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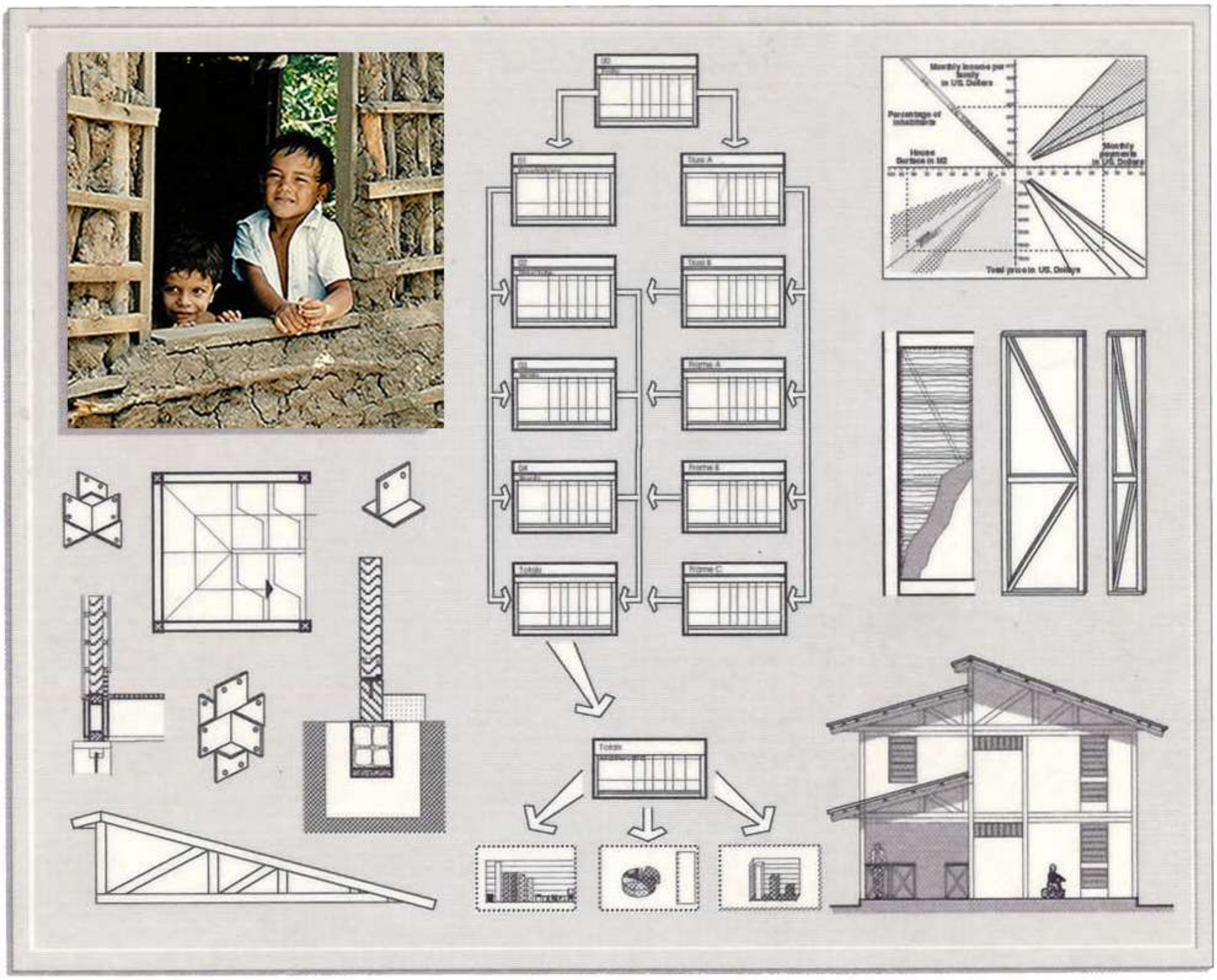

Trade-off Methodology for Low-Cost Housing Construction Technologies

Tutor: **Nabeel HAMDI**
Readers: **Reinhard GOETHERT**
Rod BURGESS
Roddy MADDOCKS

Submitted in partial fulfilment of the MSc degree in Development Practices

Carlos GUERRERO

Oxford
September 1994

A mis grandes maestros y amigos:
Mario Solís G., Jean François Mabardí, Bernard Declève,
Yves Cabannes, Nabeel Hamdi, Reinhard Goethert and Rod Burgess

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Preface

This dissertation is a part of a series of documents produced by the author over the past eight years during three different periods:

MSc. in Architecture: Thesis "*Methodologie d'Evaluation des Technologies de Construcction Appropriées a la Región Amazonienne en Equateur".* Louvain la Neuve, Belgium, 1987
This thesis was the outcome of four years of research and construction of Low-Cost timber dwellings in the Amazonian Region of Ecuador.

MSc. in Habitat and Development: Thesis "*Tecnologías apropiadas de construcción y posibilidades de prefabricación en Ecuador".*
Louvain la Neuve, Belgium, 1991
This thesis represents three years of research (1987-1990), experimentation and construction of Low-Cost earth timber and bamboo dwellings in the Coastal and Andean region of Ecuador.

Trade-off Methodology for Low-Cost Housing Construction Technologies is the continuation of the above mentioned theses and it summarises three years of research and application of technological innovations for low cost housing using appropriate technologies and information systems in Latin American countries. (Brazil, 1991-1992; Ecuador 1992-1993; El Salvador 1993).

Carlos GUERRERO
CENDEP
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Oxford, September 1994.

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Field Work:

CIUDAD	Centro de Investigaciones, Quito, Ecuador
GRET	Groupe de Recherche et d'Echanges technologiques, Paris, France
COHAB	Companhia de Habitação de Ceará, Fortaleza, Brazil
H&D	Habitat et Devélopemment, Louvain la Neuve, Belgium
FUNHABIT	Fundación Ecuatoriana del Hábitat, Quito, Ecuador
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Tutor:

Nabeel	HAMDI	Oxford Brookes University

Readers:

Reinhard	GOETHERT	MIT Massachusetts Institute of Technology
Rod	BURGESS	Oxford Brookes University
Roddy	MADDOCKS	Freelance

Abstract

As we become ever more immersed in a new "technological" era we neglect those things that are most basic and obvious to us.

In the 1970s some architects and builders, who had been experimenting with vernacular materials, decided to break away altogether from modern technologies based on concrete and steel, and return to traditional methods of construction in earth, timber and bamboo. This "return to nature" coincided with the birth of the ecological movement, providing an interesting alternative for the billions of homeless people in developing countries.

The advantages of affordability and flexibility of timber, earth and bamboo, coupled with good design, contribute to raising the living standards and improving the housing conditions of low-income populations. The simplicity of the respective construction methods facilitates self-building.

The principal objective of this thesis is to design a methodology for selecting the most appropriate technology; monitoring; site supervision and feedback for Low-Cost Housing Construction in Developing Countries.

The methodology is divided into four parts: (Figure 1)

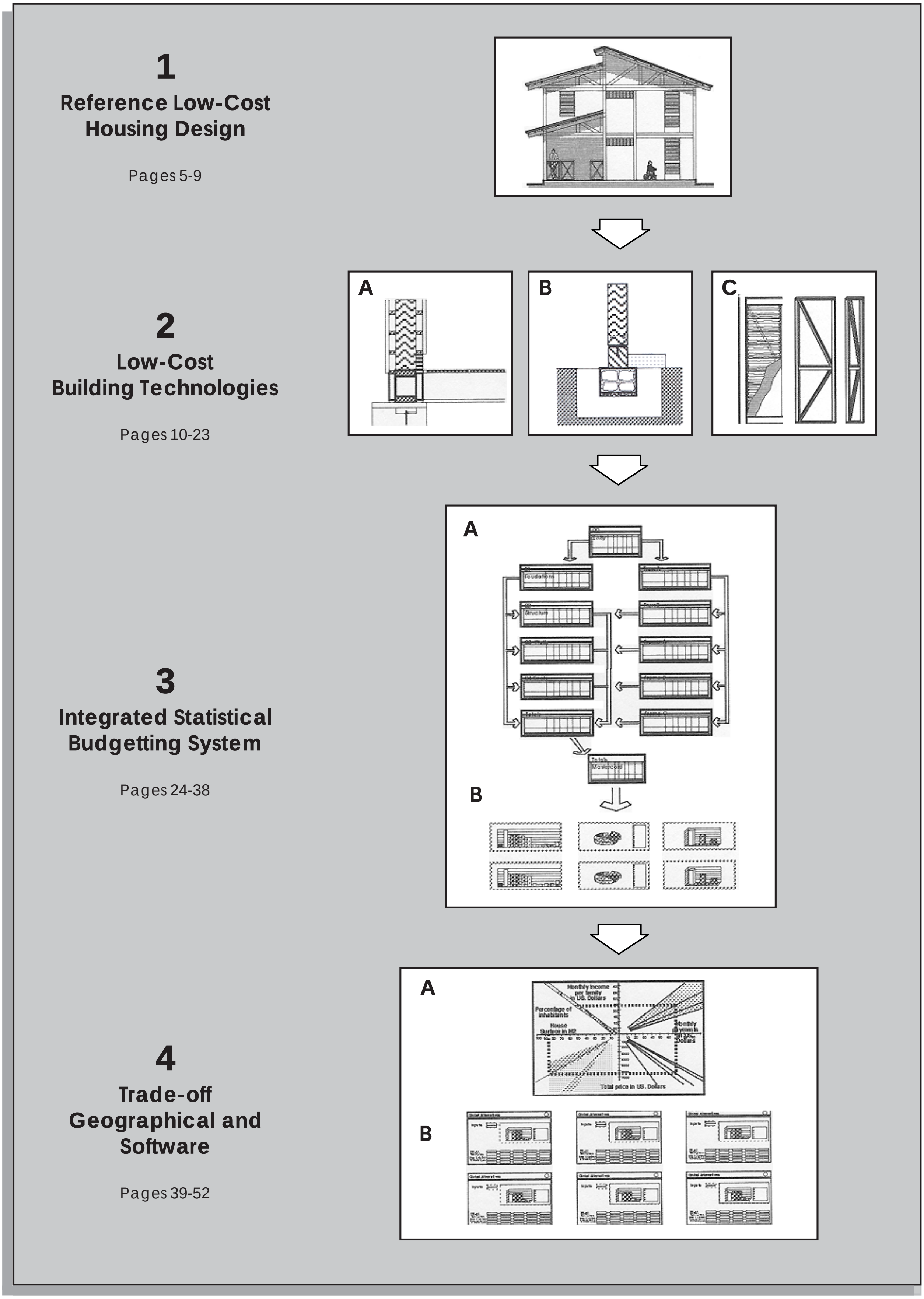
The first part is a house design suitable for low-income populations in Latin America.

In the second part, this house design offers three alternative Low-Cost Building Technologies in local materials.

The third part consists of a computerized statistical budgeting system which permits a fast and comprehensive evaluation of housing construction systems for optimal cost-saving in the construction process.

The fourth part of this thesis consists of a series of graphs and a software application which enable the professionals to select the most appropriate technology with respect to the income level of the community; interest rate on loans; length of mortgage period and the size of regular monthly payments.

This methodology has been designed to take maximum advantage of the latest computer technology and is designed to be user-friendly for those with limited computer skills.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Introduction

Since early 1970's, some Latin American pioneers decided to experiment with construction systems based on timber, earth, and bamboo, to make low-cost housing more affordable for poor people. Scepticism was the first major obstacle they came across, particularly from professionals in the civil engineering and construction sector. Despite strong opposition from these profesionals, they managed, nevertheless, to attract the attention of various international organisations (for e.g. United Nations) who have since recognised the validity of these alternative construction methods.

Currently, a number of low-cost housing programmes using timber, earth and bamboo are being implemented in different parts of the world. These materials are also being used in the construction of high-cost private housing and other building types. Now in many developing countries, the recognition and use of these construction technologies and systems, together with the intensified use of local materials, is becoming increasingly common. One of the greatest problems in the implementation of these housing programmes, is their social acceptability among the low-income, specially in urban contexts.

For the rural population who migrate to the cities, a house built from earth or timber has connotations of insecurity, poverty, obscurity and lack of basic amenities: it represents all that they hoped to leave behind, when they set off for a new life in the city. However, the quality, design and durability of housing in local materials can be equivalent or superior to "modern" reinforced concrete construction.

Low-cost housing programmes developed by governmental and non governmental organisations are usually implemented in a hierarchical manner, whether they use conventional concrete construction or local materials. In both cases, there is little, if any, user participation. These housing programmes end up reflecting exactly the "working class" that their inhabitants resent. Although they optimise self-help labour, they do not evoke the modern image the immigrant rural population aspires to.

Research and wide experience of implementation of low-cost housing programmes has led to the development of a new method of intervention based on "showhouses". Local materials are used for the construction of important buildings, such as upper-middle class houses, country clubs and luxury hotels, with excellent quality finishes so as to act as a "shop window" to enhance the prestige and social acceptability of these materials.

Meanwhile the construction of these luxury models provides great opportunity for experimenting with and consolidating various construction technologies, which can subsequently be used in large-scale housing projects for low-cost housing.

This strategy also strengthens local and regional economies by generating income through micro enterprises for the production of building components using local materials with cocal labour, thereby improving conditions for low-income communities.
Besides all these advantages, the application of information technology throughout the whole process enables low-cost building technologies to become more competitive in terms of quality, cost and affordability.

In response to the lack of modern technology available for low-cost housing, In the last three years I have developed a practical methodology for optimal use of affordable building technologies. applying the potential of modern information technology.

Use of Information Systems

Statistical-Budgeting System
The first piece of software, is the Integrated Statistical-Budgeting System, it permits a rapid cost evaluation between the component parts of any one construction technology. Thus maximum cost-savings can be achieved by selecting the most appropriate combination of these component technologies. This system also faciliates a tight control over quality (correct proportions for mortar, whitewash, joining components etc); and man-hours required per prefabricated element. With this system, total quality control for the whole project can be a reality.

Trade-Off Software
The second software, the Trade-Off System for Optimal Affordability of Appropriate Technologies, evaluates the outputs from the Statistical Budgeting System in conjunction with a series of financial variables (community income levels, constructed floor area, interest rate on loan and annuity) to achieve optimal affordability and cost recovery.

This is a practical and useful package developed to reach proffesionals in housing, policy makers, academics and students. It consists (thesis, manual and software)

Objective

The principal objective of this thesis is to design a methodology for selecting the most appropriate technology; monitoring; site supervision and feedback for Low-Cost Housing Construction in Developing Countries.

The results will be three products: this thesis which explains the methodology; a software user's manual and the software package on disk,

Areas of Application

Scale
This methodology is designed for medium and large-scale projects and programmes of over 50 houses.

Economic Sector
Family income between 1 and 6 minimum salaries per month.

Geographical Sector
Tropical and subtropical regions in developing countries

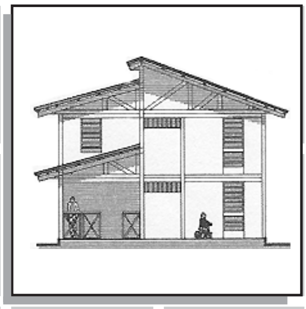
Building Technology
Self-help prefabricated construction systems

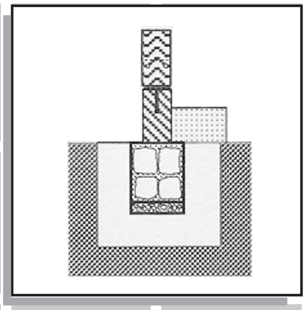
Target user
Spectrum in between: construction and information systems semi skilled agency worker and Construction Expert.

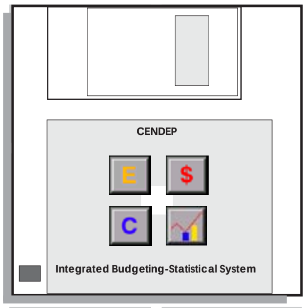
Technical Equipment
The software must be run on:

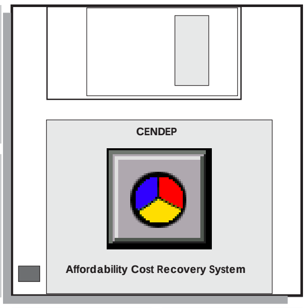
Macintosh Systems
- A Macintosh equipped with a 68020, 68030 or 68040 processor SE/30, Classic, LC series, Quadra series, Power PC series, Powerbook series and Duo series.
- System 6.05 or later
- 4 MBs of RAM
- Microsoft Excel versions 3.0, 4.0 or 5.0

IBM Compatible
- A Hardware equipped with a 286, 386 or 486 processor
- System Windows 3.0 or later
- 4 MBs of RAM
- Microsoft Excel 3.0, 4.0 or 5.0 for Windows

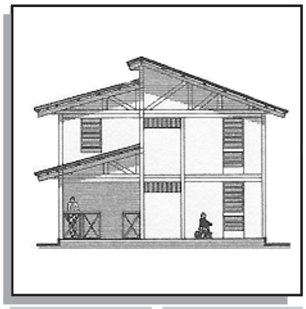








Trade-off Methodology



1

Reference Low-Cost Housing Design

This chapter describes the proposed a reference low-cost housing design which accommodates three possible building technologies. Drawings vary, illustration all three applications.

The proposal is a variation on an original design used by the author for the construction of 250 dwellings, a project carried out by "Centro de Investigaciones CIUDAD" in the coastal region of Ecuador, 1993.

The following selection criteria have been taken into account in designing this prototype:

Climate context

The proposed design responds to a temperature range of 10° to 32° C. and humidity from 50% to 90%

Area

The proposed design has a floor area of 71 m2 (including three or four bedrooms), appropriate for a high density urban sector.

Expansion

Being based on prefabricated components, the prototype can easily be added to for both horizontal and vertical modular expansion.

Aesthetics

Local traditional vernacular architecture is used as an essential parameter for designing low-cost housing.
The connotations of poverty, associated with traditional earth, timber and bamboo houses, have been addressed by giving the façade a very modern aspect, in keeping with urban trends.

Proposal

Basic Grid and the Plot

The proposal is developed on a 8.00 x 20.00 m (160.00 m2) plot; and the structure and construction components are based on a 0.8 m2 modular grid.

The main layout of the house, 2.40:2.40 x 3.20:1.60:3.20. is based on the flexibility of the grid.

The Building

The prototype is a 71 m2 semidetached two storey house with 3.20 m clearance to the site boundary.
The same plan may be used for terraced housing a 5.00 m frontage.

Ground Floor

The ground floor has 40 m2 of constructed floor area. The main entrance is through the porch into the living room. The split-tread staircase and the bathroom act as buffer to the dining room and kitchen areas. In this particular example the hammock is strung across the porch, as a traditional security measure in the Pacific culture. (Fig. 2)
The design of the elements is such that the kitchens are back to back to the kitchen of the next house, this save connection costs.
The doors and windows both have the same standardised design to minimise costs and resources.

Every consideration is given to maximise the use of space.

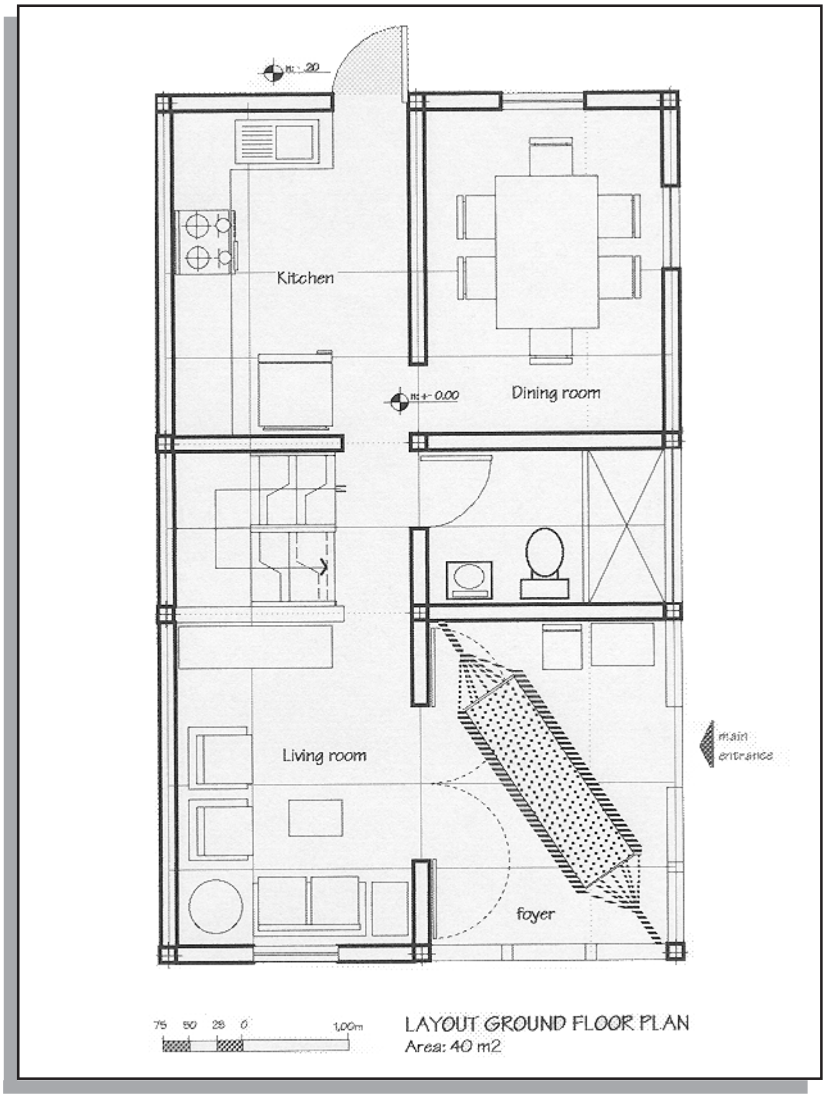


Figure 2

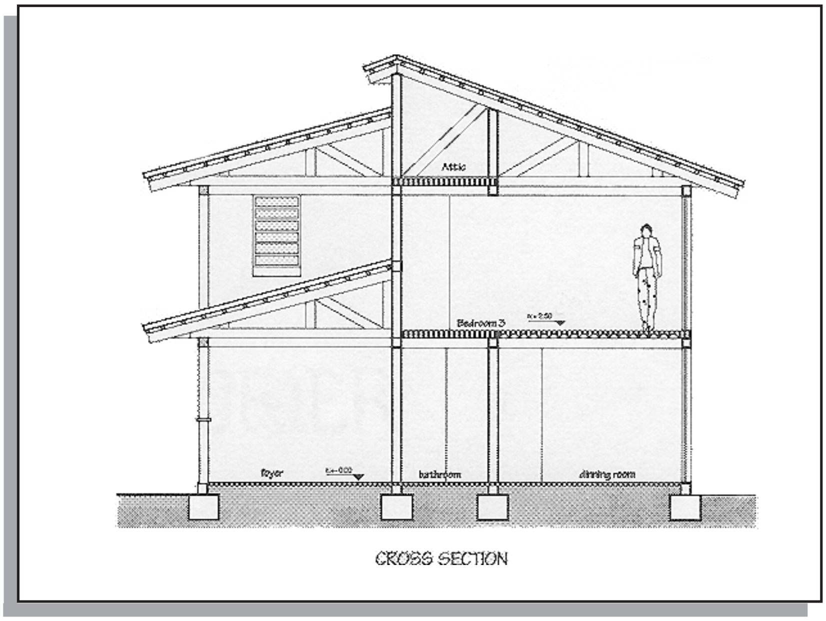


Figure 3

Storage space is provided under the stair case.
The wall construction is only 15 cm thick to minimise plot usage and maximise internal floor area space.

First Floor

The first floor is 2.60 m high and consists of 31 m2 of constructed floor area. There are three bedrooms, with the possibility of adding a fourth above the porch. The average room size is 6.9 m2. (fig. 4) It is possible to accommodate a small attic within the pitched roof. (Fig. 3)
An extra bedroom may be build over the void.

Façades

The façades are designed in such a way as to eliminate the stigma of the traditional image of low cost housing. The semi-detached houses with their alternating sloping roofs provide an engaging and responsive streetscape.
With the possibility for each household to add on extra rooms the character of the façade becomes ever more diverse.

The doors and windows are designed to follow a vertical and horizontal grid pattern in 40 cm modules. This provides a harmonious frontage to the building. (Fig. 5)

The contrast of texture and colour between the structural elements in timber and the walls painted white, gives the house a very strong modern image. This characteristic plays a very important role in encouraging the owners to fully accept the houses. (Fig. 9)

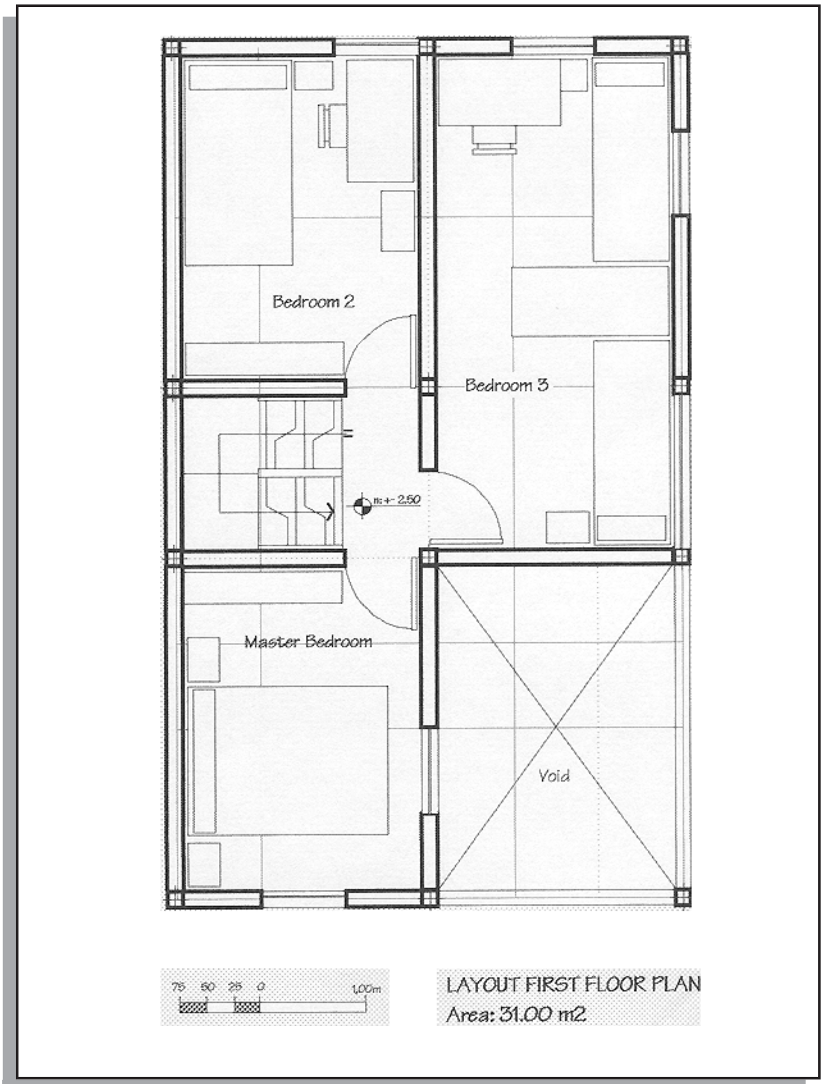


Figure 4

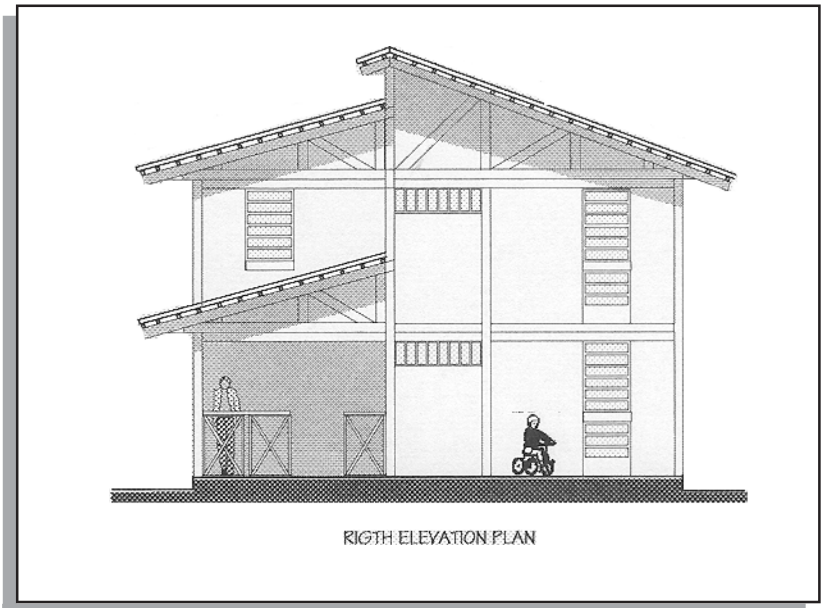


Figure 5

Roofs

The standardization and lightness of the specially designed truss facilitates the construction of an additional storey.
The roof truss construction is specifically designed to maximise cross ventilation throughout the house. It also facilitates the illumination of the stair well, which owing to the strong light will provide unusual lighting effects. (Fig. 7)

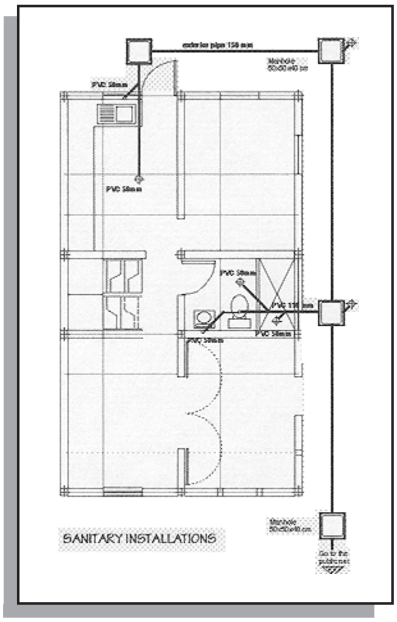


Figure 6

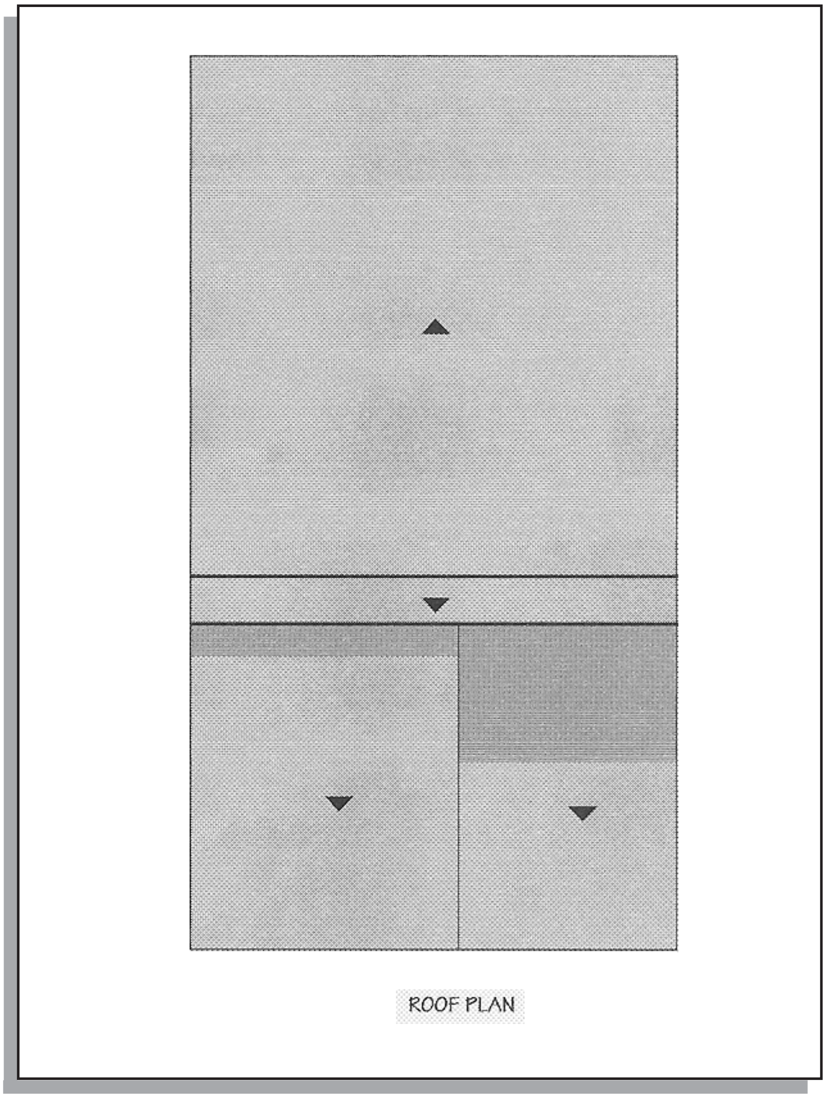


Figure 7

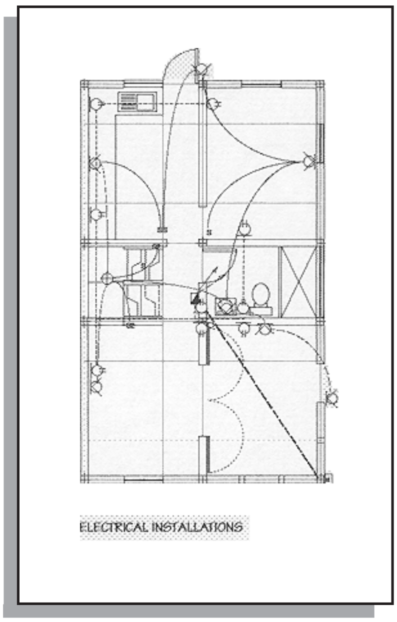


Figure 8

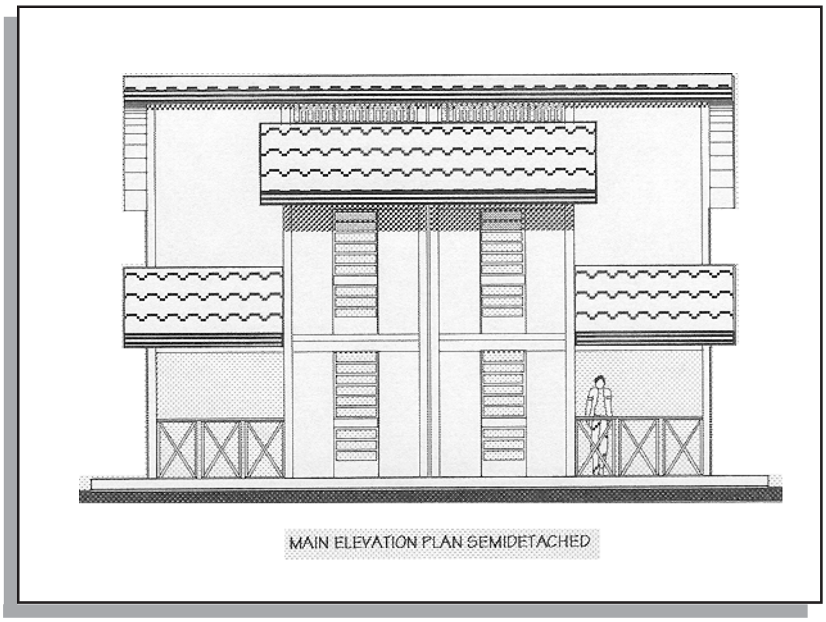
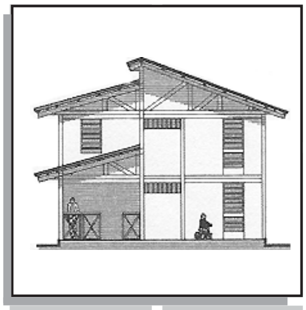
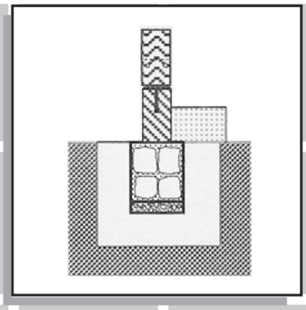


Figure 9





2

Low-Cost Building Technologies

The low-cost housing design proposed in the preceding chapter could be built with three alternative construction technologies, each of which has been researched, developed and implemented by the author in different projects and institutions.

These construction systems are based on vernacular building systems used all over Latin America for centuries.

A The first technology Wattle and Daub - Timber was developed and implemented in different low-cost housing projects in Ecuador in 1992-93.

B The second technology Timber - Mud Brick is based on "Alahua-Funhabit" structural principles and was implemented in the construction of the Guayllabamba Research Centre in Ecuador in 1988; and was refined in 1991 in a Master's thesis at Louvain University, Belgium. Thereafter, it was used as a prototype for the "Comunidades" low-cost housing project in Brazil in 1992.

C The third technology, Rammed Earth - Timber, was developed in the construction of the Guayllabamba Research Centre in Ecuador in 1987-89 and refined in different projects in Ecuador in 1992-93.

Properties of these Construction Systems

Cost
Much more economical than conventional construction systems.

Flexibility
Most of the component parts of these systems may be used in any combination i.e. interchanging the structure, foundations, roof, walls etc.

Materials
Most of the materials used in these proposals are locally available throughout the developing world (earth, timber, bamboo).

Self-Build Potential
All the components and construction systems have been designed to maximize the potential for prefabrication and self-construction.

A Wattle and Daub - Timber Proposal

This is traditionally a wooden structure rendered in earth. The innovations proposed to adapt this technology for large-scale contemporary use are: the standardization and prefabrication of all the timber elements. It is also necessary to study the composition of locally available earth in order to maximise its resistance to the external elements and the tolerances of the structure. The assembly system has also been refined to facilitate much faster construction.

The principal structural component of this system is the timber frame which bears on concrete foundations. (fig. 10) The ground floor walls are built in mud brick and the first floor is a mixture of wattle and daub with a earth-pumice plaster finish.

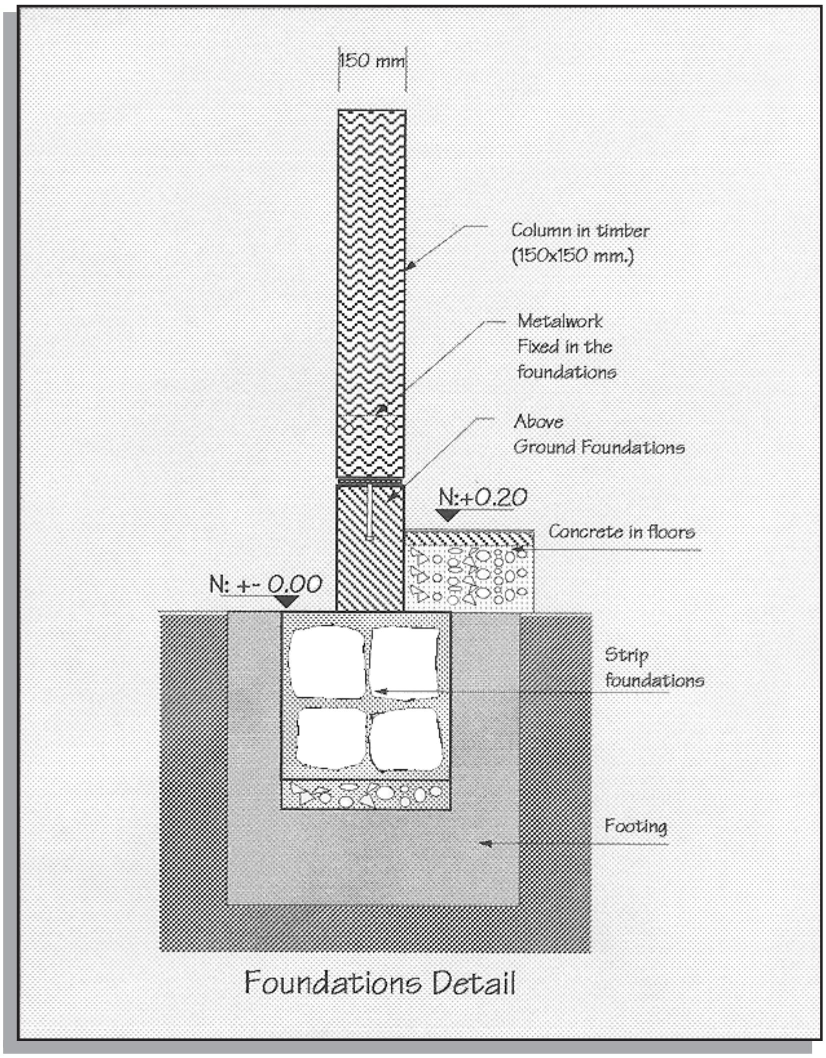


Figure 10

Construction System

The construction system does not require any sophisticated machinery for prefabrication and its components could well be manufactured in small community workshops or even directly on site.

The construction elements are so lightweight that they can easily be transported and assembled without a crane.

The Foundations

The basic structural axes must be set out with great precision as this is critical for the process of assembling the components.
The foundations consist of a series of 500x500x400 mm footings, linked by 400x400 mm concrete strip foundations with a high proportion of stone in the mixture. These foundations can be prefabricated.

Upper Foundations

The upper foundations consist of 100x200 mm prefabricated concrete beams. The upper foundations protect the walls from erosion and damp.

Columns and Beams

The columns and beams comprise two 150x75 mm timber sections, bolted together to give a total cross-section of 150x150 mm. (photo 01)
The structural axes make up a tartan grid with dimensions 2,400- 2,400 mm x 3,200 - 1,600 - 3,200 mm and their respective modules.

Joints

The joints between columns

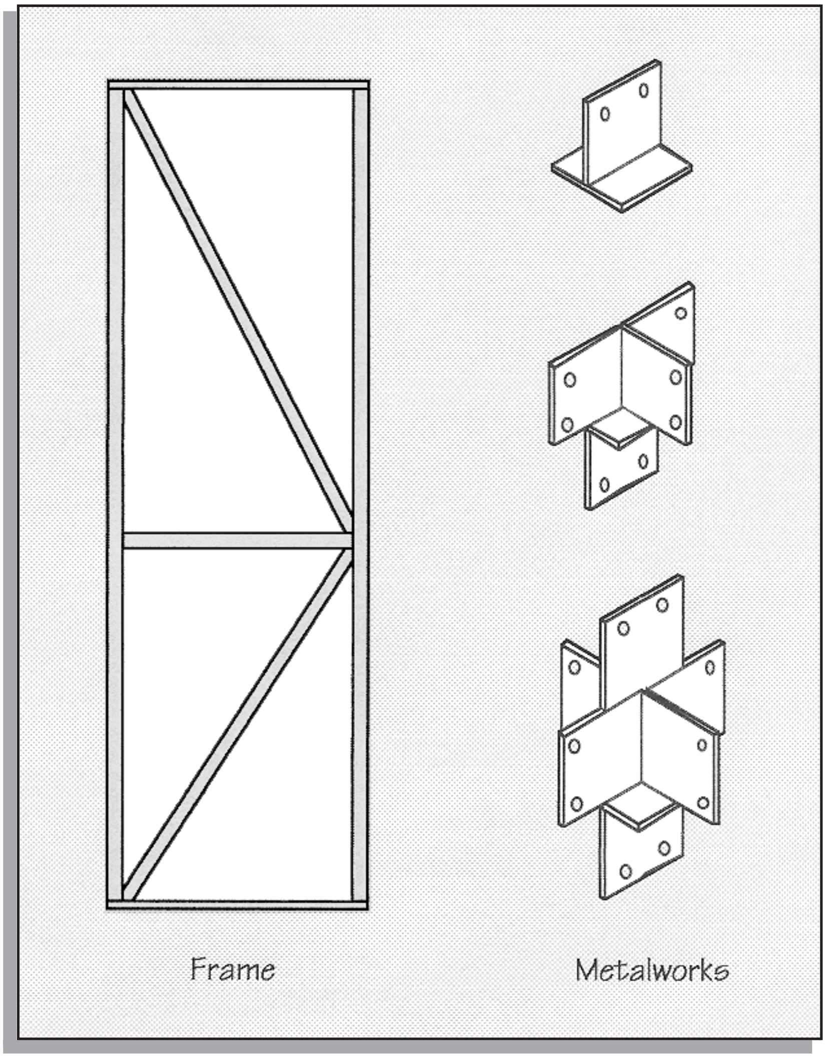


Figure 11

Photo 01

and beams are formed by bolting through metal plates, which are protected with anti-corrosion paint to prevent rusting. (Fig. 11)

Floors

The floors comprise a 50 mm concrete slab with steel reinforcement set on a permanent formwork of continuous split bamboo beams bearing on timber joists.

Ground Floor Walls

At ground level the walls comprise 140x280x80 mm compacted mud bricks, laid in a 1:16 earth-concrete mortar. (Photos 02 and 03)

First Floor Walls

Structurally, the walls are made of prefabricated timber panels based on standard modules of 80x700x2200 mm; 80x700x1,800 mm and 80x700x1,000 mm,

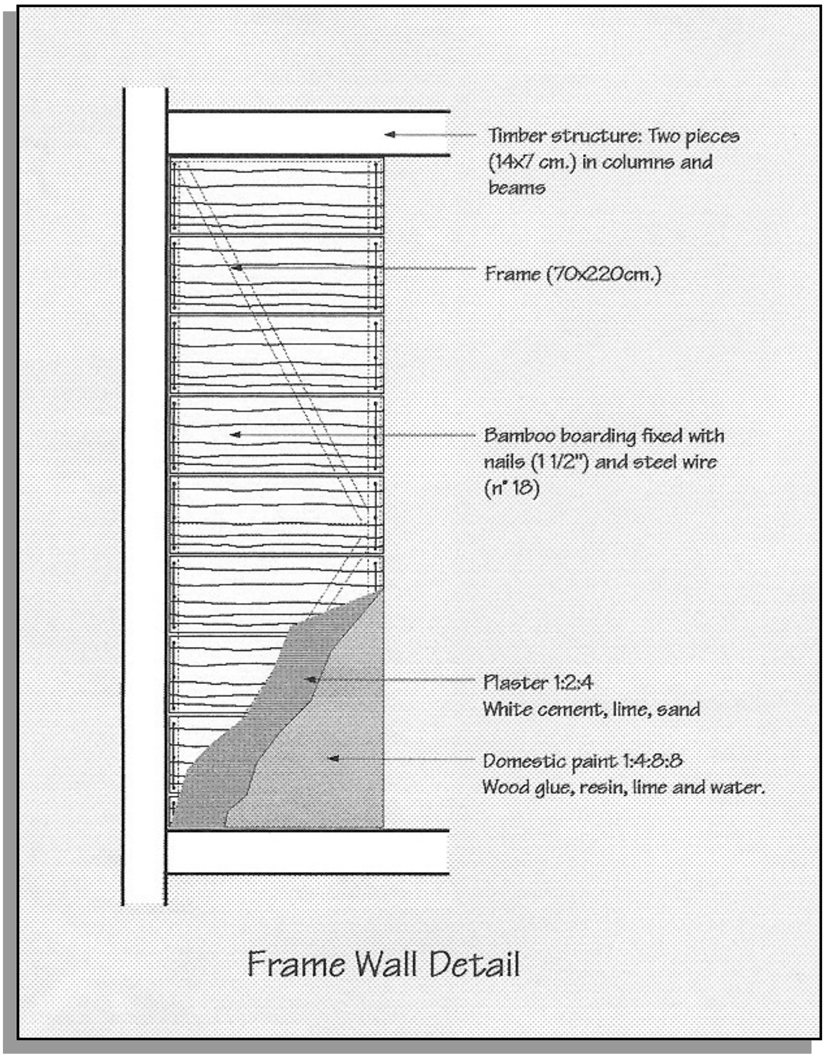


Figure 12

Photo 02

Photo 03

80x700x1,000 mm, which are fixed to the floor joists and roof beams.
Split bamboo boarding is wired to the timber frames and plastered with a 1:2:4 white cement-lime-sand mixture. Any defects can be corrected with a 1:10 water : common wood glue mixture, which forms when mixed with earth, a type of polyfilla. The interior and exterior walls are treated with a diluted mixture of this solution (1:20 glue : water), sprayed on to harden the wall finish. Finally a 1:4:8:8 wood glue : resin : lime: water paint should be applied. (Fig. 12)

The Staircase

This is a compressed staircase i.e. it rises 2.5 m in only 1.6 m on plan. This is achieved by using 2 compensating tread plans, efficiently reducing vertical circulation space to a minimum floor area.
The treads, 730x320x40 mm, are made of hardwood supported by two 40x400x1500 mm bearers running along the base of each balustrade.

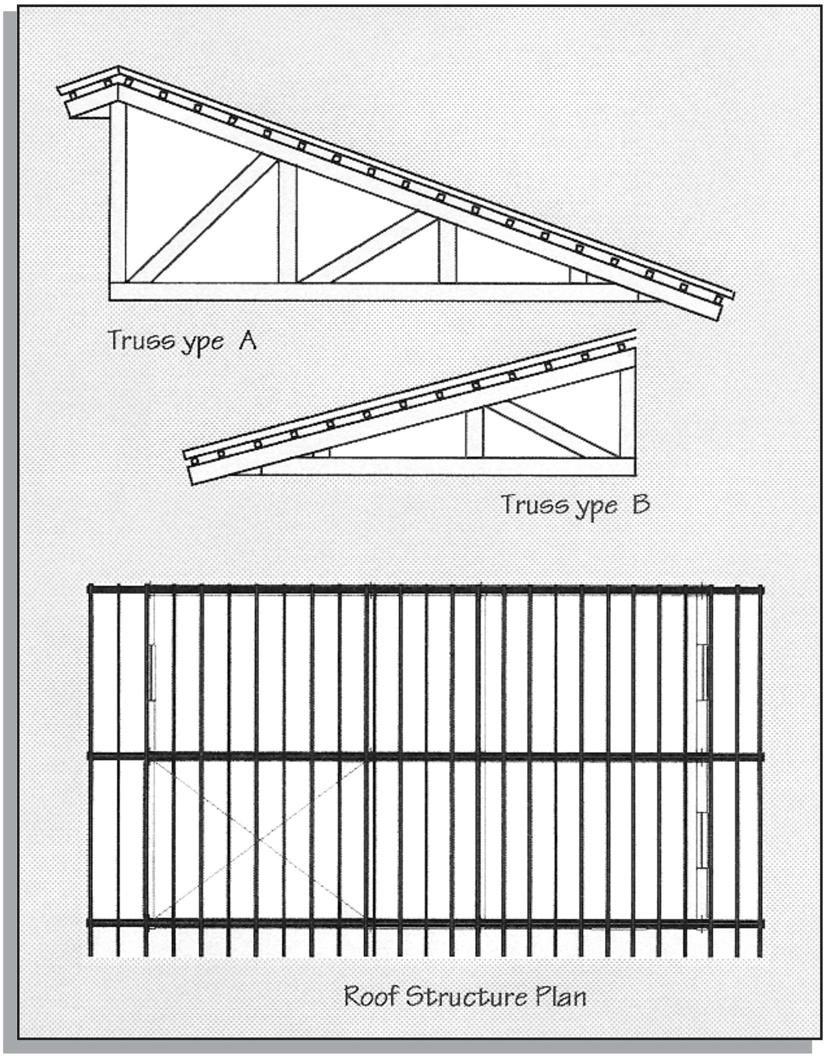


Figure 13

Roof

The roof comprises two types of prefabricated truss made up of 20x160 mm timbers glued and nailed together. The gables are closed off with vertical lengths of 20 mm ø bamboo. As the structure must be lightweight, micro concrete roof tiles are recommended. (Fig. 13, Photo 04)


Photo 04

Finishes

In the use of the wattle and daub construction system it is possible to use any type of finish, even those which are applied to conventional con-

B Timber - Mud Brick Proposal

Construction System

Like the previous construction system, this system does not require sophisticated machinery for pre-fabrication and its components could well be manufactured in small community workshops or even directly on site.

The construction elements are so lightweight that they can easily be transported and assembled without a crane.

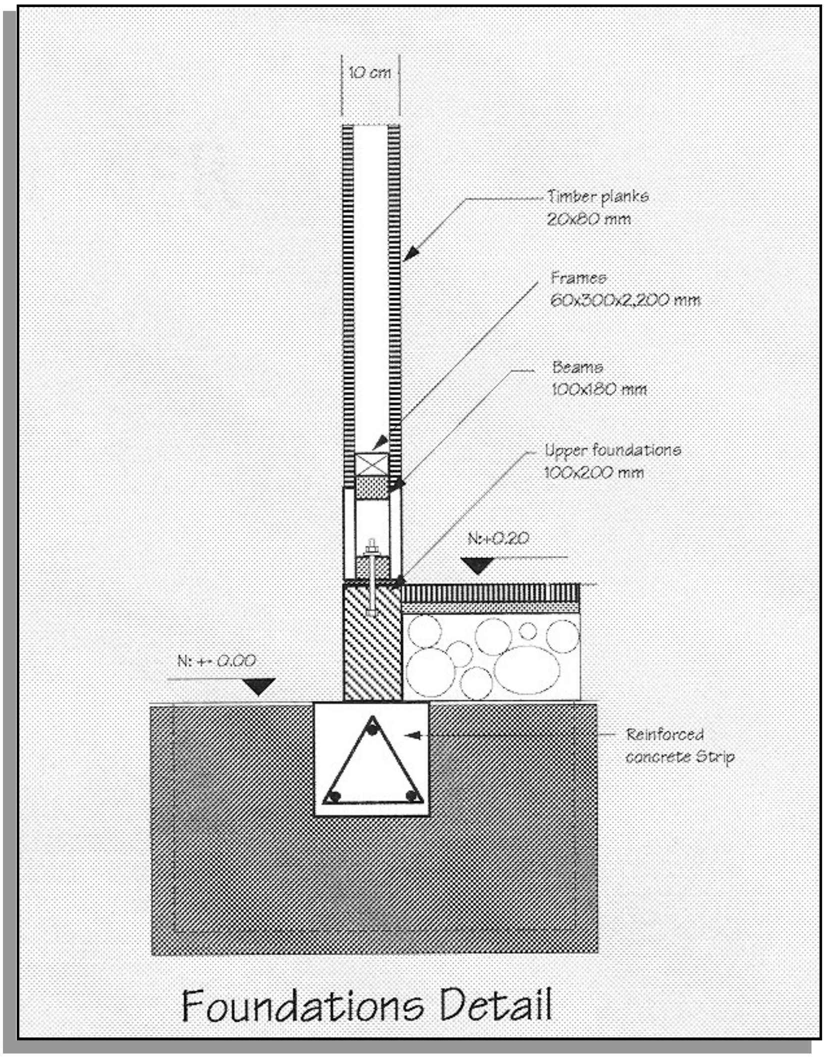


Figure 14

Foundations

The basic structural axes must be set out with great precision as the whole process of assembling the components depends on this.
The foundations consist of a series of pre-fabricated 500x500x500 mm footings, linked by a continuous 400x400 mm concrete strip foundation with a high proportion of stone in the mixture. (photo 05)

Metalwork

Set in the footings at 400 mm centres there are four 3/4" ø galvanized iron tubes which reinforce the joint between the columns and the footings. (Fig. 15)

Upper Foundations.

The upper foundations consist of 100X200 mm pre-fabricated concrete beams, set with short lengths of iron on to which the wooden wallplate is secured. The upper foundations protect the walls from erosion and damp. (Fig. 14)

Columns

The 100x100 mm columns comprise five elements: a 60x60 mm timber column clad by four 20x80 mm timber planks, glued and nailed.
The structural axes make up a tartan grid with dimensions 3,200 - 400 -3,200 mm
and respective modules.

Beams

Beams are made up of two 20x160 mm timbers, joined by two 40x60 mm studs, glued and nailed.
Where beams meet columns,

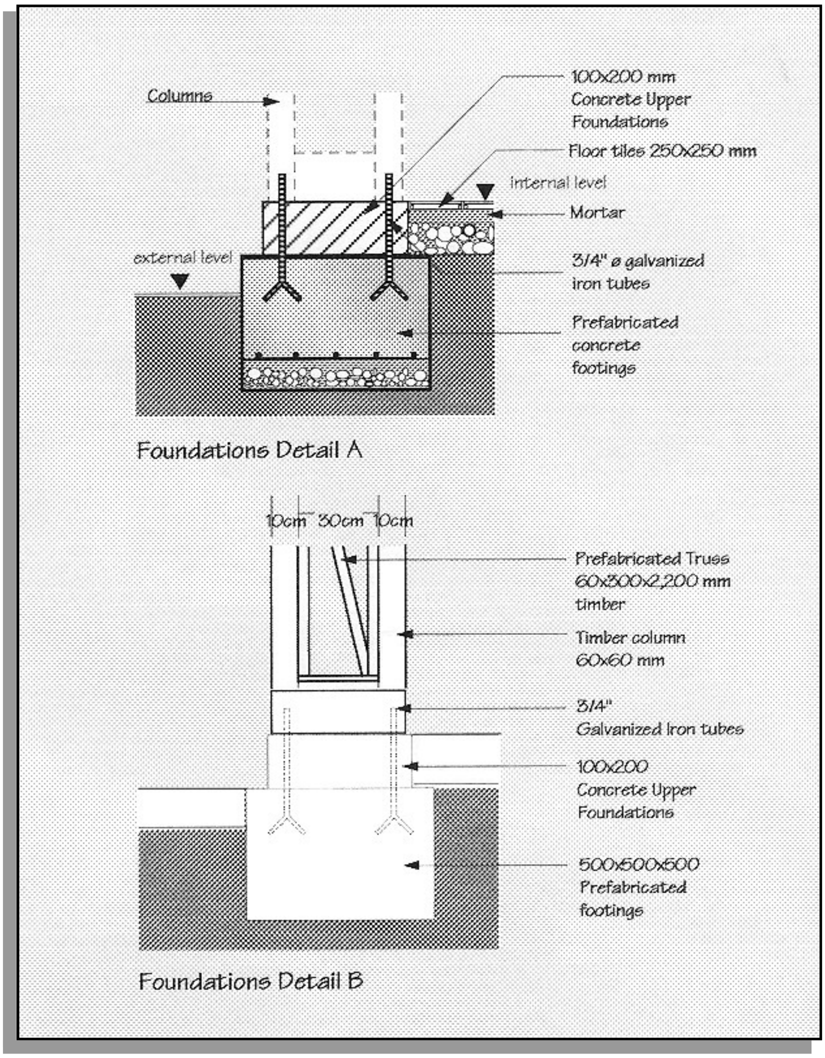


Figure 15

Photo 05

the vertical cladding of the columns is interrupted to allow the internal 60x60 mm column to receive the 20x160 mm timber beams on either side. (Photo 07)

Timber Floor

This comprises a prefabricated structure based on an 800x800 mm module, made up of 20x160 mm timbers with notched joints, and at the joint of the four beams the grid is held rigid with a 60x60x160 timber wedge, glued and nailed. The over-lying floor surface can be timber floor boards or an in-situ 50 mm concrete floor slab, lightened with pumice stone. (Fig. 16)

Ground Floor Walls

At ground level the walls comprise 140x280x80 mm compacted mud bricks, laid in a 1:16 earth : concrete mortar. (Photo 08)

Photo 06

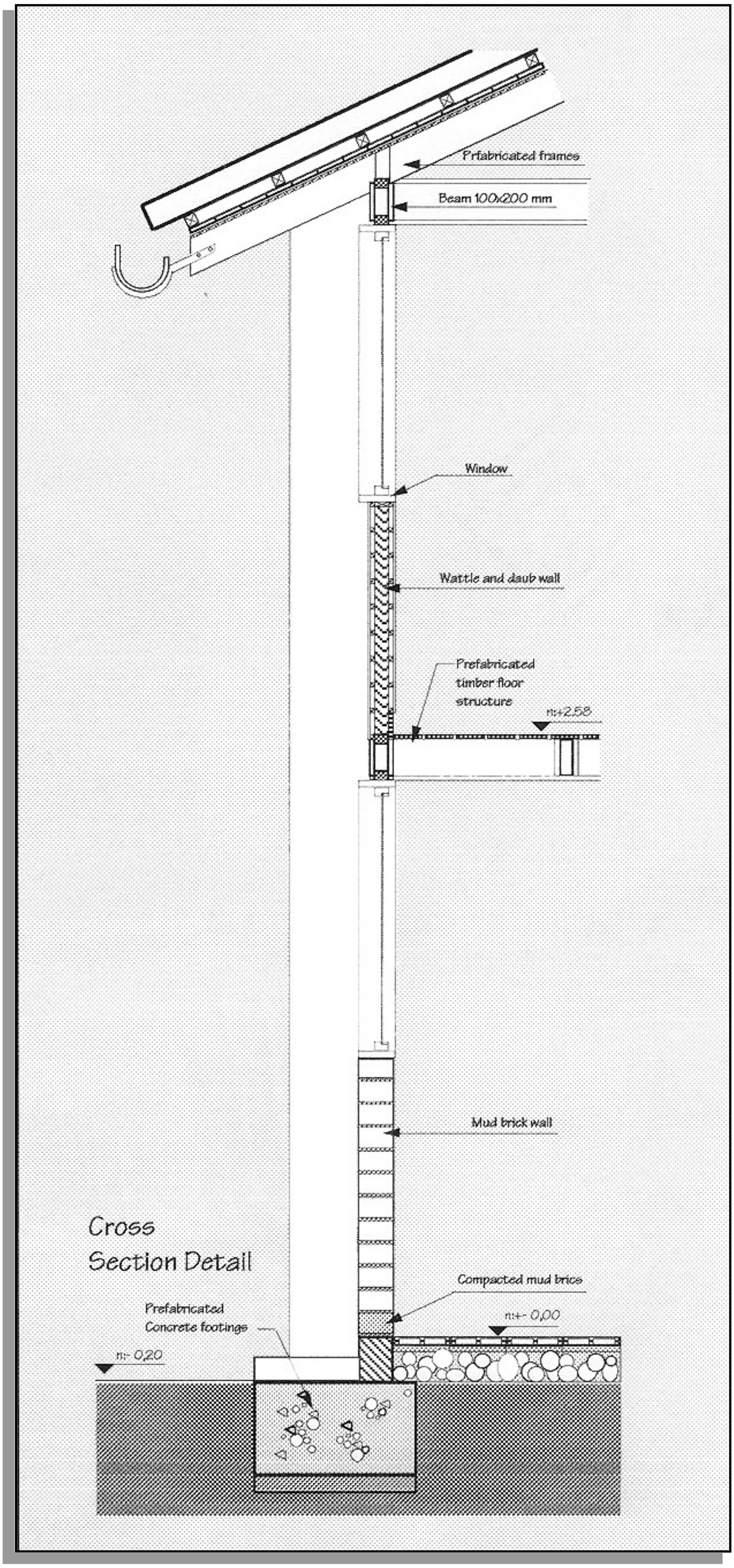


Figure 16

First Floor Walls

Structurally, the walls are made of pre-fabricated timber panels based on 60x700x2200 mm and 60x300x2200 mm standard modules, which are fixed to the floor and roof beams. (Photos 06, 09)
60x700x1000 mm and 60x300x 1000 mm frames are used for the wall below the windows or the staircases balustrades or the open-plan areas.
25x25 mm horizontal timbers are nailed on to each side of the frames, covered with chicken wire and the hollow stud wall is unfilled with a 2:1 earth-pumice mixture. Finally the wall is rendered with a 1:12 cement-earth mortar.
Any defects can be corrected with a 1:10 water-common wood glue mixture, which forms a type of polyfilla when mixed with earth. The interior and exterior walls are treated with a diluted mixture of this solution (1:20 glue-water), sprayed on to harden the wall finish.

Roof

The roof comprises 820x1580 mm and 1680x1580 mm pre-fabricated frames made up of 20x160 mm timbers, glued and nailed. These frames are clad in timber, which simultaneously acts as insulation and bracing. As the structure must be light-weight, micro concrete roof tiles are recommended.

Finishes

Any type of finish available on the market can be used on both the ground floor mud brick walls and the first floor wattle and daub walls.

Photo 07

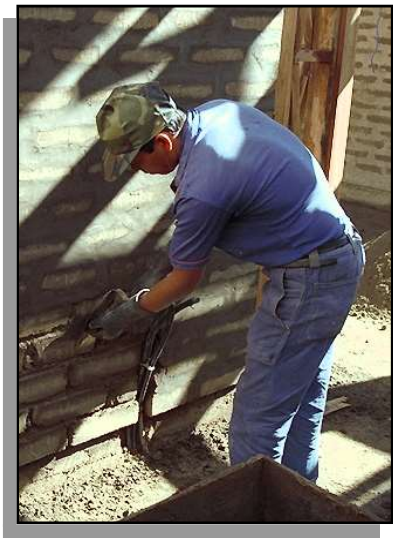


Photo 08

Photo 09

Photo 10

C Rammed Earth - Timber Proposal

This technology is based on a traditional system of thick rammed earth walls. The innovations proposed to adapt this technology for large-scale contemporary use are: reduction of wall width, standardization of the formwork and analysis of the composition of locally available earth to maximise its long-term resistance to external elements.

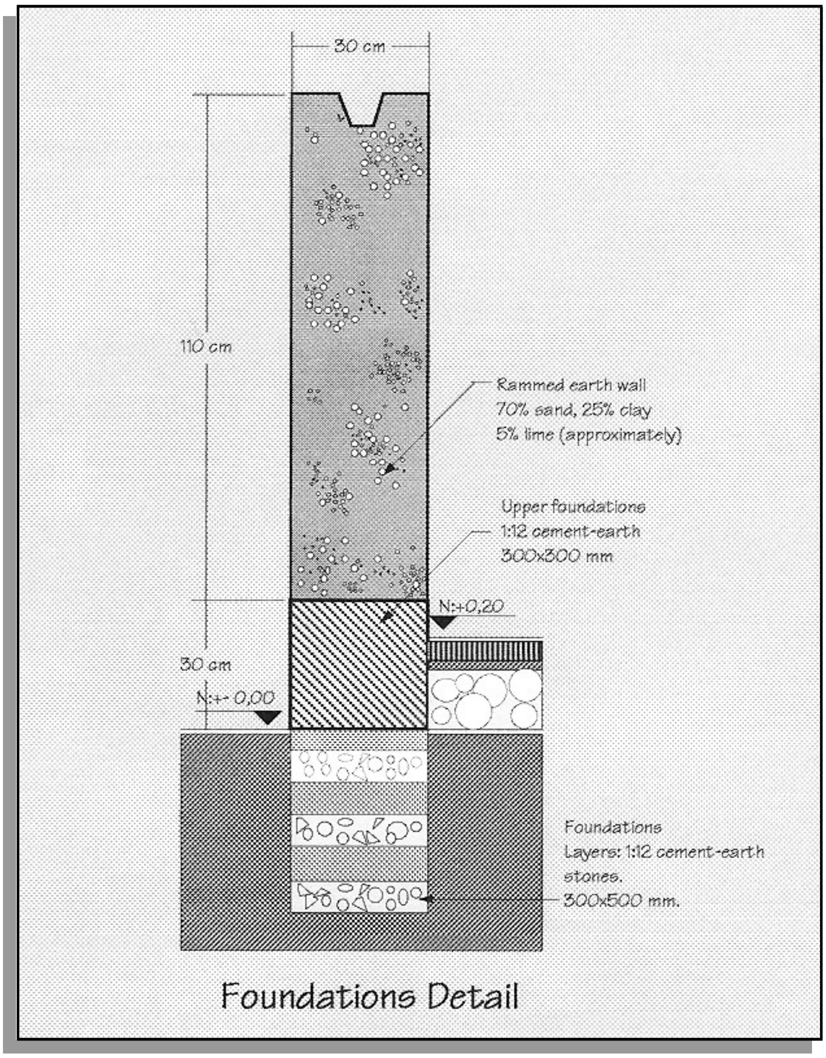


Figure 17

Rammed Earth Formwork

The formwork is made up of individual elements that can be bolted together in three different ways:

1) The "I" shape is used for straight sections of the wall. (Photo 11)

2) The "L" shape is used for solid, stable corners. (Photo 12)

3) The "T" shape is used for `T´ junctions where partition walls butt external walls, so that the whole building acts as a single structural element. (Photo 13)

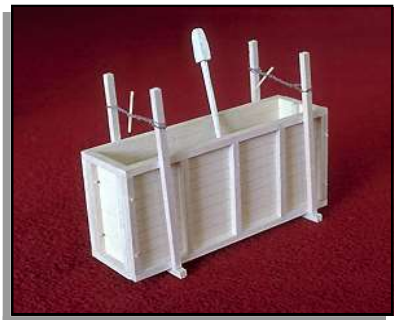


Photo 11

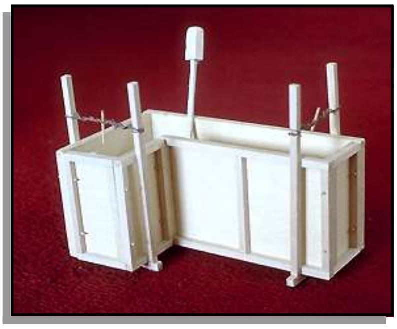


Photo 12

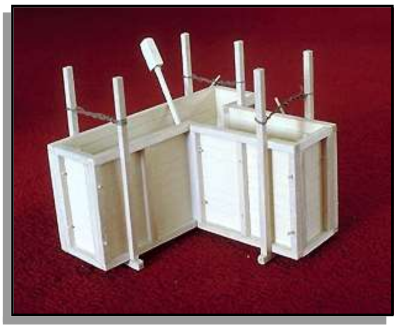


Photo 13

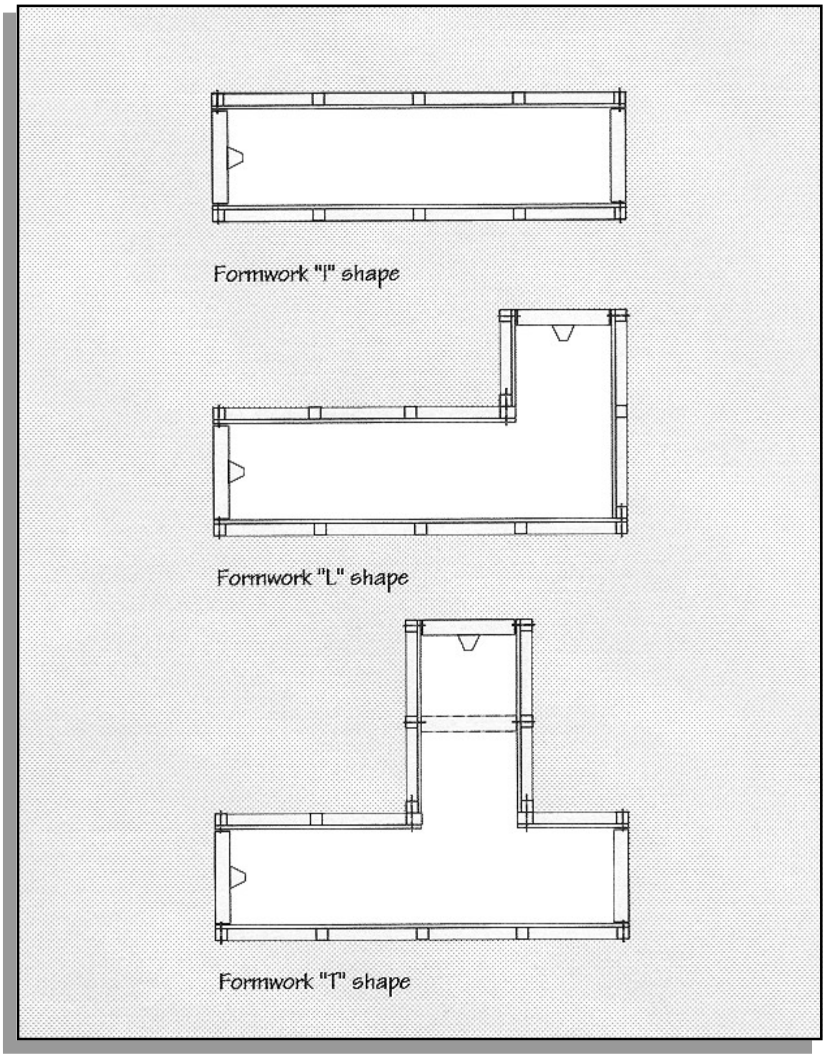


Figure 18


Photo 14

Earth

The composition of the earth to be rammed should be approximately 70 % sand, 25 % clay and 5 % lime. If the local earth composition varies greatly from these proportions, the mixture can be corrected and stabilized by adding more sand, clay or lime as appropriate.

Foundations

These are 300X500 mm 8% earth: 92% cement strip foundations, constructed of manually compacted, alternating layers of 70 mm earth cement and 70 mm stones. The wall formwork can also be used for the construction of the foundations. (Fig. 17)

Upper Foundations

The upper foundations consist only of earth cement - there are no layers of stone. Their function is to protect the rammed earth walls from erosion and damp. (Photo 14)

Walls

The walls are built using rammed earth formwork. These components have the following dimensions: 1100 mm high by 2000 mm long and 300 mm wide. They are laid in overlapping courses as in any typical brick wall. (Photo 15)
The earth is rammed in successive 70 mm layers. The horizontal forces generated by earthquakes are counteracted by reinforcing buttresses located at intervals where there are no partition walls to carry out this function. The walls are constructed first, the holes for the windows and doors are cut out of the solid wall afterwards.

Photo 15

Photo 16

Photo 17

Any defects can be corrected with a 1:10 water -wood glue mixture, which when mixed with earth, forms a type of polyfilla. The interior and exterior walls are treated with a diluted mixture of this solution, 1:20 glue-water, sprayed on to harden the wall finish. Finally a 1:4:8:8 wood glue:resin:lime: water paint should be applied. (Photo 19)

Photo 18

Roof

The walls can support roofs of any shape, pitch or material: timber, steel or concrete. The only requirement is the use of a continuous timber wall plate to spread the roof load evenly onto all the walls.

Finishes

Any type of finish can be used on rammed earth walls.
Rammed earth has the advantage that a variety of details can be carved, moulded or sculpted from its walls. Details such as architraves, shelves, cupboards and even fireplaces are possible, limited only by your imagination.

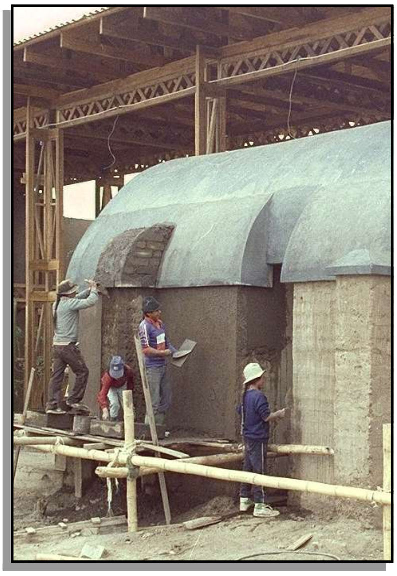
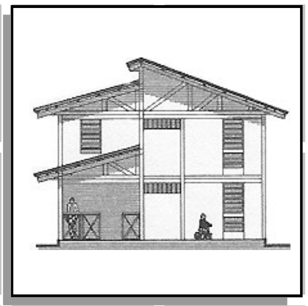
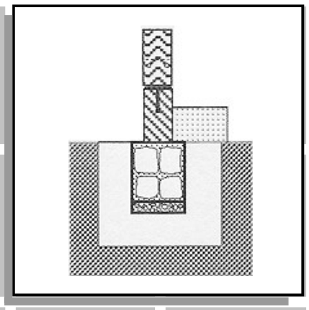
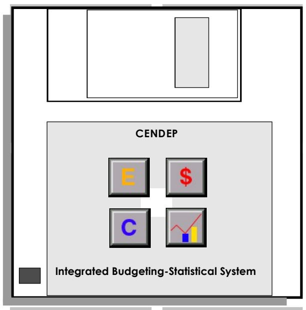


Photo 19

Photo 20







3

Integrated Statistical-Budgeting System

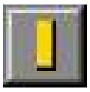
The statistical budgeting system is conceived to take maximum advantage of current computing possibilities to carry out a rigorous control of costs and returns, particularly for low-cost houses constructed with local materials.

In this particular example the system has been developed to evaluate constructive systems in wattle and daub and bamboo.

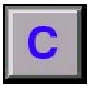
The prices have been taken from the project "Programa de vivienda para el sur de Machala" developed by the author for a project of 250 houses in Ecuador in 1993.

The software is based on Microsoft EXCEL ® versions 4.0 and 5.0 for Macintosh or for IBM ® compatible systems.

The system is based on several linked spreadsheets comprising one input workbook and three operative workbooks:

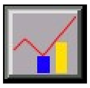


Input Spreadsheet
This has the general information valid for the whole package such as: titles, dollar rate, construction items, type of building etc. This information is linked with the entire software.



Components Workbook
This gathers the different prefabricated components spreadsheets including materials, and labour. The information produced in these sheets is automatically sent to the main workbook.

Main Workbook
This is the spreadsheets's budgeting system with eleven interlinked sheets in a standardised format. It receives information from the Inputs and Components Workbooks.



Statistical Workbook
This is the last component in the software. It analyses data from the precedent workbooks, producing six statistical graphs, facilitating evaluation and selection.

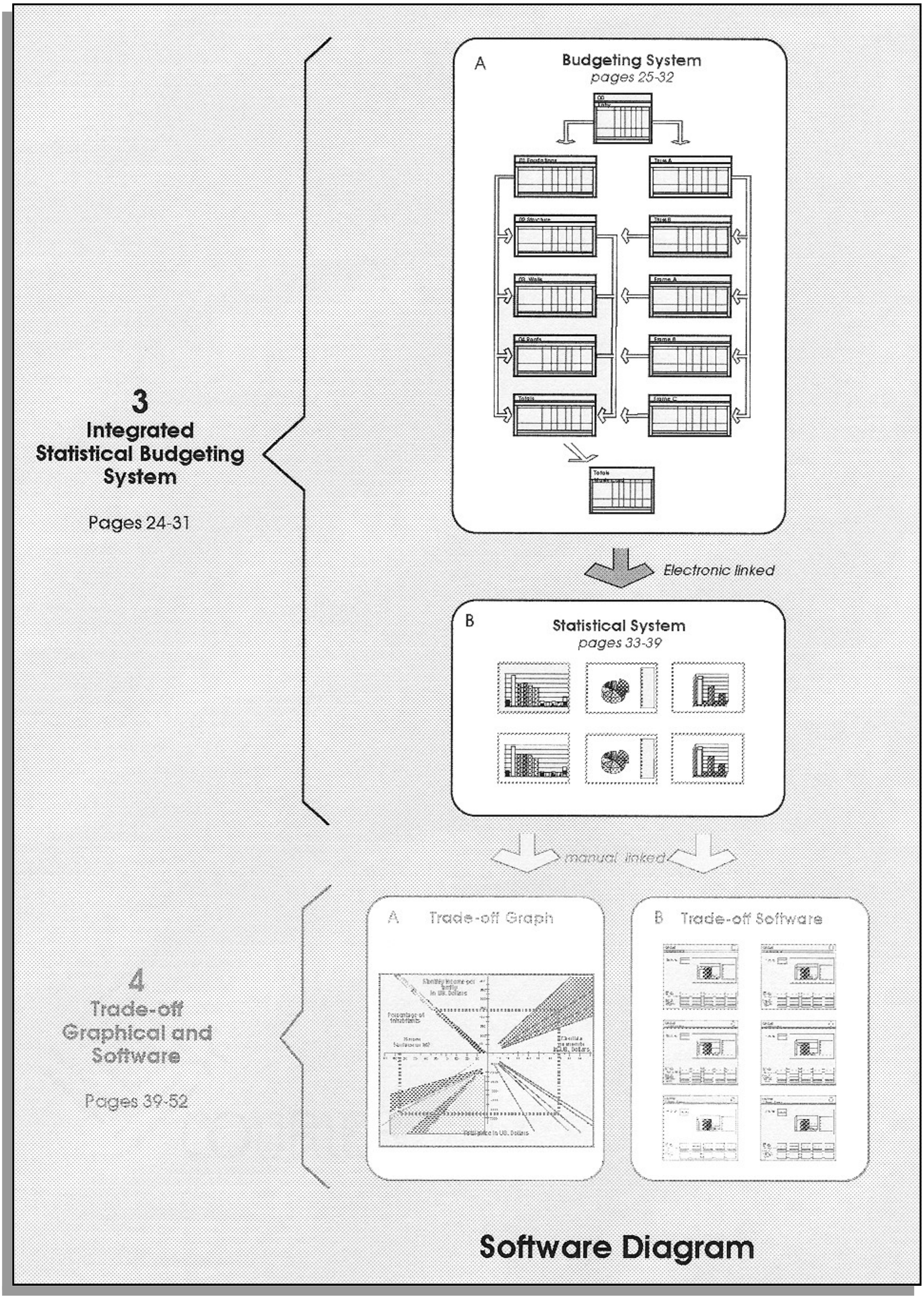

3
Integrated
Statistical Budgeting
System
Pages 24-31
A
Budgeting System
pages 25-32
Electronic linked
B
Statistical System
pages 33-39
manual linked
4
Trade-off
Graphical and
Software
Pages 39-52
A Trade-off Graph
B Trade-off Software
Software Diagram

Figure 19

A Budgeting System

The systems works with two independent inputs: US Dollars and the local currency (in this case, SUCRES, the Ecuadorian official currency).

This double information in dollars and local currency permits an effective comparison with the same or other projects through time and in different geographical contexts. This kind of system is particularly important for countries with high inflation rates.

Input Spreadsheet

This receives the general information, available for the rest of the system: Project title; Construction Technology; Date; Building; Budgeting Items; and the US Dollar rate.

Main Workbook

General Items

The first difficulty is elaborating a construction budget. The confusion lies in the variety of different building items.

In this budgeting system, this difficulty is addressed by a rational ordering of the different parts of the construction. This gives a perfectly clear and valid budgeting structure that can be utilized in any type of construction and/or construction system.

In this particular case we have eleven general interdependent but distinct items.

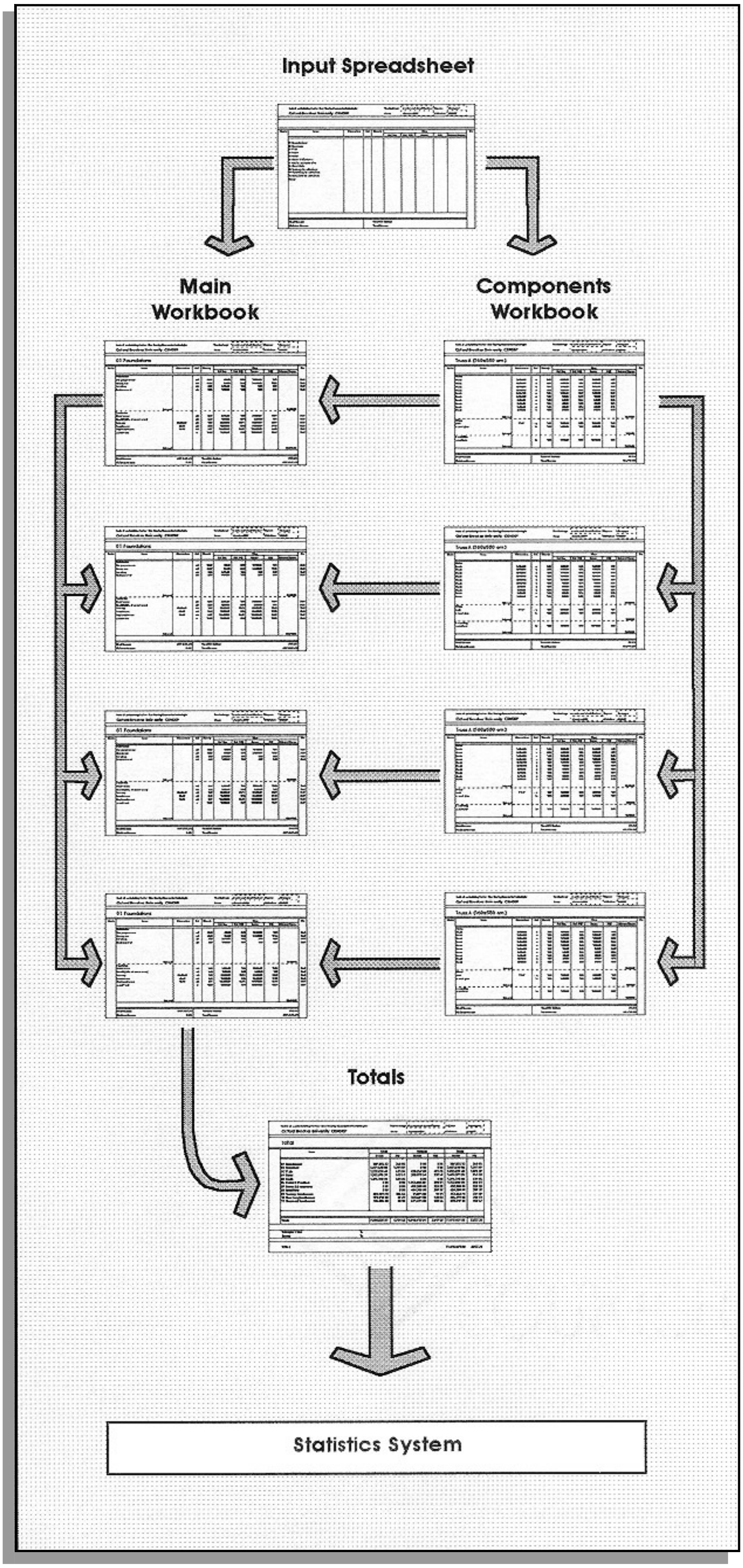


Figure 20

Main Workbook
Walls Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology:	*Wattle and Daub-Timbe*	Project:	*Prototype*
CENDEP	Date:	*October. 1994*	US Dollar:	*1.950,00*

03 Walls

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Mud Brick level + - 0.00:									
	Mud brick walls	6x15x30 (brick)	m2	54,64	8.000,00	4,10	437.120,00	224,16		Shell
	Plaster		m2	54,64	4.400,00	2,26	240.416,00	123,29		Finish
	Wall Tiles		m2	6,50	17.000,00	8,72	110.500,00	56,67		Finish
	Paint		m2	92,67	1.200,00	0,62	111.204,00	57,03		Finish
	Sub-total:								899.240,00	
	Timber and Bamboo Frame level + 2.50:									
	Mud brick walls	6x15x30 (brick)	m2	16,61	8.000,00	4,10	132.880,00	68,14		Shell
	Frame A	8x70x220	u	25	14.136,00	7,25	353.400,00	181,23		Shell
	Frame B	8x70x180	u	2	13.315,00	6,83	26.630,00	13,66		Shell
	Frame C. level +- 0.00	8x70x100	u	6	9.710,00	4,98	58.260,00	29,88		Shell
	bamboo		m2	87,06	1.800,00	0,92	156.708,00	80,36		Shell
	Assembling (30 % of bamboo price)		m2	87,06	540,00	0,28	47.012,40	24,11		Shell
	Plaster		m2	87,06	3.500,00	1,79	304.710,00	156,26		Finish
	Paint		m2	103,67	1.100,00	0,56	114.037,00	58,48		Finish
	Sub-total:								1.193.637,40	
	Shell Sucres:	**1.212.010,40**		**Total US. Dollars:**					**1.073,27**	
	Finishes Sucres:	**880.867,00**		**Total Sucres:**					**2.092.877,40**	

Figure 21

01 Foundations
02 Structure
03 Walls
04 Floors
05 Roofs
06 Doors & Windows
07 Basin & Accessories
08 Fixed Units
09 Sanitary Installations
10 Plumbing Installations
11 Electrical Installations
Total

Display

Each item can be presented separately on paper as well as in an electronic Spreadsheet, giving partial totals for each item. This constitutes a very important cost evaluation tool for the construction.

Main Workbook
Total Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology	*Wattle and Daub-Timber*	Project:	*Prototype*
CENDEP	Date:	*October. 1994*	US Dollar:	*1.950,00*

Total

Items	Shell		Finishes		Totals	
	Sucres	US $	Sucres	US $	Sucres	US $
01 Foundations	507.053,52	260,03	0,00	0,00	507.053,52	260,03
02 Structure	2.421.640,00	1.241,87	0,00	0,00	2.421.640,00	1.241,87
03 Walls	1.212.010,40	621,54	880.867,00	451,73	2.092.877,40	1.073,27
04 Floors	1.233.596,29	632,61	250.775,64	128,60	1.484.371,93	761,22
05 Roofs	1.276.140,00	654,43	0,00	0,00	1.276.140,00	654,43
06 Doors & Windows	0,00	0,00	1.132.000,00	580,51	1.132.000,00	580,51
07 Basins & Accesories	0,00	0,00	458.500,00	235,13	458.500,00	235,13
08 Fixed Units	0,00	0,00	404.200,00	207,28	404.200,00	207,28
09 Sanitary Installations	402.981,70	206,66	29.079,00	14,91	432.060,70	221,57
10 Plumbing Installations	170.598,00	87,49	235.601,00	120,82	406.199,00	208,31
11 Electrical Installations	156.006,00	80,00	699.391,00	358,66	855.397,00	438,67
Totals	7.380.025,91	3.784,63	4.090.413,64	2.097,65	11.470.439,55	5.882,28

Transport Costs	%		
Extras	%		
TOTAL		**11.470.439,55**	**5.882,28**

Figure 22

Site
It is very important to separate the shell costs from the finishes costs when working with appropriate construction technologies. The system separates each particular item giving a sub-total within each sheet and general totals at the end of the system.

1 Shell
This section comprises the principal parts of the construction: foundations, structure, floors, roofs and walls. The most important economies can be achieved on these construction components, specially when local materials are used.

2 Finishes
In this section all the final finishes only contribute to a minimal cost-saving using appropriate technologies. Nevertheless separate analysis of these items an evaluation determining maximum cost-saving possibilities.

Components Workbook
Truss Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology:	*Wattle and Daub-Timbe*	Project:	*Prototype*
CENDEP	Date:	*October. 1994*	US Dollar:	*1.950,00*

Truss A (160x580 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Plank	2x12x600	u	2,00	4.800,00	2,46	9.600,00	4,92		
	Plank	2x12x550	u	2,00	4.400,00	2,26	8.800,00	4,51		
	Plank	2x12x220	u	1,00	1.760,00	0,90	1.760,00	0,90		
	Plank	2x12x160	u	1,00	1.280,00	0,66	1.280,00	0,66		
	Plank	2x12x150	u	1,00	1.200,00	0,62	1.200,00	0,62		
	Plank	2x12x120	u	1,00	960,00	0,49	960,00	0,49		
	Plank	2x12x80	u	1,00	640,00	0,33	640,00	0,33		
	Plank	2x12x50	u	1,00	400,00	0,21	400,00	0,21		
	Plank	2x12x40	u	1,00	320,00	0,16	320,00	0,16		
	Plank	2x12x30	u	1,00	240,00	0,12	240,00	0,12		
	Sub-total:								25.200,00	
	Others:									
	Nails	1 1/2"	Kg	1,60	1.600,00	0,82	2.560,00	1,31		
	Wood glue		lt	1,00	3.000,00	1,54	3.000,00	1,54		
	Sub-total:								5.560,00	
	Assembling:									
	Man Hours		hr	9,00	1.750,00	0,90	15.750,00	8,08		
	Sub-total:								15.750,00	
	Shell Sucres:			**Total US. Dollars:**					**23,85**	
	Finishes Sucres:			**Total Sucres:**					**46.510,00**	

Figure 23

Components Workbook

As well as the previous workbook, there is also a components workbook linked to the Entrance Spreadsheet allowing the creation of titles, dollar exchange rate and basic general data changes on the pre-fabricated components spreadsheets of the construction.

Truss Spreadsheets

We have three types of truss inputs:

1 timber members
2 fixing elements (glue and nails)
3 assembly in man hours

This information facilitates the quick evaluation and quality control of components.

Components Workbook
Frame Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology: Wattle and Daub-Timber	Project:	Prototype
CENDEP	Date: October. 1994	US Dollar:	1.950,00

Frame C (70x100 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Elements	4x8x100	u	2,00	650,00	0,33	1.300,00	0,67		
	Elements	4x8x120	u	2,00	780,00	0,40	1.560,00	0,80		
	Plank	4x8x70	u	2,00	455,00	0,23	910,00	0,47		
	Sub-total:								3.770,00	
	Others:									
	Nails	1 1/2"	Kg	0,15	1.600,00	0,82	240,00	0,12		
	Wood glue		lt	0,15	3.000,00	1,54	450,00	0,23		
	Sub-total:								690,00	
	Assembling									
	Man Hours		hs	3,00	1.750,00	0,90	5.250,00	2,69		
	Sub-total:								5.250,00	
	Shell Sucres:			Total US. Dollars:					4,98	
	Finishes Sucres:			Total Sucres:					9.710,00	

Figure 24

Frames Spreadsheet

As well as the truss, we have three types of frame inputs:

1 timber members
2 fixing elements (glue and nails)
3 assembly in man hours

As well as the previous components the spreadsheet totals are directly linked to the Main Workbook and therefore to the statistical graphs.

Electronically-linked Totals Spreadsheet

The total spreadsheet receive the information from the entire system automatically and send it to the Statistics Workbook to create the final comparative statistical graphs.

B Statistical System

Conventional budgeting systems normally output a total cost saving, but the disadvantage is that it is very labour intensive to then identify which areas or components most significantly affect the total costs. The unique innovation of this system is that it illustrates the proportional values of all the components in figures, pie charts and bar graphs. The use of graphical representation accelerates the comparison and evaluation processes.

All the output information from the *Main Workbook* and the *Components Workbook* is summarised in the totals spreadsheet,

The totals information is linked and assembled to produce six simple statistical graphs in *Statistics Workbook* which facilitates a quick understanding of the information.

This process facilitates a quick evaluation of the situation and, what is more important, it will allow us to apply corrective measures to the whole system.

The information is provided through six spreadsheets-charts with the entire information in local currency (Sucres, Ecuadorian Currency in this particular example) and US Dollars, also in pay and column charts.

43	The output cells has a single outline
60	The input cells has a double outline

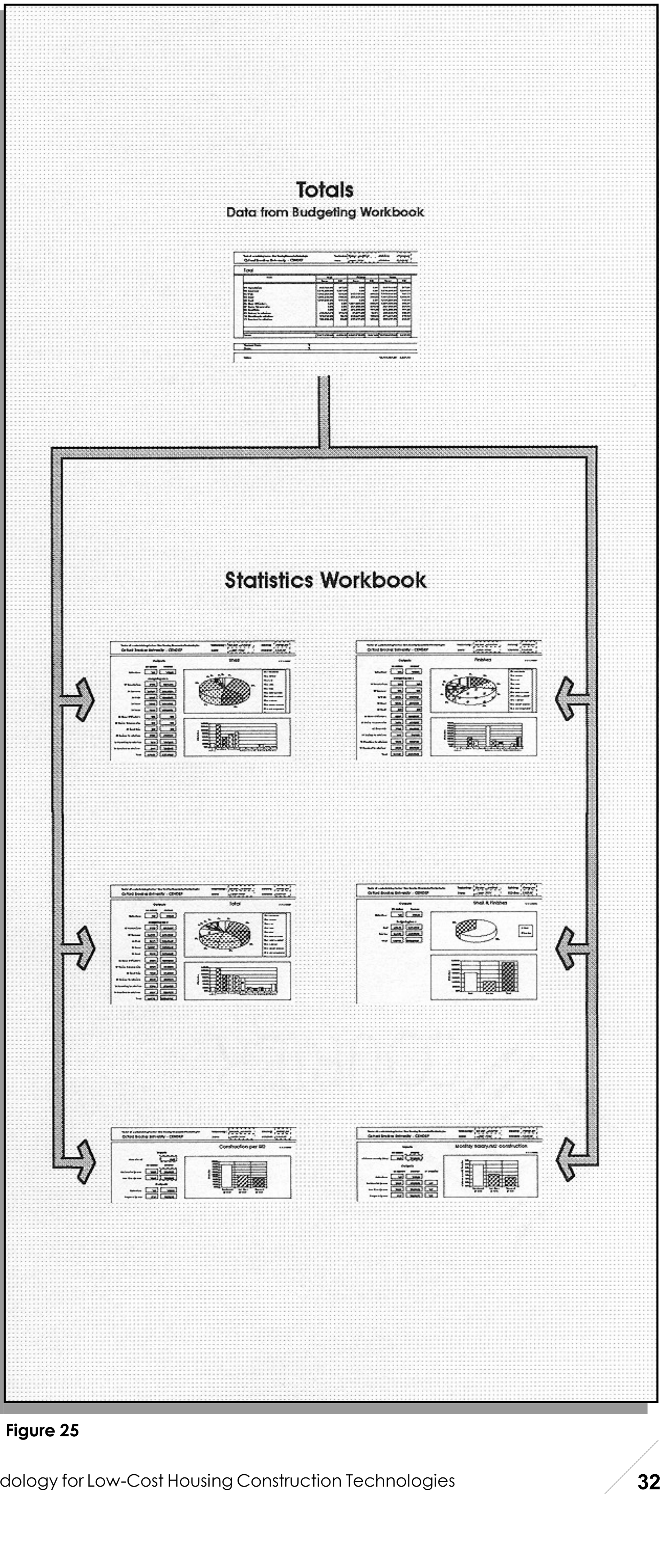


Figure 25

Shell Sheet

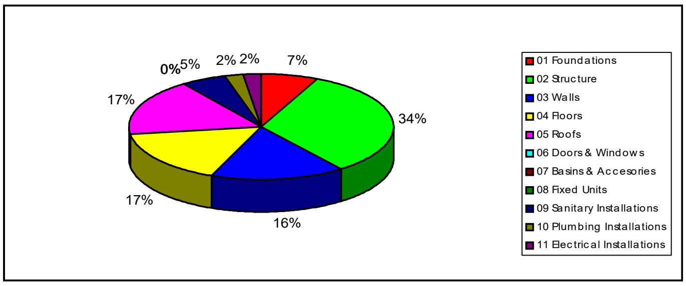
Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology:	Wattle and Daub-Timber	Project:	Prototype
CENDEP	Date:	*October. 1994*	US Dollar:	*1.950,00*

Outputs

Shell

© C. Guerrero

	US dollars	Sucres
Dollar Rate	1,00	1.950,00
Budgeting Items		
01 Foundations	260,03	507.053,52
02 Structure	1.241,87	2.421.640,00
03 Walls	621,54	1.212.010,40
04 Floors	632,61	1.233.596,29
05 Roofs	654,43	1.276.140,00
06 Doors & Windows	0,00	0,00
07 Basins & Accesories	0,00	0,00
08 Fixed Units	0,00	0,00
09 Sanitary Installations	206,66	402.981,70
10 Plumbing Installations	87,49	170.598,00
11 Electrical Installations	80,00	156.006,00
Total	3.784,63	7.380.025,91



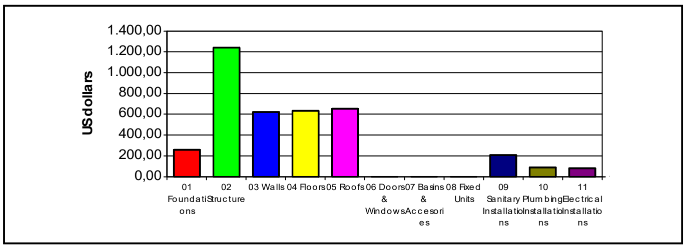


Figure 26

Graph illustrating Shell

It is possible to obtain a variety of total cost-savings with appropriate construction technologies using different local materials. Therefore, in order to maximise the cost saving, this graphical information illustrates the respective costs for each technology, enabling the most valid solution in terms of materials and labour to be identified.

Finishes Sheet

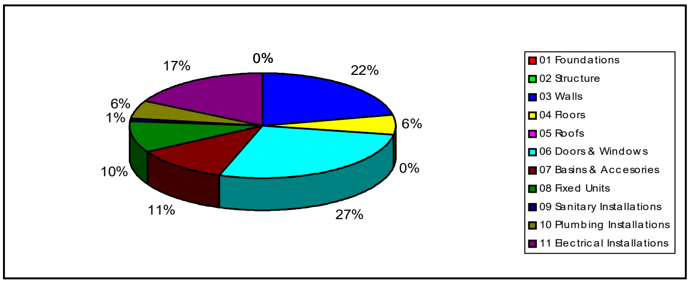
Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology: *Wattle and Daub-Timber*	Project: *Prototype*
CENDEP	Date: *October. 1994*	US Dollar: *1.950,00*

Finishes

© C. Guerrero

Outputs

	US dollars	Sucres
Dollar Rate	1,00	1.950,00
Budgeting Items		
01 Foundations	0,00	0,00
02 Structure	0,00	0,00
03 Walls	451,73	880.867,00
04 Floors	128,60	250.775,64
05 Roofs	0,00	0,00
06 Doors & Windows	580,51	1.132.000,00
07 Basins & Accesories	235,13	458.500,00
08 Fixed Units	207,28	404.200,00
09 Sanitary Installations	14,91	29.079,00
10 Plumbing Installations	120,82	235.601,00
11 Electrical Installations	358,66	699.391,00
Total	2.097,65	4.090.413,64



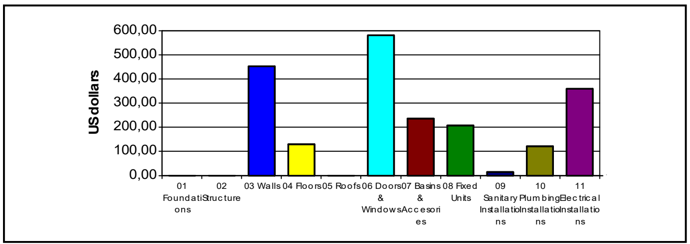


Figure 27

Graph illustrating Finishes

This graph illustrates the proportional costs of each of the finishes. The type and standard of finishes is strongly affects the self-esteem of the inhabitants. This importance implies that an analysis of achieving maximum "image" for minimum cost will significantly improve cost efficiency and user satisfaction. Although the main savings are achieved with respect to the shell, for large scale projects, maximum cost control on the finishes can provide further economies.

Total Sheet

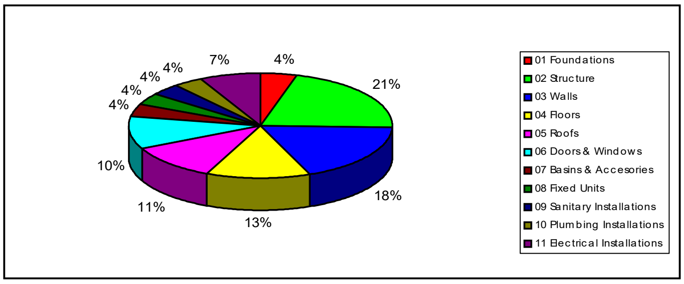
Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology: *Wattle and Daub-Timber*	Project: *Prototype*	
CENDEP	Date: *October. 1994*	US Dollar: *1.950,00*	

Total

© C. Guerrero

Outputs

	US dollars	Sucres
Dollar Rate	1,00	1.950,00
Budgeting Items		
01 Foundations	260,03	507.053,52
02 Structure	1.241,87	2.421.640,00
03 Walls	1.073,27	2.092.877,40
04 Floors	761,22	1.484.371,93
05 Roofs	654,43	1.276.140,00
06 Doors & Windows	580,51	1.132.000,00
07 Basins & Accesories	235,13	458.500,00
08 Fixed Units	207,28	404.200,00
09 Sanitary Installations	221,57	432.060,70
10 Plumbing Installations	208,31	406.199,00
11 Electrical Installations	438,67	855.397,00
Total	5.882,28	11.470.439,55



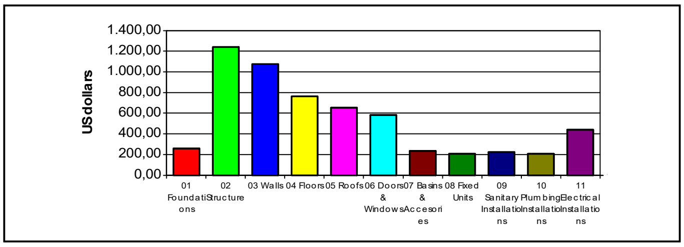


Figure 28

Graph illustrating Totals

The totals graph illustrates the different construction item enables a comparison between them. This section is particularly useful allowing a global costs approach by construction stage and comparing the viability of other constructive systems for the same architectural design.

Shell & Finishes Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies		Technology:	*Wattle and Daub-Timber*	Project:	*Prototype*
CENDEP		Date:	*October. 1994*	US Dollar:	*1.950,00*

Outputs

	US dollars	Sucres
Dollar Rate	1,00	1.950,00
Budgeting Items		
Shell	3.784,63	7.380.025,91
Finishes	2.097,65	4.090.413,64
Total	5.882,28	11.470.439,55

Shell & Finishes

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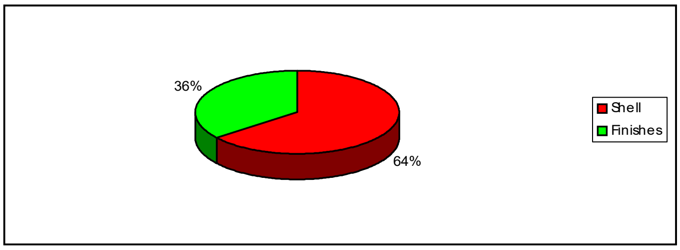

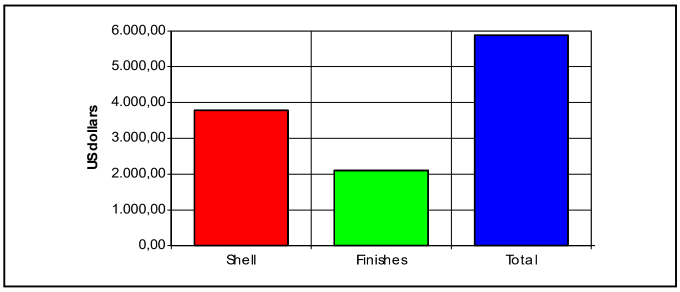

Figure 29

Graph Illustrating Relationship of Shell to Finishes

Using this graph we can compare the relationship between Shell and Finishes and identify the respective investments in each.

As a rule of thumb, for a construction cost of 1.5 minimum monthly salaries per m2 (see Graph illustrating Relationship of Construction Cost per m2 to Minimum Monthly Income, p. 35), the proportional costs Shell:Finishes are approximately 60:40.

Construction per M2 Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology:	*Wattle and Daub-Timber*	Project:	*Prototype*
CENDEP	Date:	*October. 1994*	US Dollar:	*1.950,00*

Construction per M2

© C. Guerrero

Inputs

	US dollars	Sucres
House in M2		71,00
Residential Systems	180,51	352.000,00
Low Cost Systems	100,00	195.000,00

Outputs

Dollar Rate	1,00	1.950,00
Proposed System	82,85	161.555,49

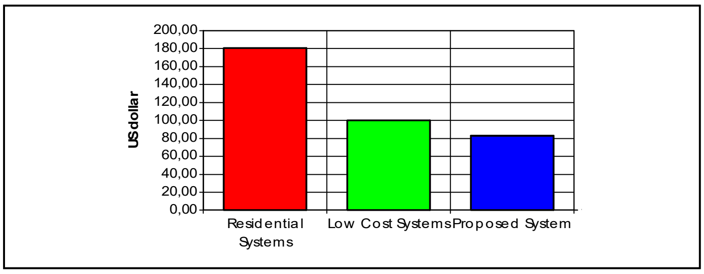

Figure 30

Graph illustrating Cost per M2 of Construction

Using this graph we can evaluate the system's validity in relation to other residential construction systems which use conventional materials such as concrete, block and brick and compare them to alternative low-cost construction systems used in the region.

Monthly Salary / M2 Construction Sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology:	*Wattle and Daub-Timber*	Project:	*Prototype*
CENDEP	Date:	*October. 1994*	US Dollar:	*1.950,00*

Inputs

	US dollars	Sucres
Minimum Monthly Salary	60,00	117.000,00

Outputs

	US dollars	Sucres	N° Salaries
Dollar Rate	1,00	1.950,00	
Residential Systems	180,51	352.000,00	3,01
Low Cost Systems	100,00	195.000,00	1,67
Proposed System	82,85	161.555,49	1,38

Monthly Salary/M2 construction

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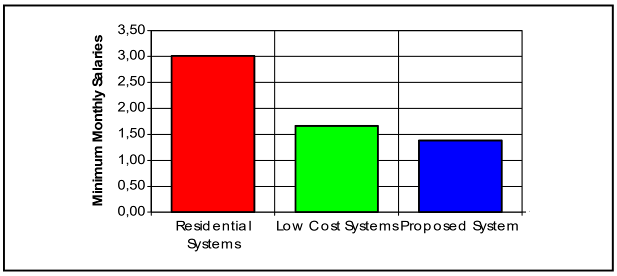
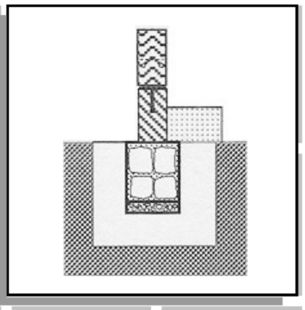
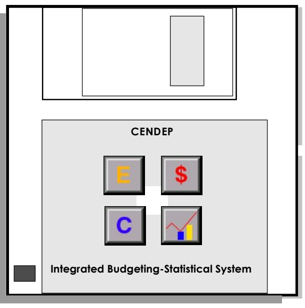


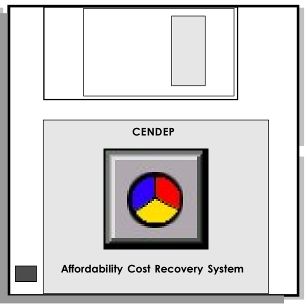
Figure 31

Graph illustrating Relationship of the Cost per m2 of Construction to Minimum Monthly Income Graph

This graph illustrates the ultimate evaluation criteria for any construction system. Conventionally low-income housing cost has been related to parameters such as the cost of a bag of cement or the cost in US$. These parameters do not take into consideration the cost of living in the respective country, which is why this system refers cost to the parameter of minimum monthly salary. If a square metre of construction can be built for less than two minimum monthly salaries, then the system is suitable for population with between 1.5 - 3 mms, if it is less, so much the better.







4

Trade-off Technologies

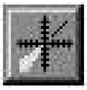
The information provided from the last chapter *statistical-budgeting System* is summarised in cost per metre square per technology.

In this chapter we show its application in financial terms to the income levels of the community, interest rate on loan, years of payments and monthly payments.

The reference data used in this chapter has been taken from the project "Programa de vivienda para el sur de Machala, Ecuador 1993"

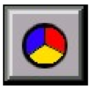
	Sucres	US Dollar
Dollar rate at June 1993	1,950.oo	1.oo
Minimum monthly income salary	117,000.oo	60.oo
Total cost of house	11,470,439.oo	5,882.28
House floor area:		71.oo m2
Total families involved in the project		250

Two applications are proposed:
1 Graphical Variable Correlations
2 Trade-off Technologies for affordability and cost recovery Software



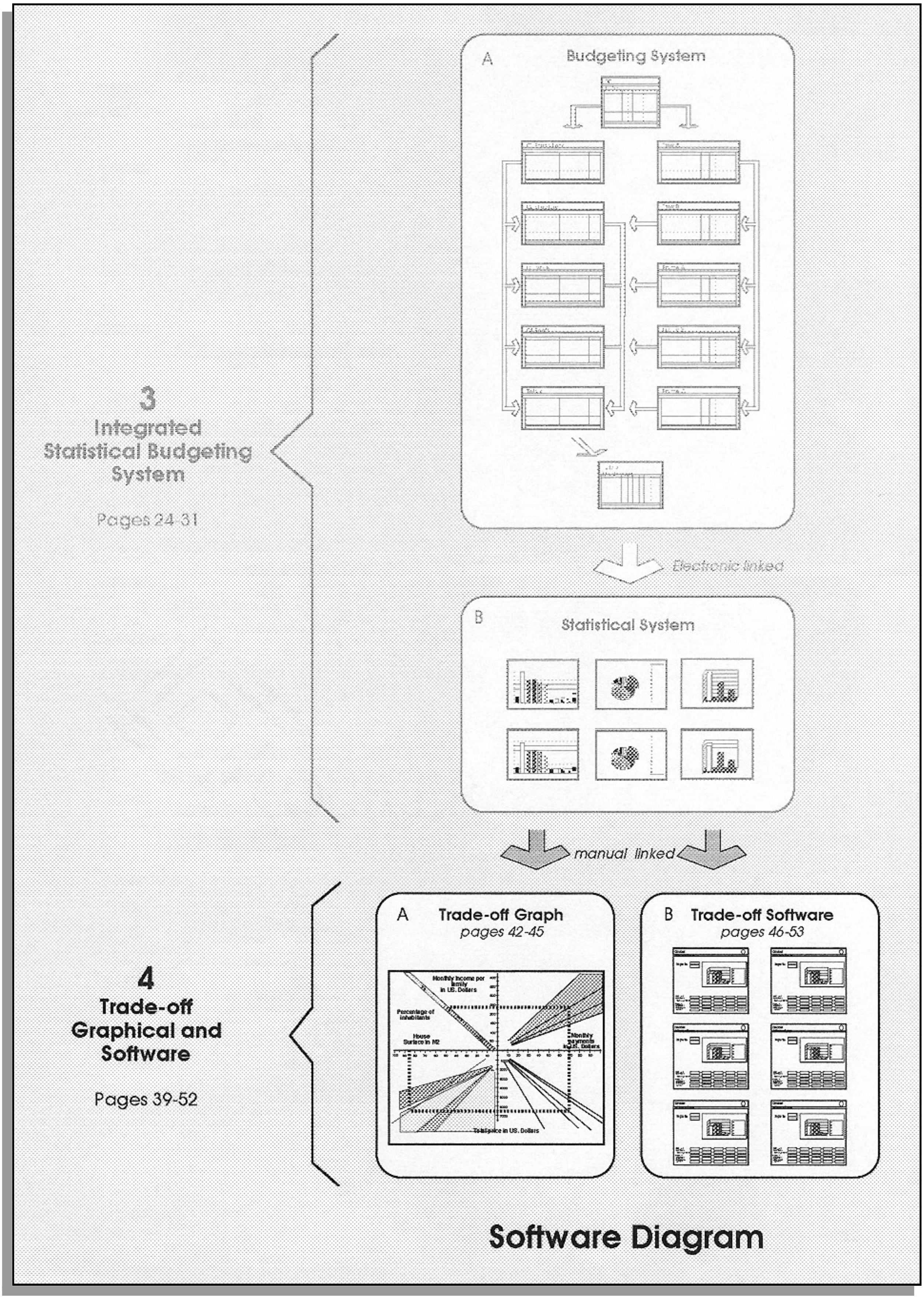
Graphical Variable Correlations

Correlations between technological alternatives, affordability, cost recovery and income categories provide a graphical method.
This graph provides the flexibility of starting from any entry or variable.
The entries are represented on **"X"** and **"y"** axes, the variables are represented on converging axes.
For the graphical representation (charts) the software is based on Claris Cad® version 2.02 and for the animation on Microsoft Power Point 3.0.



Trade-off Software

This is a software with five spreadsheets-Charts. They are interlinked with two input spreadsheets. This software uses the same information as the graphical variable correlations but provides the exact output figures for each input.



3
Integrated
Statistical Budgeting
System
Pages 24-31
A
Budgeting System
Electronic linked
B
Statistical System
manual linked
4
Trade-off
Graphical and
Software
Pages 39-52
A
Trade-off Graph
pages 42-45
Monthly income per family in US. Dollars
Percentage of inhabitants
House Surface in M2
Monthly payments in US. Dollars
Total price in US. Dollars
B
Trade-off Software
pages 46-53
Software Diagram

Figure 32

A Graphical Variable Correlations

Technological alternatives

This graph enables the user to determine the maximum area of construction available total for a set house cost in accordance with the different technological possibilities available.
The graph as well as the computerized system can be read by both entries.

Entries
Y axis: M2 of construction
X axis: Dwelling cost

Variables

- *Low-cost systems using local materials (timber, earth, bamboo)*
  We have two options: pure self-help (costs without labour) and costs including labour.
- *Low cost systems (brick, concrete)*
  Low cost systems using conventional materials and minimal finishes
- *Residential systems*
  Systems using conventional materials/processes and medium to high quality finishes.

Affordability

This graph helps determine the total dwelling cost/monthly payments in relationship with time and tale of interest on the loan.
The graph as well as the computerized system can be read by both sides.
Entries

Technological alternatives graph

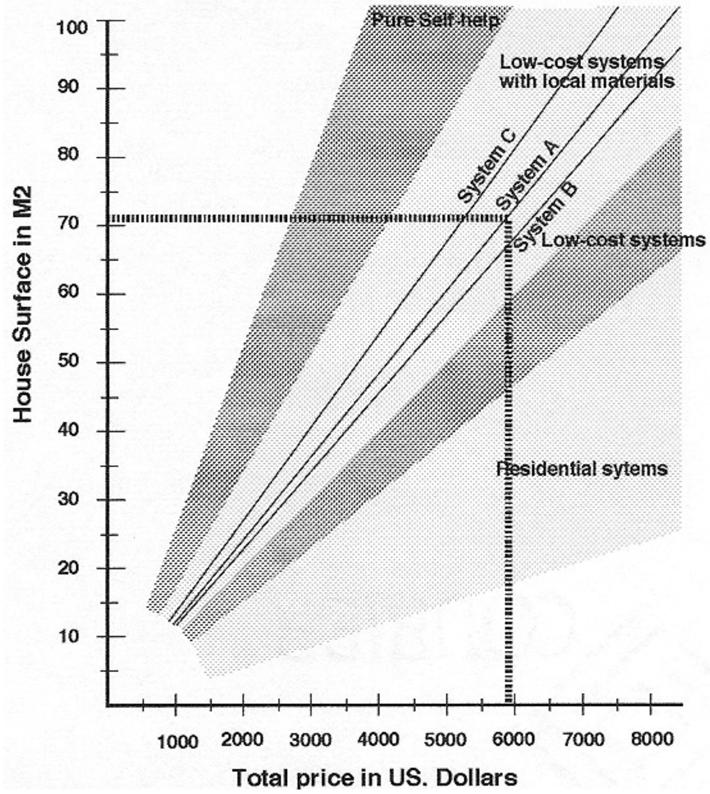


Figure 33

Affordability graph

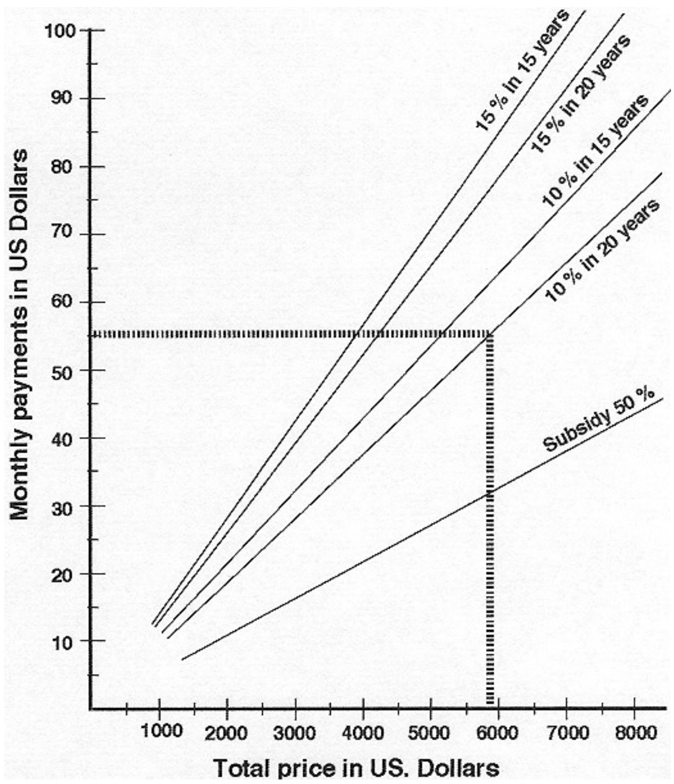


Figure 34

X axis: Total Dwelling cost
Y axis: Monthly payments

Variables
- *Subsidy*
  50%, 100%, 200%
- *Affordability*
  10% interest over 10 years
  10% interest over 15 years
  15% interest over 10 years
  15% interest over 10 years

Cost recovery

Using this graph, the monthly income per family in relation to the different monthly payment percentages can be determined. The graph as well as the computerized system can be read by both sides.

Entries
Y axis: Monthly payments
X axis: Monthly income per family

Variables
20% of the income
30% of the income
40% of the income
50% of the income

Income categories

This graph illustrates the percentage of the population in relation to the minimum monthly income.

Total graphical representation

The four components are assembled on one graph. This graph shows the correlation between the technological alternatives, affordability, cost recovery and income categories.
The example used in this graph is taken from the Ecuadorian context. The dotted line along the graph corresponds to pro-

Cost recovery graph

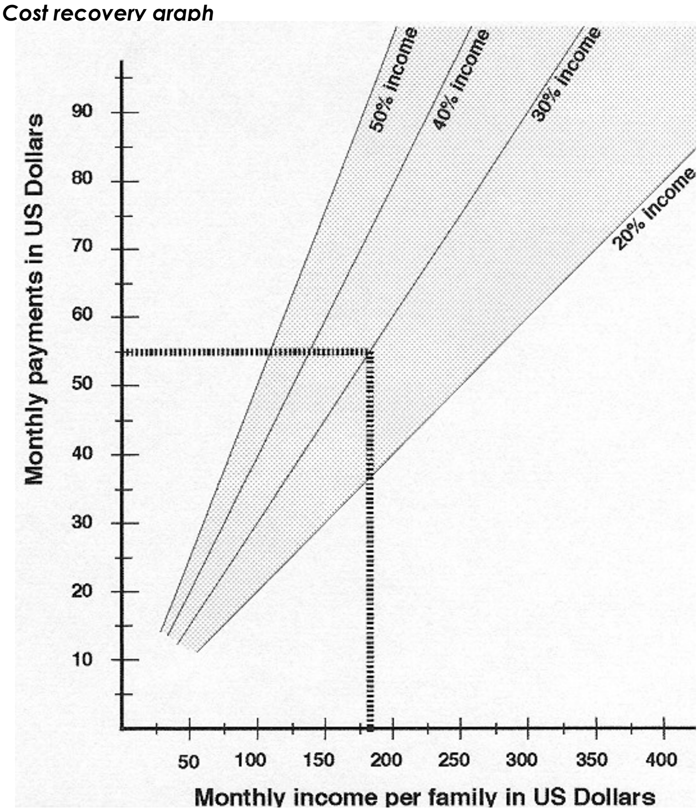


Figure 35

Income categories graph

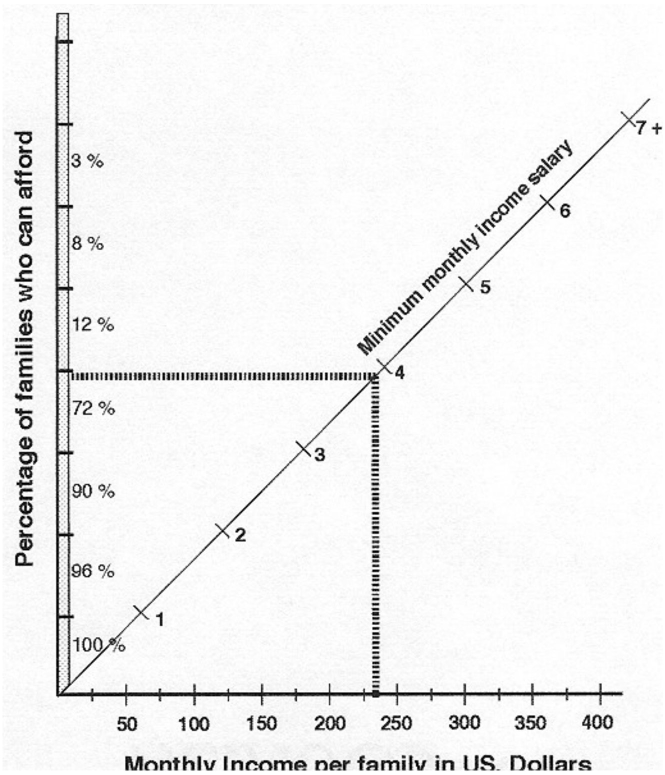


Figure 36

posal Reference Low-Cost Housing Design. (pages 5-9)

The dwelling analysed has a total constructed floor area of 71 m2. With the A constructive system proposed. (pages 10-15)

The total price is 5,882 US dollars. (pages 24-31)

We have chosen a credit system at 10% interest over a 20 year period, this category of affordability can be obtained at a monthly payment of 56 US dollars.

At $56 per month payment, for a requirement of 30% of the total monthly income per family a minimum income of $185 dollars per month is required. Equivalent to 4 minimum monthly salaries as demonstrated in the graph.

Following the dotted line further it shows that the population that can afford this proposal is 72 percent.

This system can be adapted to any geographical and economical context by altering the inputs and variables.

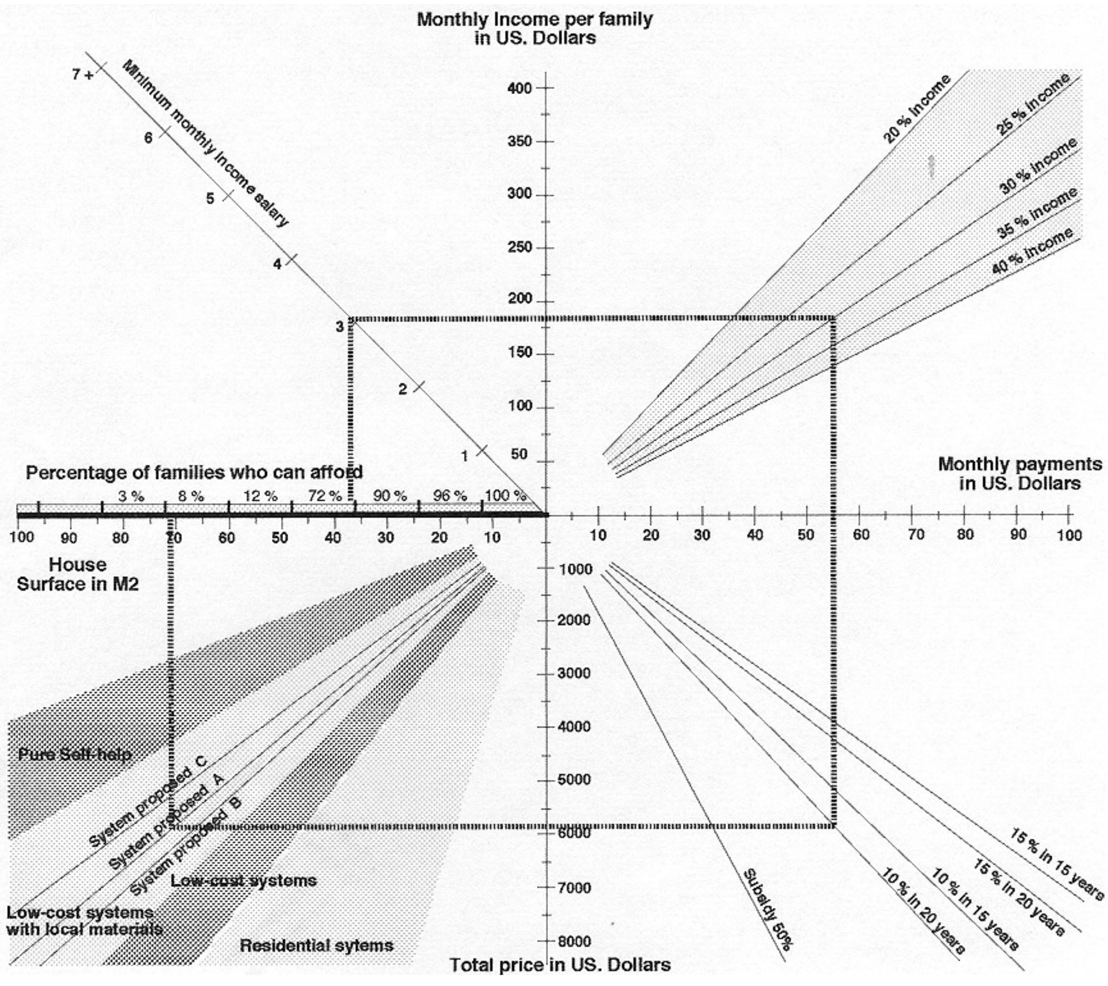


Figure 37

NOTE

1 In this example the variables used for affordability, cost recovery and income categories are to demonstrate how the model works. In the next part of this dissertation I will obtain more precise figures and will test the system with real information.

2 To create part of this graph, the structure has been taken from "Monographie de projet D'Addis Abeba á Nazareth, Un programme d'habitat à coût modéré, Septembre 1987" GRET Groupe des Recherches et d'Echanges Technologiques."

B Trade-off Software

The software is based on Microsoft EXCEL versions 4.0 and 5.0 for Macintosh and IBM compatible systems .

The main structure is composed of seven interlinked spreadsheet charts. The first two sheets receive inputs and the other five produce outputs.

Inputs Spreadsheet Charts

01 Inputs
02 Inputs

Outputs Spreadsheet Charts

03 House floor area
04 House floor area with subsidy
05 House total price
06 Monthly payments
07 Family income

In this particular example the information is provided in US Dollars, but it is possible to use any type of currency.

Each Spreadsheet chart has the project title and date at the top, and has a graphical representation of the most important information.

60 — The input cells have a double outline

43 — The output cells have a single outline

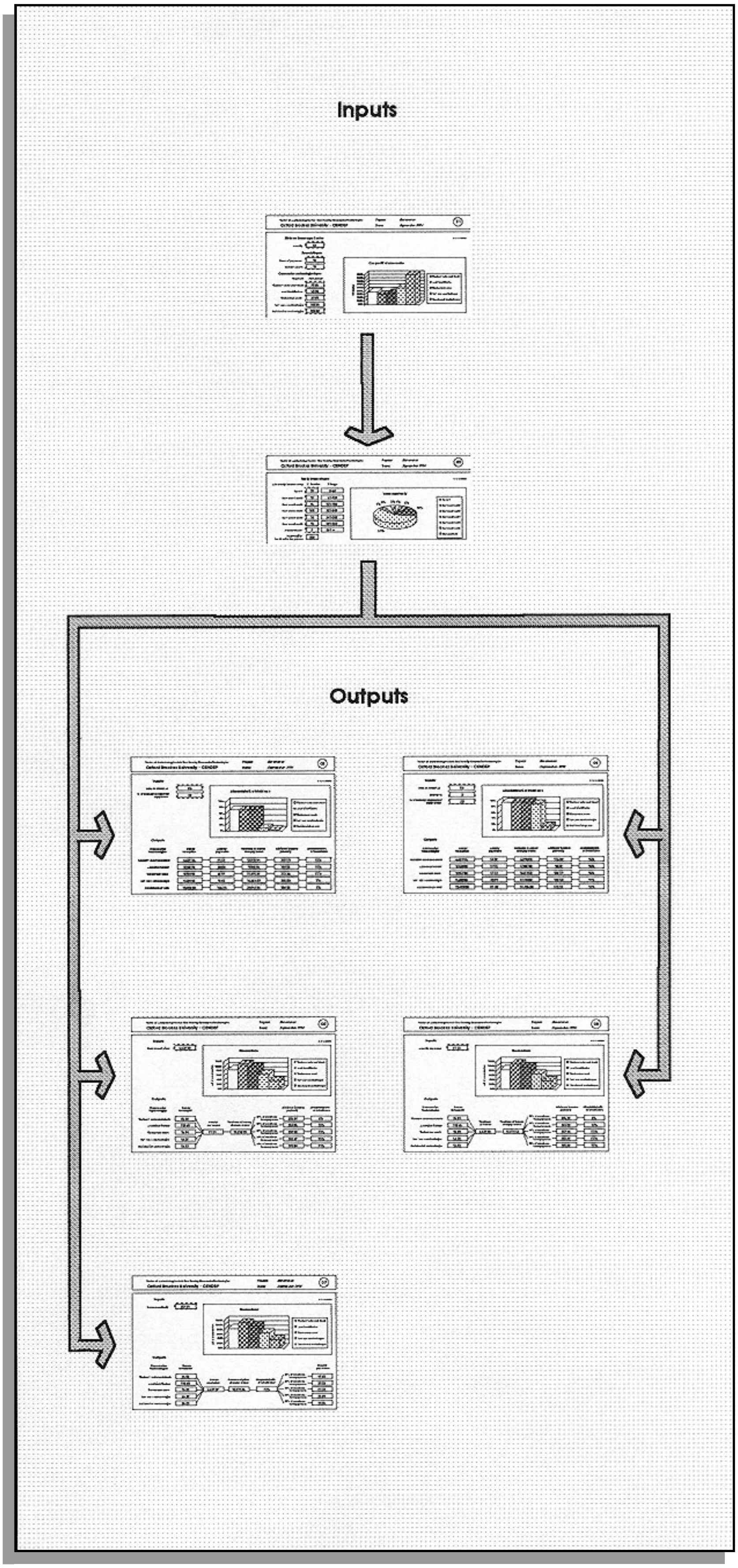


Figure 38

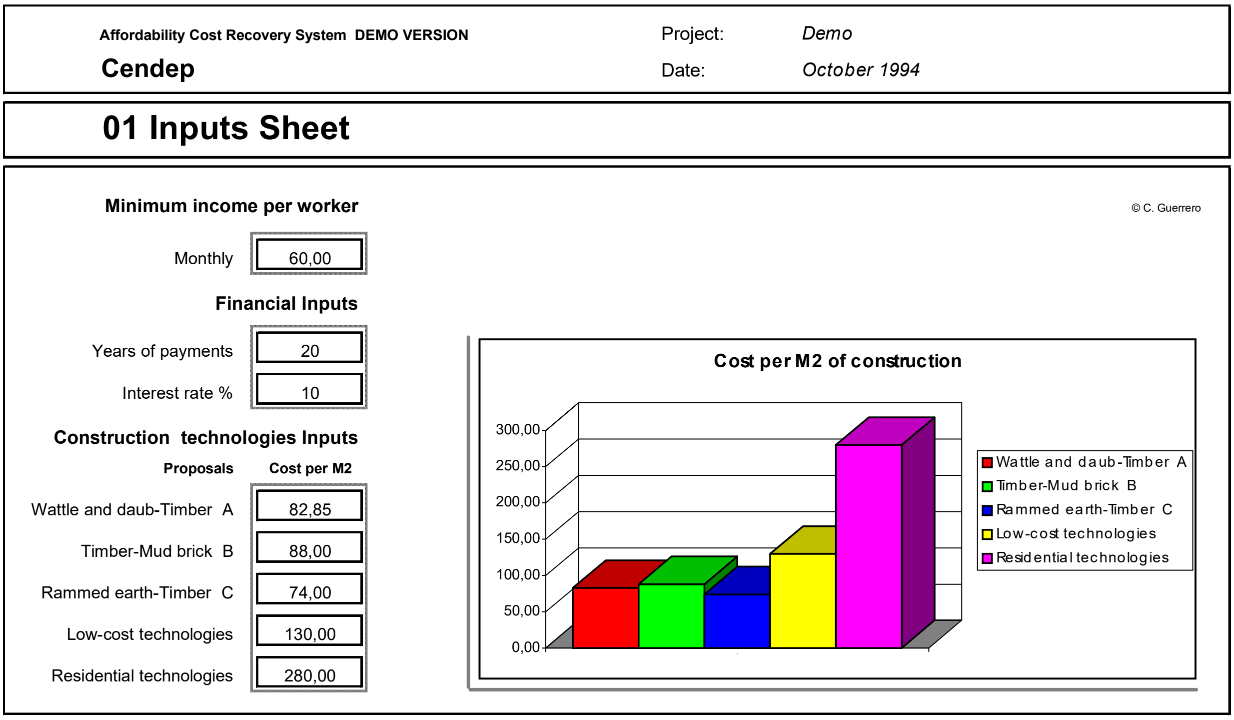


Figure 39

01 Inputs

This Spreadsheet-chart is the key to the system. The text can be changed, for example to translate the terms or to use different construction technology proposals. The changes are altered automatically on all the other sheets, as are the figures in the cells.

Minimum Monthly Income per worker

In the first cell we input the minimum monthly income per worker as given by the respective government. If this is not available we assume a value.

Financial Inputs

The criteria for the years of payments and interest per year is provided by the financial institution involved in the programme or project.

Construction Technology Inputs

In this particular example the first three cells use the information provided from *Statistical -Budgeting* chapter. The Low Cost Technologies and Residential Technologies figures are provided from local construction institutions.

Affordability Cost Recovery System DEMO VERSION

Cendep

Project: *Demo*

Date: *October 1994*

02 Inputs Sheet

Family income inputs

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Min. monthly income salary	N° Families	$ Range
Up to 1	10	-60,00
Between 1 and 2	13	61,00-120,00
Between 2 and 3	46	121,00-180,00
Between 3 and 4	150	181,00-240,00
Between 4 and 5	10	241,00-300,00
Between 5 and 6	13	301,00-360,00
Greater than 6	8	361,00 +
Total families involved in the project	250	

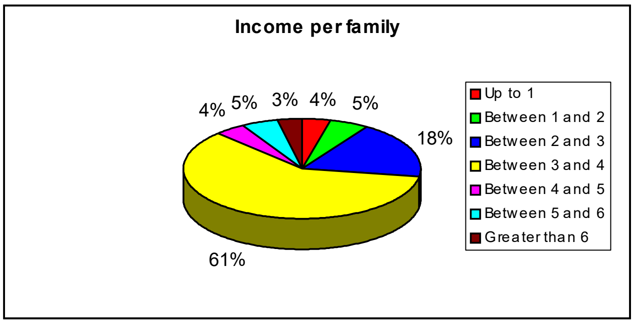


Figure 40

02 Input

This information is required to evaluate (in the following sheets) the affordability of the construction technologies for different income levels.
A survey should be taken to determine the number of families in each income range.

Family Income Inputs

We input the number of families according to income ranges. The income ranges (right-hand cells) change automatically if the minimum monthly income per worker input is changed on the 01 Inputs sheet.

Affordability Cost Recovery System DEMO VERSION

Cendep

Project: *Demo*

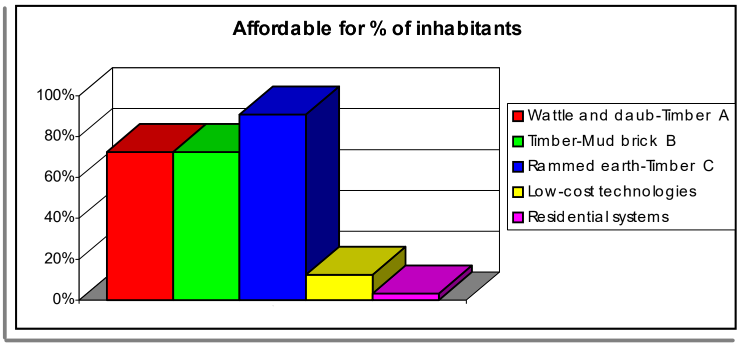
Date: *October 1994*

03 House Floor Area Sheet

Inputs

© C. Guerrero

House floor area M2	71
% of monthly income for repayments	30



Outputs

Construction Technologies	House Total price	Monthly payments	Total cost of house	Minimum income	Affordable for % of inhabitants
Wattle and daub-Timber A	5.882,35	56,77	13.623,83	189,22	72%
Timber-Mud brick B	6.248,00	60,29	14.470,69	200,98	72%
Rammed earth-Timber C	5.254,00	50,70	12.168,54	169,01	91%
Low-cost technologies	9.230,00	89,07	21.377,16	296,90	12%
Residential systems	19.880,00	191,85	46.043,11	639,49	3%

Figure 41

03 House Floor Area Sheet

Inputs

The floor area input in M2 directly affects all the output variables, facilitating the selection of the most convenient technology. The input, percentage of income for monthly repayments is related to total family income per month.

Outputs

This sheet gives the net house costs, monthly payments, the gross house cost (including interest), the minimum income per family required to afford each technology, and the percentage of families from the surveyed group who can afford it.

Affordability Cost Recovery System DEMO VERSION		Project:	*Demo*
Cendep		Date:	*October 1994*

04 House Floor Area With Subsidy Sheet

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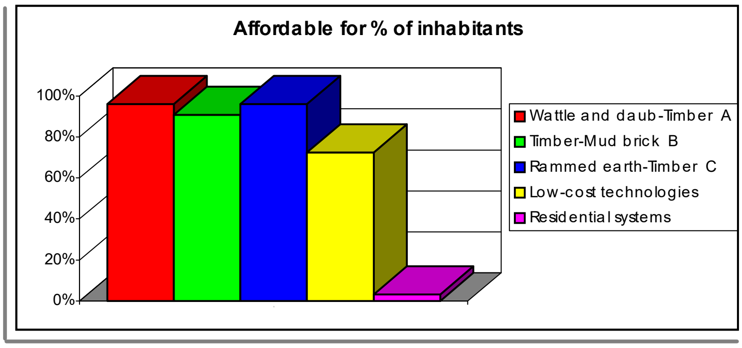
Inputs

House floor area M2	71
Subsidy %	5
% of monthly income for repayments	20



Outputs

Construction Technologies	House Total price	Monthly payments	Total cost of house	Minimum income	Affordable for % of inhabitants
Wattle and daub-Timber A	5.882,35	23,28	5.588,23	116,42	96%
Timber-Mud brick B	6.248,00	24,73	5.935,60	123,66	91%
Rammed earth-Timber C	5.254,00	20,80	4.991,30	103,99	96%
Low-cost technologies	9.230,00	36,54	8.768,50	182,68	72%
Residential systems	19.880,00	78,69	18.886,00	393,46	3%

Figure 42

04 House Floor Area With Subsidy Sheet

This sheet has the same functions as the House Floor Area Sheet except that it uses a subsidy rate in lieu of an interest rate (from 01 Input sheet).

Affordability Cost Recovery System DEMO VERSION

Cendep

Project: *Demo*

Date: *October 1994*

05 House Total Price Sheet

Inputs

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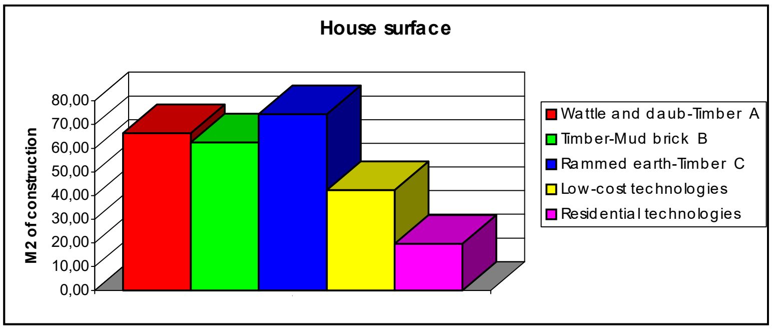
House total price: 5.500,00



Outputs

Construction Technologies	House Surface M2	Monthly payments	Total cost of house after payments	% of menth. inc. for repayments	Minimum income per family	Affordable for % of inhabitants
Wattle and daub-Timber A	66,39			20%	265,38	12%
Timber-Mud brick B	62,50			25%	212,30	72%
Rammed earth-Timber C	74,32	53,08	12.738,29	30%	176,92	91%
Low-cost technologies	42,31			35%	151,65	91%
Residential technologies	19,64			40%	132,69	91%

Figure 43

05 House Cost Sheet

The information provided on the first two sheets (01 Input and 02 Input), together with the new input on this sheet (total house cost) produces further detailed outputs and a chart.

Inputs

The input of the total house cost directly affects all the output variables, facilitating the selection of the most convenient technology.

Outputs

This sheet gives, for a specified total house cost, the variable floor areas achievable for each technology, together with the respective monthly payments, and the gross cost of the house (including interest) for each. This sheet also outputs, the minimum monthly income per family required to pay off this cost and the percentage of families from the surveyed group who can afford this cost. These values vary according to the percentage of family income dedicated to repayments .

Affordability Cost Recovery System DEMO VERSION

Cendep

Project: *Demo*

Date: *October 1994*

06 Monthly Payments Sheet

Inputs

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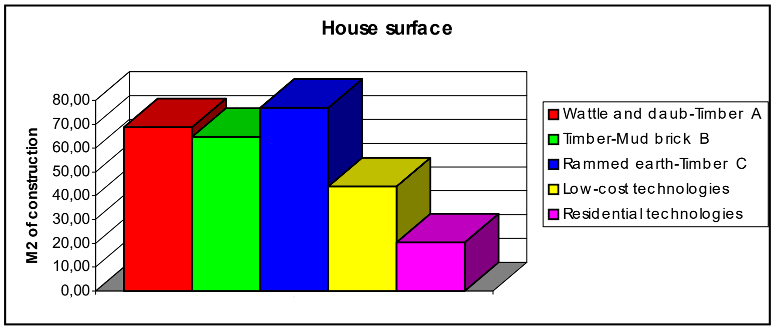
Monthly payments: 55,00



Outputs

Construction Technologies	House Surface M2	Total cost of house	Total cost of house	% of menth. inc. for repayments	Minimum income	Affordable for %
Wattle and daub-Timber A	68,79			20,00	275,00	12%
Timber-Mud brick B	64,77			25,00	220,00	72%
Rammed earth-Timber C	77,02	5.699,35	13.200,00	30,00	183,33	72%
Low-cost technologies	43,84			35,00	157,14	91%
Residential technologies	20,35			40,00	137,50	91%

Figure 44

06 Monthly Payments Sheet

The information provided on the first two sheets (01 Input and 02 Input), together with the new input on this sheet (Monthly Payments Sheet) produces further detailed outputs and a chart.

Inputs

The input, Monthly Payments affects directly all the output variables, facilitating the selection of the most convenient technology.

Outputs

This sheet gives, for a specific monthly payment, the variable floor areas achievable for each technology, the net house cost, the gross house cost (including interest), the minimum monthly income per family required to pay off this cost and the percentage of families from the surveyed group who can afford this cost. These values vary according to the percentage of family income dedicated to repayments .

Affordability Cost Recovery System DEMO VERSION

Cendep

Project: *Demo*

Date: *October 1994*

07 Income Per Family Sheet

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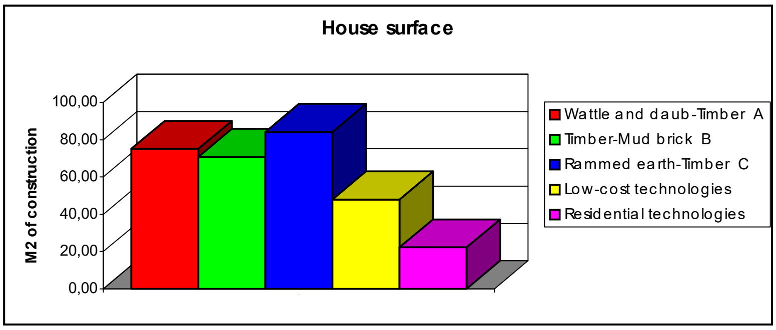
Inputs

Income per family: 200,00



Outputs

Construction Technologies	House Surface M2
Wattle and daub-Timber A	75,04
Timber-Mud brick B	70,65
Rammed earth-Timber C	84,02
Low-cost technologies	47,83
Residential technologies	22,21

House total price	House total price after payments	Affordable for %
6.217,48	14.400,00	72%

% of menth. inc. for repayments	Monthly payments
20	40,00
25	50,00
30	60,00
35	70,00
40	80,00

Figure 45

07 Income per Family

The information provided on the first two sheets (01 Input and 02 Input), together with the new input on this sheet (Income per Family) produces further detailed outputs and a chart.

Inputs

The input, Income per family affects directly all the output variables, facilitating the selection of the most convenient technology.

Outputs

This sheet gives, for a specific income per family, the variable floor areas achievable for each technology, the net house cost, the gross house cost (including interest), the percentage of families from the surveyed group who can afford this cost and the respective monthly payments. These values vary according to the percentage of family income dedicated to repayments.

Conclusions

Most developing countries have not yet reached the level of specialisation that is found in the industrialised countries of the North, for example Architects usually do their own quantity surveying. Although software quantity-surveying programmes are available for conventional concrete construction in developing countries, computer technology has not been applied to the area of low-cost housing. Ironically, it is precisely the area of low-cost housing that would most benefit from a rigorous cost-benefit analysis.

Although housing institutions in developing countries are beginning to use computers for administrative tasks, nevertheless the whole design process is still carried out manually due to the absence of user-friendly, easily obtainable and affordable software. The methodology proposed in this thesis addresses the deficit of information technology, and the advantages of the proposal are compared with the weakness of the few existing systems.

Disadvantages of the existing systems

- Interminable lists of materials and prices with no clear separations between the constituent parts of low-cost buildings (e.g.. foundations, walls, roofs etc.)
- None of the existing systems incorporate graphical statistical information.
- Little flexibility to incorporate pre-costed self-build prefabricated components
- No flexibility to take account of rapid inflation which affects prices from month to month in some developing countries
- Does not distinguish between shell and finishes
- Systems are only available for conventional concrete or similar "modern" construction methods.
- Usually the systems are based on data base applications which are neither user-friendly nor readily available.
- Great volume of information on Hard Disk
- Very expensive

Advantages of the proposed information technology systems

Integrated Statistical-Budgeting System

- Classification of the building elements with interlinked spreadsheets.
- The incorporation of statistical graphics such as bar charts and pie charts which are easily understood even by people with little training in construction and computer technology.
- The system is structured to incorporate prefabricated elements (in the Components Workbook).
- The system automatically adjusts with respect to interest and exchange rates.
- Developed principally for construction with appropriate technologies.

- This system is based on Excel, one of the most popular computer applications with versions available in IBM-compatible and Macintosh systems with immediate compatibility between the two operative systems.
- Can easily be tailored to the specific requirements of every project and organisation which uses this product.
- Uses minimal space in the Hard Disk (300 K)
- Will be distributed at cost price

Trade-off Software

- Possesses the same advantages as the Integrated Statistical-Budgeting System.
- It is the first software of its type to be developed.
- Enables a real trade-off between different construction systems, incorporating financial and economic information of the sector or country of application.
- Extreme flexibility - can also be applied for high cost projects, be they housing or public buildings.
- Valid for any geographic and economic context.

The three software packages are currently being tested and refined by organisations and technicians who work with low-cost housing, and will thereafter be distributed worldwide.

The next steps will be the incorporation of land and infrastructure costs in the computerised evaluation process, the creation of a more sustainable financial options like a International Guarantee Fund to facilitate the discussion of housing and sustainable economic policies.

Habitat Guides as a next Step

In order to establish a source of information that promotes awareness and understanding of the habitat issues on the world-wide level we recommend the creation of a Internet guide that provides current information on housing, water and sanitation, and low-cost construction technologies throughout the world.

HOME, The Housing guide may offer information about the aspects of housing on five continents.

TECHNO, Techno may offers information about low-cost housing technologies for the construction of habitat throughout the world.

INFO, The world water guide may offers information about the aspects of water throughout the world.

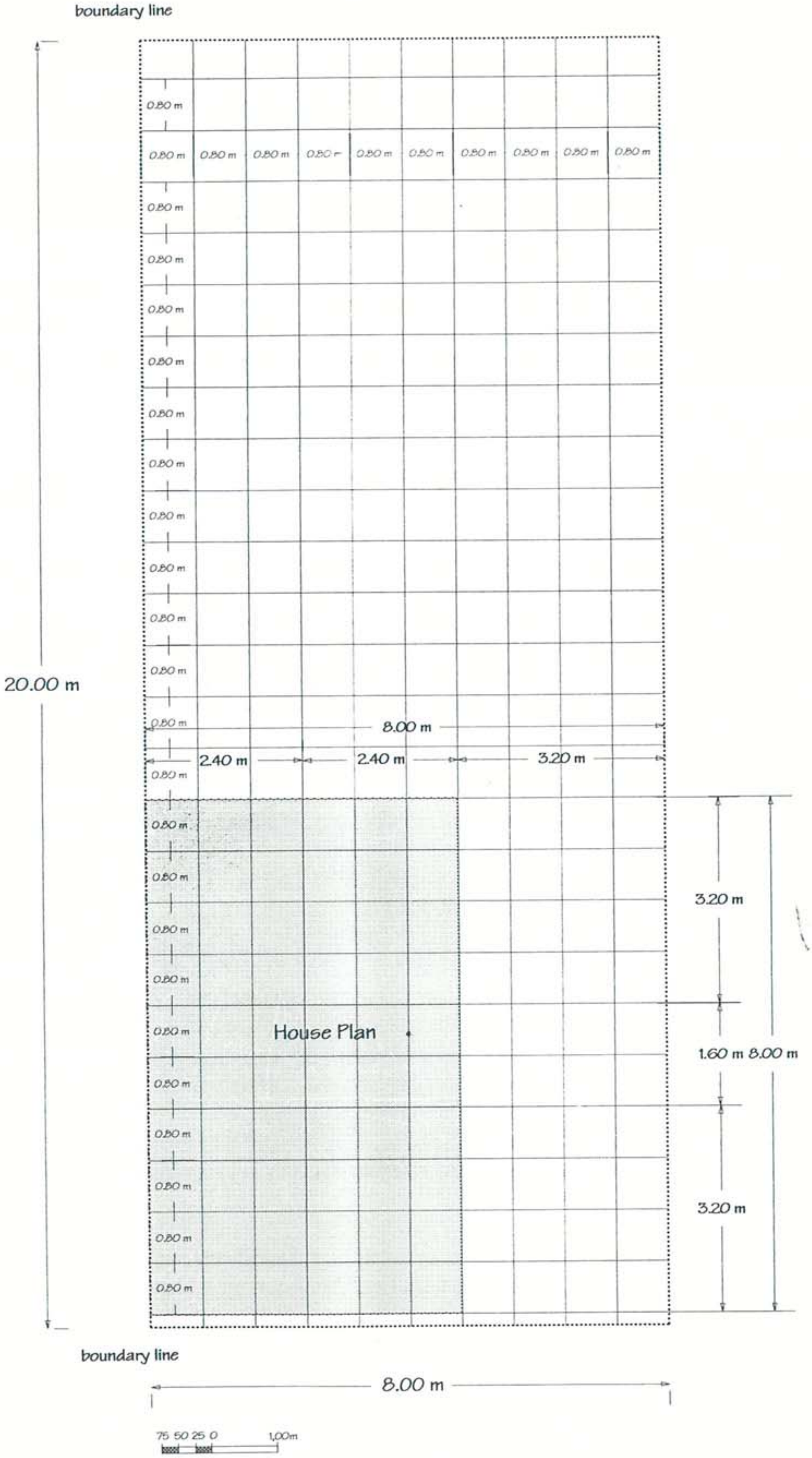
Carlos Guerrero
Oxford, September 1994

Appendix

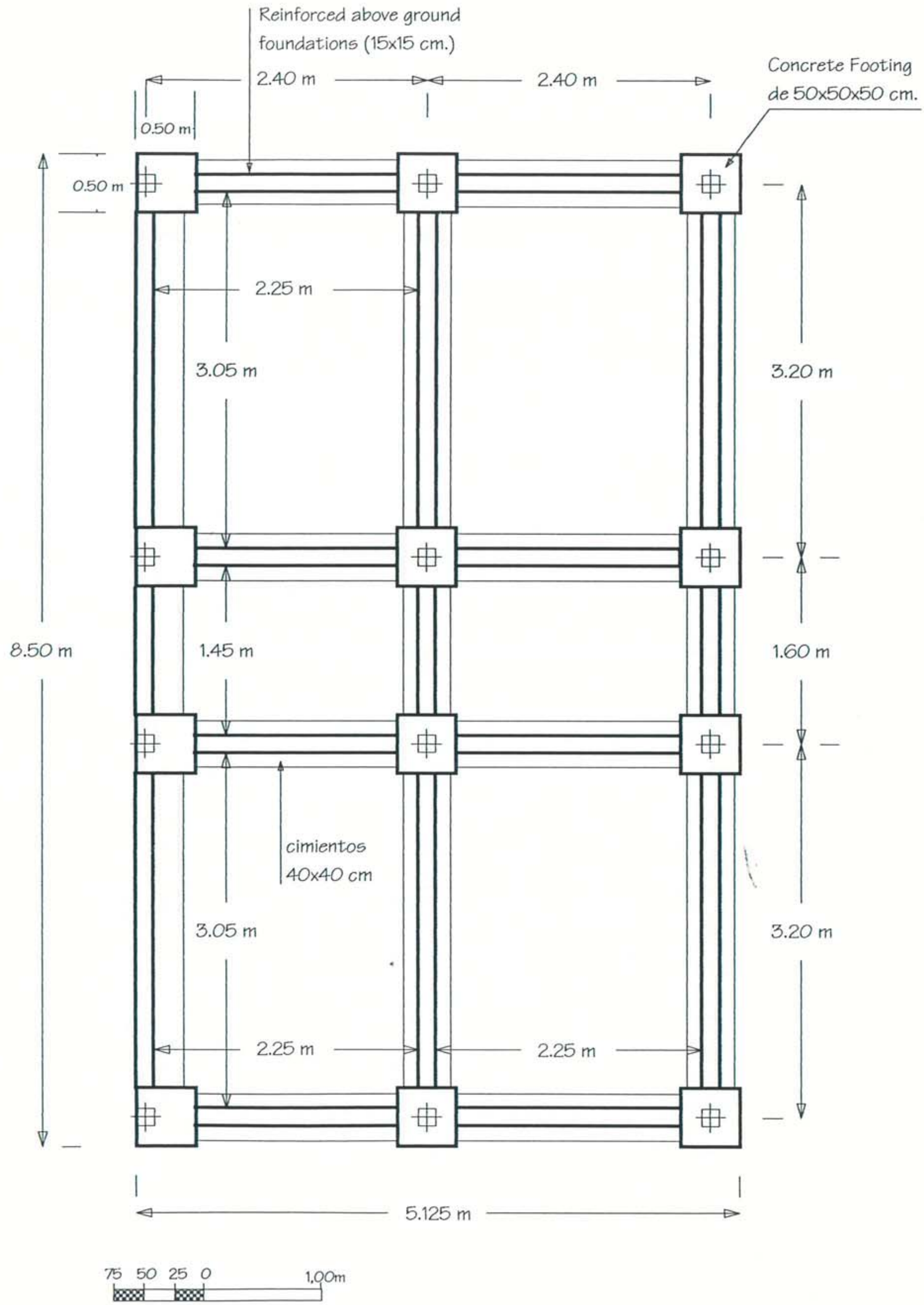
a

Reference Low-Cost Housing Design

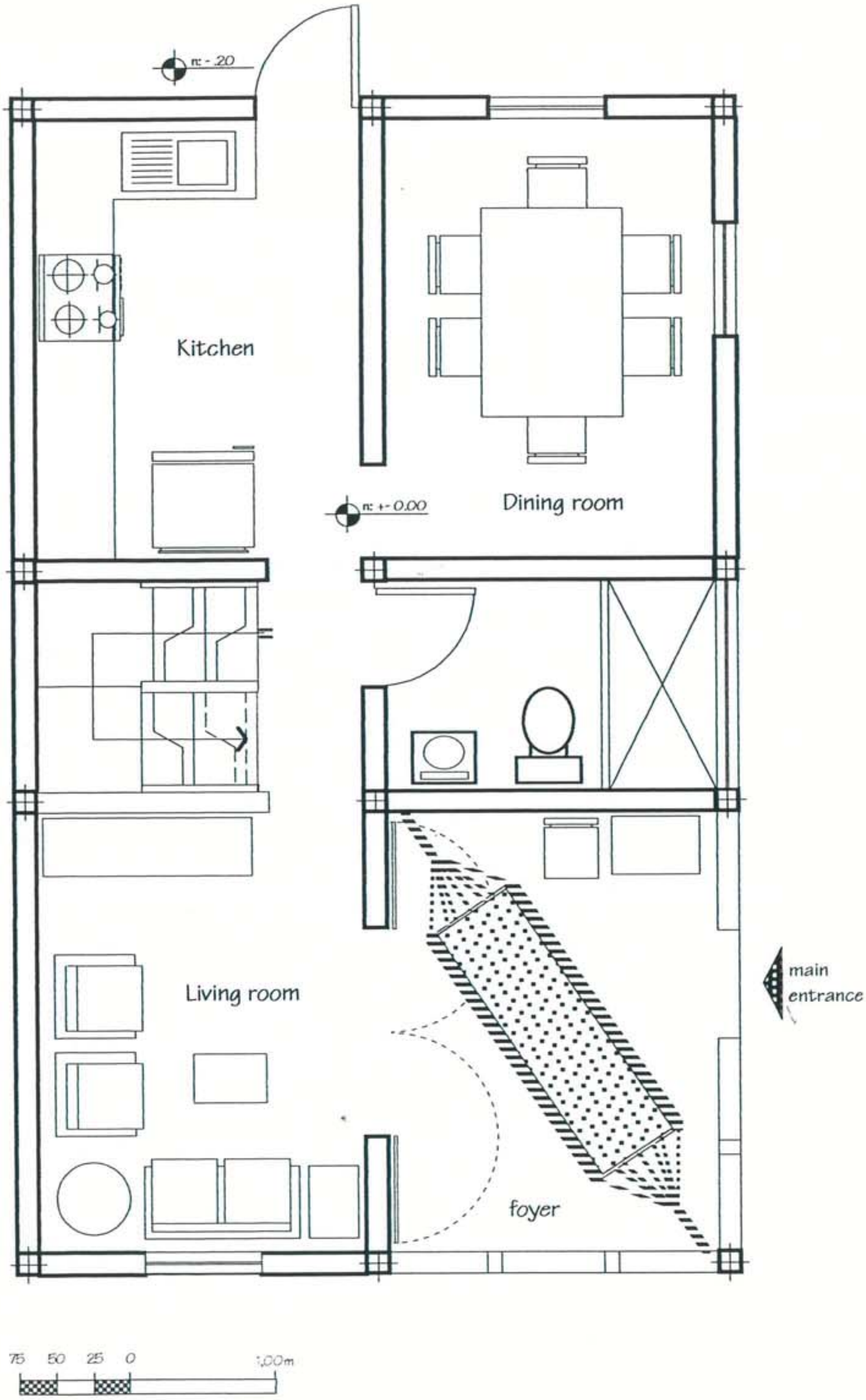
Plot and grid plan
Foundations plan
Layout ground floor plan
Technical ground floor plan
Layout first floor plan
Technical first floor plan
Layout cross section
Technical cross section
Roof structure roof plan
Roof plan
Main elevation plan
Main elevation semidetached plan
Back elevation plan
Back elevation semidetached plan
Right elevation plan
Sanitary installations
Plumbing installations
Electrical installations GF
Electrical Installations FF



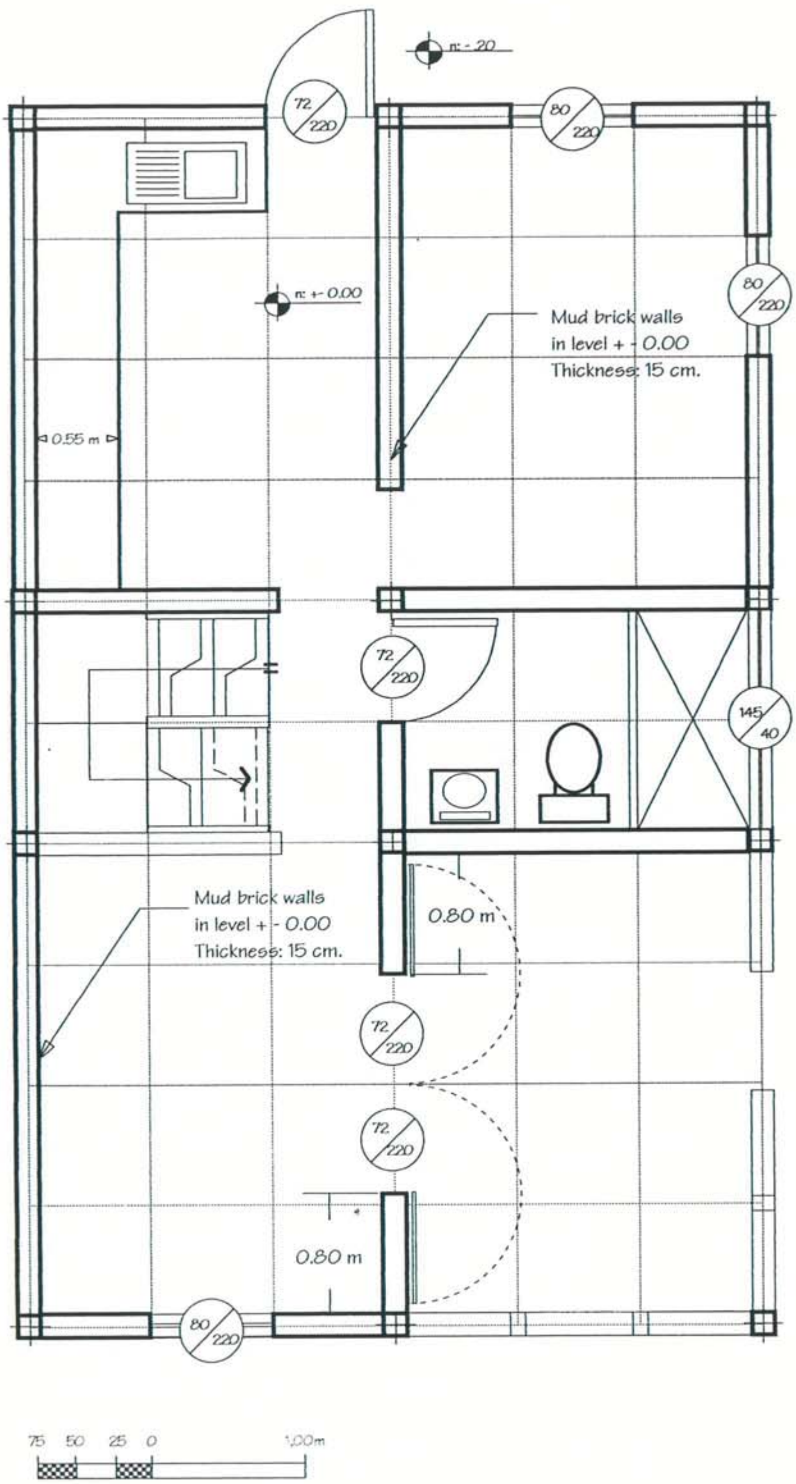
PLOT AND GRID PLAN
Area: 160 m2



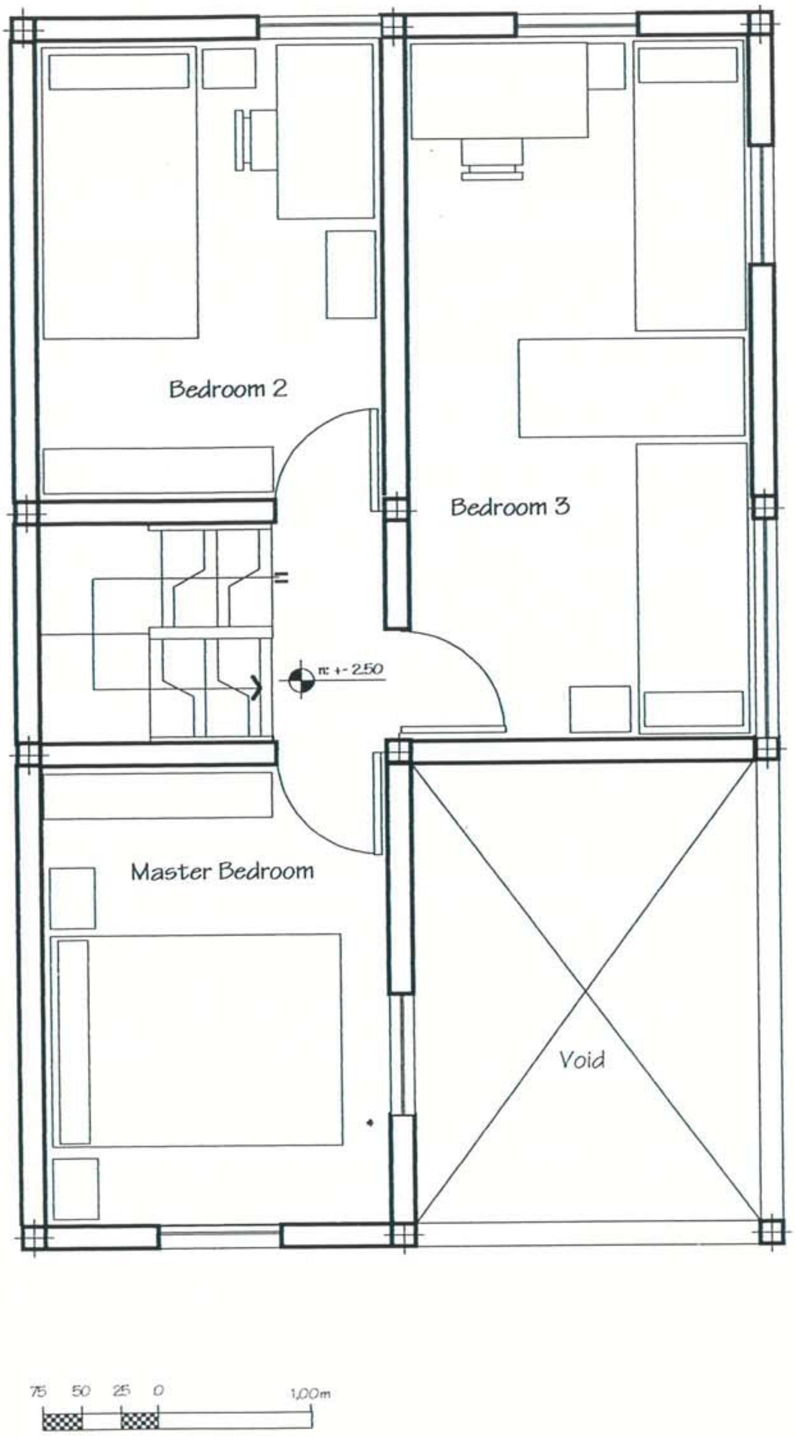
FOUNDATION PLAN



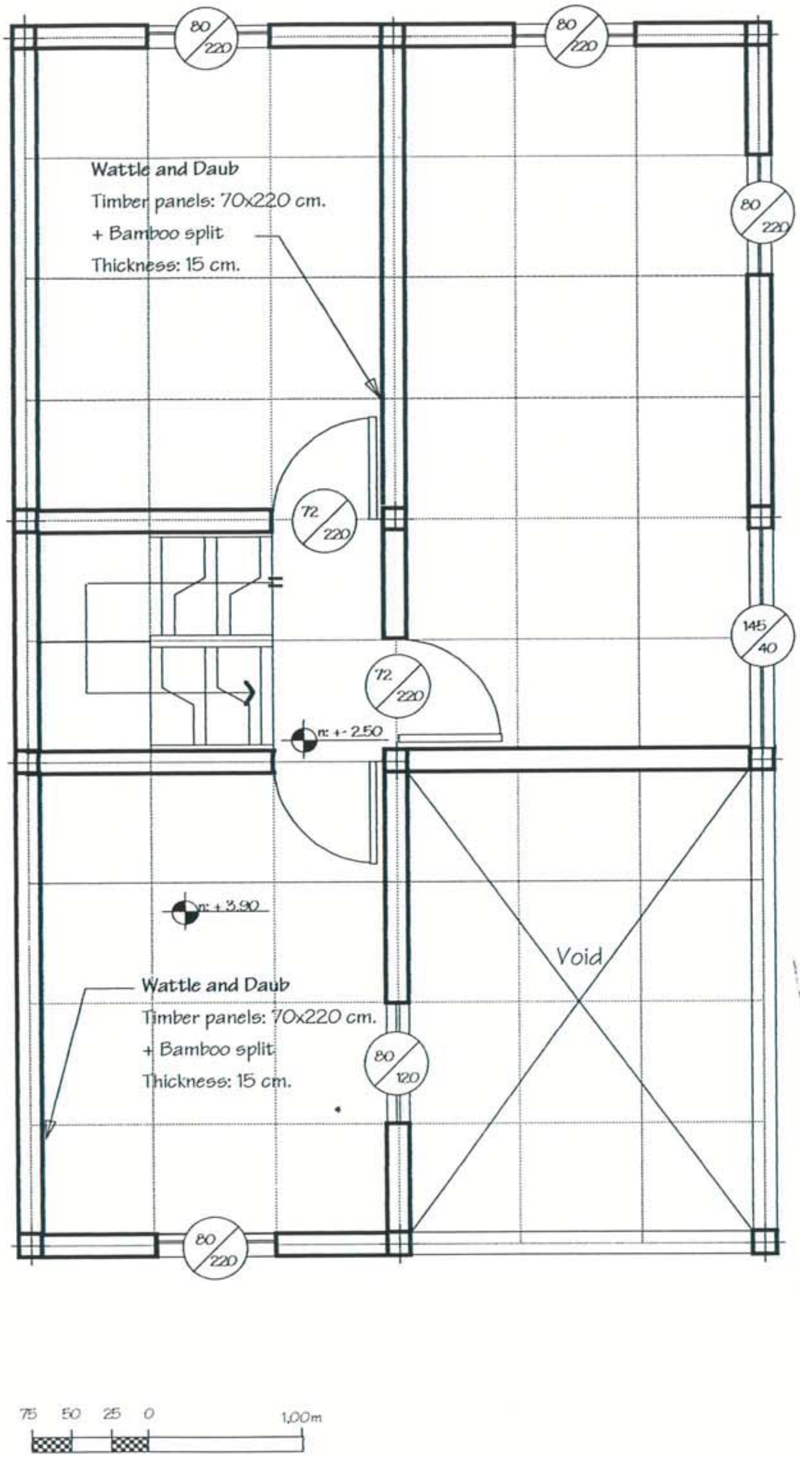
LAYOUT GROUND FLOOR PLAN
Area: 40 m2



TECHNICAL GROUND FLOOR PLAN
Area: 40 m2

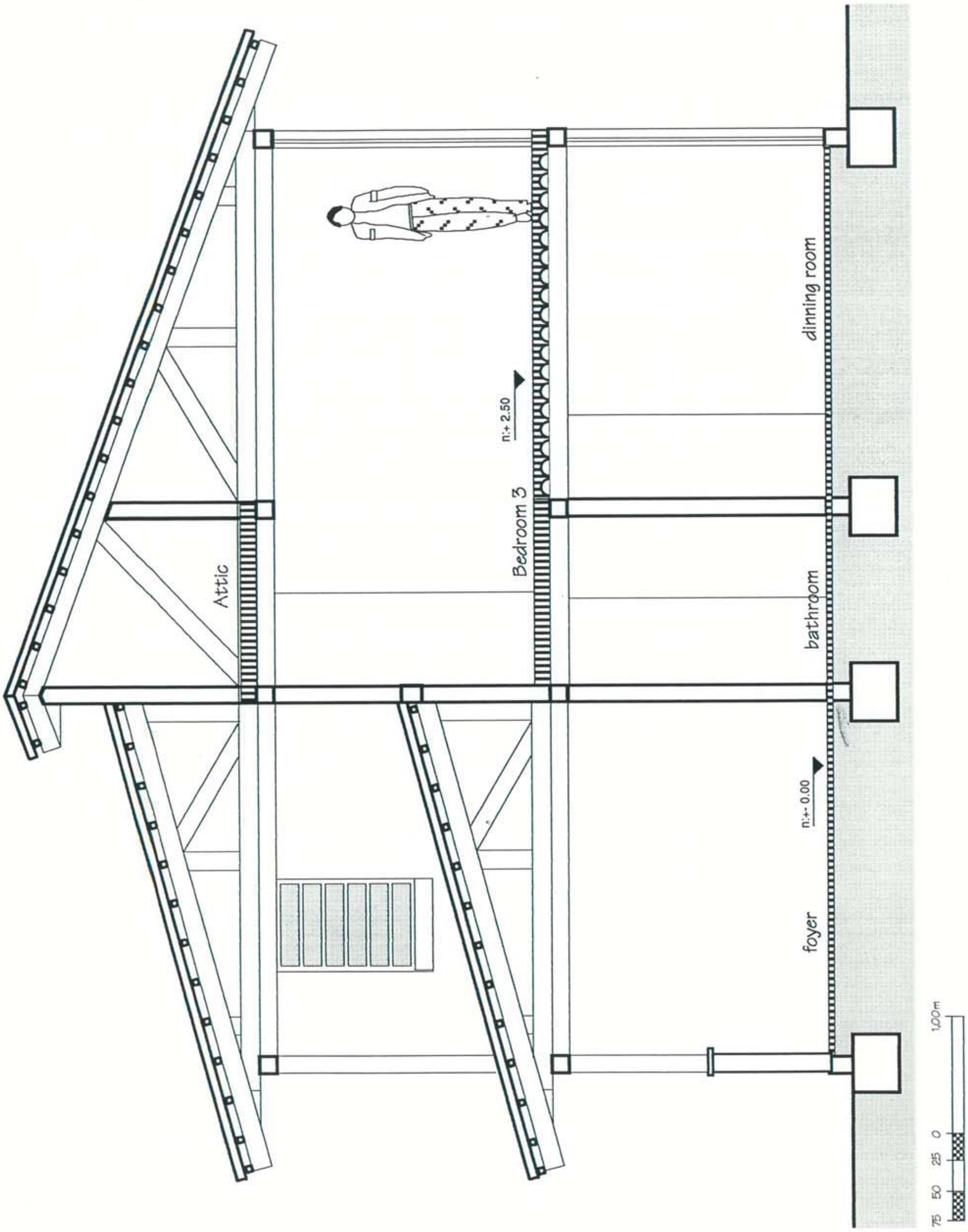


LAYOUT FIRST FLOOR PLAN
Area: 31.00 m2

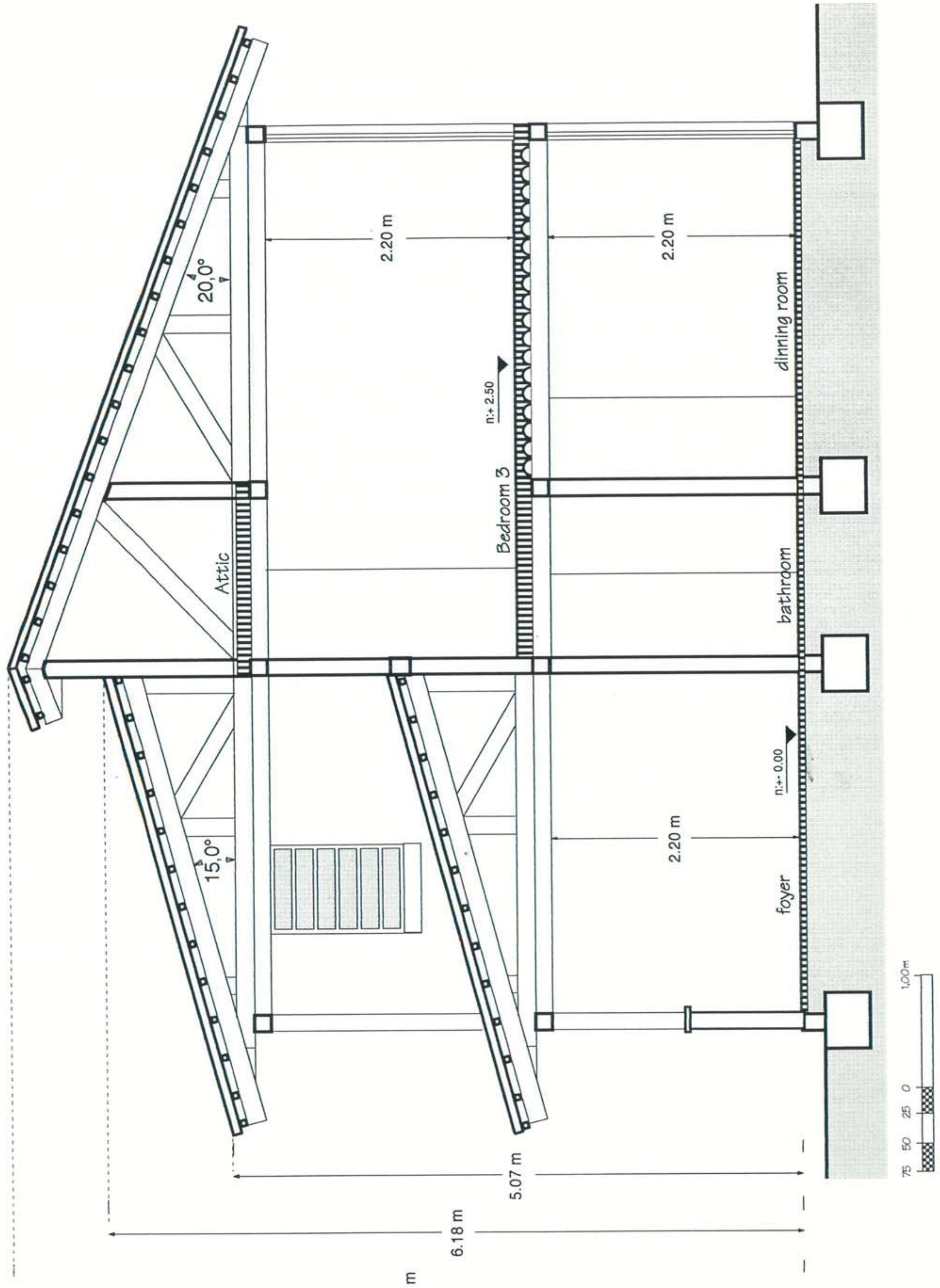


TECHNICAL FIRST FLOOR PLAN

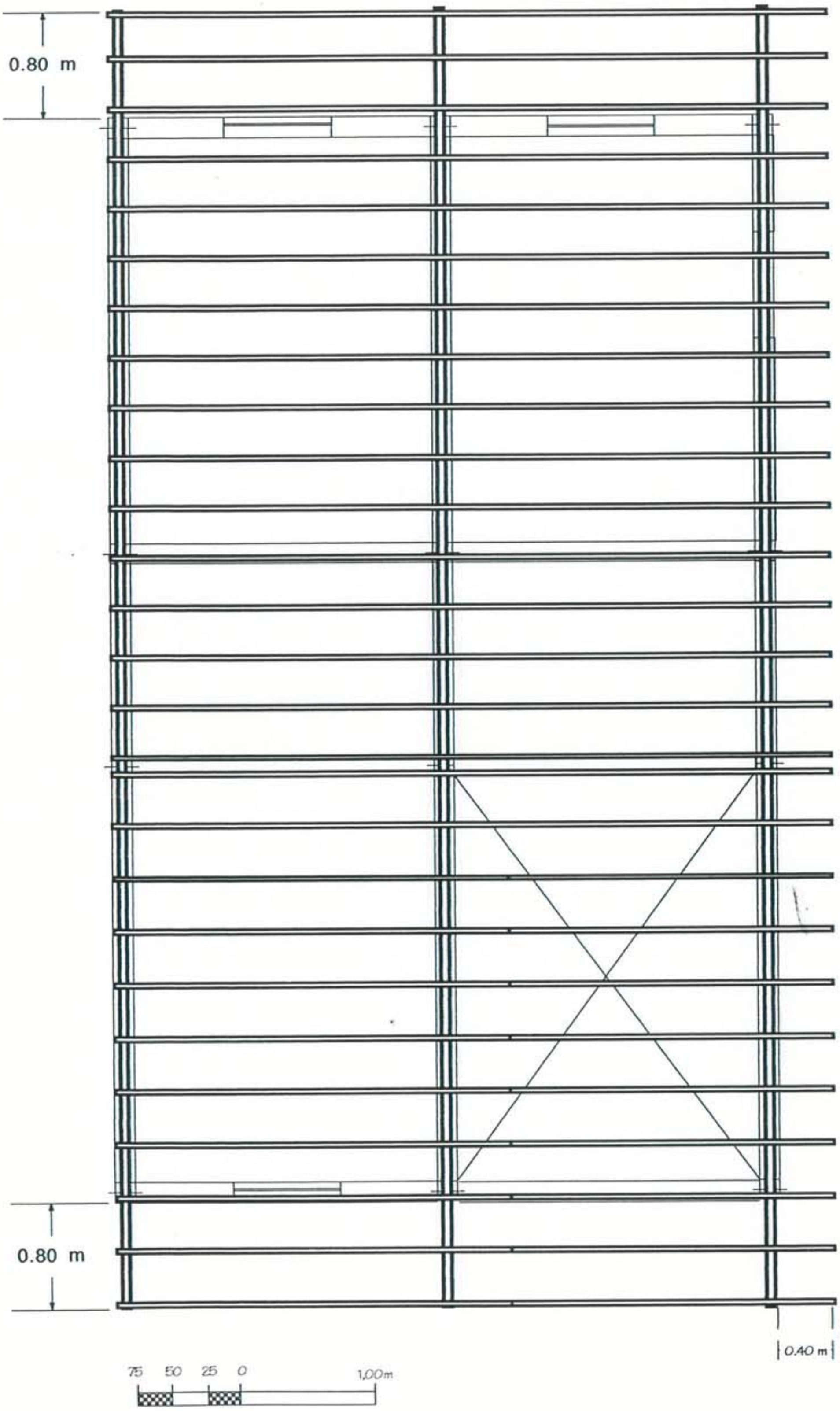
Area: 31.00 m2



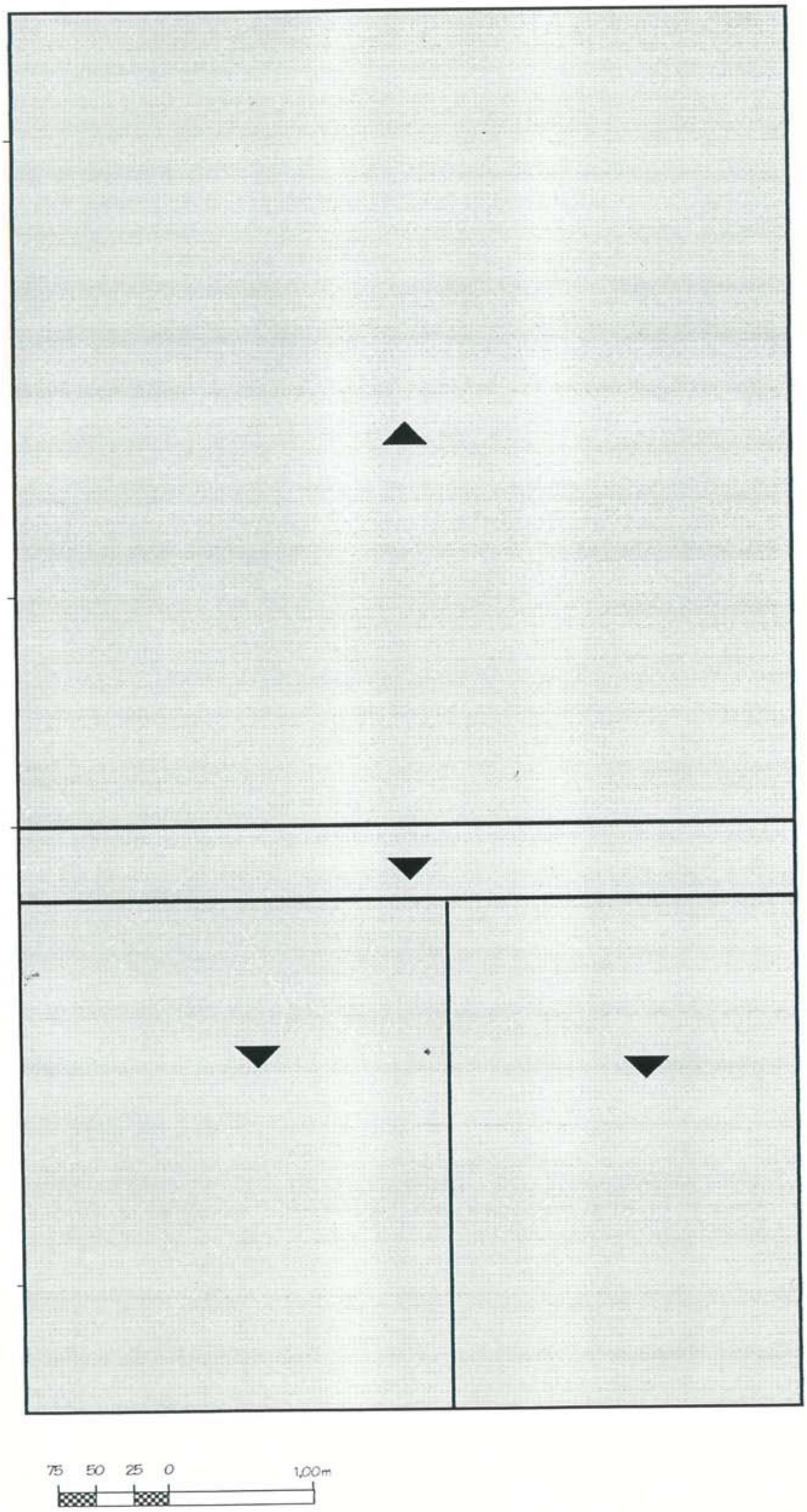
LAYOUT CROSS SECTION



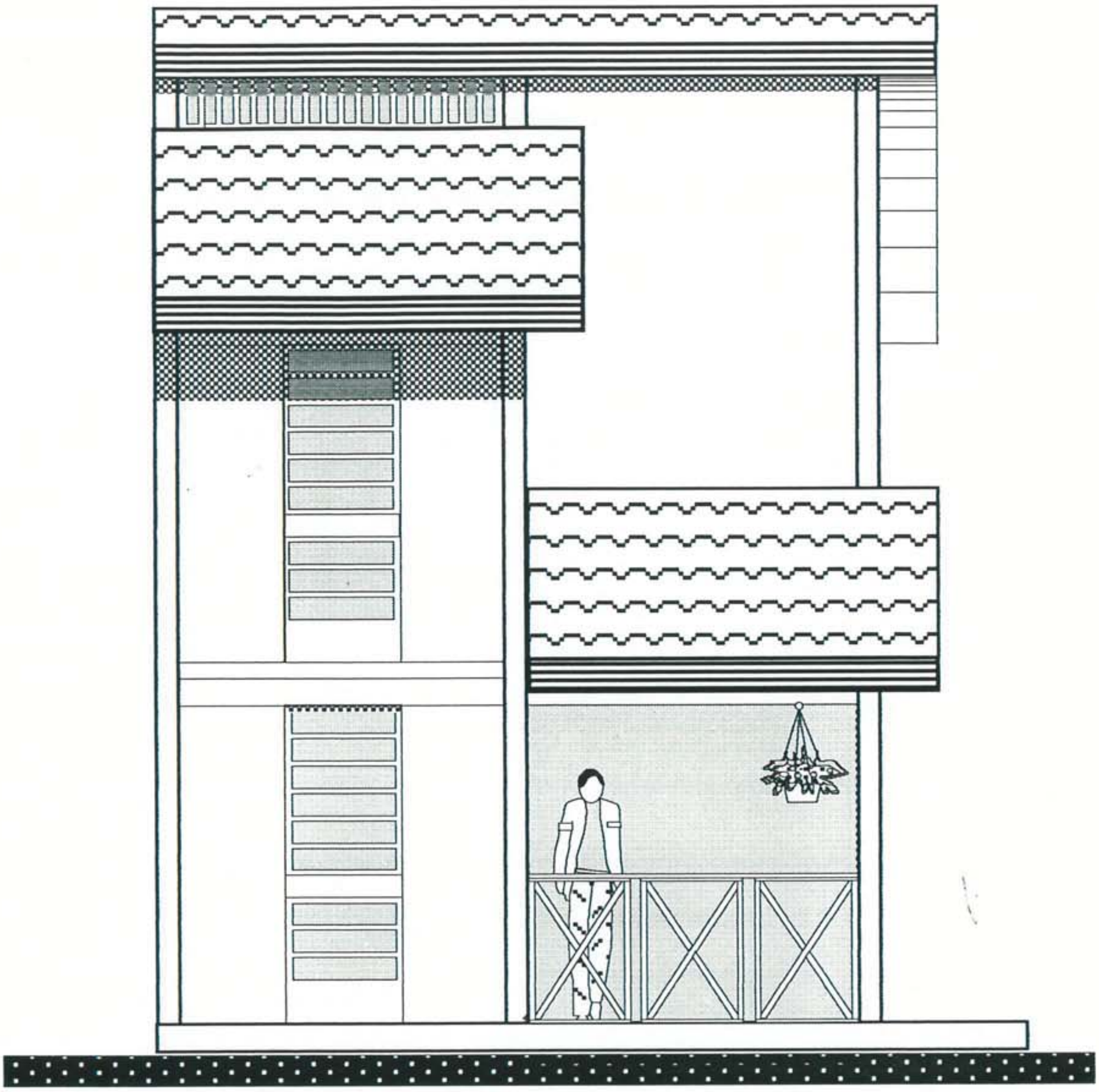
TECHNICAL CROSS SECTION

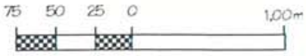


ROOF STRUCTURE PLAN

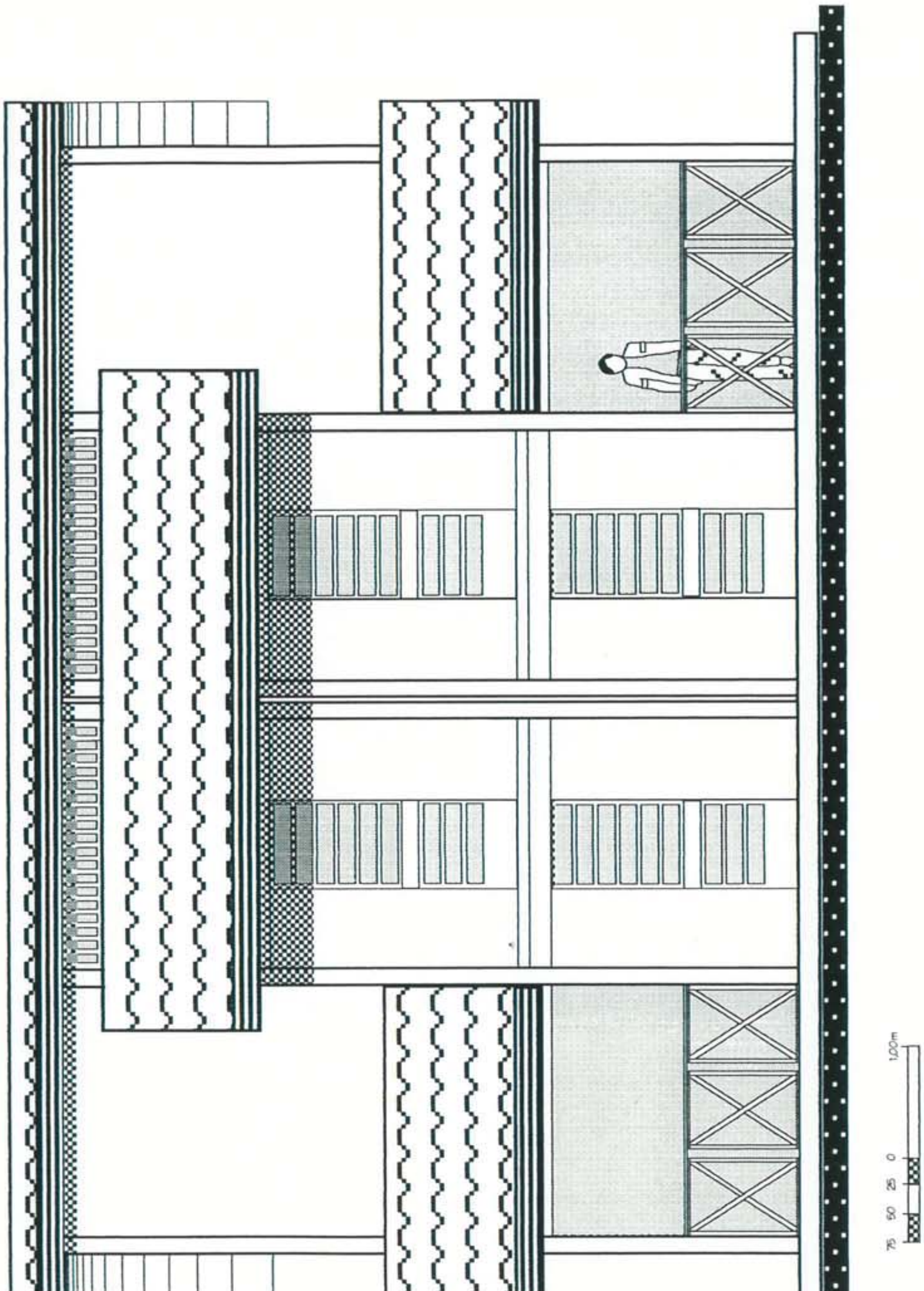


ROOF PLAN

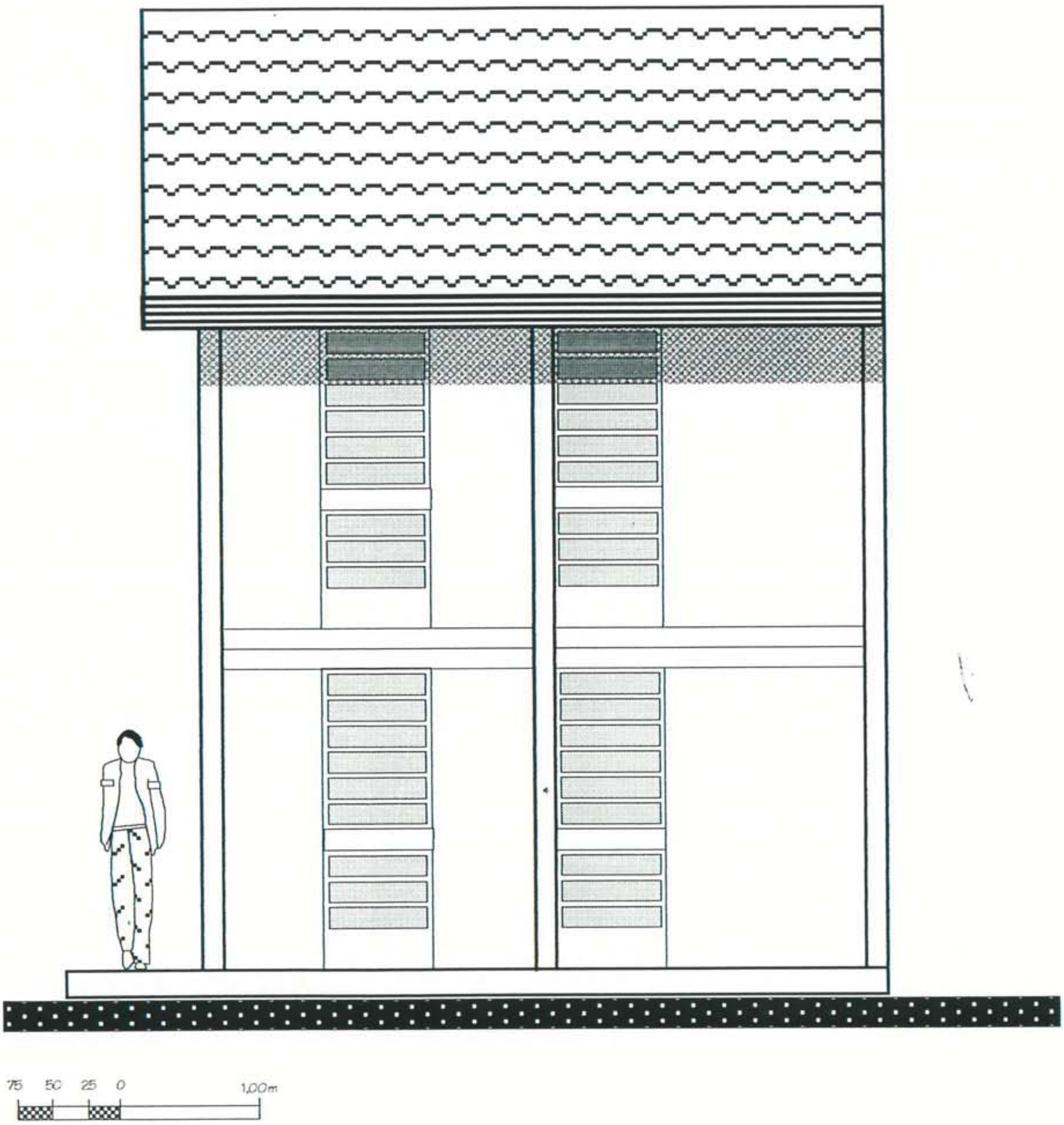




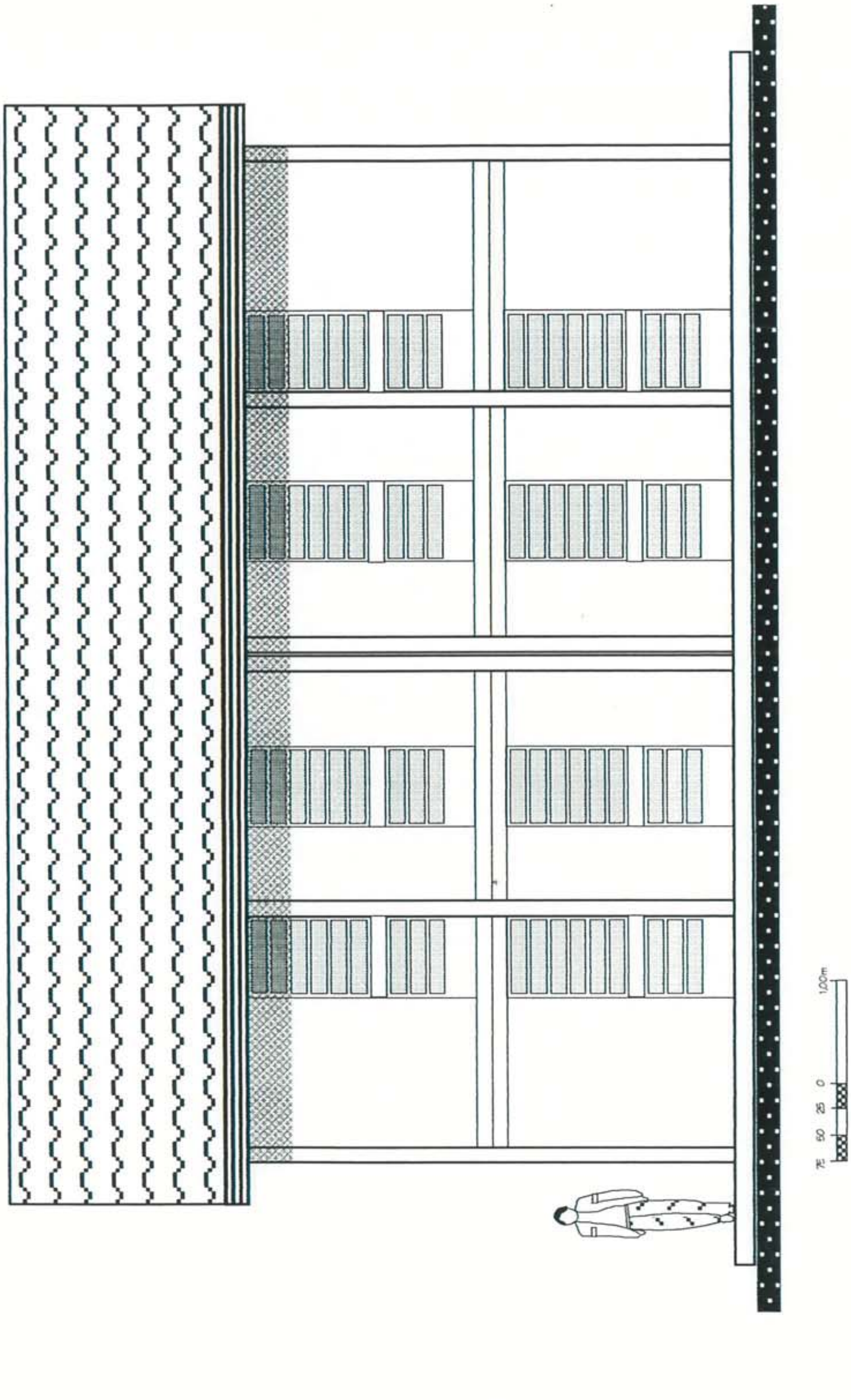
MAIN ELEVATION PLAN



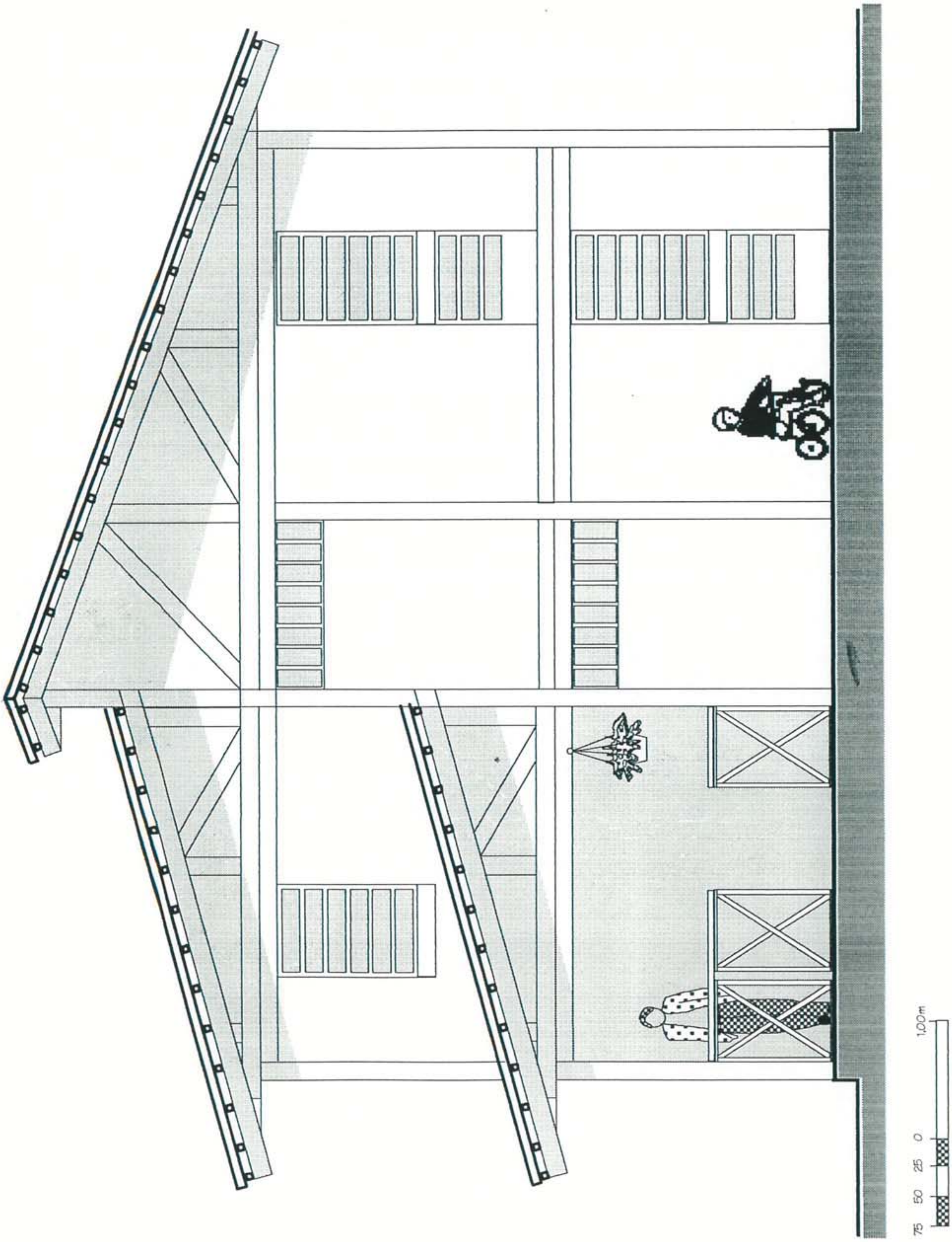
MAIN ELEVATION PLAN SEMIDETACHED



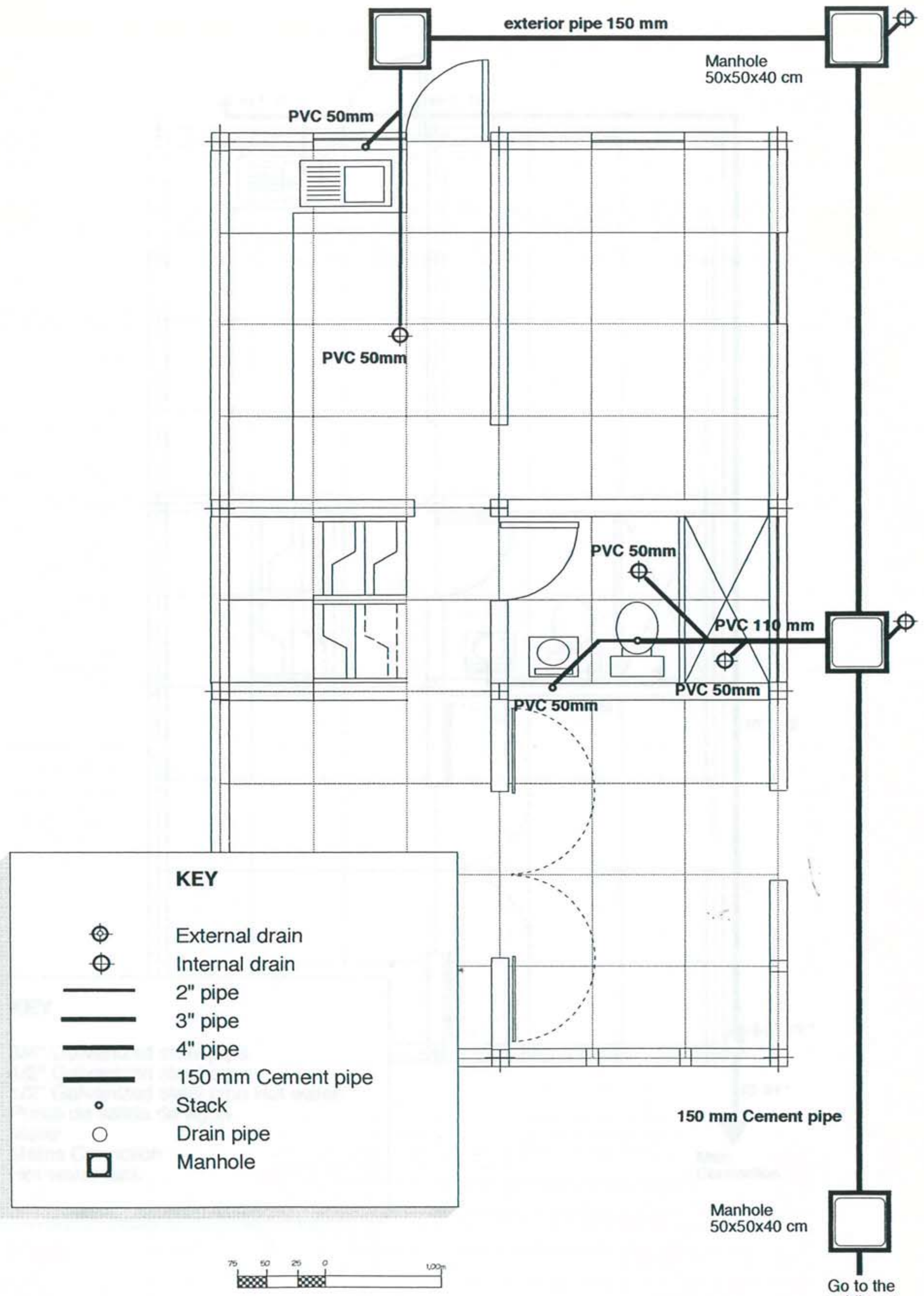
BACK ELEVATION PLAN



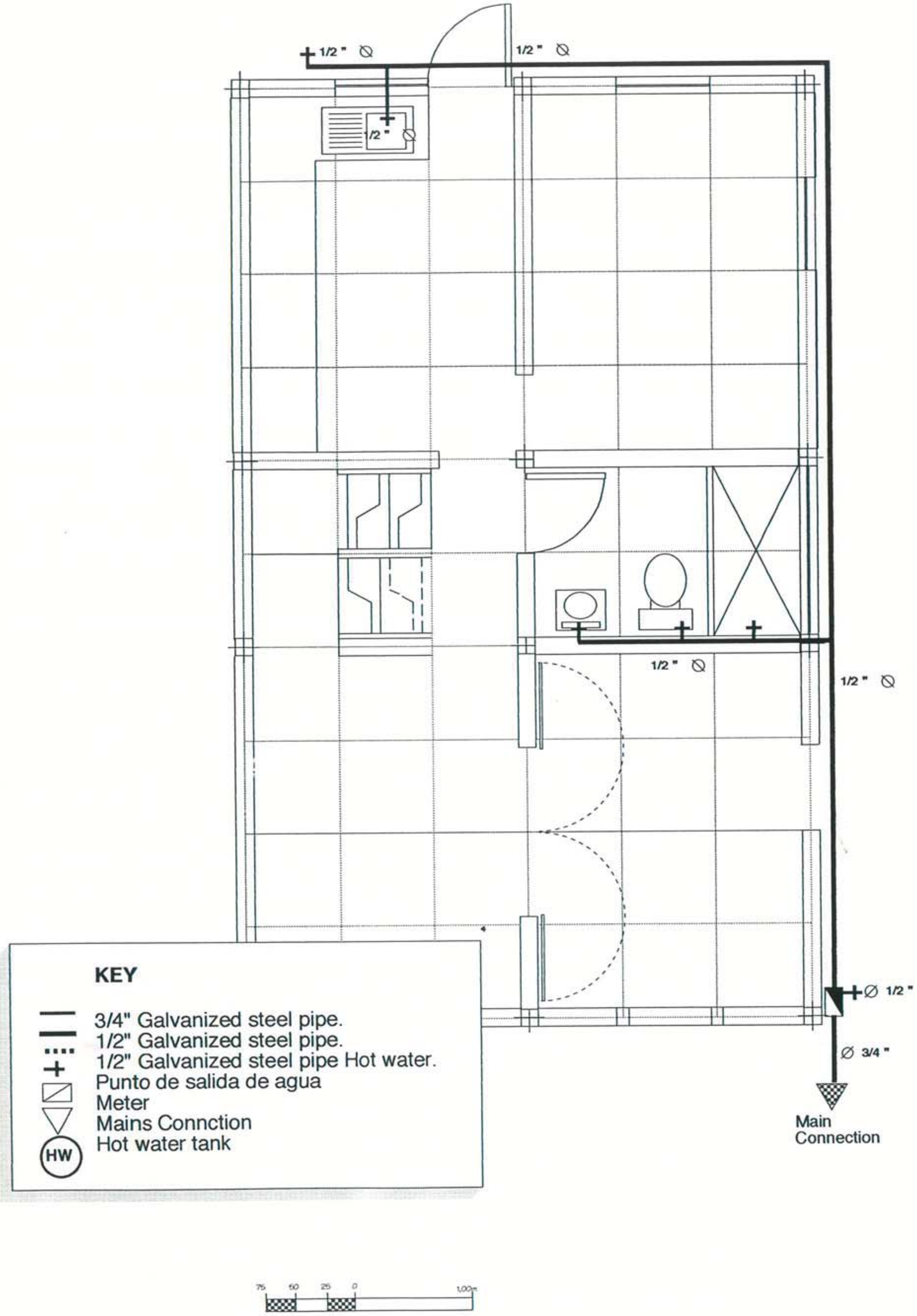
BACK ELEVATION PLAN SEMIDETACHED



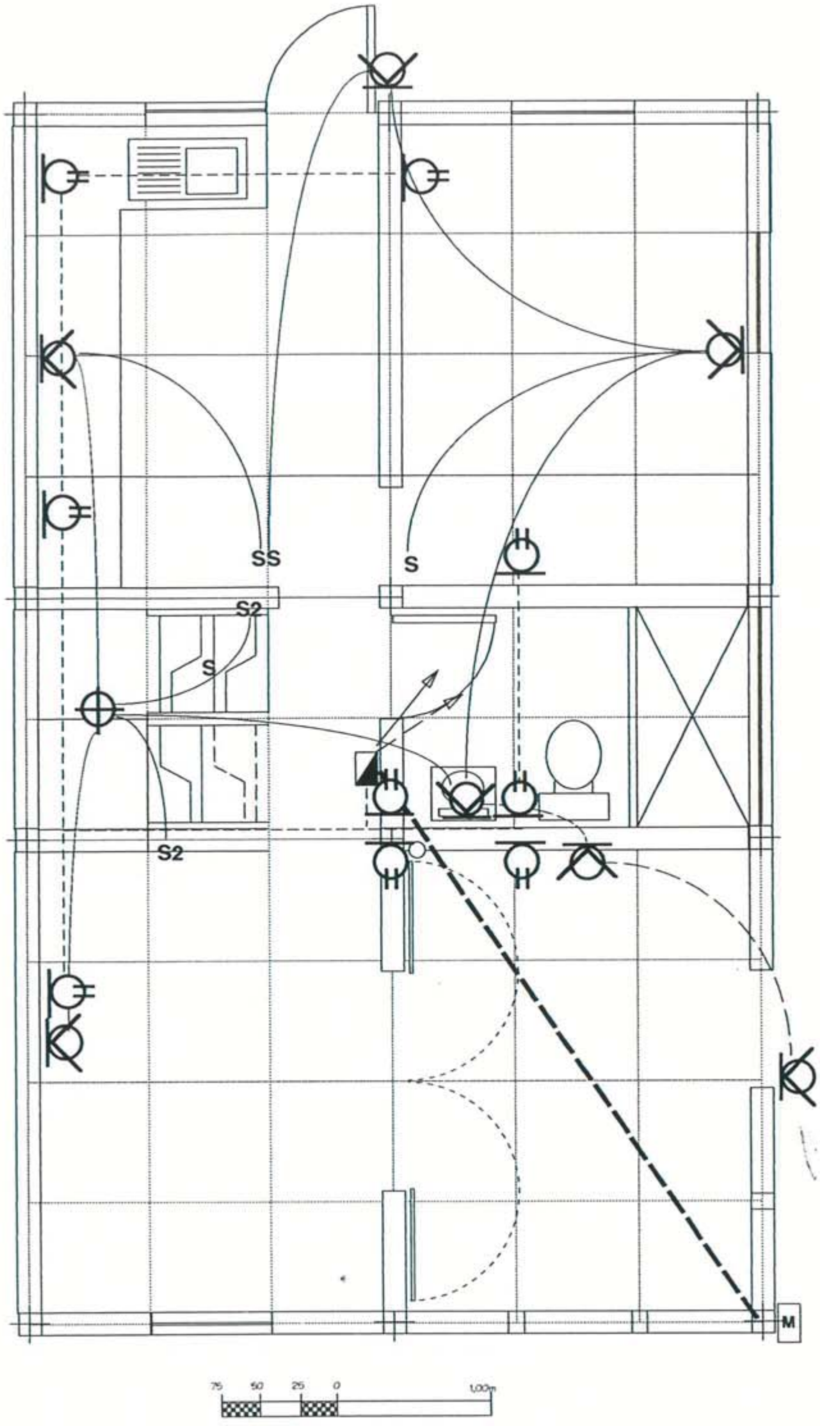
RIGTH ELEVATION PLAN



SANITARY INSTALLATIONS



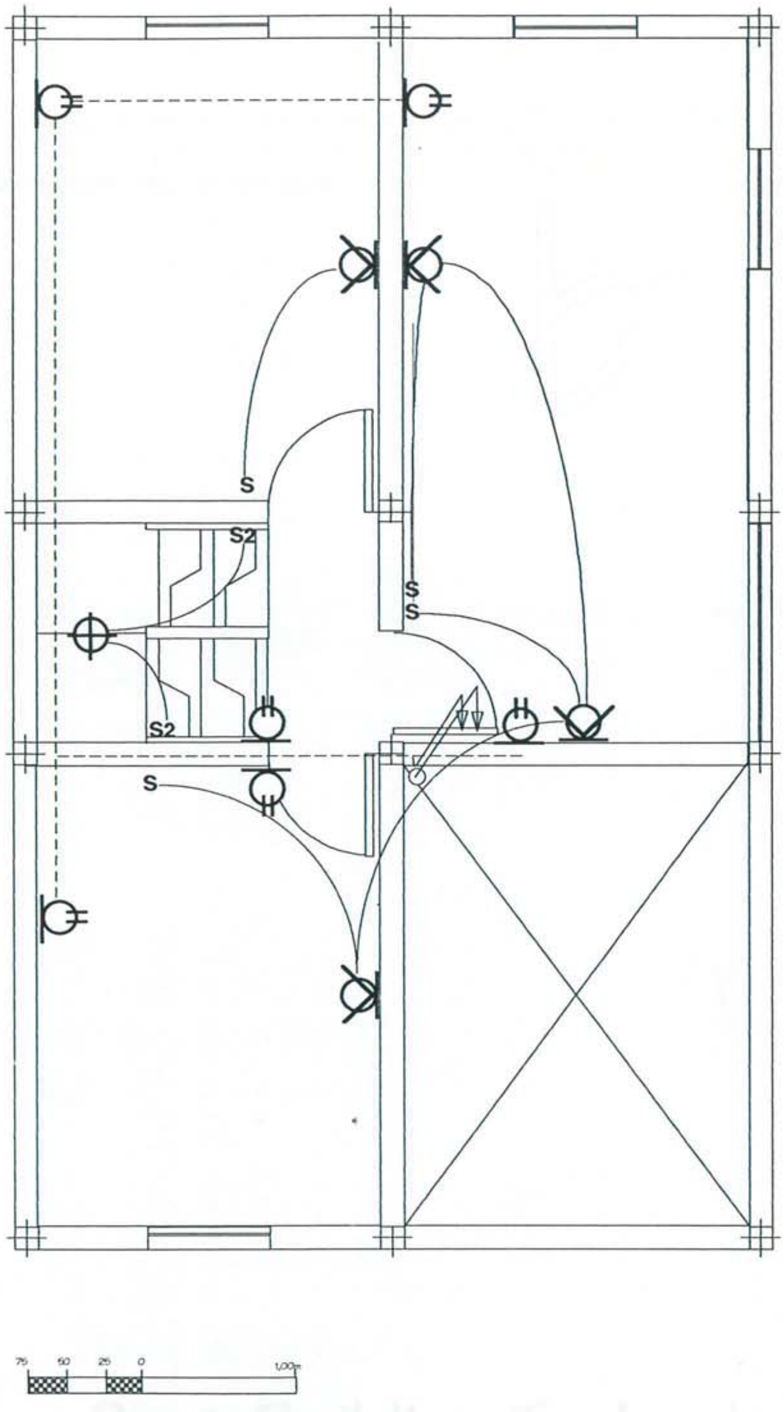
PLUMBING INSTALLATIONS



ELECTRICAL INSTALLATIONS

KEY

- Light connections point
- Twin power point
- Spot lights
- S Single switch
- 2S double switch
- S2 2-way switch
- 2 cables conduit N° 14 high level
- 3 cables conduit N° 14 high level
- 2 cables conduit N° 14 low level
- Mains connection N° 10
- Vertical mains conduit up
- Vertical mains conduit down
- Fuse box
- M Meter

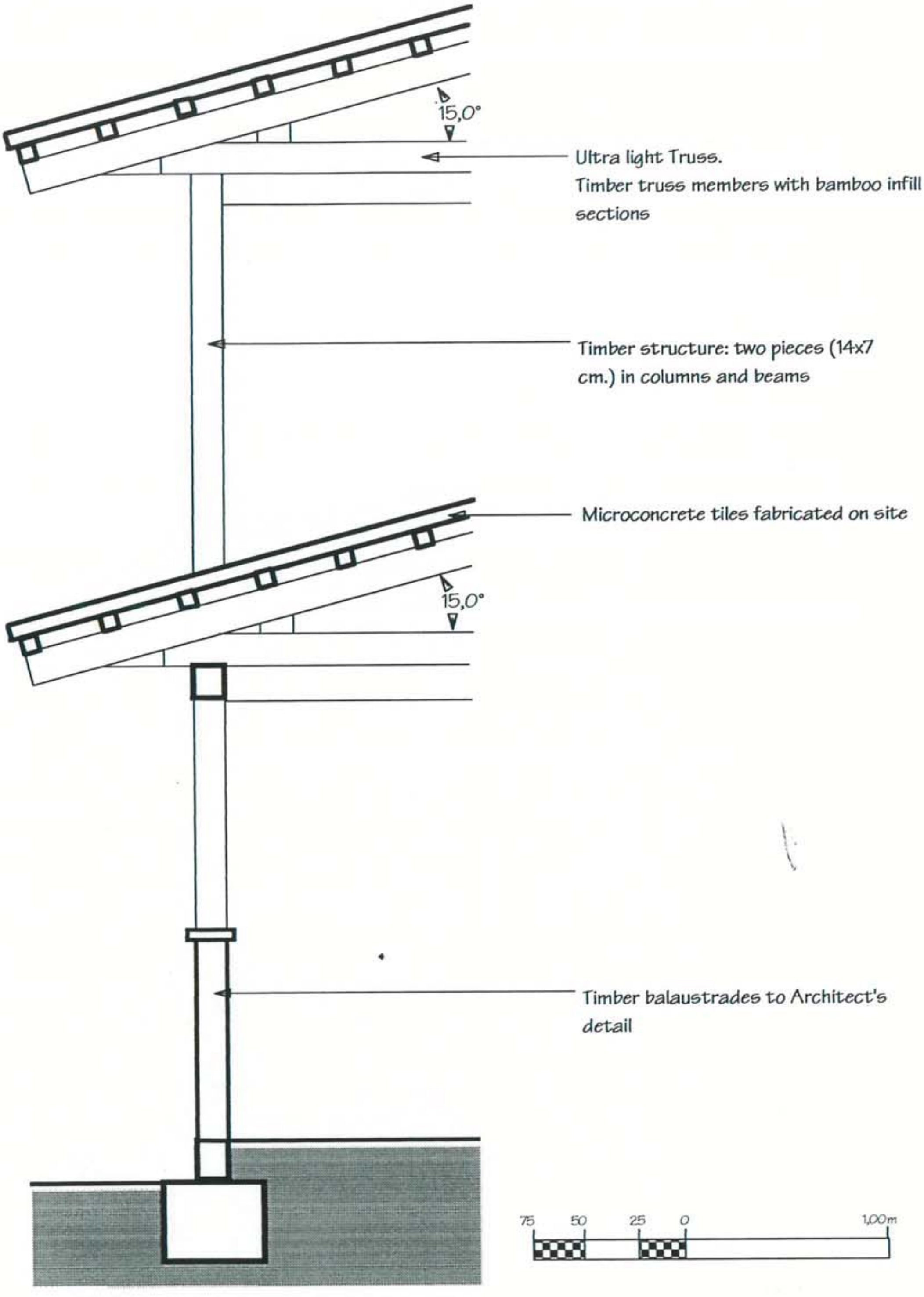


ELECTRICAL INSTALLATIONS

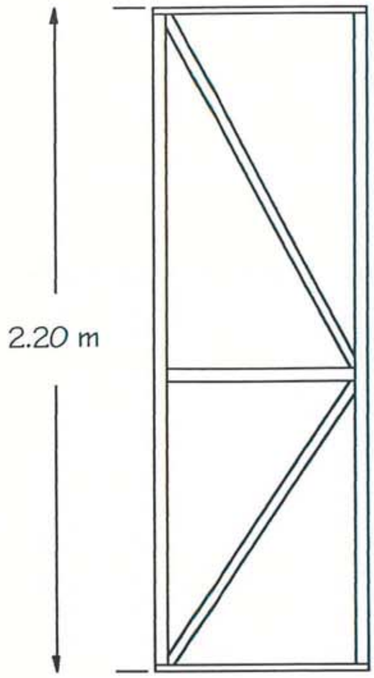
b

Low-Cost Building Technologies

Cross section detail
Frame detail
Frame and plaster detail
Metalwork detail
Truss detail
Staircase detail



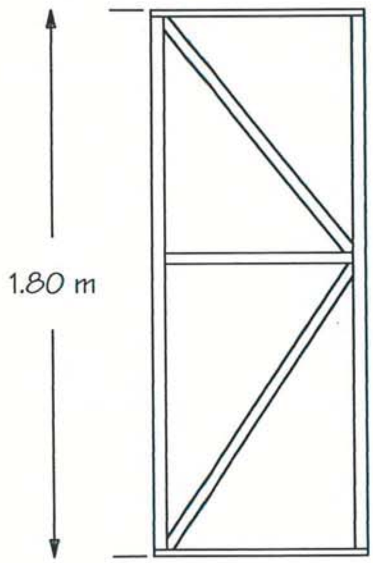
STRUCTURE AND WALLS DETAIL



Frame A

Elements

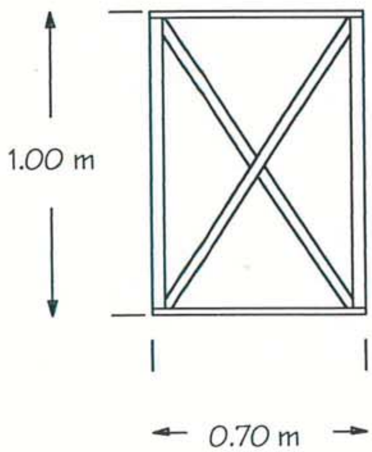
Elements	Quantity	Dimention
Element	2	4x8x2.16
Element	1	4x8x1.34
Element	1	4x8x1.12
Element	1	4x8x0.70
Element	2	2x8x0.70



Frame B

Elements

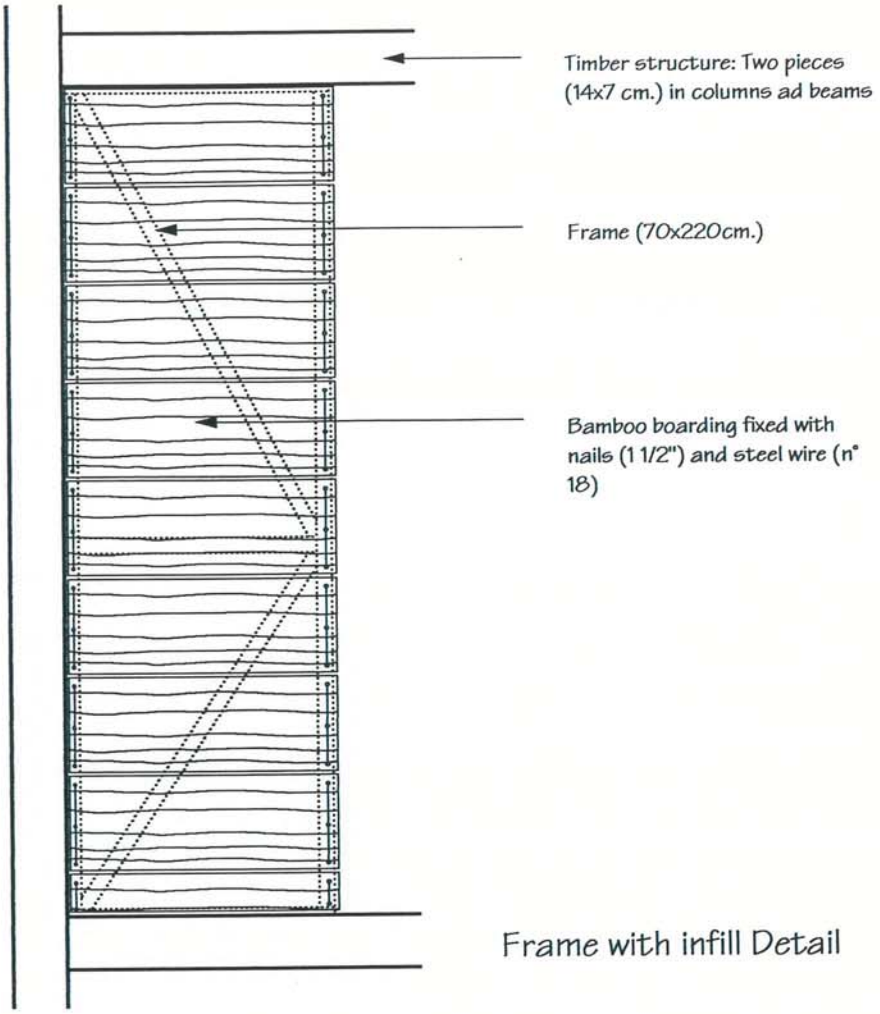
Elements	Quantity	Dimention
Element	2	4x8x1.76
Element	1	4x8x1.13
Element	1	4x8x1.01
Element	1	4x8x0.70
Element	2	2x8x0.70



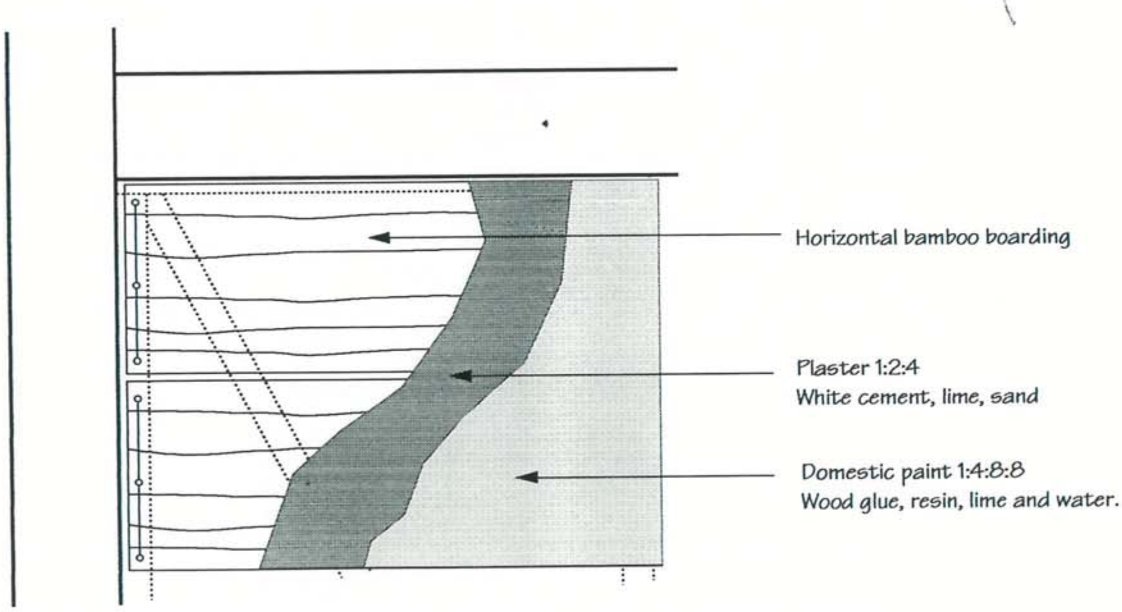
Frame C

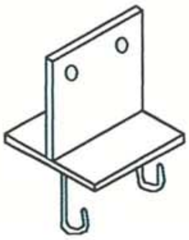
Elements

Element	Quantity	Dimention
Element	2	4x8x0.96
Element	2	4x8x1.13
Element	2	2x8x0.70

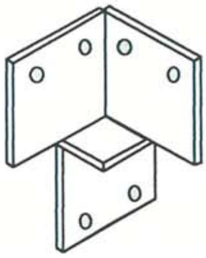


Frame with infill Detail

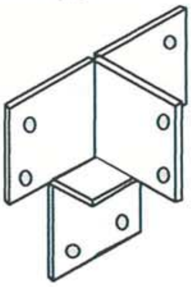




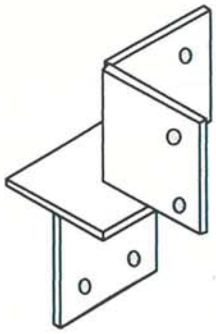
Element A



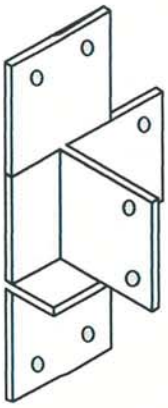
Element B



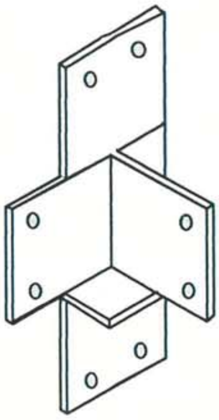
Element C



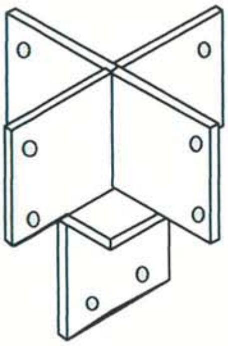
Element D



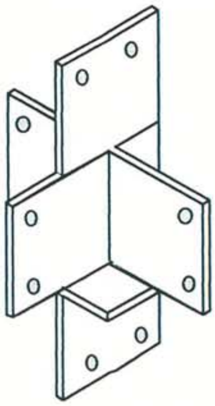
Element E



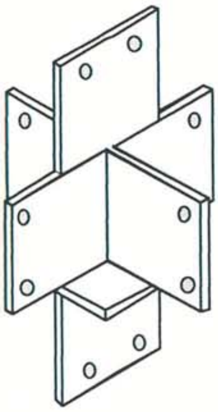
Element F



Element G



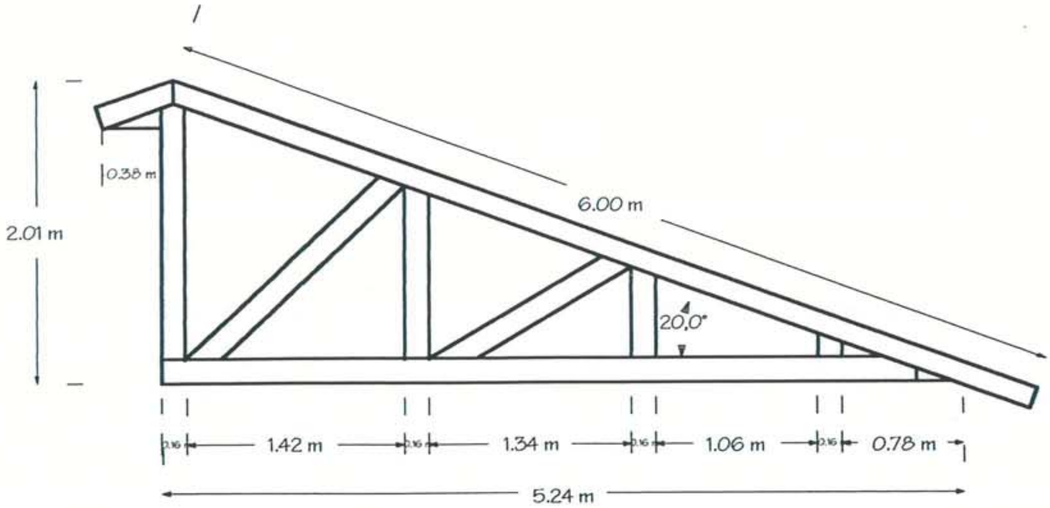
Element H



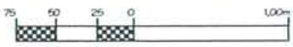
Element I

Element

Element	Type	Quantity
Element	A	12
Element	B	2
Element	C	6
Element	D	2
Element	E	2
Element	F	2
Element	G	2
Element	H	6
Element	I	2

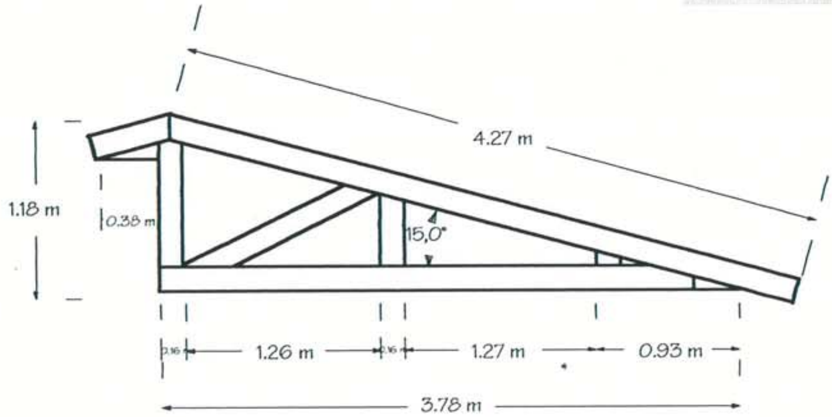


Truss A

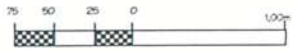


Element

Element	Quantity	Dimention
Planks	2	2x16x6.00
Planks	2	2x16x5.24
Planks	1	2x16x2.20
Planks	1	2x16x1.54
Planks	1	2x16x1.40
Panks	1	2x16x1.10
Planks	1	2x16x0.80
Planks	2	2x16x0.60
Planks	1	2x16x0.45
Planks	1	2x16x0.40

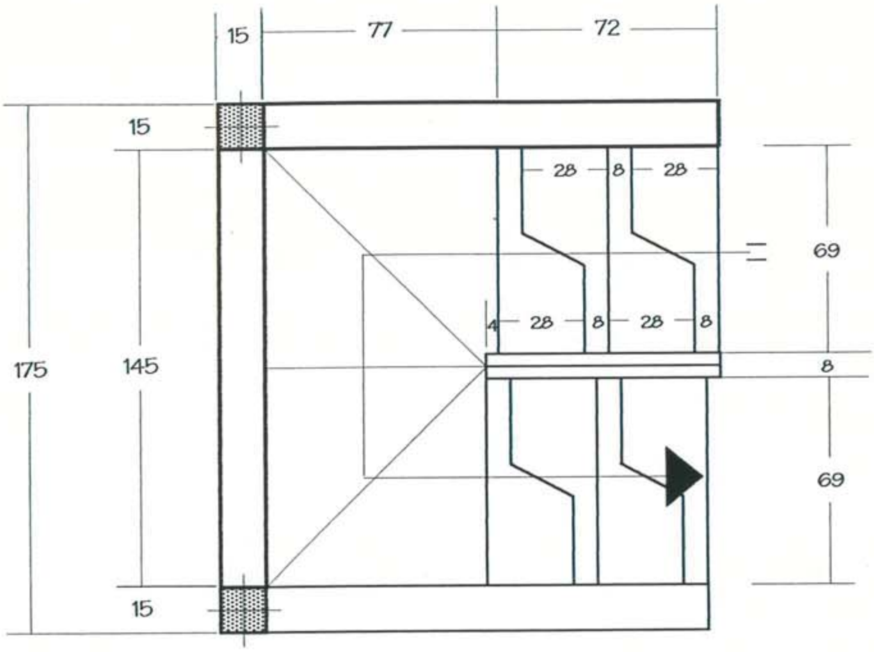


Truss B

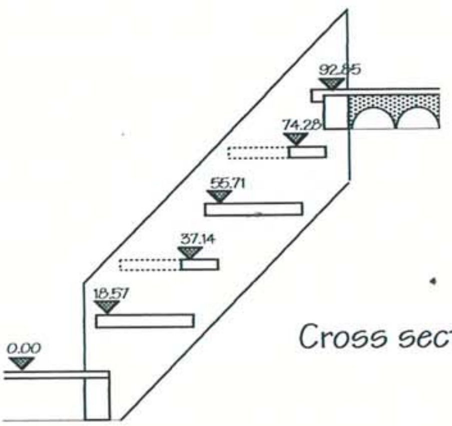


Element

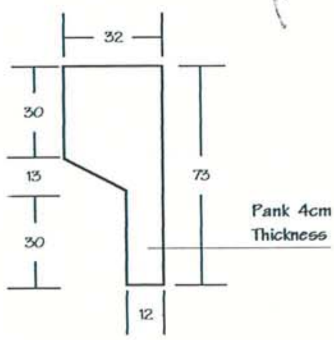
Elements	Quantity	Dimention
Planks	2	2x16x4.27
Planks	2	2x16x3.78
Planks	1	2x16x1.70
Planks	1	2x16x1.18
Planks	1	2x16x0.80
Planks	2	2x16x0.60
Planks	1	2x16x0.45
Planks	1	2x16x0.40



Plan

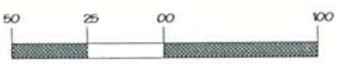


Cross section



Tread Plan

Stairs Detail



C

Budgeting System

General Cover
Inputs sheet
Components Workbook
Truss A sheet
Truss B sheet
Frame A sheet
Frame B sheet
Frame C sheet
Main Workbook
Foundations 01
Structure 02
Walls 03
Floors 04
Roofs 05
Doors and windows 06
Basins and accessories 07
Fixed units 08
Sanitary installations 09
Plumbing installations 10
Electrical Installations 11
Total

CENDEP

Gipsy Lane Campus
Headington Oxford
0X3 OBP
United Kingdom
Tel: ++ 44-865-483413
Fax: ++ 44-865-483298

oxford brookes university oxford brookes university oxford brookes university

Multitechnology Buteting System DEMO VERSION	v. B	Oct-94

Institution Name:

CENDEP

Project: *Prototype*

Date: *October 1994*

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

00 General Inputs

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	01 Foundations									
	02 Structure									
	03 Walls									
	04 Floors									
	05 Roofs									
	06 Doors & Windows									
	07 Basins & Accesories									
	08 Fixed Units									
	09 Sanitary Installations									
	10 Plumbing Installations									
	11 Electrical Installations									
	Total									

Shell Sucres:

Finishes Sucres:

Total US. Dollars:

Total Sucres:

Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Truss A (160x580 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Plank	2x12x600	u	2.00	4,800.00	2.46	9,600.00	4.92		
	Plank	2x12x550	u	2.00	4,400.00	2.26	8,800.00	4.51		
	Plank	2x12x220	u	1.00	1,760.00	0.90	1,760.00	0.90		
	Plank	2x12x160	u	1.00	1,280.00	0.66	1,280.00	0.66		
	Plank	2x12x150	u	1.00	1,200.00	0.62	1,200.00	0.62		
	Plank	2x12x120	u	1.00	960.00	0.49	960.00	0.49		
	Plank	2x12x80	u	1.00	640.00	0.33	640.00	0.33		
	Plank	2x12x50	u	1.00	400.00	0.21	400.00	0.21		
	Plank	2x12x40	u	1.00	320.00	0.16	320.00	0.16		
	Plank	2x12x30	u	1.00	240.00	0.12	240.00	0.12		
	Sub-total:								25,200.00	
	Others:									
	Nails	1 1/2"	Kg	1.60	1,600.00	0.82	2,560.00	1.31		
	Wood glue		lt	1.00	3,000.00	1.54	3,000.00	1.54		
	Sub-total:								5,560.00	
	Assembling:									
	Man Hours		hr	9.00	1,750.00	0.90	15,750.00	8.08		
	Sub-total:								15,750.00	
	Shell Sucres:			**Total US. Dollars:**					**23.85**	
	Finishes Sucres:			**Total Sucres:**					**46,510.00**	

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Truss B (120x410 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Plank	2x12x430	u	2.00	3,440.00	1.76	6,880.00	3.53		
	Plank	2x12x400	u	2.00	3,200.00	1.64	6,400.00	3.28		
	Plank	2x12x170	u	1.00	1,360.00	0.70	1,360.00	0.70		
	Plank	2x12x120	u	1.00	960.00	0.49	960.00	0.49		
	Plank	2x12x90	u	1.00	720.00	0.37	720.00	0.37		
	Plank	2x12x50	u	1.00	400.00	0.21	400.00	0.21		
	Plank	2x12x40	u	1.00	320.00	0.16	320.00	0.16		
	Plank	2x12x30	u	1.00	240.00	0.12	240.00	0.12		
	Sub-total:								17,280.00	
	Others:									
	Nails	1 1/2"	Kg	1.50	1,600.00	0.82	2,400.00	1.23		
	Wood glue		lt	0.90	3,000.00	1.54	2,700.00	1.38		
	Sub-total:								5,100.00	
	Assembling									
	Man Hours		hs	8.00	1,750.00	0.90	14,000.00	7.18		
	Sub-total:								14,000.00	

Shell Sucres:		**Total US. Dollars:**	**18.66**
Finishes Sucres:		**Total Sucres:**	**36,380.00**

Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Frame A (70x220 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Elements	4x8x220	u	2.00	1,408.00	0.72	2,816.00	1.44		
	Elements	4x8x140	u	1.00	910.00	0.47	910.00	0.47		
	Elements	4x8x120	u	1.00	780.00	0.40	780.00	0.40		
	Elements	4x8x100	u	1.00	650.00	0.33	650.00	0.33		
	Plank	4x8x70	u	2.00	455.00	0.23	910.00	0.47		
	Sub-total:								6,066.00	
	Others:									
	Nails	1 1/2"	Kg	0.20	1,600.00	0.82	320.00	0.16		
	Wood glue		lt	0.25	3,000.00	1.54	750.00	0.38		
	Sub-total:								1,070.00	
	Assembling									
	Man Hours		hs	4.00	1,750.00	0.90	7,000.00	3.59		
	Sub-total:								7,000.00	

Shell Sucres:	**Total US. Dollars:**	7.25
Finishes Sucres:	**Total Sucres:**	14,136.00

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Frame B (70x180 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Elements	4x8x180	u	2.00	1,170.00	0.60	2,340.00	1.20		
	Elements	4x8x120	u	1.00	780.00	0.40	780.00	0.40		
	Elements	4x8x110	u	1.00	715.00	0.37	715.00	0.37		
	Elements	4x8x100	u	1.00	650.00	0.33	650.00	0.33		
	Plank	4x8x70	u	2.00	455.00	0.23	910.00	0.47		
	Sub-total:								5,395.00	
	Others:									
	Nails	1 1/2"	Kg	0.20	1,600.00	0.82	320.00	0.16		
	Wood glue		ls	0.20	3,000.00	1.54	600.00	0.31		
	Sub-total:								920.00	
	Assembling									
	Man Hours		hs	4.00	1,750.00	0.90	7,000.00	3.59		
	Sub-total:								7,000.00	

Shell Sucres:		**Total US. Dollars:**	6.83
Finishes Sucres:		**Total Sucres:**	13,315.00

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Frame C (70x100 cm.)

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Timber:									
	Elements	4x8x100	u	2.00	650.00	0.33	1,300.00	0.67		
	Elements	4x8x120	u	2.00	780.00	0.40	1,560.00	0.80		
	Plank	4x8x70	u	2.00	455.00	0.23	910.00	0.47		
	Sub-total:								3,770.00	
	Others:									
	Nails	1 1/2"	Kg	0.15	1,600.00	0.82	240.00	0.12		
	Wood glue		lt	0.15	3,000.00	1.54	450.00	0.23		
	Sub-total:								690.00	
	Assembling									
	Man Hours		hs	3.00	1,750.00	0.90	5,250.00	2.69		
	Sub-total:								5,250.00	

Shell Sucres:	**Total US. Dollars:**	**4.98**
Finishes Sucres:	**Total Sucres:**	**9,710.00**

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

01 Foundations

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Preliminaries:									
	Site preparation		m2	45.00	425.00	0.22	19,125.00	9.81		Shell
	Setting out		m2	45.00	764.00	0.39	34,380.00	17.63		Shell
	Levelling		m3	0.00	3,243.00	1.66	0.00	0.00		Shell
	Earth removal		m3	0.00	1,950.00	1.00	0.00	0.00		Shell
	Sub-total:								53,505.00	
	Foundations									
	Excavation		m3	6.64	3,243.00	1.66	21,533.52	11.04		Shell
	Backfill (50% of excavation)		m3	3.32	1,000.00	0.51	3,320.00	1.70		Shell
	Footings	50x50x40	m3	1.20	58,000.00	29.74	69,600.00	35.69		Shell
	Foundations	40x40	m3	5.44	10,000.00	5.13	54,400.00	27.90		Shell
	Strip foundations	15x15	m3	0.77	163,000.00	83.59	124,695.00	63.95		Shell
	Metalwork		u	12.00	15,000.00	7.69	180,000.00	92.31		Shell
	Sub-total:								453,548.52	

Shell Sucres:	**507,053.52**	**Total US. Dollars:**	**260.03**
Finishes Sucres:	**0.00**	**Total Sucres:**	**507,053.52**

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

02 Structure

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Columns:									
	Principal columns	7x15x250	u	48	8,000.00	4.10	384,000.00	196.92		Shell
	Secondary columns	7x15x125	u	0	4,000.00	2.05	0.00	0.00		Shell
	Sub-total:								384,000.00	
	Beams:									
	Principal	7x15x350	u	24	12,000.00	6.15	288,000.00	147.69		Shell
	Secondary	7x15x250	u	32	8,000.00	4.10	256,000.00	131.28		Shell
	Tertiary	7x15x180	u	0	6,000.00	3.08	0.00	0.00		Shell
	Bracing	7x15x100	u	47	3,000.00	1.54	141,000.00	72.31		Shell
	Sub-total:								685,000.00	
	Internal Ladder tread stair:									
	Strings	4x40x150	u	6	16,000.00	8.21	96,000.00	49.23		Shell
	Treads	4x36x80	u	12	8,000.00	4.10	96,000.00	49.23		Shell
	Bannister	4x12x350	u	3	7,000.00	3.59	21,000.00	10.77		Shell
	Sub-total:								213,000.00	
	External Stair:									
	Strings	4x40x200	u	0	20,000.00	10.26	0.00	0.00		Shell
	Treads	4x28x80	u	0	5,000.00	2.56	0.00	0.00		Shell
	Bannister									
	Sub-total:								0.00	
	Various:									
	Nuts and Bolts	1/2"	u	232	900.00	0.46	208,800.00	107.08		Shell
	Metalwork		u	24	15,500.00	7.95	372,000.00	190.77	580,800.00	Shell
	Assembly Labour (30%)						558,840.00	286.58		Shell

Shell Sucres:	**2,421,640.00**	**Total US. Dollars:**	**1,241.87**
Finishes Sucres:	**0.00**	**Total Sucres:**	**2,421,640.00**

03 Walls

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Mud Brick level + - 0.00:									
	Mud brick walls	6x15x30 (brick)	m2	54.64	8,000.00	4.10	437,120.00	224.16		Shell
	Plaster		m2	54.64	4,400.00	2.26	240,416.00	123.29		Finish
	Wall Tiles		m2	6.50	17,000.00	8.72	110,500.00	56.67		Finish
	Paint		m2	92.67	1,200.00	0.62	111,204.00	57.03		Finish
	Sub-total:								899,240.00	
	Timber and Bamboo Frame level + 2.50:									
	Mud brick walls	6x15x30 (brick)	m2	16.61	8,000.00	4.10	132,880.00	68.14		Shell
	Frame A	8x70x220	u	25	14,136.00	7.25	353,400.00	181.23		Shell
	Frame B	8x70x180	u	2	13,315.00	6.83	26,630.00	13.66		Shell
	Frame C. level +- 0.00	8x70x100	u	6	9,710.00	4.98	58,260.00	29.88		Shell
	bamboo		m2	87.06	1,800.00	0.92	156,708.00	80.36		Shell
	Assembling (30 % of bamboo price)		m2	87.06	540.00	0.28	47,012.40	24.11		Shell
	Plaster		m2	87.06	3,500.00	1.79	304,710.00	156.26		Finish
	Paint		m2	103.67	1,100.00	0.56	114,037.00	58.48		Finish
	Sub-total:								1,193,637.40	

Shell Sucres:	1,212,010.40	**Total US. Dollars:**	1,073.27
Finishes Sucres:	880,867.00	**Total Sucres:**	2,092,877.40

04 Floors

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Ground Floor:									
	Infill	5cm	m3	1.33	2,642.00	1.35	3,503.29	1.80		Shell
	Blinding	15cm	m3	3.99	11,100.00	5.69	44,289.00	22.71		Shell
	Plastic membrane DPM		m2	43.68	700.00	0.36	30,576.00	15.68		Shell
	Concrete	4cm	m2	43.68	10,000.00	5.13	436,800.00	224.00		Shell
	Screed		m2	43.68	3,372.00	1.73	147,288.96	75.53		Finish
	Floor tiles	2cm	m2	0.00	7,079.00	3.63	0.00	0.00		Finish
	Sub-total:								662,457.25	
	Other Floors:									
	Bamboo structure	1/2 caña	m2	30.69	2,000.00	1.03	61,380.00	31.48		Shell
	Plastic membrane DPM		m2	30.69	700.00	0.36	21,483.00	11.02		Shell
	Steel reinforcement		m2	30.69	3,500.00	1.79	107,415.00	55.08		Shell
	Concrete	8cm	m3	2.45	210,000.00	107.69	514,500.00	263.85		Shell
	Screed		m2	30.69	3,372.00	1.73	103,486.68	53.07		Finish
	Concrete in Stairs (landing)	6 cm	m3	0.07	210,000.00	107.69	13,650.00	7.00		Shell
	Sub-total:								821,914.68	

Shell Sucres:	**1,233,596.29**	**Total US. Dollars:**	**761.22**
Finishes Sucres:	**250,775.64**	**Total Sucres:**	**1,484,371.93**

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

05 Roofs

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Pitch Roofs:									
	Prefabricated Truss A	6x155x570	u	3	46,510.00	23.85	139,530.00	71.55		Shell
	Prefabricated Truss B	6x120x400	u	4	36,380.00	18.66	145,520.00	74.63		Shell
	Tiling battens	4x4	m	150.00	400.00	0.21	60,000.00	30.77		Shell
	Micro concrete tiles (12.5 x m2)	50x25 cm	m2	61.82	12,000.00	6.15	741,840.00	380.43		Shell
	Micro concrete ridge tiles		m2	1.30	13,000.00	6.67	16,900.00	8.67		Shell
	Micro concrete tiles special		m2	0.00	10,000.00	5.13	0.00	0.00		Shell
	Isect mesh	fina	m2	1.20	6,000.00	3.08	7,200.00	3.69		Shell
	Paint									Finish
	Sub-total:								1,110,990.00	
	Ventilators :									
	Type A	225x110	m2	2.47	45,000.00	23.08	111,150.00	57.00		Shell
	Type B	300x40	m2	1.20	45,000.00	23.08	54,000.00	27.69		Shell
	Sub-total:								165,150.00	

Shell Sucres:	1,276,140.00	**Total US. Dollars:**	654.43
Finishes Sucres:	0.00	**Total Sucres:**	1,276,140.00

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

06 Doors & Windows

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Doors:									
	Door D1	4x72x220	u	4	70,000.00	35.90	280,000.00	143.59		Finish
	Door D2 (fix with glass)	4x72x220	u	3	80,000.00	41.03	240,000.00	123.08		Finish
	Sub-total:								520,000.00	
	Windows:									
	Window W1	4x72x220	u	7	70,000.00	35.90	490,000.00	251.28		Finish
	Window W2	4x72x120	u	1	40,000.00	20.51	40,000.00	20.51		Finish
	Window W3	4x40x145	u	2	41,000.00	21.03	82,000.00	42.05		Finish
	Sub-total:								612,000.00	

Shell Sucres:	**0.00**	**Total US. Dollars:**	**580.51**
Finishes Sucres:	**1,132,000.00**	**Total Sucres:**	**1,132,000.00**

07 Basins & Accesories

Code	Items	Dimensions	Unit	Quantity	Price: Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	Site
	Bathroom fittings:									
	Toilet		u	1	135,000.00	69.23	135,000.00	69.23		Finish
	Wash basin		u	1	30,000.00	15.38	30,000.00	15.38		Finish
	Bath		u							Finish
	Shower		u	1	29,000.00	14.87	29,000.00	14.87		Finish
	Bathroom accesories		set	1	17,000.00	8.72	17,000.00	8.72		Finish
	Sub-total:								211,000.00	
	Ironmongery:									
	Principal Locks		u	2	35,000.00	17.95	70,000.00	35.90		Finish
	Secundary Locks									
	Tirtiary Locks		u	3	16,000.00	8.21	48,000.00	24.62		Finish
	Bathroom Locks		u	1	14,000.00	7.18	14,000.00	7.18		Finish
	Window stays		u	9	4,500.00	2.31	40,500.00	20.77		Finish
	Sub-total:								172,500.00	
	Appliances:									
	Sink		u	1	25,000.00	12.82	25,000.00	12.82		Finish
	Utility sink		u	1	50,000.00	25.64	50,000.00	25.64		Finish
	Hot water Tank		u							
	Sub-total:								75,000.00	

Shell Sucres:	0.00	**Total US. Dollars:**	235.13
Finishes Sucres:	458,500.00	**Total Sucres:**	458,500.00

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

08 Fixed Units

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Kitchen:									
	Floor cabinets		m	4.00	62,000.00	31.79	248,000.00	127.18		Finish
	Wall cabinets		m	2.20	71,000.00	36.41	156,200.00	80.10		Finish
	Sub-total:								404,200.00	
	Bedrooms:									
	Built in wardrobes		m2	0.00	0.00	0.00	0.00	0.00		Finish
	Sub-total:								0.00	
	Others:									
	Sub-total:									

Shell Sucres:	0.00	**Total US. Dollars:**	207.28
Finishes Sucres:	404,200.00	**Total Sucres:**	404,200.00

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

09 Sanitary Installations

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Pipework:									
	PVC Pipe	50mm	m	8.00	3,767.00	1.93	30,136.00	15.45		Shell
	PVC Pipe	75mm	m	0.00	6,150.00	3.15	0.00	0.00		Shell
	PVC Pipe	110mm	m	2.10	7,237.00	3.71	15,197.70	7.79		Shell
	PVC Foul water drainage pipes	110mm	m	0.00	7,140.00	3.66	0.00	0.00		Shell
	CP External foul water drainage pipes	100mm	m	0.00	7,834.00	4.02	0.00	0.00		Shell
	CP External foul water drainage pipes	150mm	m	17.00	9,988.00	5.12	169,796.00	87.07		Shell
	Sub-total:								215,129.70	
	Floor Drains:									
	Internal floor drain	50mm	u	3	6,587.00	3.38	19,761.00	10.13		Finish
	External floor drain	100mm	u	1	9,318.00	4.78	9,318.00	4.78		Finish
	Sub-total:								29,079.00	
	Elements:									
	Manholes		u	4	25,000.00	12.82	100,000.00	51.28		Shell
	Septinc tank		u	0	500,000.00	256.41	0.00	0.00		Shell
	Drain water roof gutter		m	0.00	6,000.00	3.08	0.00	0.00		Finish
	Sub-total:								100,000.00	
	Labour per connection:									
	Foul water		u	6	14,642.00	7.51	87,852.00	45.05		Shell
	Surface water		u	0	19,180.00	9.84	0.00	0.00		Shell
	Sub-total:								87,852.00	

Shell Sucres:	**402,981.70**	**Total US. Dollars:**	**221.57**
Finishes Sucres:	**29,079.00**	**Total Sucres:**	**432,060.70**

Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

10 Plumbing Installations

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Pipes & accessories:									
	PVC cold water pipes	1/2"	m	21	5,140.00	2.64	107,940.00	55.35		Shell
	PVC cold water pipes	3/4"	m	4	5,818.00	2.98	23,272.00	11.93		Shell
	Check valve	1/2"	u	1	19,510.00	10.01	19,510.00	10.01		Shell
	Pass tape	3/4"	u	1	10,749.00	5.51	10,749.00	5.51		Shell
	Control tape	1/2"	u	1	9,127.00	4.68	9,127.00	4.68		Shell
	Sub-total:								170,598.00	
	Labour per connection:									
	Cold water		pt	6	32,677.00	16.76	196,062.00	100.54		Shell
	Hot water		pt	0	32,677.00	16.76	0.00	0.00		Shell
	Meter		pt	1	39,539.00	20.28	39,539.00	20.28		Shell
	Appliances		pt	0	34,079.00	17.48	0.00	0.00		Shell
	Sub-total:								235,601.00	

Shell Sucres:	**170,598.00**	**Total US. Dollars:**	**208.31**
Finishes Sucres:	**235,601.00**	**Total Sucres:**	**406,199.00**

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

11 Electrical Installations

Code	Items	Dimensions	Unit	Quantity	Price					Site
					Unit Suc.	Unit. US $	Sucres	US $	Subtotal Sucres	
	Electrical:									
	Light connections points		pt	12	22,000.00	11.28	264,000.00	135.38		Finish
	Spot lights		u	0	28,000.00	14.36	0.00	0.00		Finish
	Plug points		pt	15	21,700.00	11.13	325,500.00	166.92		Finish
	Fuse box		u	1	92,786.00	47.58	92,786.00	47.58		Finish
	Mains connection		m	9	17,334.00	8.89	156,006.00	80.00		Shell
	Sub-total:								838,292.00	
	Bell and Telephone:									
	Mains connection		m	0	3,911.00	2.01	0.00	0.00		AC
	Telephone points		pto	0	12,365.00	6.34	0.00	0.00		AC
	Bell installation		u	1	17,105.00	8.77	17,105.00	8.77		AC
	Special plugs points		pto	0	25,869.00	13.27	0.00	0.00		AC
	Sub-total:								17,105.00	

Shell Sucres:	**156,006.00**	**Total US. Dollars:**	**438.67**
Finishes Sucres:	**699,391.00**	**Total Sucres:**	**855,397.00**

Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Total

Items	Shell		Finishes		Totals	
	Sucres	**US $**	**Sucres**	**US $**	**Sucres**	**US $**
01 Foundations	507,053.52	260.03	0.00	0.00	507,053.52	260.03
02 Structure	2,421,640.00	1,241.87	0.00	0.00	2,421,640.00	1,241.87
03 Walls	1,212,010.40	621.54	880,867.00	451.73	2,092,877.40	1,073.27
04 Floors	1,233,596.29	632.61	250,775.64	128.60	1,484,371.93	761.22
05 Roofs	1,276,140.00	654.43	0.00	0.00	1,276,140.00	654.43
06 Doors & Windows	0.00	0.00	1,132,000.00	580.51	1,132,000.00	580.51
07 Basins & Accesories	0.00	0.00	458,500.00	235.13	458,500.00	235.13
08 Fixed Units	0.00	0.00	404,200.00	207.28	404,200.00	207.28
09 Sanitary Installations	402,981.70	206.66	29,079.00	14.91	432,060.70	221.57
10 Plumbing Installations	170,598.00	87.49	235,601.00	120.82	406,199.00	208.31
11 Electrical Installations	156,006.00	80.00	699,391.00	358.66	855,397.00	438.67
Totals	7,380,025.91	3,784.63	4,090,413.64	2,097.65	11,470,439.55	5,882.28

Transport Costs	%		
Extras	%		
TOTAL		**11,470,439.55**	**5,882.28**

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Statistical System

Shell sheet
Finishes sheet
Total sheet
Shell and finishes sheet
Construction per m2 sheet
Monthly salary / m2 construction sheet

Trade-off Methodolology for Low-Cost Housing Construction Technologies

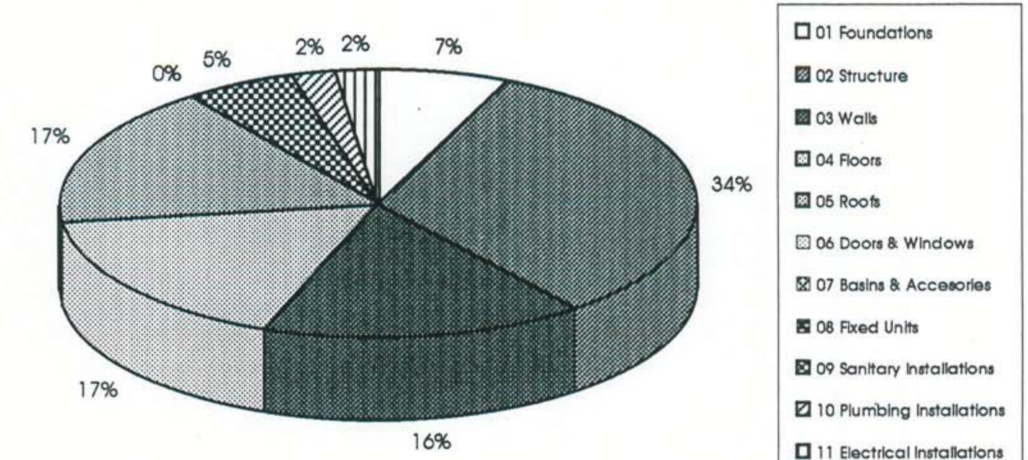
CENDEP

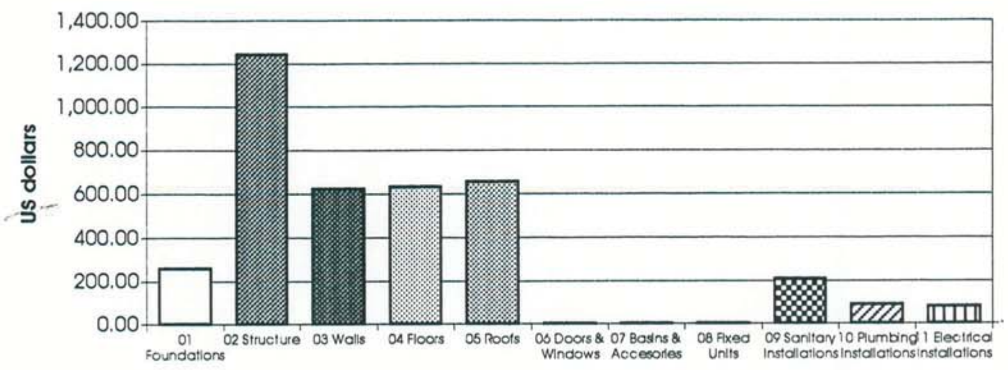
Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

Shell

Outputs

	US dollars	Sucres
Dollar Rate	1.00	1,950.00
Budgeting Items		
01 Foundations	260.03	507,053.52
02 Structure	1,241.87	2,421,640.00
03 Walls	621.54	1,212,010.40
04 Floors	632.61	1,233,596.29
05 Roofs	654.43	1,276,140.00
06 Doors & Windows	0.00	0.00
07 Basins & Accesories	0.00	0.00
08 Fixed Units	0.00	0.00
09 Sanitary Installations	206.66	402,981.70
10 Plumbing Installations	87.49	170,598.00
11 Electrical Installations	80.00	156,006.00
Total	3,784.63	7,380,025.91





Trade-off Methodolology for Low-Cost Housing Construction Technologies	Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
CENDEP	Date:	*October 1994*	US Dollar:	*1,950.00*

Finishes

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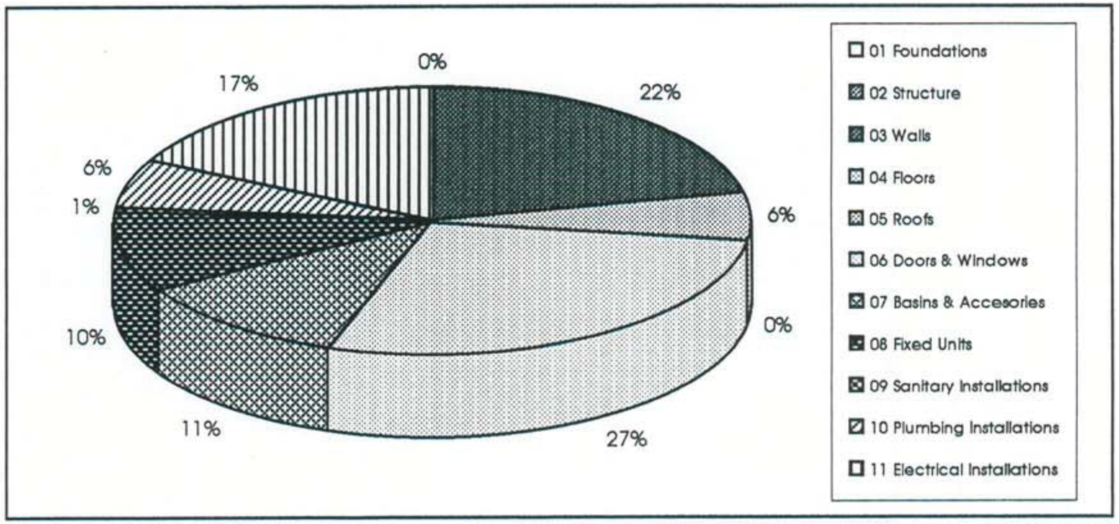
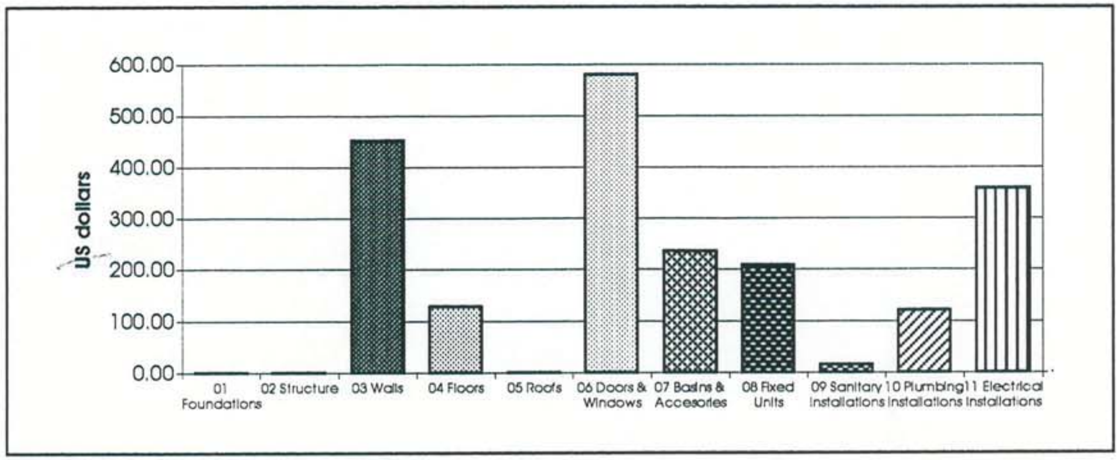
Outputs

	US dollars	Sucres
Dollar Rate	1.00	1,950.00
Budgeting Items		
01 Foundations	0.00	0.00
02 Structure	0.00	0.00
03 Walls	451.73	880,867.00
04 Floors	128.60	250,775.64
05 Roofs	0.00	0.00
06 Doors & Windows	580.51	1,132,000.00
07 Basins & Accesories	235.13	458,500.00
08 Fixed Units	207.28	404,200.00
09 Sanitary Installations	14.91	29,079.00
10 Plumbing Installations	120.82	235,601.00
11 Electrical Installations	358.66	699,391.00
Total	2,097.65	4,090,413.64





Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

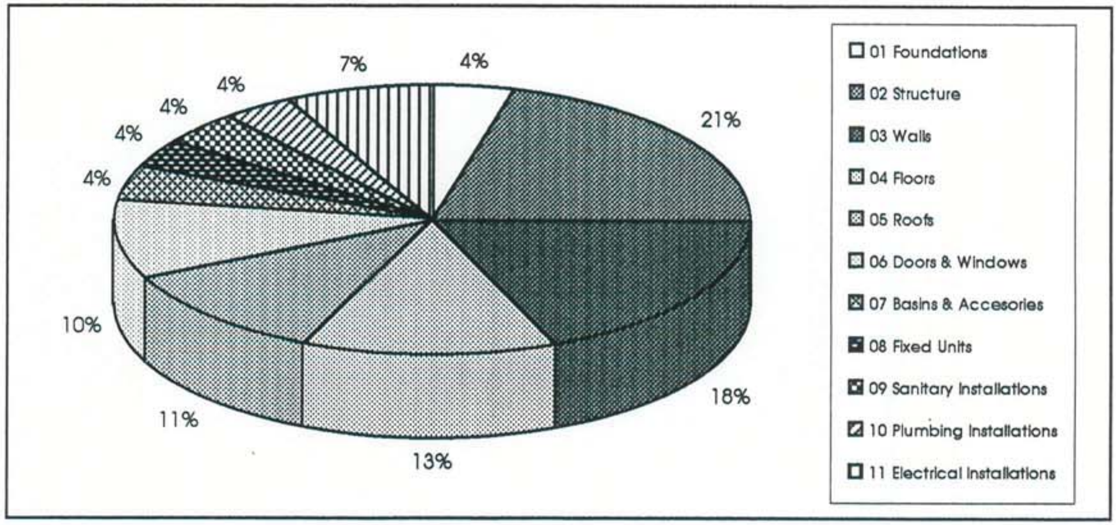
Outputs

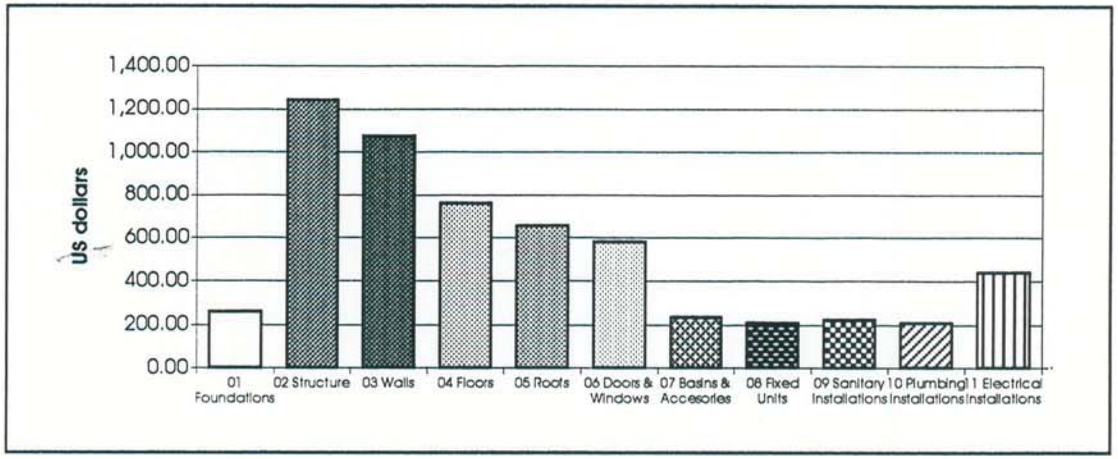
Total

	US dollars	Sucres
Dollar Rate	1.00	1,950.00

Budgeting Items

	US dollars	Sucres
01 Foundations	260.03	507,053.52
02 Structure	1,241.87	2,421,640.00
03 Walls	1,073.27	2,092,877.40
04 Floors	761.22	1,484,371.93
05 Roofs	654.43	1,276,140.00
06 Doors & Windows	580.51	1,132,000.00
07 Basins & Accesories	235.13	458,500.00
08 Fixed Units	207.28	404,200.00
09 Sanitary Installations	221.57	432,060.70
10 Plumbing Installations	208.31	406,199.00
11 Electrical Installations	438.67	855,397.00
Total	5,882.28	11,470,439.55





Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

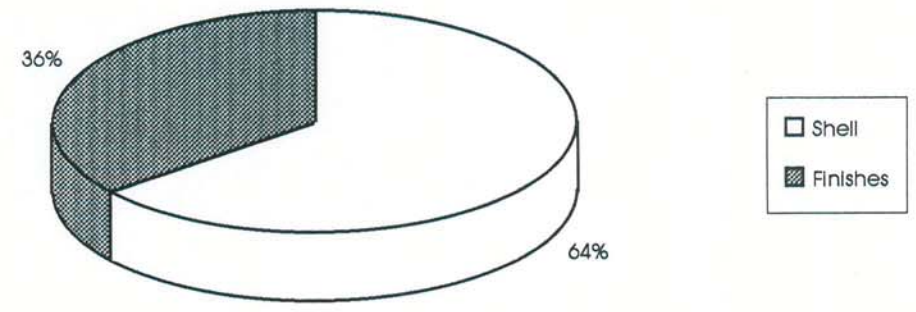
Outputs

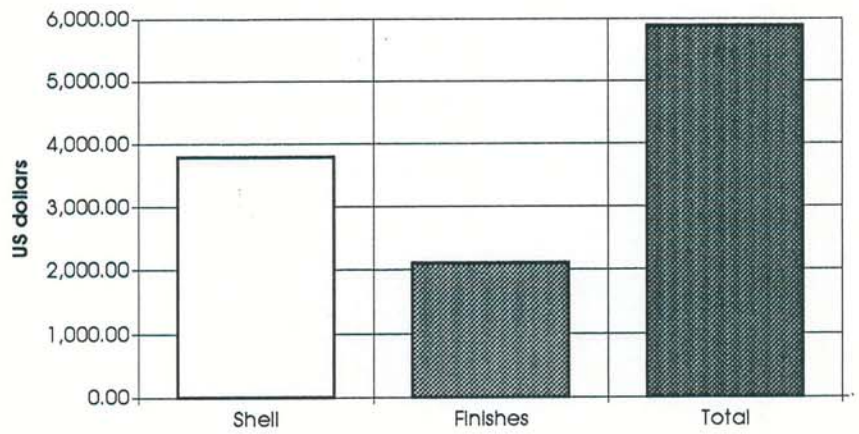
	US dollars	Sucres
Dollar Rate	1.00	1,950.00

Budgeting Items

Shell	3,784.63	7,380,025.91
Finishes	2,097.65	4,090,413.64
Total	5,882.28	11,470,439.55

Shell & Finishes





Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

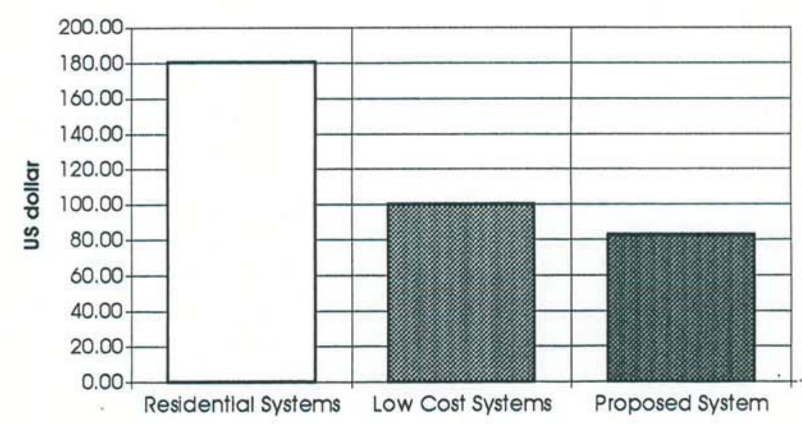
Construction per M2

Inputs

	US dollars	Sucres
House In M2		71.00
Residential Systems	180.51	352,000.00
Low Cost Systems	100.00	195,000.00

Outputs

Dollar Rate	1.00	1,950.00
Proposed System	82.85	161,555.49



Trade-off Methodolology for Low-Cost Housing Construction Technologies

CENDEP

Technology:	*Wattle and daub-Timber*	Project:	*Prototype*
Date:	*October 1994*	US Dollar:	*1,950.00*

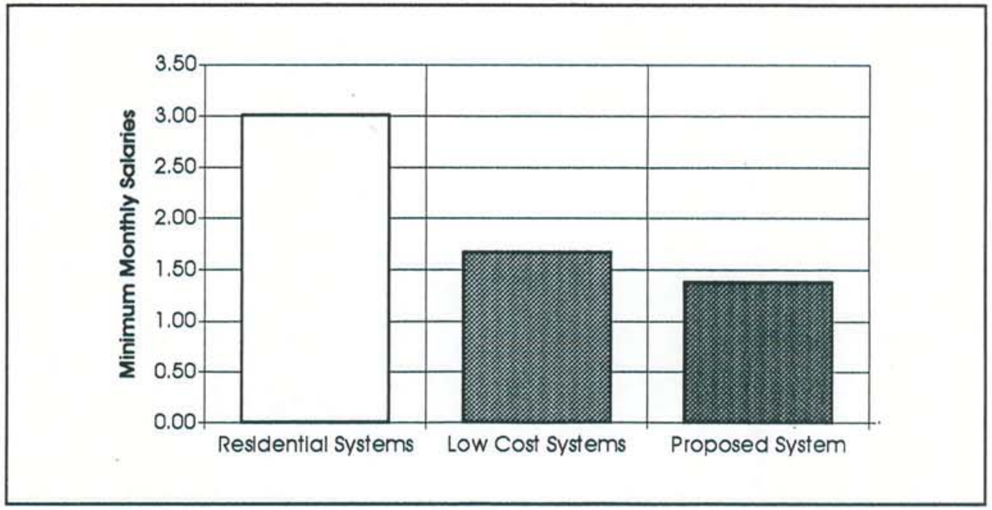
Inputs

	US dollars	Sucres
Minimum Monthly Salary	60.00	117,000.00

Outputs

	US dollars	Sucres	N° Salaries
Dollar Rate	1.00	1,950.00	
Residential Systems	180.51	352,000.00	3.01
Low Cost Systems	100.00	195,000.00	1.67
Proposed System	82.85	161,555.49	1.38

Monthly Salary/M2 construction



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Trade-off Software

Graphical general graph
Cover
Inputs sheet 01
Inputs sheet 02
House surface sheet 03
House surface subsidy sheet 04
House total price sheet 05
Monthly payments sheet 06
Income per family sheet 07

CENDEP

Gipsy Lane Campus
Headington Oxford
OX3 OBP
United Kingdom
Tel: 44-865-483413
Fax: 44-865-483298

oxford brookes university oxford brookes university oxford brookes university

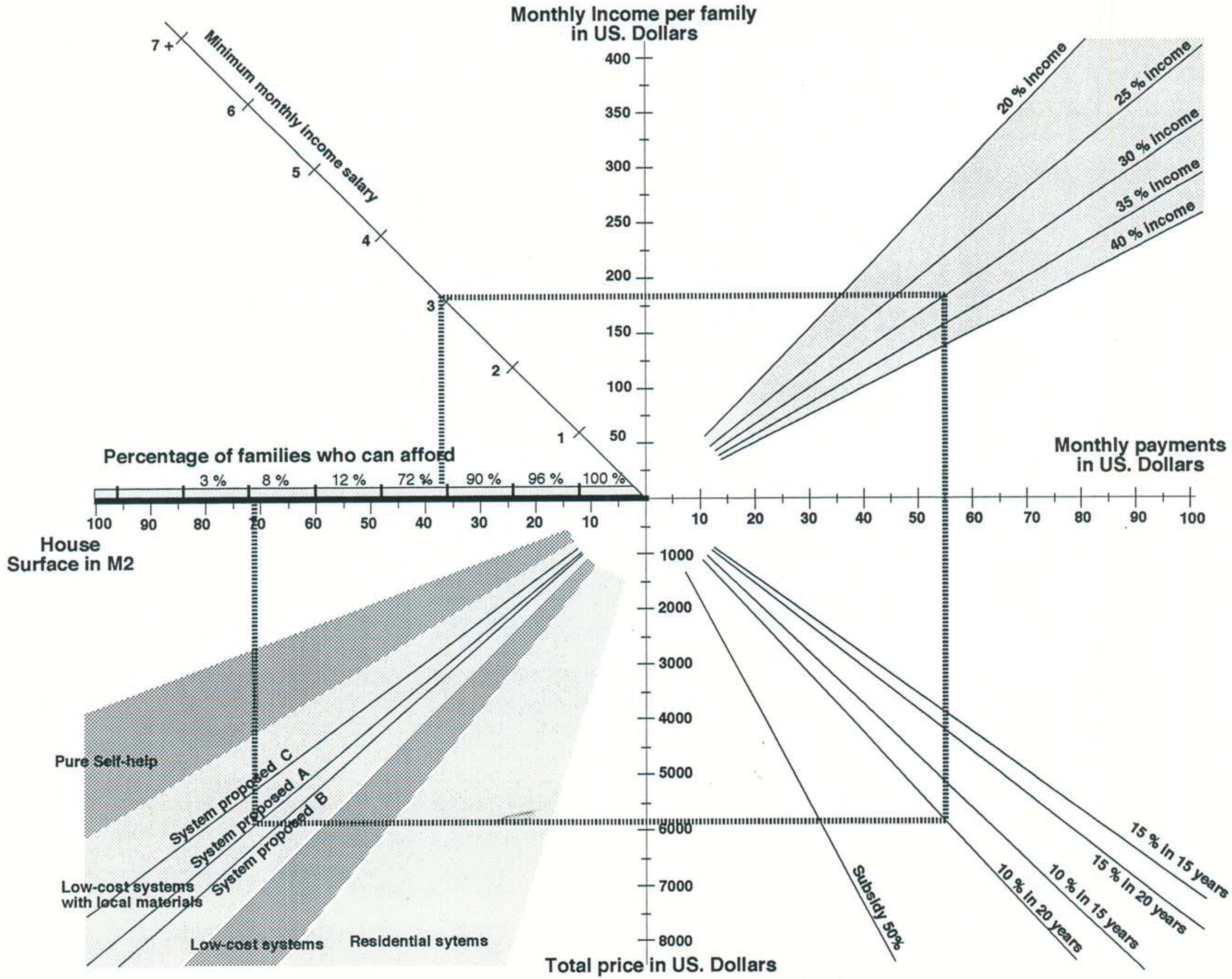
Affordability Cost Recovery System DEMO VERSION	v. B	Oct-94

Institution Name:

Cendep

Project: *Demo*

Date: *October 1994*



Monthly Income per family
in US. Dollars
400
350
300
250
200
150
100
50
Minimum monthly income salary
7 +
6
5
4
3
2
1
20 % Income
25 % Income
30 % Income
35 % Income
40 % Income
Percentage of families who can afford
3 %
8 %
12 %
72 %
90 %
96 %
100 %
House
Surface in M2
100
90
80
70
60
50
40
30
20
10
Monthly payments
in US. Dollars
10
20
30
40
50
60
70
80
90
100
1000
2000
3000
4000
5000
6000
7000
8000
Total price in US. Dollars
Pure Self-help
System proposed C
System proposed A
System proposed B
Low-cost systems
with local materials
Low-cost systems
Residential sytems
Subsidy 50%
10 % in 20 years
10 % in 15 years
15 % in 20 years
15 % in 15 years

Affordability Cost Recovery System DEMO VERSION

Project: *Demo*

Cendep

Date: *October 1994*

01 Inputs Sheet

Minimum income per worker

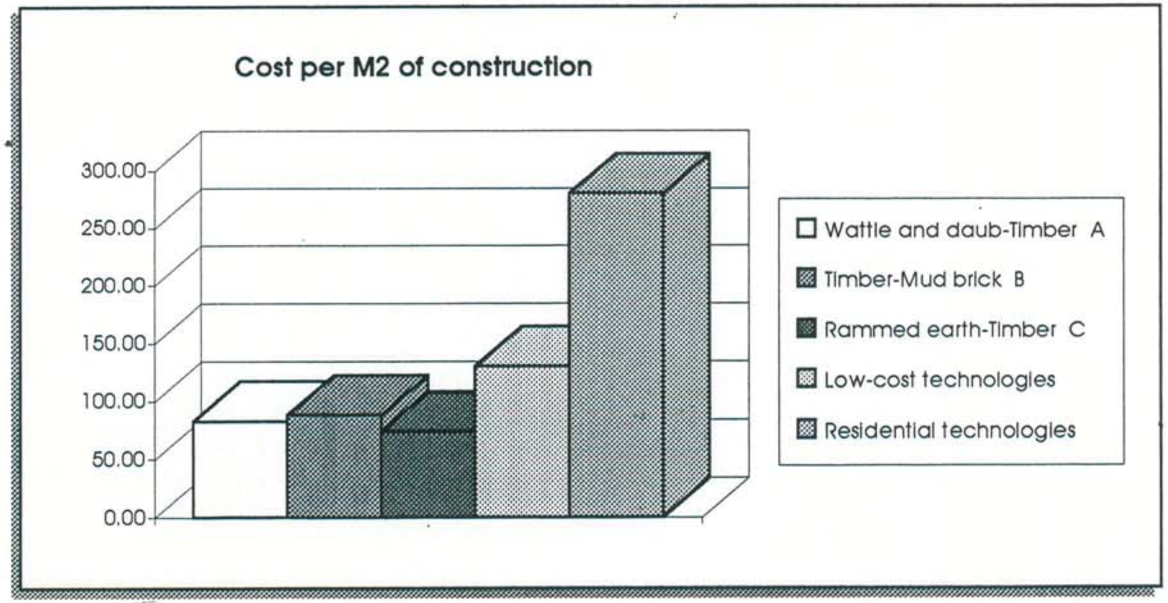
Monthly	60.00

Financial Inputs

Years of payments	20
Interest rate %	10

Construction technologies Inputs

Proposals	Cost per M2
Wattle and daub-Timber A	82.85
Timber-Mud brick B	88.00
Rammed earth-Timber C	74.00
Low-cost technologies	130.00
Residential technologies	280.00



Affordability Cost Recovery System DEMO VERSION

Project: *Demo*

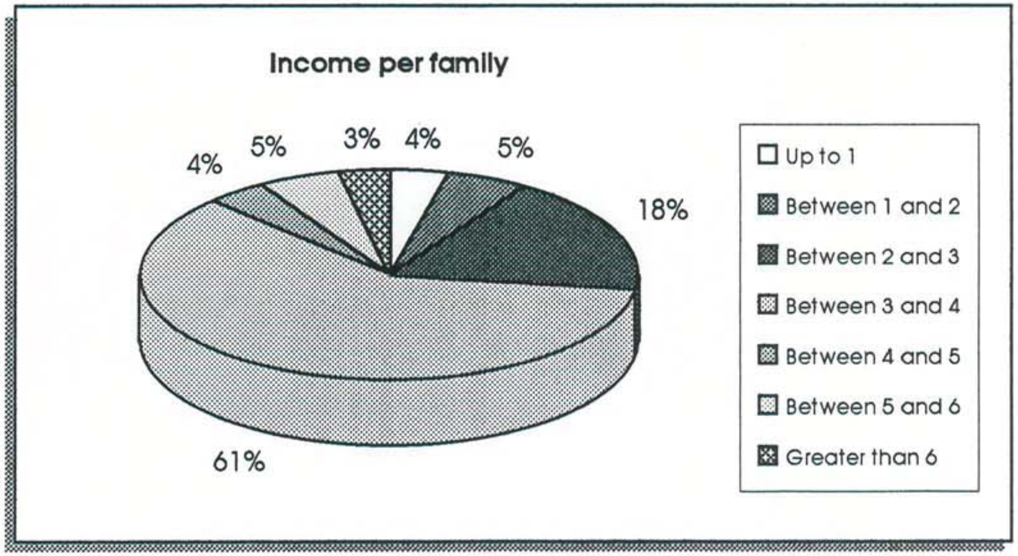
Cendep

Date: *October 1994*

02 Inputs Sheet

Family income inputs

Min. monthly income salary	N° Families	$ Range
Up to 1	10	-60.00
Between 1 and 2	13	61.00-120.00
Between 2 and 3	46	121.00-180.00
Between 3 and 4	150	181.00-240.00
Between 4 and 5	10	241.00-300.00
Between 5 and 6	13	301.00-360.00
Greater than 6	8	361.00 +
Total families involved in the project	250	



Affordability Cost Recovery System DEMO VERSION

Project: *Demo*

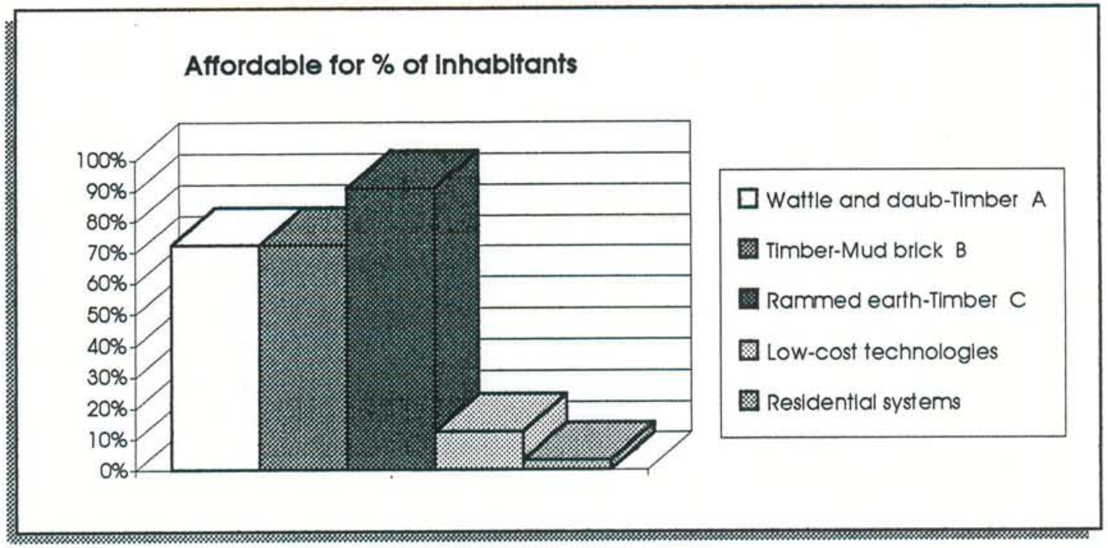
Cendep

Date: *October 1994*

03 House Floor Area Sheet

Inputs

House floor area M2	71
% of monthly income for repayments	30



Outputs

Construction Technologies	House Total price	Monthly payments	Total cost of house after payments	Minimum income per family	Affordable for % of inhabitants
Wattle and daub-Timber A	5,882.35	56.77	13,623.83	189.22	72%
Timber-Mud brick B	6,248.00	60.29	14,470.69	200.98	72%
Rammed earth-Timber C	5,254.00	50.70	12,168.54	169.01	91%
Low-cost technologies	9,230.00	89.07	21,377.16	296.90	12%
Residential systems	19,880.00	191.85	46,043.11	639.49	3%

Affordability Cost Recovery System DEMO VERSION

Project: *Demo*

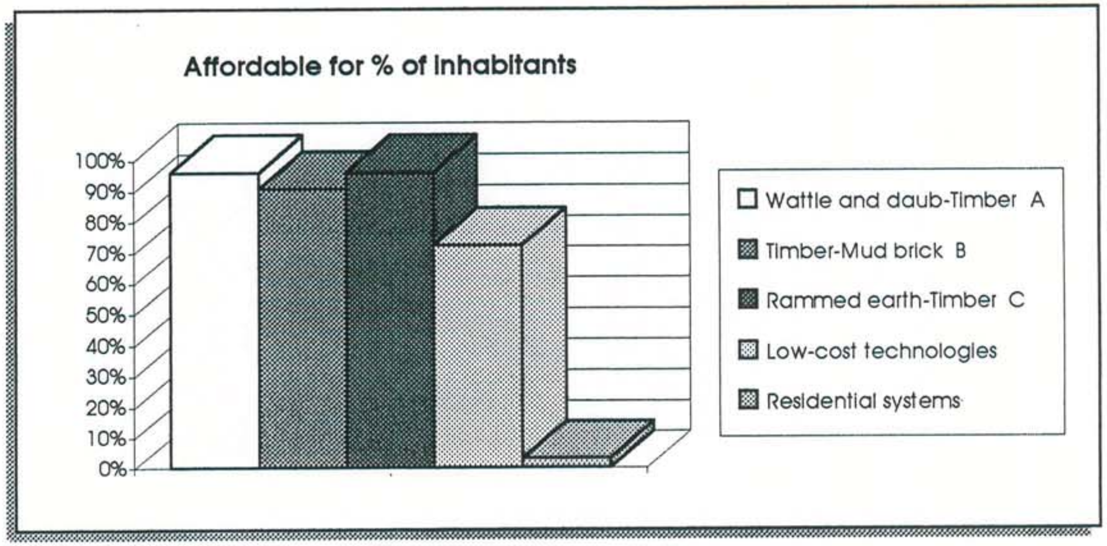
Cendep

Date: *October 1994*

04 House Floor Area With Subsidy Sheet

Inputs

House floor area M2	71
Subsidy %	5
% of monthly income for repayments	20



Outputs

Construction Technologies	House Total price	Monthly payments	Total cost of house after payments	Minimum income per family	Affordable for % of inhabitants
Wattle and daub-Timber A	5,882.35	23.28	5,588.23	116.42	96%
Timber-Mud brick B	6,248.00	24.73	5,935.60	123.66	91%
Rammed earth-Timber C	5,254.00	20.80	4,991.30	103.99	96%
Low-cost technologies	9,230.00	36.54	8,768.50	182.68	72%
Residential systems	19,880.00	78.69	18,886.00	393.46	3%

Affordability Cost Recovery System DEMO VERSION

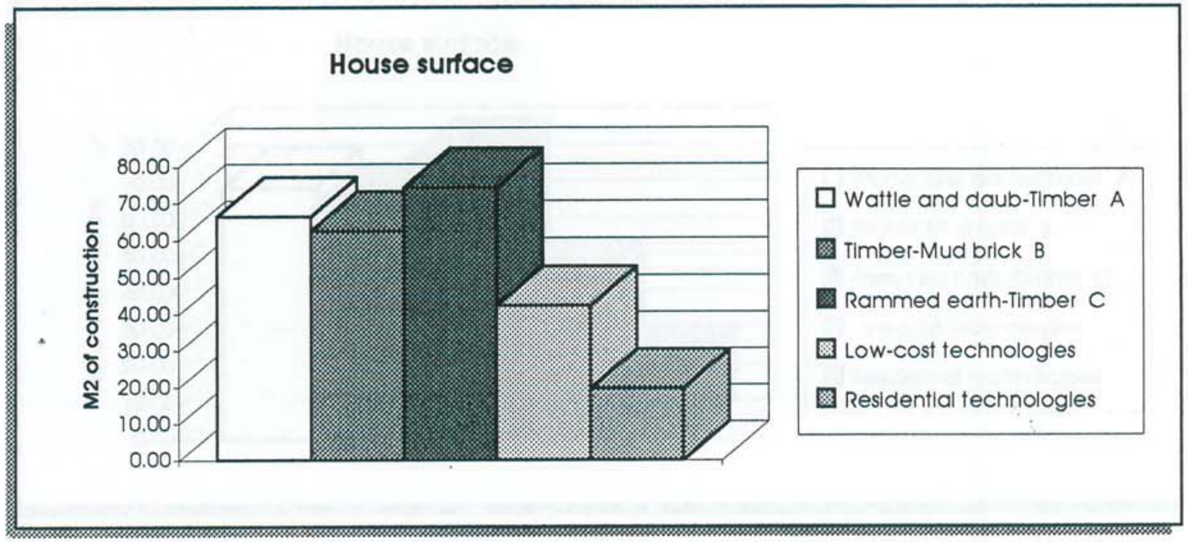
Cendep

Project: *Demo*
Date: *October 1994*

05 House Total Price Sheet

Inputs

House total price	5,500.00



Outputs

Construction Technologies	House Surface M2	Monthly payments	Total cost of house after payments	% of menth. inc. for repayments	Minimum income per family	Affordable for % of inhabitants
Wattle and daub-Timber A	66.39	53.08	12,738.29	20%	265.38	12%
Timber-Mud brick B	62.50			25%	212.30	72%
Rammed earth-Timber C	74.32			30%	176.92	91%
Low-cost technologies	42.31			35%	151.65	91%
Residential technologies	19.64			40%	132.69	91%

Affordability Cost Recovery System DEMO VERSION

Cendep

Project: *Demo*

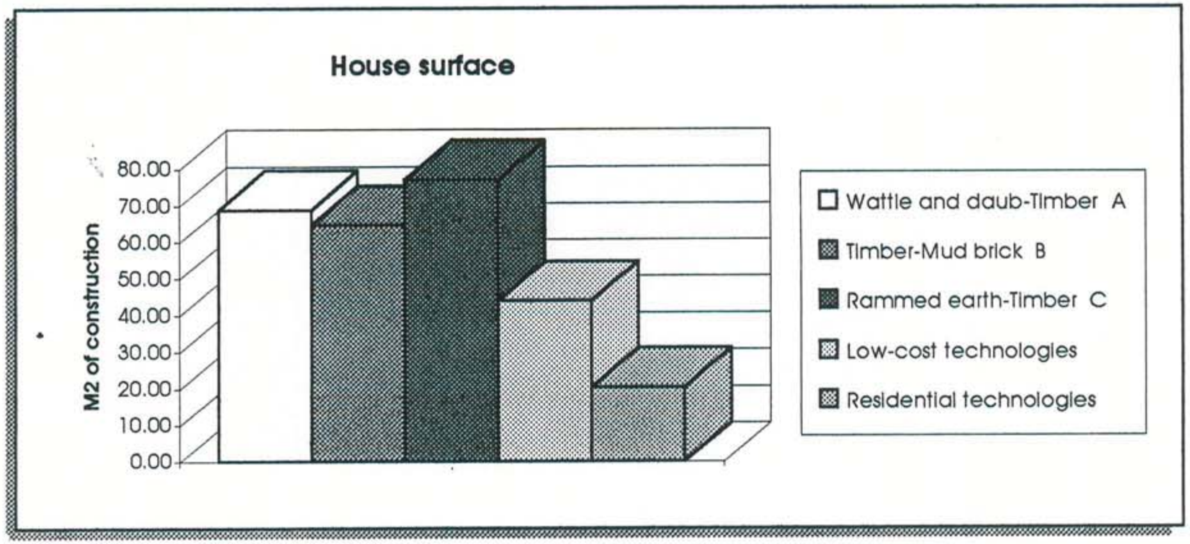
Date: *October 1994*

06 Monthly Payments Sheet

© C. Guerrero

Inputs

Monthly payments: 55.00



Outputs

Construction Technologies	House Surface M2	% of menth. inc. for repayments	Minimum income per family	Affordable for % of inhabitants
Wattle and daub-Timber A	68.79	20.00	275.00	12%
Timber-Mud brick B	64.77	25.00	220.00	72%
Rammed earth-Timber C	77.02	30.00	183.33	72%
Low-cost technologies	43.84	35.00	157.14	91%
Residential technologies	20.35	40.00	137.50	91%

Total cost of house: 5,699.35

Total cost of house after payments: 13,200.00

Affordability Cost Recovery System DEMO VERSION

Project: *Demo*

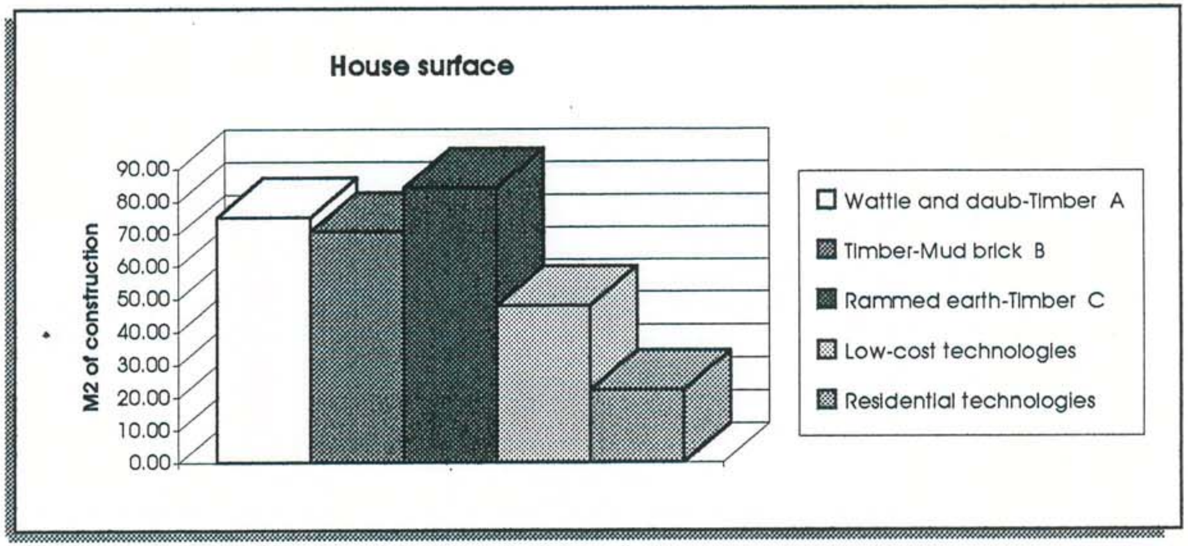
Cendep

Date: *October 1994*

07 Income Per Family Sheet

Inputs

Income per family: 200.00



Outputs

Construction Technologies	House Surface M2
Wattle and daub-Timber A	75.04
Timber-Mud brick B	70.65
Rammed earth-Timber C	84.02
Low-cost technologies	47.83
Residential technologies	22.21

House total price	House total price after payments	Affordable for % of inhabitants
6,217.48	14,400.00	72%

% of menth. Inc. for repayments	Monthly payments
20	40.00
25	50.00
30	60.00
35	70.00
40	80.00

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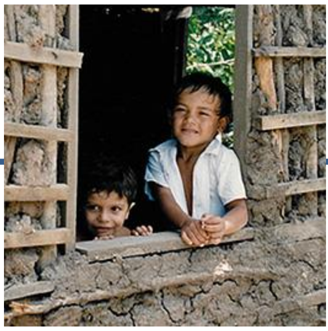

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By Carlos Guerrero
Oxford, September

CENDEP
Centre for Development
and Emergency Planning
Oxford Brookes University
Gypsy Lane Campus
Headington, Oxford
OX3 OBP U.K.