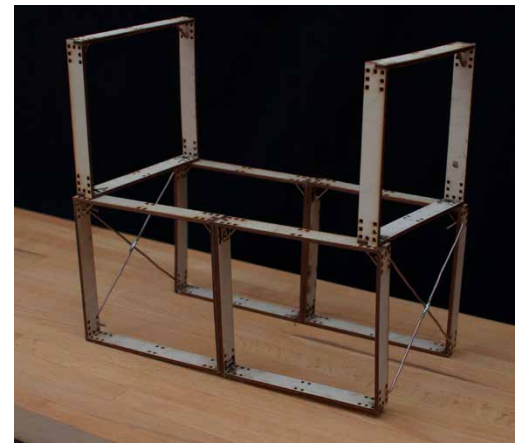
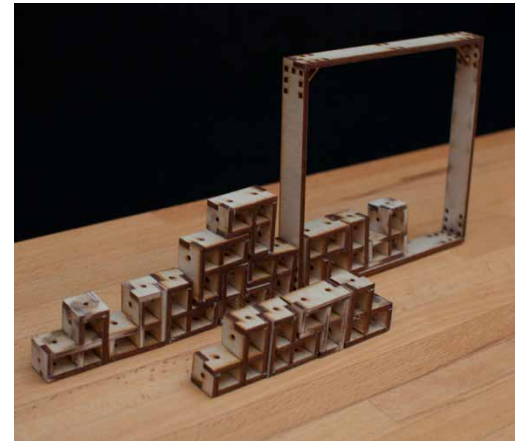
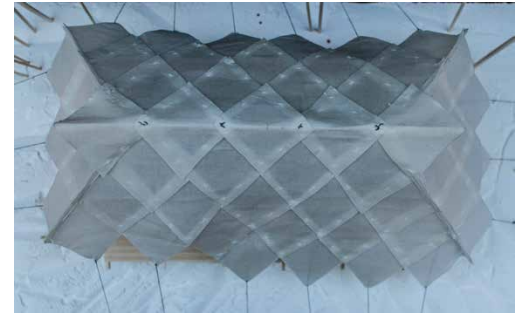
## APPENDIX 3: SCALE MODEL AND POSTERS

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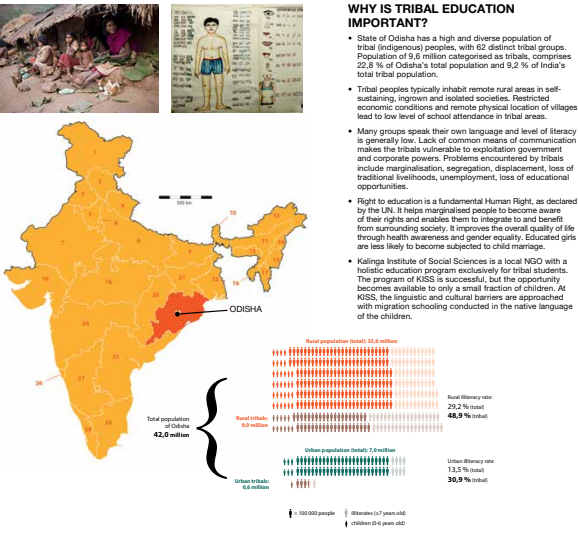
**A set of posters and a concept model in scale 1:50 was prepared and publicly exhibited with the thesis. The model shows the shape of a two-floor structure with partially extended roof, on a generic site. Working models of furniture and frame elements at scale 1:20 were also displayed.**

**Model: Page 121**

**Posters: Page 122**



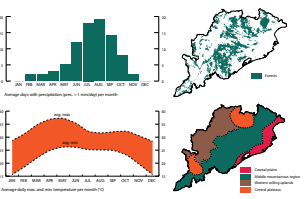
### WHY IS TRIBAL EDUCATION IMPORTANT?



- State of Odisha has a high and diverse population of tribal (indigenous) peoples, with 62 distinct tribal groups. Population of 9.9 million categorized as tribals, comprising 22.8% of Odisha's total population and 9.2% of India's total tribal population.
- Tribal peoples typically inhabit remote rural areas in self-sustaining, ingrown and isolated societies. Restricted economic conditions and remote physical location of villages lead to low level of school attendance in tribal areas.
- Many groups speak their own language and level of literacy is generally low. Lack of common means of communication makes the tribals vulnerable to exploitation by government and corporate powers. Problems encountered by tribals include marginalisation, segregation, displacement, loss of traditional livelihoods, unemployment, loss of educational opportunities.
- Right to education is a fundamental Human Right, as declared by the UN. It helps marginalised people to become aware of their rights and enables them to integrate to and benefit from surrounding society. It improves the overall quality of life through health awareness and gender equality. Educated girls are less likely to become subjected to child marriage.
- Kalinga Institute of Social Sciences is a local NGO with a holistic education program exclusively for tribal students. The program of KISS is successful, but the opportunity becomes available to only a small fraction of children. At KISS, the linguistic and cultural barriers are approached with migration schooling conducted in the native language of the children.

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### PHYSICAL GEOGRAPHY OF ODISHA



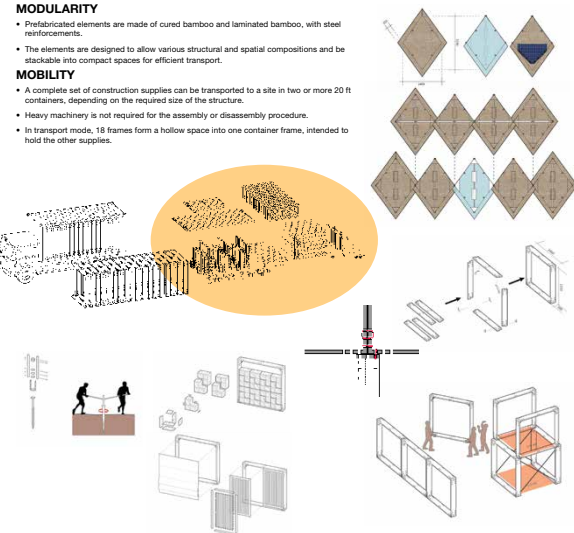
- Odisha is a state located at the Eastern coast of India, and belongs to tropical climate zone. Heat waves, rainfall and windstorms at varying degree of severity are typical hazards occurring on a seasonal basis. Odisha receives most of its annual rainfall (1200-1700 mm) during the monsoon period between June and September.
- The mountainous region in the middle of the state constitutes approximately three quarters of Odisha's area. Generally the topography is undulating, with the exception of the high plateaus and coastal plain areas. Forest coverage is relatively high, approximately 32% of the state's total area, most abundant in the middle region.

### PERFORMANCE IN TROPICAL ENVIRONMENT

- The roof provides effective shade during daytime, when the structure is occupied and the solar radiation is most intense. Compared to a steel roofing, the fabric roof would have substantially smaller heat transmission through the roof, contributing to a better thermal comfort. The roof is equipped with solar cells, to provide electric power for necessary appliances. High-pitched roof with a 'breathing' scale-like structure and ventilation openings at the ridge lets warm air out from the top, creating a cooling draft inside.
- Noise caused by rain hitting the roof can prevent teaching and studying. During rainfall, the canvas roof creates less noise than more conventional roofing materials, such as iron sheets. The fabric is treated to withstand rain, and overlapping edges prevent water from entering inside from between the sheets.
- Structure raised upon stilts separates it from the ground, which may be temporarily flooded during rain. However, in areas prone to severe flooding the stilts must be higher and the foundations driven deeper into the ground, which may restrict the applicability of this proposal in said areas. Steel base of foundations effectively prevents ground vermin, like termites, from entering the structures.
- The roof sheets are reinforced with sewn-in steel cable on all edges. When assembled the cables form a large mesh, which is anchored to ground with screw anchors at several points. The roof becomes resistant against wind. The eaves can be extended downwards for added cover and better aerodynamic shape.

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### MODULARITY AND MOBILITY

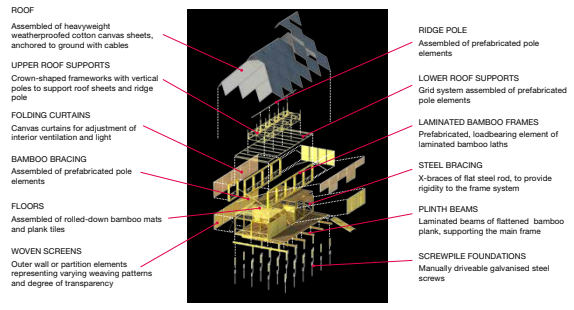


- Prefabricated elements are made of cured bamboo and laminated bamboo, with steel reinforcements.
- The elements are designed to allow various structural and spatial compositions and are stackable into compact spaces for efficient transport.

### MOBILITY

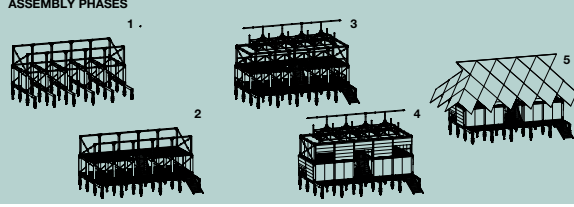
- A complete set of construction supplies can be transported to a site in two or more 20 ft containers, depending on the required size of the structure.
- Heavy machinery is not required for the assembly or disassembly procedure.
- In transport mode, 18 frames form a hollow space into one container frame, intended to hold the other supplies.

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- ROOF**  
Assembled of heavyweight weatherproofed cotton canvas sheets, anchored to ground with cables.
- UPPER ROOF SUPPORTS**  
Crown-shaped frameworks with vertical poles to support roof sheets and ridge pole.
- FOLDING CURTAINS**  
Canvas curtains for adjustment of interior ventilation and light.
- BAMBOO BRACING**  
Assembled of prefabricated pole elements.
- FLOORS**  
Assembled of rolled-down bamboo mats and plank tiles.
- WOVEN SCREENS**  
Outer wall or partition elements representing varying weaving patterns and degree of transparency.
- RIDGE POLE**  
Assembled of prefabricated pole elements.
- LOWER ROOF SUPPORTS**  
Grid system assembled of prefabricated pole elements.
- LAMINATED BAMBOO FRAMES**  
Prefabricated, loadbearing element of laminated bamboo laths.
- STEEL BRACING**  
X-braces of flat steel rod, to provide rigidity to the frame system.
- PLINTH BEAMS**  
Laminated beams of flattened bamboo plank, supporting the main frame.
- SCREWPILE FOUNDATIONS**  
Manually driveable galvanised steel screws.

### ASSEMBLY PHASES



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Modular shelves in the classroom are intended to display a variety of objects and artefacts familiar to pupils. Explorative studying of familiar and unfamiliar things eventually enables children to communicate in common language and attend formal education. The furniture blocks can also be used as chairs, benches and creative play constructions.

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