MEDICOS SIN FRONTERAS

SMALL CONSTRUCTIONS MANUAL

version 1.0 / 2011

In collaboration with

Master of International Cooperation:
Sustainable Emergency Architecture

SMALL CONSTRUCTIONS MANUAL

Version 1.0 / 2011

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PREFACE

This first version of the Small Construction Manual is intended to show the most effective ways of building facilities to support our activities in the field .
It may be the case that you will find some discrepancies or differences according to your experiences, where the information in this manual might need to be upgraded or better explained.

Please help us improve this handbook with your comments and questions.

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INDEX:

1. INTRODUCTION

The construction manual you have before you is intended to be a supportive tool for our logistical staff in the field, wherever small construction and rehabilitation works are needed. It ensures a good understanding of constructions' basic concepts, and guarantees a standard of quality that can fulfill medical and logistical needs.

Before construction on any permanent structure can begin, the 5 field prerequisites for construction programs stated by MSF have to be fulfilled. These can be found on the dvd-LOG: 08 Shelter & Construction/01 Construction/01 Policies & Guidelines/5 prerequisites_prérequis/8A Construction Five prerequisites EN.pdf

IMPORTANT: This manual is NOT intended to be used for the construction of large scale and/or complex infrastructure or buildings, as the constructional techniques explained here will prove to be insufficient. Rather, for projects of larger dimensions, MSF headquarters and coordination team will decide according to the complexity of the project and the availability of resources which kind of specialized staff will follow the design stage as well as the whole construction process.

In the second chapter, this manual will help professionals in the field to supervise the construction process in a suitable way, and to deal with the basic organizational needs of construction projects. This ranges from simple contract agreements, over bills of quantity for material and cost calculations, to guidelines for supervision of the actual construction site, including safety measures.
Furthermore, the manual will help to make correct choices regarding the selection for a suitable site for the construction, and to determine the type of building that is best suited for the climatic conditions of every context. It will teach the reader to take into account various natural hazards such as earthquakes or hurricanes, to make sure the building is resilient in these circumstances. It will also explore some different options for building typologies in different climatic circumstances.

The third chapter provides an introduction to various construction materials. It is important to know the suitability of different materials in varying circumstances. It is also important to have some guidelines on the assessment of materials' quality, to be able to determine whether a contractor or supplier is providing adequate quality of materials. Also, some guidelines on the good use of materials will be included, such as for example correct mixing techniques for concrete.

The fourth chapter provides an intuitive and graphic guidance, which shows step-by-step the different stages in a construction process of a new building, starting from the foundations, and ending with the finishing such as plastering. It aims to explain these concepts as clearly as possible, both graphically and linguistically, aimed at people with little or no background in construction. It will provide tips on correct supervision during construction of every building element, to ensure it is executed correctly. Also, it will give some alternatives for some building elements, depending on the locally available materials or traditions.

The fifth chapter deals with extension of existing buildings. It will give some aspects to take into account, that might be different from creating a completely new building, such as analysis of the existing structure, and determining a good location for the extension.

The sixth chapter provides techniques on rehabilitation of existing buildings, to bring them up to a standard that fulfills our operational needs. It will provide guidance on how to assess the quality of an existing building, to determine the course of action, and techniques and methods on how to improve and fix the various building elements.

Finally, the end of the manual includes a bibliography of written materials that can be consulted for further information on specific topics.
All of the construction methods and solutions in this manual are well-established and have proven their use and reliability. Therefore, they can safely be applied in contexts where safety and reliability are essential. Also, they aim to be as environmentally sustainable as possible, from the building typology to the materials.
Special attention should be given to the suitability of the construction in different contexts and cultures. Therefore, there are some alternative building solutions given for some construction elements.

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

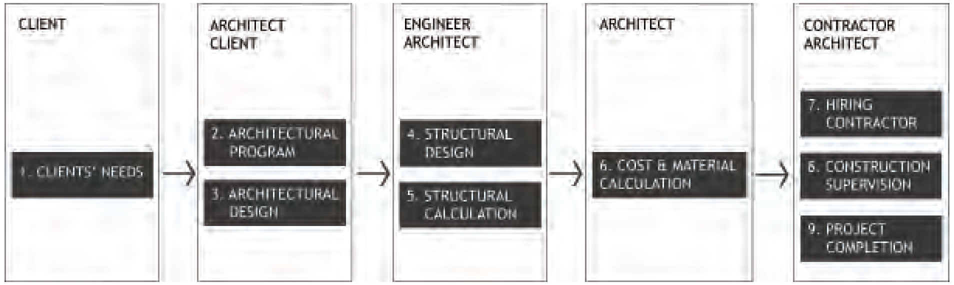
MEDICOS SIN FRONTERAS

2. PROJECT MANAGEMENT GUIDELINES

Project management is an essential part of any building project. It means the management and follow-up of all the steps involved in the building process, from start to finish. Depending on the type of project, this management will be done by different people. In large construction projects, a dedicated project manager may be appointed, while on smaller projects, the architect usually takes up this task. In the case of the small projects of MSF, the logistician will be the person in charge of the project management cycle. In this chapter, we will explain the general project cycle, and give a more detailed overview of the most important aspects for the follow-up of projects in the field.

Usual building process for small to medium scale buildings

This section explains briefly the construction process that is usually followed in the case of an average construction process for a private client. The intention of this part is to give some insight into the world of construction.



1. CLIENTS' NEEDS
A building project always starts with the need of a client to have a space for a certain type of activity. For this need to be fulfilled, he wants to build something, which is why he will usually need an architect.

2. ARCHITECTURAL PROGRAM
Together with the architect, he will establish a so called architectural program. This program will convert the needs into actual spaces and equipment to be designed. For example, a family may have a need to house a mother, father and three children. The architectural program articulates this as a house with a living room, a kitchen, a bathroom, and three bedrooms.

3. ARCHITECTURAL DESIGN
Next, the architect can start making an architectural design according to the program. This is done in close collaboration with the client, who may need to provide further input about the details of his needs and preferences. The architectural design is finished when the client feels the design suits all of his needs, and the client and architect are satisfied with the aesthetical and constructional aspects.

4. STRUCTURAL DESIGN
With the architectural design finished, a structural engineer usually designs the structure of the building, meaning the type of structure, the materials, etc. This is done in collaboration with the architect, to suit the buildings' needs.

5. STRUCTURAL CALCULATION
A structural engineer also calculates the loads the structure will have to carry, and the corresponding necessary material thickness of the walls, beams, etc, to be able to support this load.

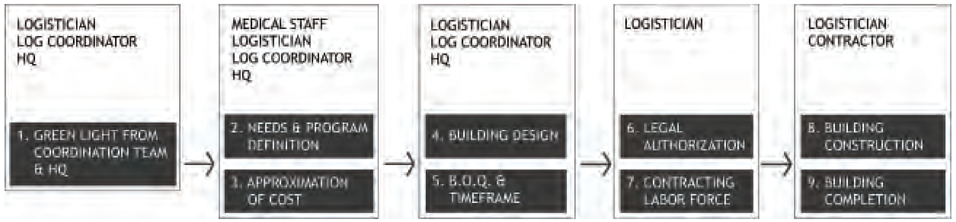
6. COST & MATERIAL CALCULATION
With the design and structure completed, the cost and materials necessary for the construction can be calculated. This will be done through a bill of quantities, which provides a basic framework for the input of materials and prices, and the output of total costs. The cost has to be agreed upon with the client.

7. HIRING A CONTRACTOR
When the building is ready for construction, someone to execute the construction needs to be hired. This can be a contractor who has different professionals working for him, or a labor force comprising of different independent professionals. A contract needs to be established between the contractor and the client, detailing all of the responsibilities and liabilities.

8. CONSTRUCTION SUPERVISION
During the construction, the architect usually supervises the construction, or hires someone to supervise it for him.

9. PROJECT COMPLETION
After the construction is completed, the project is finished, and the building can become operational.

Building process in the case of MSF



The construction process in the case of MSF will differ significantly from the average building process for a private client, because of the specific mode of operation of MSF. This section provides some steps to follow in the case of a small construction process for MSF, where the project is managed by a logistician in the field with little or no background in construction projects. It is based on the step-by-step process for more complex constructions by MSF, which can be found in the dvd-LOG 08 Shelter &

1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex

Construction/01 Construction/01 Policies & Guidelines/Step by Step MSF OCBA/200905 EN Step by Step construction procedures OCBA.pdf

1. GET A GREEN LIGHT DECISION FROM COORDINATION TEAM AND HQ.
When a possibility of a construction appears in the field, the operational relevance has to be assessed before starting the process, and it needs to get approval from the national coordination team, which in turn gets approval from HQ level.

2. DEFINITION OF THE PROJECT
The medical staff in the field has to be consulted about the medical needs the building will fulfill. This has to be expressed in terms of the need for spaces to be built, such as number of rooms, size of the rooms, the patient flow, etc. A timetable also has to be made to determine a deadline and the priorities for the project.
This step is equivalent to the definition of the architectural program in a common construction project.

3. APPROXIMATION OF COST AND HR NEEDS
A rough approximation of area and cost needs to be done on the basis of previous projects by MSF or other actors in the area. This cost should get a preliminary approvement from the higher levels such as the national level and HQ.
Also an approximation of the needs for extra staff regarding the construction or the operation of the new building needs to be assessed and cleared with HQ.

4. ELABORATION OF THE BUILDINGS' DESIGN
The logistician should at this point, using this manual, elaborate the buildings' design, including plans and elevations, etc. In a common building project, this step is done by an architect with the consultation of an engineer, but in the case of these small building projects, the logistician can do this on his own through the help of this manual.
These building documents need to be sent to the Log Coordinator, who in turn sends them to HQ, to keep them up-to-date on the construction process. The design can be adjusted according to their recommendations.

5. B.O.Q. AND TIMEFRAME
With the building design finished, the logistician should complete the B.O.Q. and the exact cost calculation. Also a precise timetable should be established with regards to the different steps of construction and the final deadline.

6. LEGAL AUTHORIZATION
Where applicable, legal authorization from the land / urbanism authority needs to be obtained.

7. Contracting labor force
A choice needs to be made regarding the work force for the construction. This can be an external contractor or an MSF building team.

In the case of an external contractor, a tender needs to be organized to establish the most suitable contractor at the best price. This is to avoid unfair competition advantages. A contract needs to be signed with the contractor, according to the guidelines in this manual.

8. CONSTRUCTION OF THE BUILDING
When the construction is done by an MSF building team, a supply chain needs to be set up for the procurement of building materials. In the case of an external contractor, the contractor supplies the materials, but strict quality control needs to be done by the MSF logistician, through the guidelines in this manual.
During the construction process, continuous supervision needs to be done, according to the principles in this manual.

9. COMPLETION OF THE BUILDING
The provisional reception of the building takes place when the contractor finishes his works. The building can begin to be used, and an inauguration ceremony with the authorities can be considered. Sometimes some constructional defects become apparent at this time. The contractor needs to fix these defects according to the agreements of the contract. After a period of 6 or 12 months, the final reception and handover of the building can take place, and the contract with the contractor is finished.

Within the project management, there are three main elements, the CONTRACT, the BoQ, and CONSTRUCTION SUPERVISION. We will explain here each of these three elements.

2.1 Contract

General guidelines for establishing a contract are presented here, to clarify the main topics that need to be addressed when creating a contract. A construction contract is a legally binding agreement between two parties on the details and cost of a construction project. The type of contract may change according to the complexity of the project, the elements that compose it, and the country where it is going to be implemented. In the annex number 9.1, an example contract is included for better comprehension of these issues.

In order to establish a construction contract, it is necessary to state all issues regarding both parties. The contract should be clear and establish the responsibilities and competencies of each party. The contract will consist of the following sections:

The general introduction should include the identification of the parties involved, the objective of the contract, the location of the works, the type of contract, the documents it includes, the supervision process, the responsibilities of the project manager, the issues regarding site ownership (taken care by the administration in the field before the signing of the contract), the contractor's responsibilities in regards to local regulations, safety procedures, machinery to be used, and the settlement of disputes.

1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex

MEDICOS SIN FRONTERAS

The time control section should explain the issues regarding the compliance to the construction timetable. It refers to each party's responsibilities, the initiation and the planning of the works, the quality control, and sub-contracting procedures.

The cost control refers to monetary aspects of the project, identifying responsibilities, payment timetables, possible penalties and procedures should a party not comply, and a retention money procedure.

The 'finishing the contract' section refers to the procedures to apply when finishing construction: establishing the hand-over, the defects liability period, the final certificate of completion, and establishing possible situations that may give reason for a termination of the contract.

Finally, the main agreement section refers to the recognition and signature of the contract by all parties involved, acknowledging full understanding of and pledging full compliance to all the elements therein.
A contract should always be understood as a tool for the normal and regular execution of the necessary works, defending the interests of both parties.

In Annex 9.1 you will find an example of a Contract. It explains the structure to apply to it, the different elements to include, and their explanation. It does not represent a real contract. Possible changes have to be done according to the local context and the specifics of the project.

2.2 Bill of quantities (BOQ)

One of the most important elements of a project is the Bill of Quantities (BoQ). The BoQ can be defined as the list of all the necessary materials for the construction works. The listing should be done dividing them into different sections, and following the components that are part of the building. Along the listing of the materials and their quantities, there is also the listing of the price for each element. The quantity, the unit of measurement (related with the technical drawings), and the price per unit need to be described for each element of the list. The price rate has to follow the normal local market price.

The techniques to use when applying some of the materials should also be briefly described in the material list. For instance, when describing the plastering process, it is not only necessary to present the type of material to apply, but also the type of technique to use when performing this kind of finishing. This has to be done when it is necessary to apply any type of specific technique, because this could also impact the price of the application.

The BoQ starts with the designation of the technicians involved in the project and the construction, issues related with the logistics and workmanship of the construction work, for instance the transport and storage of material, the acts related with the workers, and others (consult the example BoQ) – this initial section is called the **general preliminaries**.

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

Next, it describes particular issues and definitions about the pricing of the materials, the measurement units used by the BoQ, and others (consult the example BoQ) – this second section is called **particular preliminaries**.

Concluding this initial section are the working conditions, which include all the issues about the conditions for the workers on the site, the necessary facilities, and others (consult the example BoQ) – this section is called **working conditions**.

These three sections together compose the first bill of the BoQ, called **preliminaries**. In case any of the topics of this bill include any costs, it is necessary to state them, and at the end present the total sum of this bill. This concludes bill nº. 1. (Consult the annex example BoQ)

The second bill included is called the BoQ. It is the listing of all the materials to be used, their quantities, their units of measurement, and their price rates per unit, presenting their total value (quantity*rate). This listing should be done following the chronological order of the components of the building process, starting from the foundations, going through the structure, walls, roofing, finishing's, and doors and windows. At the end of this second bill there are the partial sums for each element section (substructures; walls, roofing, and others), and in the end the total sum is made for all the element sections. This concludes bill no. 2. (Consult the annex example BoQ)

If the construction work includes any type of landscaping, or civil works (such as roads, sidewalks, etc), the listing of necessary materials for these should be done in different bills. For instance, a **civil works bill**, or a **landscape works bill**. Works and materials related with facilities (electricity, water, gas, septic tank, etc.) also have to be presented in a different bill (**facilities bill**). In the end the sums of these bills have to be included in the grand summary bill.

Bill nº. 3 is the summary of all the previous bills, and it includes the final sums for each bill, and the total sum of all bills. It is necessary to include the value of the taxes applied in the country of the project. In the end of the bill, there will be the signature of the tendered, and of a witness, including their names, the date, and the locale. This bill is called the **grand summary**. The grand summary represents the total value for all the necessary materials and works for the construction.

In Annex 9.3 you will find an example of a BoQ for a better understanding of the previous explanation. It is important to realize that the presented BoQ is not a complete and final version, but a condensed version that includes the structure to apply to the table, the different elements, some examples of the materials to include, and the way of calculating and representing their quantities, the measurement units, their rate, and their value. The annex example includes a bill nº. 1 (preliminaries), a bill nº. 2 (BoQ), and a bill no. 3 (grand summary). The actual contents and values of the tables will of course depend on the context and the specifics of the project..

MEDICOS SIN FRONTERAS

2.3 Construction supervision

The main goal of a construction process is to have a final execution of the architectural project and objectives. Within this process there are various actors that take part in the decisions and issues of construction at different levels, and with different roles. It is of major importance to create a dialogue between those actors, so that it is possible to have the best possible final product and quality of construction. This dialogue has to be established as a routine, having official records of it, so that the whole construction process is documented in the end.

The supervision process is intended as a tool of observance and reporting of the construction work, with the participation of all actors involved in the works. It supervises the exact execution of the project and its changes, of the contract, of the bill of quantities, and of the construction timetable and deadlines.

The process consists of different steps:

Visits to the construction site – (at least once a week) – where the supervisor should observe and register on-site the accomplishment and development of the construction work.
Photographs of the construction site should be taken to register the evolution of the works, connecting it with the stages of the construction process, making remarks and considerations when necessary.

Weekly meetings – (contractor; MSF;) – where is discussed: the development of the construction work; changes on the project, if necessary; the approval of materials; the execution of the construction work; the financial aspect of the construction; other issues that are relevant for that week;
These meetings should always take place on the construction site.

Reporting weekly meetings – (written minute) - recognized and signed by the contractor and MSF – after each weekly meeting, a written minute of the issues discussed should be made, reviewed and signed by the contractor and MSF. This way, there is a recognized record of the construction process, accessible for consultation.

Three copies of these documents are to be produced each time – MSF (1); contractor (1); building site (1);

Monthly reports – (written report) – recognized and signed by MSF – At the end of each month of the construction timeline, a report should be made about the works done during that period. It should contain: the development of the construction work; the changes on the project; the approval of materials; the execution of the construction work; the financial aspects of the construction; other issues that are relevant for that month;

Final report – (written report) – recognized and signed by MSF – At the end of the construction works, a report should be made about the work done. It should contain: the development of the construction work; the changes on the project; the approval of materials; the execution of the construction work; the financial aspects of the construction; other issues that are relevant; It is a final evaluation of all the work done.

Four copies of these documents are to be produced each time – MSF - local (1); MSF – Coordination (1); contractor (1); building site (1);

The supervisor is also responsible to certify that rules and guidelines about safety and hygiene in the construction site are being applied by the contractor.

The use of this manual should allow the person present in the field to undertake this assignment correctly. If the complexity of an issue justifies it, there is the possibility to report it, and ask the National Coordination Team or MSF headquarters for technical guidance.

2.4 Project management timetable

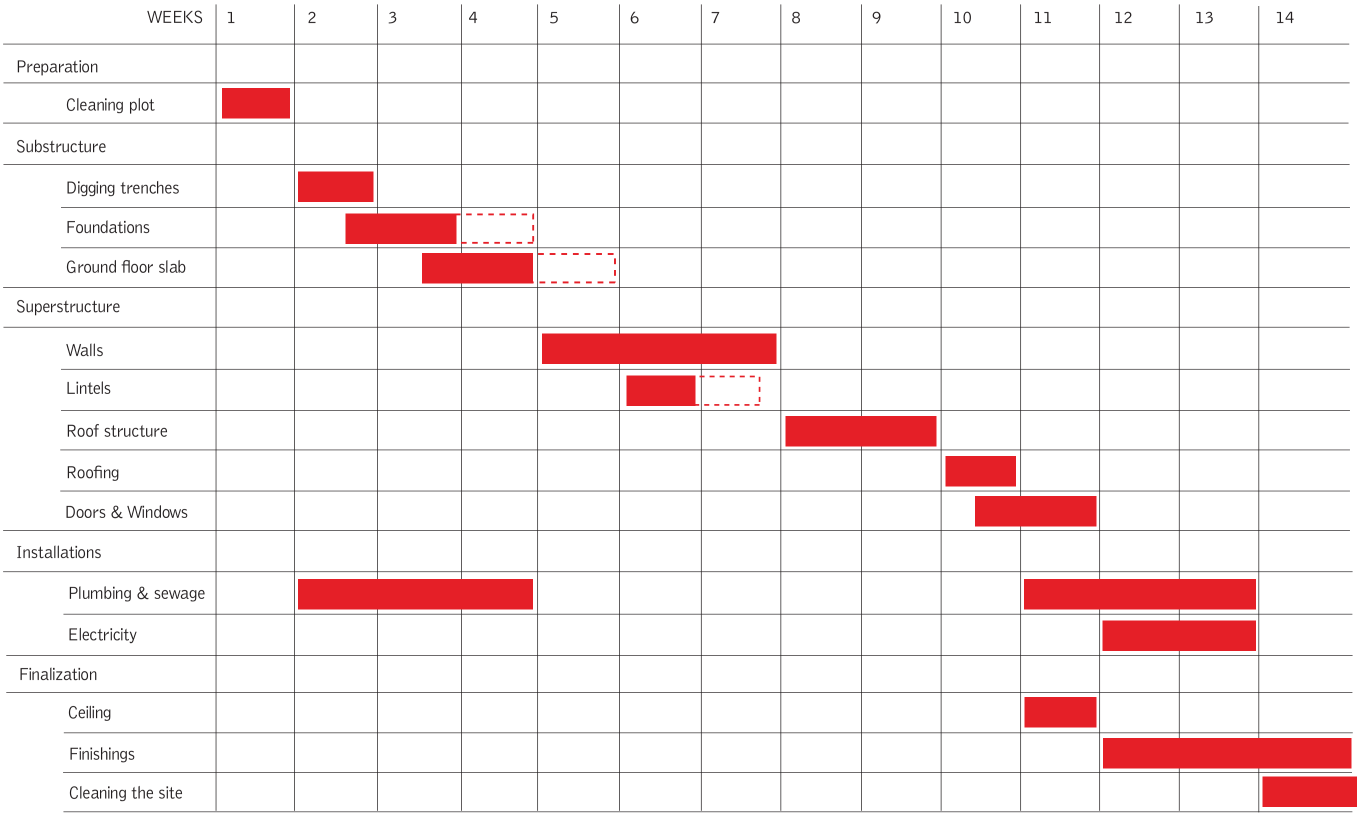
One of the important things to do when supervising a project is making a timetable for the construction, to estimate when the building should be finished and can become operational. This also allows for better coordination, so that certain tasks can be started while others are still under construction. It will help to plan ahead in hiring the workforce for certain tasks, and to buy the building materials for each building phase.

In the table on the next page you will find an example of a timetable, which can be easily made in Excel for instance. The times indicated for each task are indicative, because it will depend on the building to construct, and of the workforce available (number of people, experience, skill, ...).

It is useful however to see the overlap of certain tasks, which indicates when tasks can or have be done simultaneously. For example, the collector pipes of the plumbing have to be placed simultaneously with the foundations and the slab, because they need to be cast into them. Other things can be done simultaneously to win time, since they don't interfere with each other, such as placing the ceiling and placing installations such as electricity and plumbing.

In other cases, the construction of one part has to wait until another part is completed. For example, the construction of the walls can only begin when the foundations are completely finished and have hardened sufficiently to support the wall's weight. Or the electricity can only be put in place when the doors and windows are completely finished, so that the building is wind and water proof.

1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex


WEEKS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Preparation
Cleaning plot
Substructure
Digging trenches
Foundations
Ground floor slab
Superstructure
Walls
Lintels
Roof structure
Roofing
Doors & Windows
Installations
Plumbing & sewage
Electricity
Finalization
Ceiling
Finishings
Cleaning the site

3. PRELIMINARY GUIDELINES

In this chapter, some choices that have to be made before construction can begin are discussed, such as choosing a good site to build, and choosing a suitable typology for each climate.

3.1 Site selection criteria

3.1.1 Natural hazard exposure and topography

Landslides

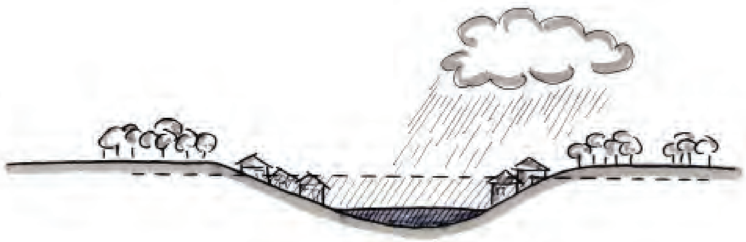
When selecting a site, one should take care not to build on areas which are vulnerable to landslides, such as on top of an unstable hill, or at the bottom of an unstable hill. Indicators of instability may be ongoing erosion of a slope, with little or no trees or plants to hold the soil during heavy rainfall. Also the shape of the slope is an indicator of stability. If it is very steep in some parts, with a lot of earth mass on the upper parts, this is an indicator of instability. If the hill is uniformly angled at maximum 30° to 45° from top to bottom, with some big trees on the slopes, it is probably quite stable.

Building located on top of a landslide risk area

Building located bellow landslide risk area

Flooding

Lower-lying areas close to rivers, lakes or seas are prone to flooding during periods of heavy rainfall. When a 'flooding map' of previous floods can be found, this can be used to assess the risk of future flooding. When this is not available, a topographical map of the area may provide information regarding the lower-lying areas prone to flooding. One can also consult local populations on areas of former flooding.



Flooding area - lower lying areas close to rivers

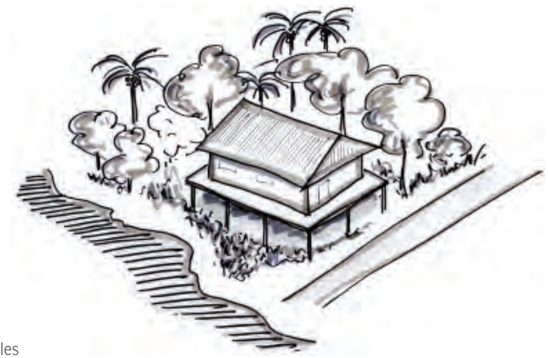
1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

If possible, one should build on the highest available level ground.

Construction on the lower level ground - not advisable

Construction on the highest level ground - advisable

If one cannot prevent building in an area prone to flooding, precautions need to be taken to protect the building in the event of flooding: such as raising it on poles.

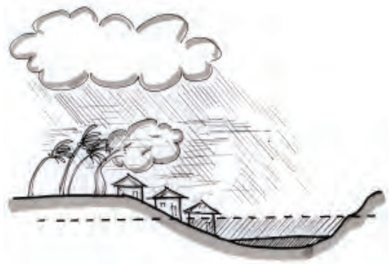


Raising the building on poles

Hurricanes

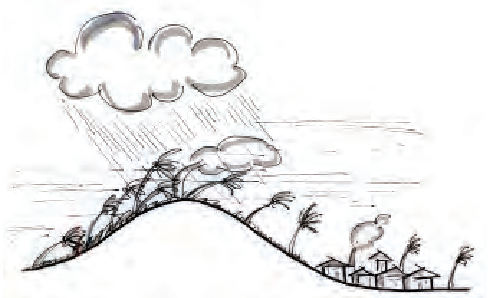
The precautions that are necessary for flooding and landslides are also applicable to hurricanes, since they are accompanied by heavy rainfall. Furthermore, large open areas that are more exposed to winds need to be avoided.

Exposure to the wind - danger of falling trees



Flooding areas

Where possible, one should build in an area that is more or less sheltered from the prevailing wind direction. Also, you should avoid building too close to large trees, which could fall down and crush the building in the case of heavy winds.



Sheltered area from the prevailing wind direction

Earthquakes

Not every area is equally prone to earthquakes; it depends on the proximity to fault lines in the earths' crust. You need to consult a seismic map of the country or region to check whether the area is vulnerable to earthquakes. On a local scale, if an earthquake has occurred recently, it is possible to see some fault lines in the earth in the form of cracks, gaps and tears. One needs to build as far away from these phenomena as possible. Also building close to trees should be avoided in earthquake-prone areas, since they could fall and crush the building.

Presence of fault lines and trees - advisable to build as far away to these phenomena as possible

When working in an earthquake-prone region, one must always adjust the building typology to reduce the risk of building collapse. It is possible to build buildings that will withstand most earthquakes without a lot of extra costs, but one must take into account some basic principles during the construction. We won't go deeper into these techniques in this manual. For this we refer to specialized literature.

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

3.1.2 Soil conditions

General soil quality indicators

One should never build on soils that have been recently filled with loose sand, rubble, garbage, or anything similar. Because these soils are not compacted, they are unstable when building on, and can cause the sides of the buildings to settle unevenly, causing cracks in the walls, etc. One should also try to avoid building on old landfills, since the ongoing composting of the waste will cause it to decrease in volume, causing instability. Also, the heat produced by the composting process sometimes causes fires.

Soil types

The type of soil is important for drainage and the carrying capacity of the soil for construction. Sites with permeable soils are preferable for drainage of rainwater and for the construction of latrines. Impermeable soils make infiltration difficult, and therefore are unsuitable for construction of latrines and wastewater infiltration or treatment systems.

Impermeable soils usually contain a lot of clay, which causes further problems with accessibility in the rainy season in tropical areas. On the other hand, soils containing a lot of clay could be used to make mud or clay bricks on site, with some low-tech manufacturing techniques.

Sandy soils are more permeable, but are also more unstable during the excavation of the foundations or drainage trenches. Therefore, care should be taken to prevent them from collapsing.

Rocky terrains are obviously the most stable base for foundations of the building, but they are also less permeable, and can require more work to dig the foundations. [1]

For a more detailed investigation of the soil's strength for foundations, and which types of foundations need to be used, we refer to chapter 5.4: Foundations.

3.1.3 Climatic conditions

The most suitable site to use with regards to sun, wind, temperature, etc. depends on the climate you are working in.

Very hot climates

In very hot climates, exposure of the building to sunlight should be minimized. This can be done by orienting the building with it's shortest sides to the east and west, because this is where the sunrays hit the facades in the morning and late afternoon. At mid-day, the sun hits the roof mostly, and the roof overhang will protect the sides from the rays. To minimize exposure, elements such as vegetation, landscape elements (rocks, hills, ...) or nearby buildings can also be used.

1. Temporary health structures Guideline. Medicins Sans Frontières, 2009, p. 12

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

Exposure of the building to prevailing wind directions is critical to be able to ventilate the building and lower interior temperatures. The longest facade of the building should therefore be exposed to the prevailing wind direction. In very dry, dusty areas however, it is important not to expose the building to open, windy areas, because of possible sandstorms.

Very cold climates

In very cold climates, exposure of the building to solar rays should be maximized, in order to use the energy for natural heating. One should bear in mind the trajectory of the sun in the winter, when the sun is at its lowest point. Also, shading by geographical features such as rock formations or mountains should be avoided.

The buildings' longest façade should be oriented towards the south. Window surfaces should be maximized on south-eastern, southern and south-western facades, and minimized on north-eastern, northern, and northwestern facades. If possible, the topography of the site could be used to partially bury the northern facades of the building, to decrease heat loss on those sides.

Wind exposure should be minimized, because winds increase the loss of heat through walls. Local vegetation and topography can be used to avoid exposing the building to winds, and areas such as narrow valleys or rifts should be avoided, as well as the top ridge of a mountain.

If it is not possible to shelter the entire building from the wind, the orientation of the building should be used to minimize wind exposure. The longest façade of the building should be sheltered, and thus be placed parallel to the prevailing wind direction.

3.1.4 Accessibility and suitability

Accessibility

The site of the new health facility has to be accessible all year round to all different communities, patients, families and supply vehicles. Sometimes, access can be easy during the dry season but impossible during the rainy season. It is advisable to pay particular attention to waterways, streams and rivers, which may be trickles of water during the dry season but surging torrents during the rainy season. If site access is interrupted over a period of months, storage capacity needs to be adjusted accordingly.

The advantages and disadvantages, in terms of security, supply and access to information etc., due to proximity to a village or town, should be evaluated. ([2])

Access to water

The proximity of the site to water sources should be taken into account. The water should be drinkable or easily treatable to a useable condition, and should be sufficient to provide the facility with water all year round if possible. Also, the use of water by the facility should not interfere with the water provision for drinking or agriculture for the surrounding population.

2. Temporary health structures Guideline. Medicins Sans Frontières, 2009, p. 10

Social & cultural suitability

Some sites may be inappropriate to use for cultural or religious reasons. Local inhabitants or land users, principally elders, can be helpful in selecting a site that is appropriate in this regard.

Environmental impact

When selecting the site, one should take care to minimize the impact on the environment. First of all, one should avoid building in zones of protected ecosystems and environments. Secondly, one should take care that the removal of the vegetation cover and trees of the plot will not cause erosion, or remove natural protection from wind and sun. Thirdly, when local materials will be used, one should take care that the procurement of these materials, such as timber or firewood for firing bricks, will not result in local deforestation and increased erosion.

Health risks

The site on which the health facility is to be constructed should not present any major health risks. It is necessary to find out about endemic sicknesses prevalent in the area (malaria, sleeping sickness, etc.).

In tropical zones, stagnant water, swamps and ponds represent a danger to patients, as they provide an area for mosquitoes, which are one of the most important vectors of pathogens, to reproduce. Natural drainage of rainwater needs to be efficient to avoid puddles forming, where larvae might develop. Hollows and trenches in the immediate vicinity of the site should be filled. Pits created by digging for construction materials should also be filled.

Areas where there is significant industrial pollution should be avoided, as should ground near rubbish dumps. ([3])

3.2 Climate issues / ventilation techniques

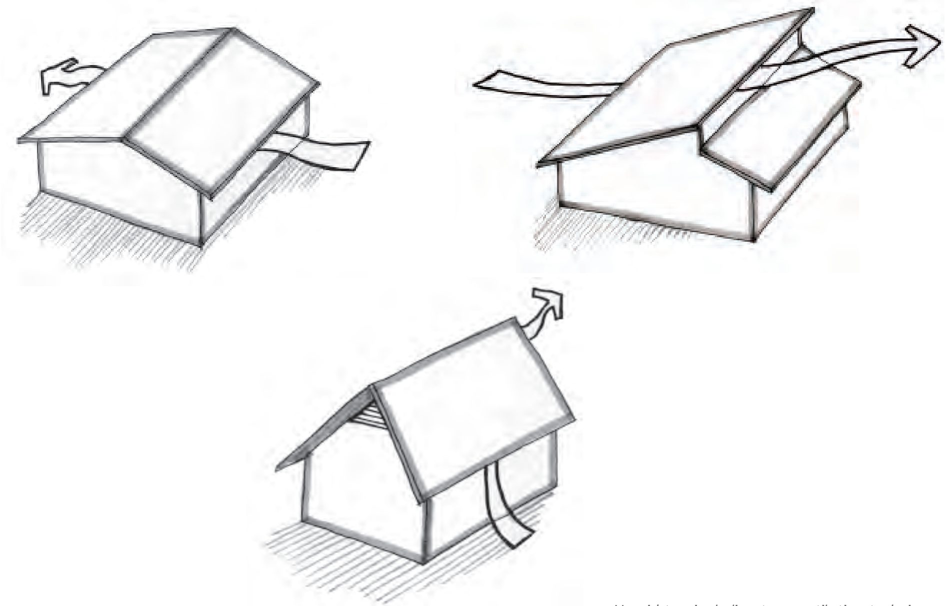
In this section you will find some examples of building types, general construction guidelines, and possible ventilation techniques, according to the various climatic conditions.

Humid tropical climate:

Build close to hills or elevated sites – more air circulation;
Thin, light walls;
High ceilings - improves ventilation;
Sloped roofs – rain water drainage;
Large windows – improves ventilation;
Separate buildings - allows cool breezes to circulate;
Elevate the building – prevent the earth's humidity from entering;
Appropriate local materials: wood; bamboo and reeds.

3. Temporary health structures Guideline. Medicins Sans Frontières, 2009, p. 14

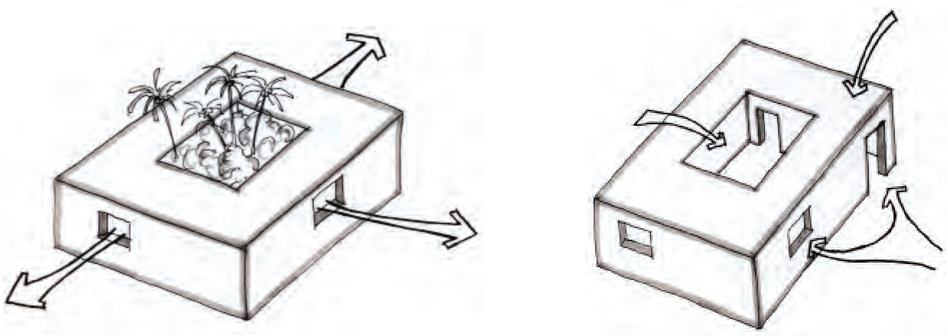
1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex



Humid tropical climate - ventilation techniques

Dry tropical climate:

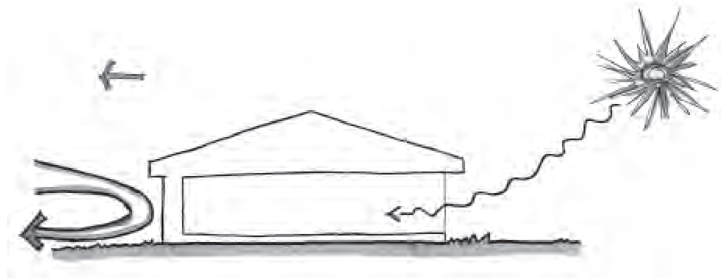
Build close to hills or elevated sites – more air circulation;
Thick, heavy walls – thermal mass protects from the heat during day, and the cold during the night;
High ceilings - improves ventilation;
Small windows;
Join buildings - gives shade;
Interior patios;
Take advantage of the cool ground temperature;
Appropriate materials: stones; adobe; bricks; and blocks;



Dry tropical climate - ventilation techniques

Temperate to cold climate:

Maximize exposure to the sun;
Thick, heavy walls – thermal mass prevents the heat to escape quickly;
Lower ceilings - requires less heating;
Insulate the roof or ceiling - prevents heat loss;
Roofs – average pitch;
Small windows on the south side, and large windows on the north side (Southern Hemisphere);
(do the opposite in the Northern Hemisphere);
Protection of the building from winds, with vegetation;
Join buildings - protects from cold and wind;
Appropriate materials: wood; adobe; bricks and blocks;

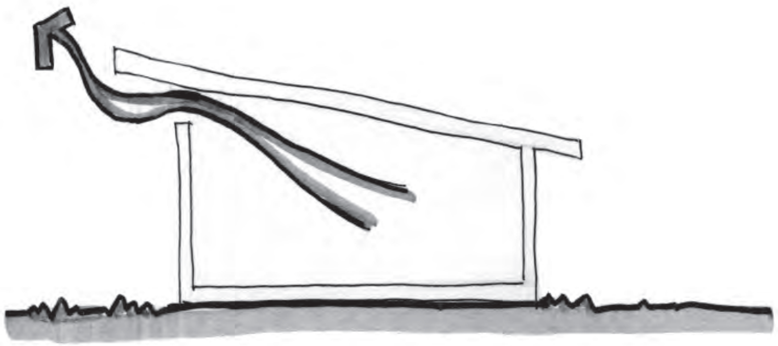


Temperate climate - ventilation techniques and the use of sun heat

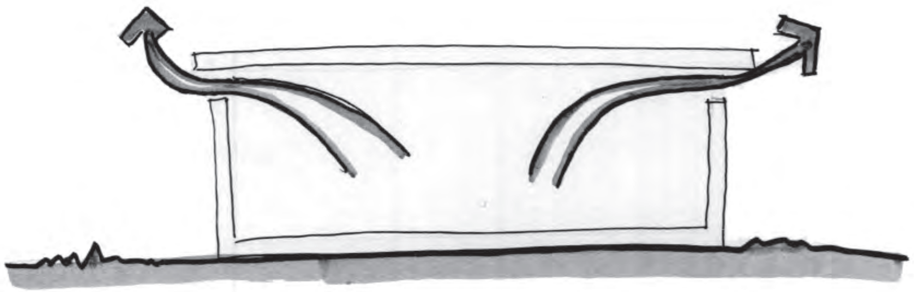
Using the environmental elements as an asset

General concepts of ventilation:

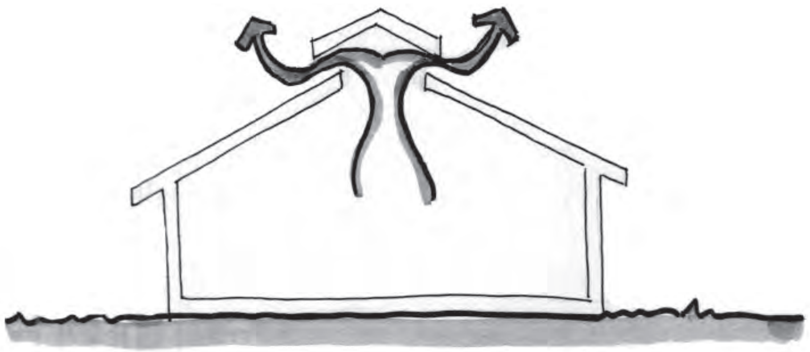
Remember as a general rule that cool air enters below, and hot air naturally rises up and is best removed through openings at the top. There should always be both air intake and exhaust for a good airflow.



Hot air exits through openings in the upper walls



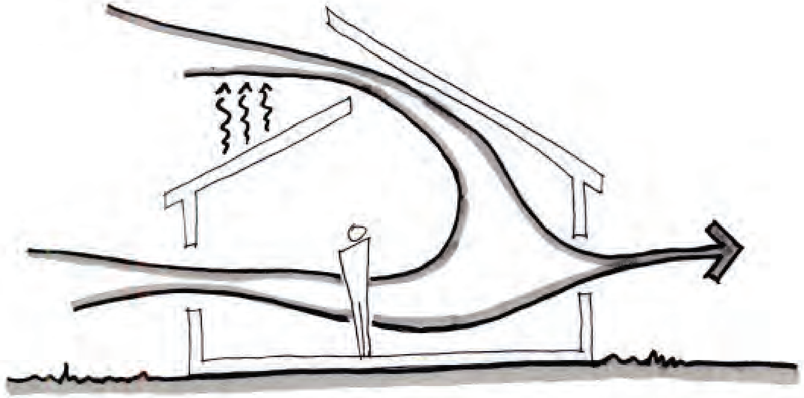
Hot air exits through openings in the upper walls



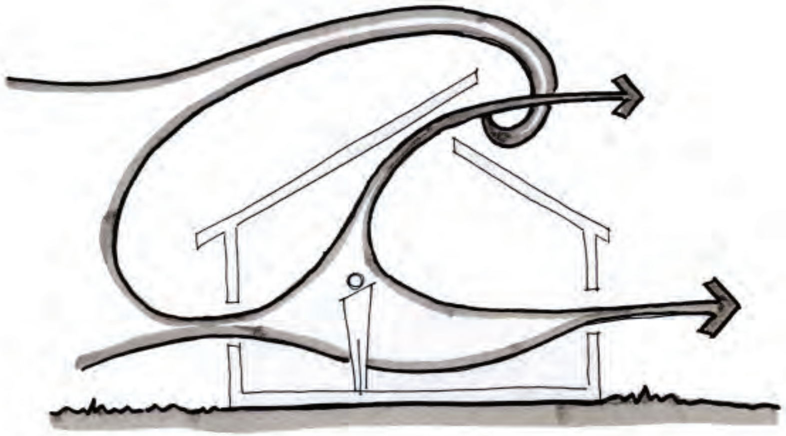
Hot air exits through roof openings

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

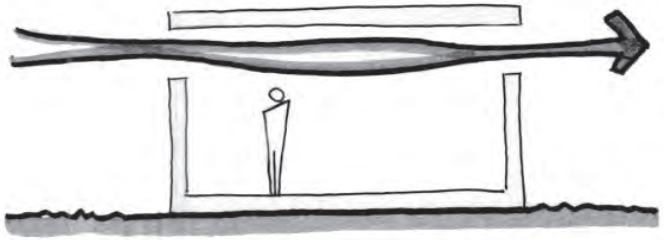
Hot air exits through roof openings



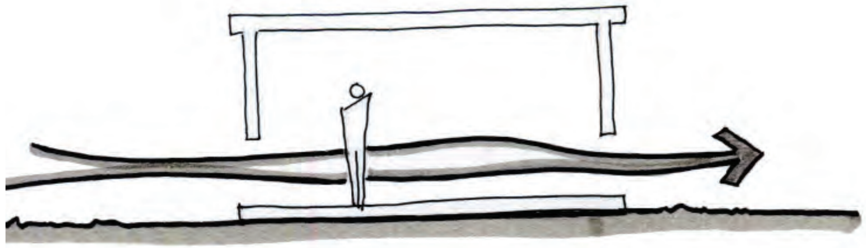
The heat exits through the roof due to radiation



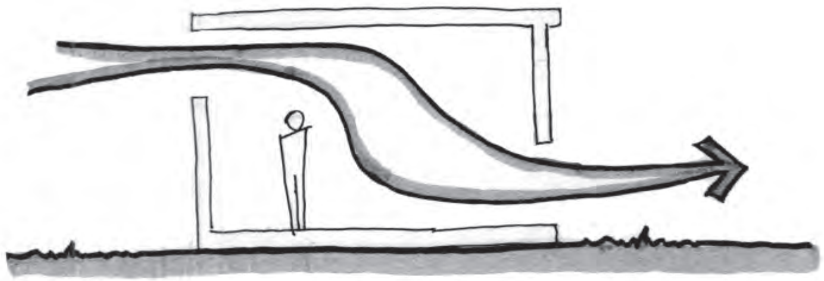
The heat exits the building due to the airflow through the building



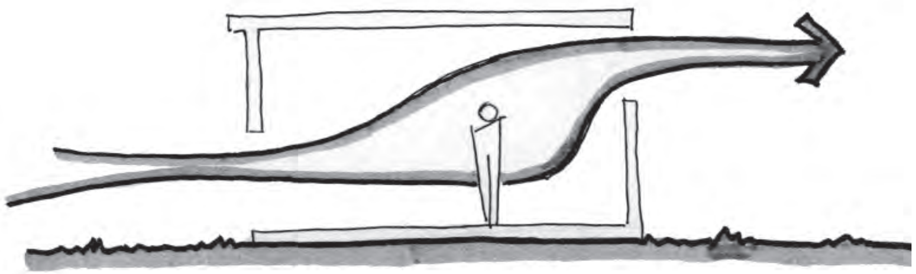
Upper windows - the hot air flows above the head



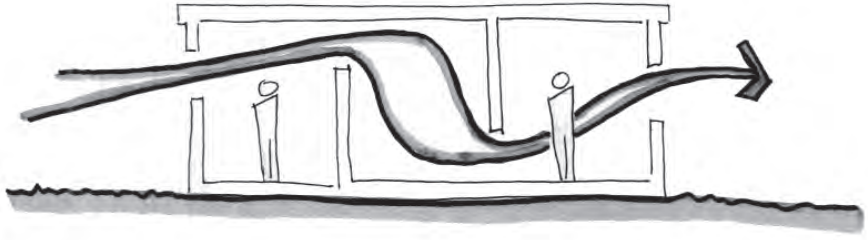
Lower windows - the cool breeze is felt



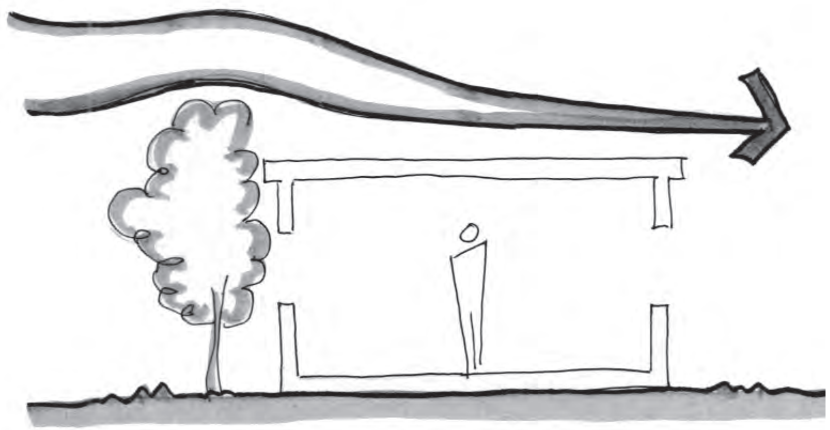
Air circulating from above to below is not very efficient



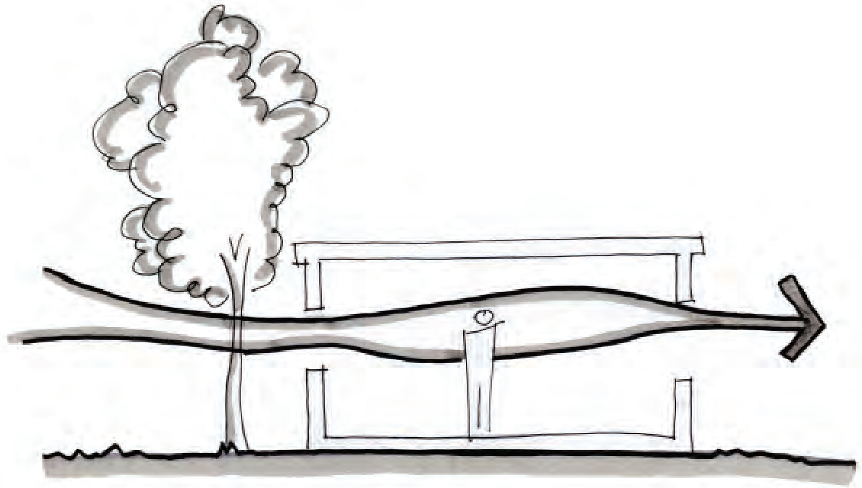
Air circulating from below to above is much more efficient



Cross-circulation is more effective with openings in the lower part of doors



Lower trees - the breeze rises and does not enter



High trees - the breeze descends and cools

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

4. MATERIALS GUIDELINES

In this chapter we give an overview of some common building materials that will be worked with throughout this manual. It is important to understand the properties, strengths and weaknesses, warnings and techniques of all the materials on a construction site. This is the only way a safe and sound building can be constructed. It also helps the project manager keep an eye on the quality of materials and techniques a contractor may be using, and to make improvements where necessary.

4.1 Cement

Cement is a fine powder that gets binding properties through a chemical reaction called hydration when combined with water. After this reaction, it becomes rock hard. Cement is typically the most important binding element in materials such as mortar or concrete.
Hydraulic cement is a type of cement that also binds with water without being exposed to air, meaning it can become hard underwater.
Portland cement is the strongest binding type of cement.

4.2 Mortar

Mortar is a mixture of sand, lime or cement (the binding material), and water. The sand acts as an inert material, to give strength to the dried mass, and to avoid cracks that would occur when using only the binding material. Water should be added until the mixture has a sufficient plasticity, but it should not become so liquid that it would run off the bricks when applied. The mixing can be done by hand, or mechanically in a concrete mixer. The substance hardens while drying and binds together for example bricks in masonry. The time it takes to dry ranges from 1 to 7 days.

For the mortar mixture for brick walls, the following quantities have to be used:
- 1 bag of cement (50kg) + 0,24 m³ sand (4 wheelbarrows) + 100 liters of water

For the mortar mixture for outdoor plastering:
- 1 bag of cement (50kg) + 0,15 m³ sand (2,5 wheelbarrows) + 80 liters of water

For the mortar mixture for indoor plastering:
- 1 bag of lime (50kg) + 1 bag of cement (50kg) + 0,36 m³ sand (6 wheelbarrows) + 160 liters of water

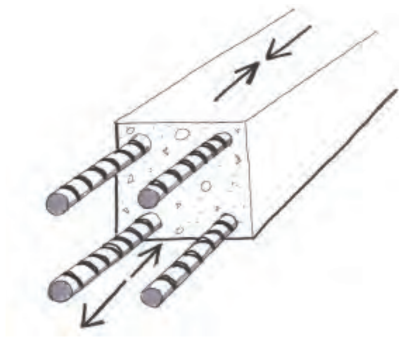
Mortar mixing

4.3 Reinforced Concrete

Concrete building elements such as columns, beams and floor elements can be bought prefabricated or can be cast on the building site. Prefabricated elements are faster and cheaper, but only allow some predetermined forms and dimensions to be used. Casting the concrete on site takes more time, but it allows for greater freedom. For the scope of this manual, it is probable that the concrete will be cast on site, due to availability constraints. Therefore we will focus on this process.

Concrete is a mixture of cement, sand, gravel and water. The gravel and sand acts as inert particles which are held together by the active binding mixture of cement and water. After hardening due to the chemical reaction of the water and cement, together they form one solid, composite, rocky material, of which the gravel and sand make up the majority of the volume. It has excellent capacity to withstand compression forces, such as occur in columns. It cannot withstand tension forces however, such as occur in the lower part of a beam or a floor slab, which could cause the concrete to crack or break.

For this reason, the concrete is often reinforced with reinforcement steel, in the form of bars or nets. The steel is placed inside of the concrete in the areas where it will have to take tension forces. So when it hardens it forms one composite material, and because steel has an excellent capacity to absorb tension forces, the reinforced concrete becomes much more useful to withstand tension forces as well.



Tension forces in the bottom of the concrete element, compression forces in the top.

4.3.1 Composing elements

- Water: The water used to mix the concrete should be clean, because dirty water will prevent the good chemical binding of the cement with the water. Preferably, potable water should be used.
The water cannot contain any acids, alkaloids, limes, salts, grease or organic material.

- Cement: The most common cement used in making concrete is Portland cement, which is a hydraulic cement. Other types of cement are sometimes used, depending on the required properties of the concrete.

- Sand: There are different types of sand, based on their origin. Not all of them can be used for mixing concrete. Before usingw the sand, it should be sifted to get rid of all the impurities, and to obtain a sand with uniform particles.

Riverbed sand: Not recommended for use, since they often contain clay and organic material.

Sand from mines: Also contain clay and organic material. Depending on the level of purity, they have yellow, grey or red color.

Yellow sand: Are the most pure sands, and suitable to use. Grey sands contain a large amount of dust, and red sands contain oxides.

Beach or dune sand: Contains a lot of salt, and should only be used after being washed in fresh water. The salt would prevent the concrete from hardening and obtaining the correct strength.

Artificial sand: Is made from grinding rocks until the particles have a diameter from 0.02 to 6 mm. They are useful for mixing concrete.

- Aggregates: The aggregate particles should be shaped as cubes or spheres approximately. This is important to obtain a compact and economical mixture, with not too much cement and sand in between the particles, which would happen when aggregates with very irregular shapes are used. It is important to have an equal distribution of all sizes of the aggregates over the mixture. They should also be clean, and their moisture content should be taken into account while mixing the concrete (less water should be used when using wet aggregates).

Aggregates with good shape and compacting (left) and bad shape and compacting (right)

- Steel reinforcement bars: The steel reinforcement bars should be of the ribbed type. This improves the contact between the concrete and the bars, so that they can work as one composite material.

4.3.2 Mixing the concrete

To mix the concrete, the quantities of each element are very important, as they will determine the final strength of the concrete. Using more water than can bind with the cement will cause the excess water to hamper the drying and strengthening of the mixture.

The quantities of the mixture depend on the necessary strength of the element, and of the diameter of the gravel and sand used. For columns and beams, more cement will be used in the mixture than for ground floors or walls for example. To calculate the exact quantities, we refer to the Excel file in the CD-LOG of MSF(:\08 Shelter & Construction\01 Construction\04 Tools & Software). For quick reference, some common strengths, mixtures and their applications are included:

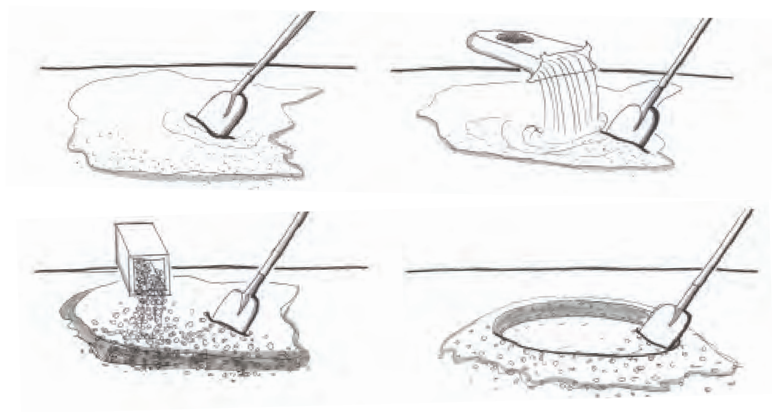
- 150 kg/cm^2: floors on solid soil, concrete tiles, septic tanks, ... = 1 bag of cement (50kg) + 0,052 m^3 sand (1 wheelbarrow) + 0,1 m^3 of gravel (2 wheelbarrows) + 50 liters of water

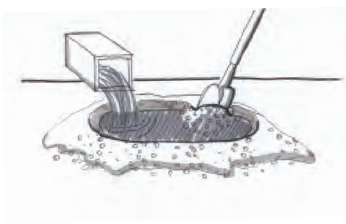
- 200 kg/cm^2: structural elements in concrete, such as foundations, reinforced walls, beams, floor plates = 1 bag of cement (50kg) + 0,045 m^3 of sand (0,9 wheelbarrow) + 0,08 m^3 of gravel (1,6 wheelbarrows) + 50 liters of water

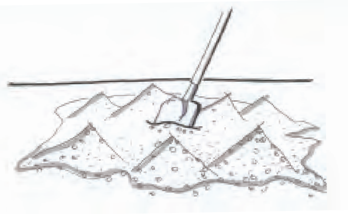
- 250 kg/cm^2: columns for multistory buildings, and beams and floors with large spans

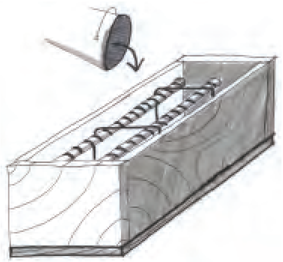
The mixing can be done by hand, mechanically or in a factory and brought to the site in a mixing truck. We include here the manual mixing process, as this will be quite common in the field. The manual mixing should be done in the following steps:

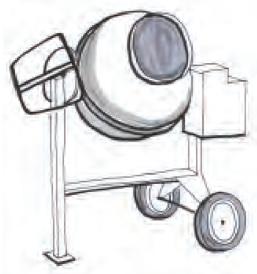
1. Provide a surface for the mixing, clean from dust and dirt. When it is a wooden surface, it has to be impregnated with diesel or used motor oil. A hard, clean concrete surface can also be used.
2. Pour the sand onto the surface, and spread it out with a shovel.
3. Mix in the sand with the cement with a shovel until you have a uniform mixture.
4. Mix in the gravel with a shovel, until you have a uniform mixture.
5. Make a 'crater' in the mixtureand pour in the correct amount of water. Start mixing it in with the dry materials with a shovel, until a uniform mixture is obtained. No more than 30 minutes should pass before applying the concrete. If the concrete has become too dry because of waiting too long, DO NOT add more water, as this will decrease the final strength.
6. Pour the mixture into the prepared wooden form with the reinforcements in the right place.
7. Use a shovel or, when available, an electric vibration needle to compact the mixture. This will make sure the form is completely filled, and prevent air bubbles remaining in the mixture, which is vital to the strength of the concrete.











Pouring the concrete in the formwork

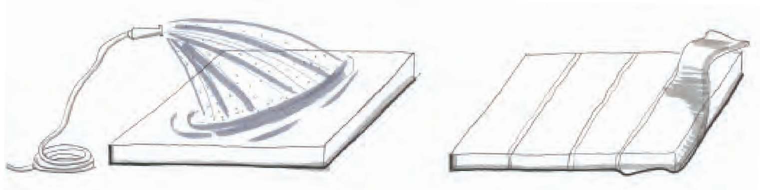
Mechanical concrete mixer

When using a mechanical concrete mixer, the same order of mixing is appropriate, but the elements are combined in the machine, and poured from the machine into the formwork.
Always be sure to make enough concrete to pour the element in one phase, by estimating beforehand how much you need. Pouring the element in multiple times will decrease it's strength significantly.

4.3.3 Drying and hardening

The concrete begins hardening as soon as the water and cement are mixed. The concrete should be poured into the form no later than 30 minutes after the mixing.

Care should be taken, especially in warm climates, to not let the concrete dry too fast. This would cause cracks to form and deteriorate the strength. Preferably it should be poured during the early morning or late afternoon/evening, when the temperatures are at their lowest. The concrete should not be exposed to direct sunlight. The wooden forms should be kept in place as long as possible, and afterwards the concrete should be covered with cardboard or plastic. Alternatively, the concrete must be 'cured', which means sprinkling it with water regularly for a period of 20 to 28 days, depending on the weather.



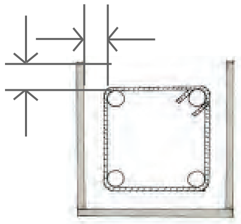
Curing the concrete by sprinkling water (left) or covering it (right)

This prevents the concrete from drying out before the hydration of the cement is completed.
The concrete takes about a week to dry, and about 30 days to develop its full strength. This should be taken into account before applying the full load to concrete structural elements.

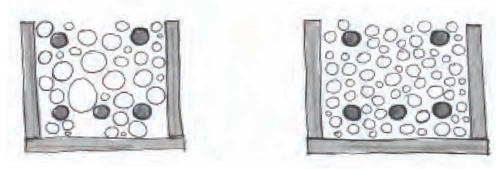
4.3.4 Reinforcing concrete

When placing reinforcement bars, they should be placed in the wooden form before casting the concrete. It is important that the bars are covered by at least a few centimeters of concrete, to prevent corrosion through exposure to the air, and to ensure a good interaction between the steel and the concrete. The bars should therefore be placed on placeholders of stone or concrete. The necessary thickness of the concrete cover depends on the strength of the concrete and the environment in which it is used. In very humid or salty surroundings, more concrete cover is necessary. As a minimum, we can say to use at least 20 mm, and in corrosive environments up to 35 mm.

The place, diameter and amount of reinforcement bars will depend on the building element they are used in, and we refer to the corresponding chapters for this. A few standardised bar sizes are: no. 2: 6,4mm, no. 3: 9,525mm, no. 4: 12,7mm, no. 5: 15,875mm, no. 6: 19,05mm, no. 7:22,225mm. As a general rule, the bars are more important in the part of the concrete element that is taking the tension forces, which means the bottom of the element in beams, lintels and floor slabs.

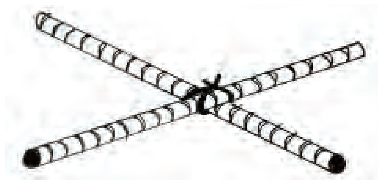


Minimum concrete cover



Correct (right) and incorrect (left) diameter of gravel in relation to the reinforcement

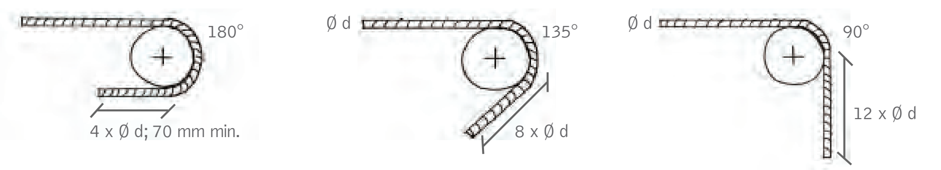
Bars crossing each other to form a net have to be tied together by metal wires. Afterwards, the loose ends have to be cut, to make sure they don't prevent the concrete from flowing smoothly through the form.



Tieing two bars together

Minimum overlap

The reinforcement bars should be anchored by a rod of a smaller diameter, so that the bars and anchors together form a kind of 'cage'. For example in an element with 4 reinforcement bars, the anchor rod is bent in a square around the 4 bars, and bent in an angle of 90°, 135° or 180° at both ends. The necessary length of the anchor after the bend depends on the angle in which it is bent, and the diameter of the anchor, as shown on the picture.



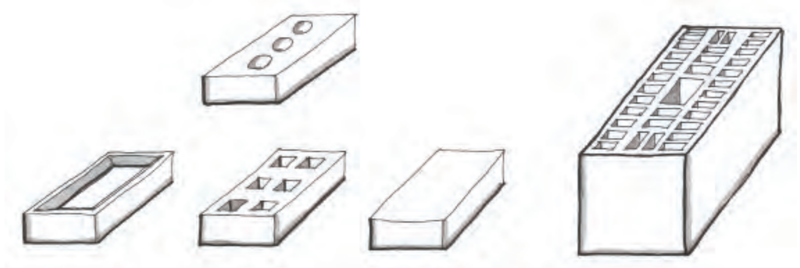
Minimum achor lengths depending on the angle of the bend.

When two shorter bars are tied together to form one long bar, they should overlap to ensure a good connection between the bars and the concrete. The amount of overlap depends on the diameter of the bar. The corresponding required overlap is: no. 2: 30cm, no. 3: 40cm, no. 4: 50cm, no. 5: 65cm. In the case the bars are welded together, 30cm is sufficient for all diameters.

4.4 Brick

There are different types and sizes of brick, depending on the material they are made of, and their intended application. The types of brick that can be found also differ from country to country. Traditionally in Europe bricks were made of a baked mixture of sand, clay and lime. In some countries, sun-dried earth bricks are also common. However, concrete bricks have become very common all over the world.

Bricks come in many different shapes and sizes. They can be divided into two formats generally: façade bricks and bricks for structural masonry.
The façade bricks are usually narrower, around 9cm wide, and less high. They can have a full profile, or with holes. They cannot be used for structural masonry.
The structural bricks are wider, longer and higher, around 14 cm wide, for increased stability. They usually contain holes in the center to decrease the weight and material use. This is the type we will use throughout this manual.



Façade bricks (left) and structural brick (right)

We won't go into the brick manufacturing process here, as it is assumed that bricks will be bought from a specialized manufacturer, and not be created on site.

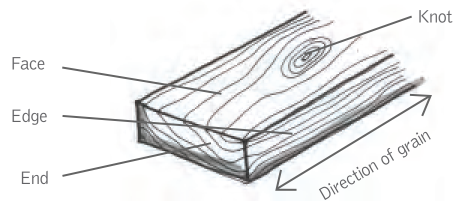
4.5 Timber and bamboo

For a very detailed description of timber in humanitarian operations, we refer to the manual 'Timber as a construction material in humanitarian operations' (2009) made by UNOCHA, IFRC and CARE International. (4) For the sake of this manual, we will only go into the basic, most important issues.

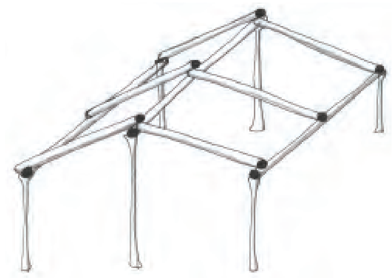
Timber is a lightweight and flexible material, which makes it especially useful in earthquake-prone areas. Buildings constructed with timber are also easily maintained and repaired with locally available techniques. When the source of the timber is from well-managed forests, it is also an environmentally friendly and renewable material. However, finding and identifying sustainable timber can be difficult.

4.5.1 Types of timber and bamboo

- Sawn timber: Sawn timber is timber that is literally 'sawn' from large trees into standard sizes. It can be seasoned (dried) and treated afterwards, to increase its durability. 'Green timber', which is timber that is unseasoned and untreated, can also be used. (4)



- Poles: Poles are pieces of wood procured from young trees or from the trimming of larger trees. The bark is removed, and they can be used, treated or not. They can be very strong, because they use the natural shape and strength of the tree, with the direction of the fibers always along the length of the pole. They are often cheaper than sawn wood, because they require less processing. (4)

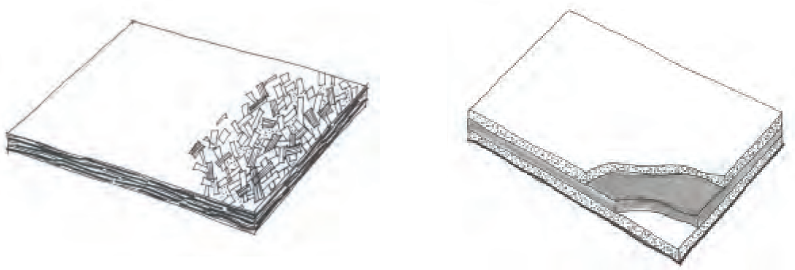


- Timber composites: These are products which have timber as a base material, but are manufactured into a different form. They are usually made of layers of fine timber or timber chips or chunks, glued together to form plates. Common examples are MDF (Medium Density Fiberboard), OSB (Oriented

4. Timber as a construction manual in humanitarian operations. United Nations, the Office for the Coordination of Humanitarian Affairs (OCHA), the International Federation of Red Cross and Red Crescent Societies (IFRC) and CARE International, 2009

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

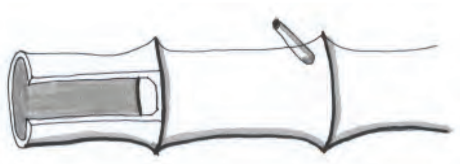
Strand Board) and plywood. They are strong, lightweight and low-cost. They can also provide good resistance against decay and pests, depending on the adhesives and raisins used. They can be used for walls, floors, concrete formwork, and furniture.



Oriented Strand Board (OSB) (left) and plywood (right)

- Palm timber: This is a resource that is often overlooked. Palm trees do not produce growth rings as other trees do, and the timber is softer in the centre. The trunk can be used for wooden structures, but it should be taken into account that the wood is softer in the center, whereas it is harder in the center for normal timber. (4)

- Bamboo: Bamboo is not actually a tree, but a fast-growing grass, reproducing through its roots. Because it is fast-growing, it is attracting more and more interest as a construction material. There are about 1,200 different botanical species of bamboo, with over 250 varieties suitable for construction. Each species has different properties, so local knowledge is essential when using it. A bamboo culm (the stem of the grass) can be between 2.5 and 30m long. Commercial sizes are commonly available at between 4m and 6m. Although solid species do exist, bamboo normally is made up of hollow cavities separated by nodes. (4)



Bamboo culm

It is an interesting material to use for structures, because the fibers are situated where the strength is most useful: on the outside of the beams. The inside is hollow, which makes the beams lightweight as well. Special techniques have to be used when making the connections between different beams however, to prevent the material from splitting or getting crushed. Therefore, it should be done by experienced people.

4.5.2 Environmental protection

It is important to be aware of the source of the timber before using it. Timber can be an environmentally friendly material, if forests are replanted after procuring it.

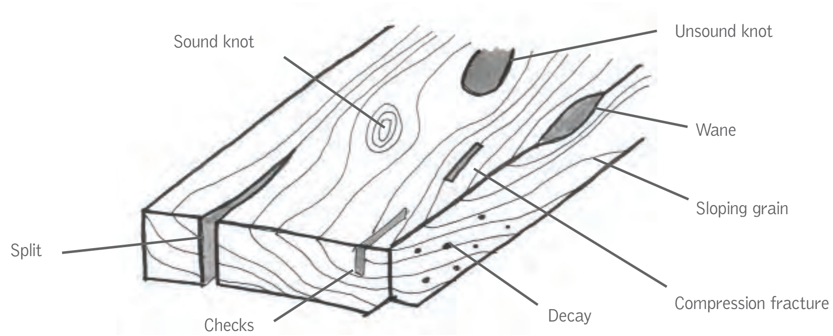
When procuring timber from a big contractor or manufacturer in the capital, a certificate can be demanded to prove the sustainable origin of the timber. There are national and international certificates. National certificates are issued by a certification organization within the country, but can be prone to corruption, so care needs to be taken. International independent organizations also provide certificates and information on legality and origins of timber. The following resources can always be consulted: The National Forest Program Facility (at www.nfp-facility.org); WWF's Global Forest and Trade Network (http://gftn.panda.org/); Forest Law Enforcement and Governance (FLEG) - http://web.worldbank.org; (4)

When procuring timber from a local merchant or contractor, it can be difficult or impossible to obtain a certificate. However, one should always keep an eye open to clues about the origin of the timber. If harmful deforestation is going on in the area, one should consider other building materials, not to aggravate the situation.

4.5.3 Quality control

When a delivery of timber arrives at the building site, the logistician should inspect its quality. Sapwood should be avoided (from the outside of the trunk), as it is less strong than heartwood (from the inside of the trunk). At the most basic level, you can check the surfaces for defects which can be easily identified. Furthermore, you should see if it is straight along the length and width. The image below gives an overview of some common defects to sawn timber.

Compression fractures and decay from fungus, bacteria or pests are unacceptable, and should not be present. Decay can be visible as fine sawdust or holes., or if the wood is soft and breaks along the grain, or breaks into cubes and has a cotton-thread-like consistency. Knots, wanes, splits, checks and sloping grain can be present, but must be limited.

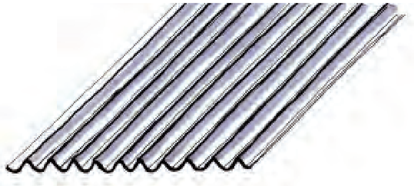


4.6 Roofing materials

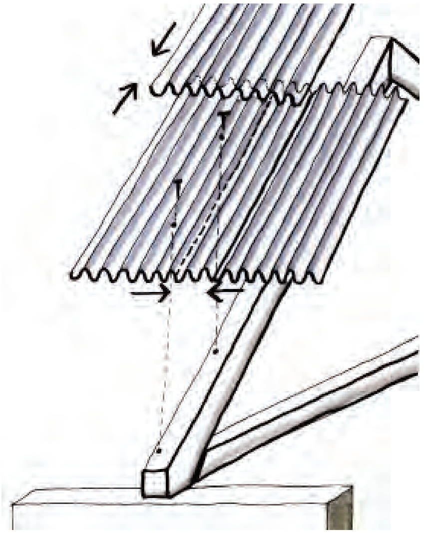
4.6.1 Corrugated metal sheeting

Corrugated metal sheets are made from galvanized iron that has been cold-rolled through a machine to give them a corrugated pattern. This pattern increases their bending strength in the direction perpendicular to the corrugations.

The main advantages of the material are that it is lightweight, easily transportable, cheap and fast to build with. The main disadvantages are that they don't insulate from heat or cold, and will rust over time, which makes replacement necessary after a few years.



The application is done by bolting, screwing or nailing the sheets to a supporting structure, such as a wooden or metal truss. They have to be placed on pithed roofs, to enable rainwater to run off. They have to be placed overlapping a few corrugations in the lateral direction, and about 15cm in the longitudinal direction, to make sure they are waterproof. Pay attention to the overhang of the sheets at the eaves, to prevent rain from entering the building. When using this material, you should consider providing extra insulation against heat and cold on the inside of the panels, in between the rafters. This will also dampen the noise from heavy rains onto the metal roof.

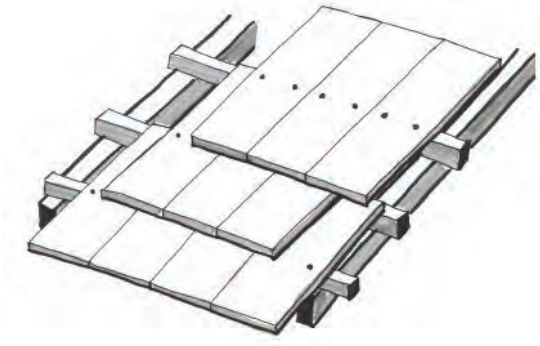


Placing corrugated metal sheeting on a wooden roof structure

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

4.6.2 Shingles

Roof shingles are rectangular elements that are placed overlapping each other. They can be made from various materials such as wood, slate, asbestos cement, asphalt composites or ceramics. For health reasons, asbestos cement shingles should not be used anymore. The easiest to work with are probably wood or asphalt shingles, but wooden shingles could pose a fire hazard. Also, these types of shingles degrade over time, and will need to be replaced over the years. Ceramic shingles are more durable, but they are also more brittle and prone to fracture.

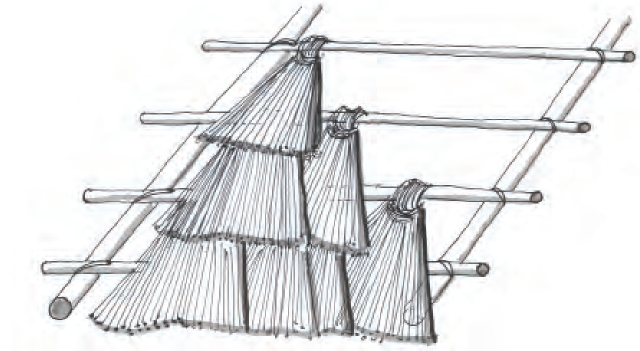


Shingles nailed to a wooden roof structure

Shingles must be placed on roofs with a slope of more than 15 degrees, to prevent winds from lifting them up, and to ensure that there is a good rainwater runoff. They are nailed to the purlins or to the boards of a wooden roof structure. They are placed in rows, which overlap a few centimeters, starting from the eaves, and working your way up to the ridge of the roof. This allows for rainwater runoff.

4.6.3 Thatch or leaf-cover

Thatch is a roof cover made with dry vegetation such as reeds, straw, leaves, etc. Usually it is made with locally available vegetation.



Thatched roofing on a pole roof structure

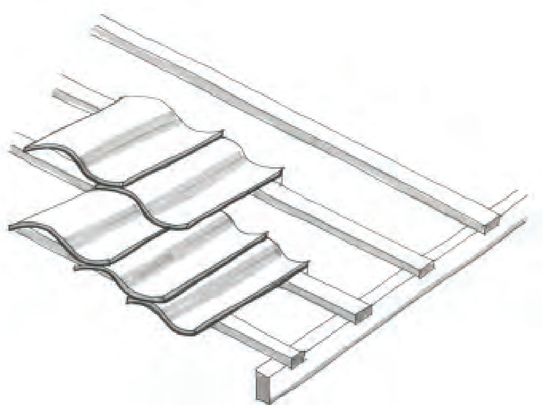
The advantages of thatched roofs are that they are cheap, made with local materials, culturally accepted, aesthetically appealing, and provide good insulation against heat. Disadvantages are that they are home to all kinds of insects or even reptiles, which can pose hygienic problems, and that they have to be replaced frequently because of degradation.
For the scope of the projects of MSF, these roofing materials are less suitable, because of the hygienic and health issues. For this reason, we discourage the use of those materials in these projects.

4.6.4 Clay tiles

Clay tile roofs are made from baked ceramic clay tiles placed on a wooden roof structure. The roof should have a slope between 30 and 45 degrees, to ensure good rainwater runoff.

The advantages of clay tile roofs are that they are durable and aesthetically pleasing. Disadvantages are that they are brittle and blown off by heavy winds. For this reason, this roofing material should not be used in hurricane-prone areas.

The clay tiles are attached to the purlins of a wooden roof structure. They are shaped so that they can be placed 'hanging' on the purlins without a mechanical connection such as nails or bolts. They are placed in rows, overlapping each other from the eaves to the ridge of the roof. This ensures rainwater runoff, and makes them hold each other down by their weight.

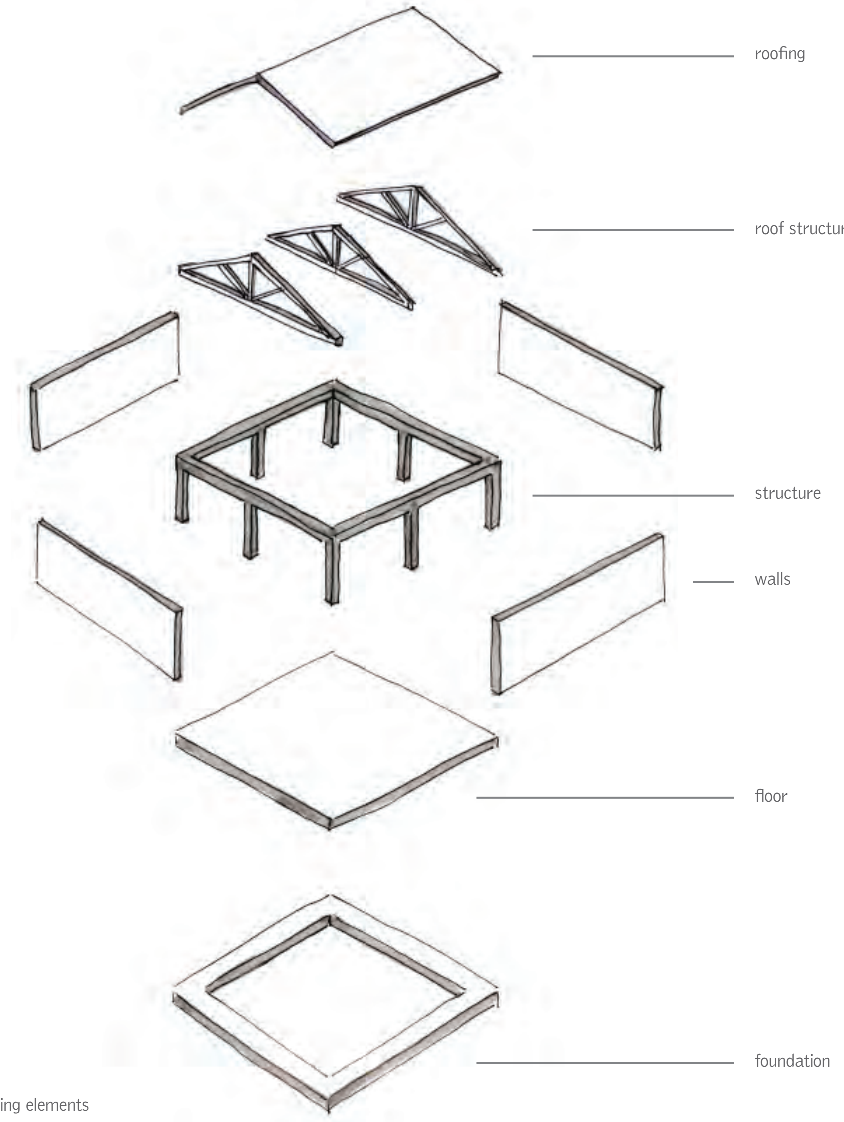


Clay tiles on a wooden roof structure

5. NEW BUILDING CONSTRUCTION

This chapter provides an intuitive and graphic guidance, going through all the components of a new building, covering step-by-step every stage of the construction.

A building functions as a whole, with different levels of components, and its construction process has different stages, with different complexity levels.



Building elements

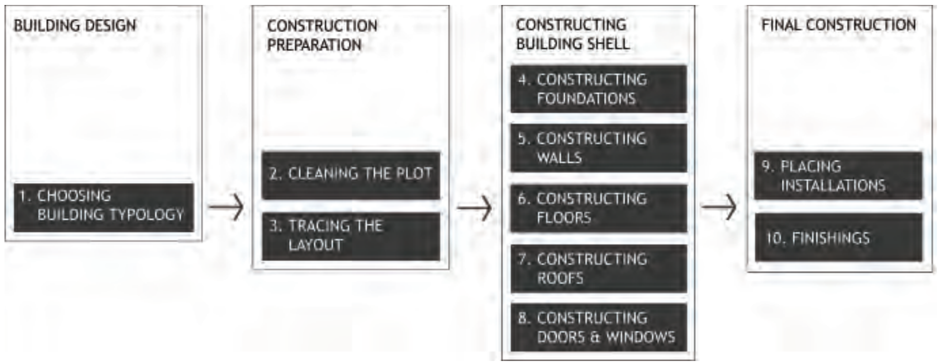
The structural components function as the spine of the building. It is of major importance to achieve a precise structure, in order to have a stable and structurally sound building. As a structural starting point there are the foundations, which could be referred to as the footprint of the building, the tie between the soil and the building itself. Furthermore, the foundation beam makes the connection between the foundations and the superstructure. The superstructure consists of the beams and pillars, or the structural masonry.

The roof functions as the cover of the building, and the roof structure is also one of the most important elements of the buildings' structure. Special care needs to be taken when building the roof structure, in order to achieve a structurally sound roof that won't collapse or put its users in danger. The roof structure has to be able to support the weight of the roofing material.

The walls function as the exterior skin of the building, protecting the interior from the elements. The walls can function as the main supporting structure, or just as an infill for a beams and columns structure. Within the walls, we can find the windows and doors. Their construction and integration must be done according to certain rules, so as not to compromise the walls' structural integrity.

When the shell of the building is finished, the installations such as water and electricity can be placed. For some of these, provisions have to be made when constructing the building's shell, such as placing piping in the concrete floor slab.

The final step of construction is the finishing. This step includes the application of all the materials that will protect the wall, floors, and structure, and determine their aesthetics. In the case of medical functions, the finishing is also important for hygienic reasons, and specific choices will be made in this regard.



In this chapter you will find the explanation of different construction techniques for the building components, according to the materials to use. The sections follow the chronological order of a construction process, starting with technical drawings and their comprehension, the initial stage regarding the plot, continuing with the construction of the building's shell from the bottom up: foundations, walls, floors, roofs, doors and windows, and finally placing the installations, and doing the finishing.

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

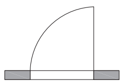
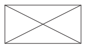
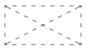
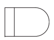
5.1 Building typologies and documents

The first step when constructing a new building is designing the typology, dimensions, structure and materials to be used. This has to be done in collaboration with the final users of the building, the medical staff in the case of a medical facility, to identify the needs, and with the help of this manual.

When the building's layout has been decided, it should be put on paper, as a means of communicating it to the contractor or workforce, and to the coordination team and HQ. It is important to produce a readable document, which includes all important measurements, so that it can serve as a basic working document on the construction site. Included in this chapter is an example of a very basic doctor's office with a reception/waiting room and two lavatories. The documents should include the following:

- A ground floor plan, which means a view when you would cut through the building horizontally and look at the floor.
- 2 sections; which means a view of the building when you would cut it vertically, in both the longitudinal direction and the one perpendicular to it
- 2 elevations of the facades of the building, which means a view of the building when you would stand in front of it.

These documents should be drawn accurately, and to a certain scale. A scale 1/100 is a good starting point, which means that 1 centimeter on the drawing represents 1 meter in real life. For the documents which will be used on the building site, it can be better to draw it a little bit bigger, such as scale 1/50, which means every centimeter on the plan represents 50 centimeters in real life, so 2 centimeters on the plan represent 1 meter in real life.

	window
	door
	closet
	hanging closet
	chair
	lavatory
	toilet

Some important drawing conventions for drawing floor plans

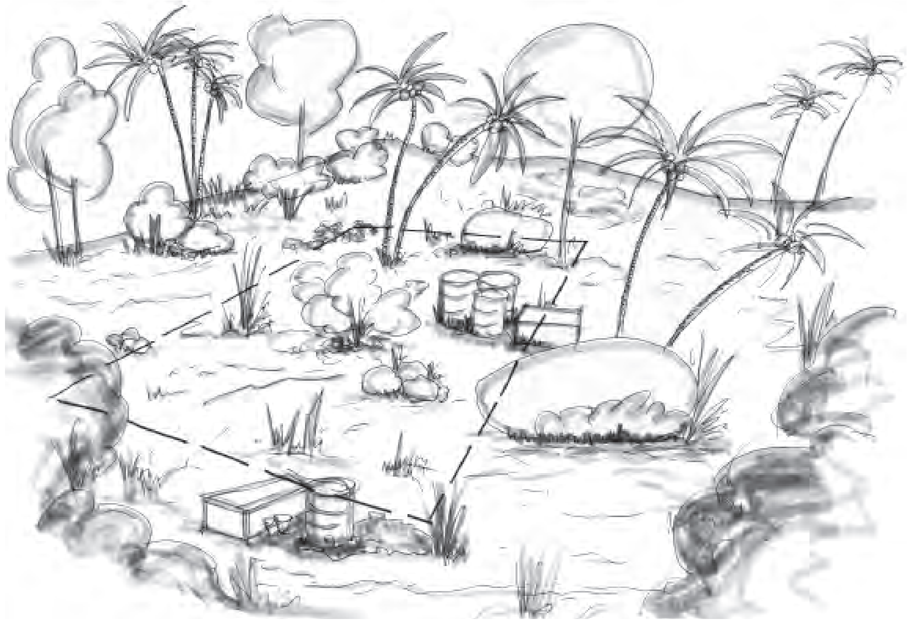
In Annex 9.2 you can find a small example of the drawings for a small doctor's practice. It has been drawn with professional software, but there is very easy-to-use and free software available to produce the same kind of drawings. The most popular is Google SketchUp, which can be downloaded and used for free, and which includes some quick tutorials to get started. If this kind of software can for some reason not be used, it is preferable to draw the building by hand, using just a ruler, a pencil and a piece of paper, and following the drawing conventions of the example. This ensures at least that the measurements are accurate and to a certain scale. It is absolutely NOT recommended to start drawing in software such as Microsoft Word or Excel, as this will produce inaccurate and difficult to understand drawings.

5.2 Cleaning the plot

It is important to clean the plot before the construction of the building can start. If garbage or plants remain on the plot underneath the building, it can cause subsidence after a while, causing cracks etc, and compromising the building's structural integrity.

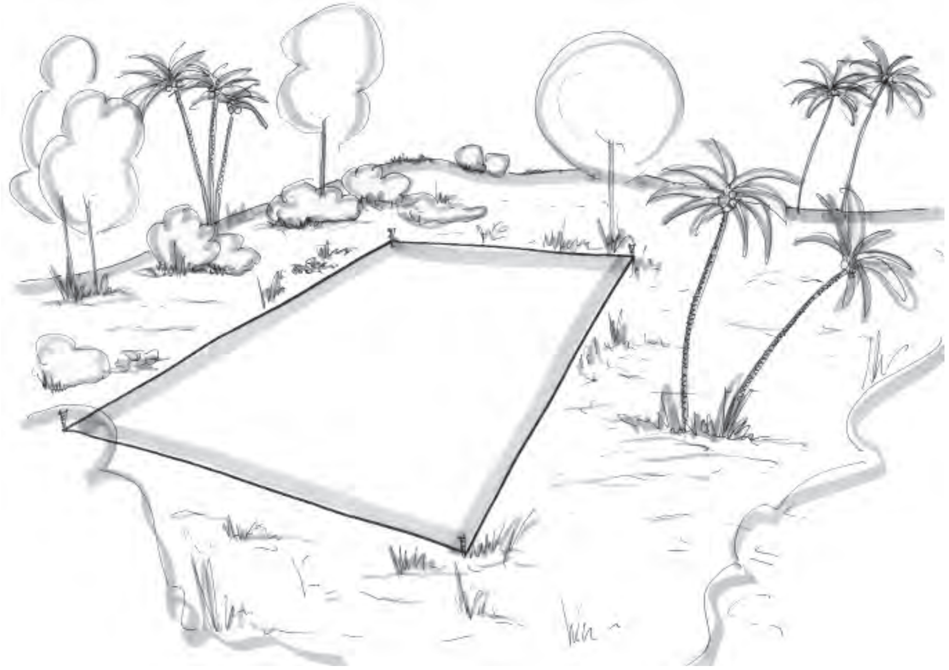
For the cleaning of the plot, a few tools are needed such as shovels, pick-axes, and a wheelbarrow. The following things should be removed from the plot:

- Vegetation such as bushes and weeds. Trees should be kept as much as possible.
- All kinds of dirt and garbage
- Rocks or other irregularities in the terrain. This does not apply when the soil exists mostly out of a rocky soil.



Future building plot location

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex



Future building plot cleared and ready to begin construction

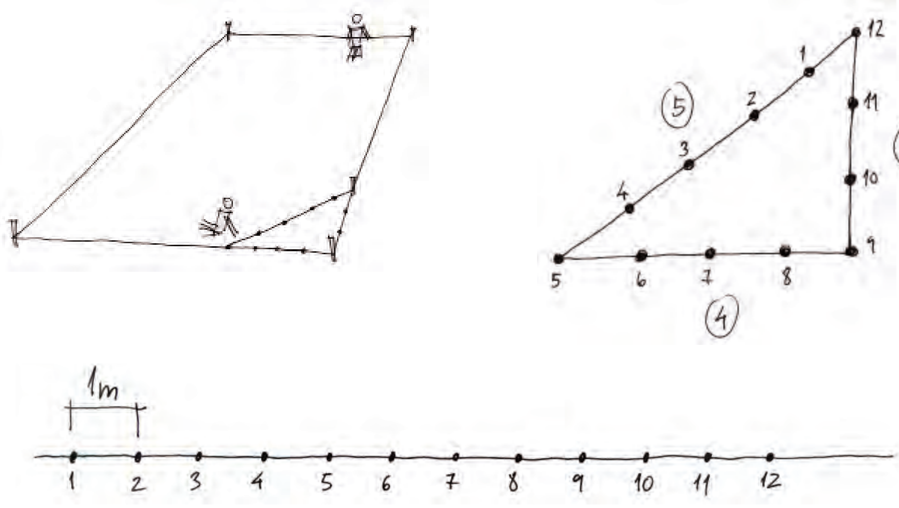
5.3 Demarcation of the plot

When the plot is cleaned, one can start demarcating the plot according to the chosen layout of the building. This will serve as a base for the construction of the foundations.

It is important to make sure that the demarcation of the building is angled in the right way in relation to the neighboring buildings and roads. Usually, the angle will need to be perpendicular, and therefore you need a wooden triangle with an angle of 90° to measure with.

All of the outer and inner walls of the building have to be demarcated by a wire, held up a few centimeters above the soil by wooden or metal stakes. You need a measuring tape to be able to measure the correct length for all future walls. Every wall needs to be demarcated by two parallel wires, spaced as far apart as the width of the foundation walls.

To make sure the wires of two intersecting walls are exactly perpendicular to each other, one can put a third wire at the outer ends of both walls. The following formula can be used to determine whether they are perpendicular: (length third wire)^2 = (length first wall)^2 + (length second wall)^2. The (length of the wall)^2 means multiplying the length of the wall with itself. So for example if the one wall is 3 meters



Example of the demarcation of the plot

long, and the second wall 4 meters, the length of the third wire should be 5 meters, because (5*5) = (3*3) + (4*4).
When all the wires are in place, the walls can be demarcated on the soil by chalk lines. For this, you need a pot of chalk with a hole in the bottom, and run it along the wires.

One also needs to be aware of the possible inclination of the terrain. Make sure that the wires indicating the future walls are horizontal. This will help construct the foundations to be exactly level. To measure this, you can use a bubble level, or a transparent hose filled with water. The laws of physics dictate that the water level on both sides of the hose is always equal, so this can help determine if the both sides of the wire are perfectly at the same level. When digging the foundations, you need to make sure that the level of the bottom plane of the foundation is also perfectly horizontal, which can be tested with the level as well.

5.4 Foundations

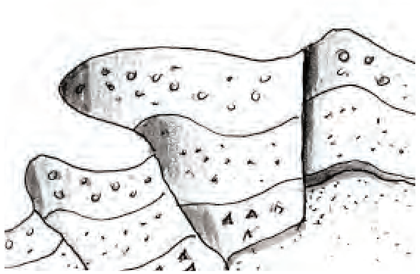
It is not always necessary to create a foundation for a building construction. It is possible to build a building directly on the ground with buried trunks. However it is better to support the building, its walls and roof structure, on a foundation. This poses fewer risks regarding building settling, humidity, and problems created by bugs (for instance, white ants can compromise the stability of the building).

A foundation works as a footprint of the building. It supports it and functions as a tie between the construction and the soil. Depending on the type of soil on the construction site, there are different types of foundation techniques and issues to consider within its construction process.

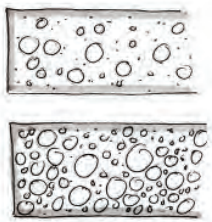
The initial step is always to identify the type of soil that we are dealing with on site. Depending on the type of soil and it's humidity, there are different types of foundations to use, also impacting their width and their height.

It is not possible to identify the existing type of soil just by observing it's surface. It is always necessary to investigate below the surface to identify the soil's resistance. The soil's resistance is defined by the materials that it contains, and its rate of compactness. In the end it is possible to divide it into three types: hard, medium and soft. It is extremely important to know the rate of compactness of the soil in order to avoid problems related with settling of the construction.

Soil is composed of different layers, which may have different rate of compression. Just as there are bubbles below the surface of mineral water, bellow the soil's surface there are empty spaces that are filled with water and air. The soil can be classified as less compressible if it has more solid material than water or air, and more compressible with increasing amounts of water and air in it. In other words the soil's rate of compactness is higher if the soil is more compact or more resistant to compression.



Different soil layers



Bubbles of air present in water . Soil empty gaps filled with water and air

There are four methods to investigate the soil's rate of compactness:

- Comparison:
This consists in comparing the behaviour of the different terrains in the surrounding buildings.

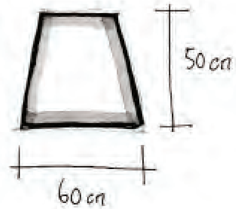
- Direct investigation:
This consists of applying direct charges (weights) in one or more than one location of the terrain, in order to determine how much load the soil can stand.

- Samples:
This consists in the detailed study of the mechanical behaviour of the soil. It is necessary to collect samples in different locations within the plot. This method is highly recommended although it has to be performed by a qualified professional.

- Drilling:
This consists of drilling into the soil in specific locations, while measuring the amount of force that is needed to push the drill into the soil. This way the different soil layers can be analyzed. Although highly accurate, this method is very expensive. It is advisable to use it when working with pole foundations in very bad soil or very wet areas. It has to be performed by a specialized professional, and it involves the use of specific machinery.

This manual is intended for the construction of structures with a low degree of complexity, and with a limited amount of stories and thus weight, so it is advisable to use the first two methods presented. If the complexity of the construction justifies it, or when constructing a multi-story building, it would be better to contract a professional to perform these kinds of geological studies. Either way, it is important to mention the necessity of knowing and identifying the type of soil of the construction plot.

Soft soils – can be described as good for farming purpose, and are composed of small particles. When sand particles are predominant, it's consistence is loose and dry. These are highly deformable, creating problems with building settling, so it is advisable, if possible, to dig to a deeper, more solid level to construct the foundations on. The minimum height of the foundation should be 50 cm, and the minimum width 60 cm.



Medium soils – can be described as sediments, combining small particles (sand) with natural binders (such as clay), which over time gain a high rate of compactness. It is possible to encounter big stones within these soils. This type of soil is suitable to support the foundations, due to their good resistance and compactness.

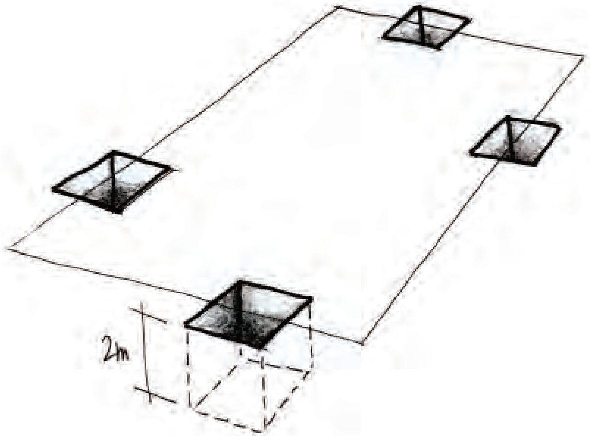
Hard soils – can be described as rocky soils, combined with gravel and small portions of sand particles. These offer great resistance, and are the most suitable to support the foundation of a building. Special care is necessary, due to the possibility of caves and instability of rocks due to high soil inclination.

Soft soils

Medium soils

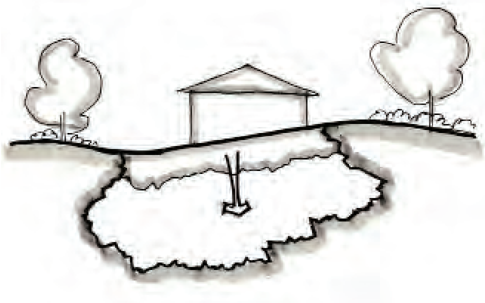
Hard soils

It is advisable to dig along the place where the foundation is going to be located, in order to identify the type of existing soil. This should be done, no less than two meters deep. The minimum number of places to dig in is four. These should be located on each of the sides of the building.



Digging points

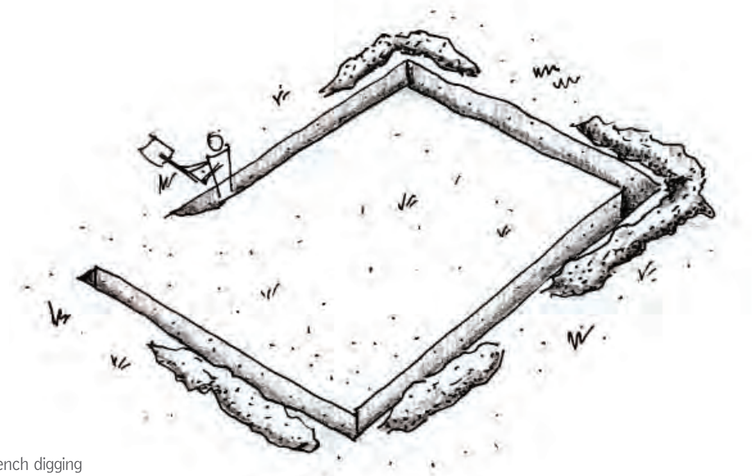
When chosing the site for building one should be aware to specific situations that might put the building in danger. Apart from the landslides and flooding risk areas, one should be aware of possible geological phenomena, such as caves, or natural wells. It is advisable to consult the local records about these phenomena before construction, or to perform a special geological survey. Do not place your building in these locations.



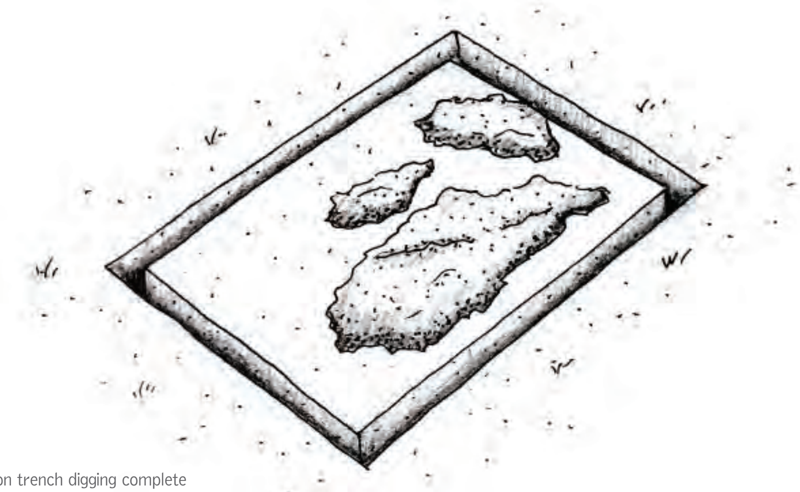
Cave

Natural well

After the demarcation of the plot, and the demarcation of the foundations' location, it is necessary to dig the foundation trench.



Foundation trench digging



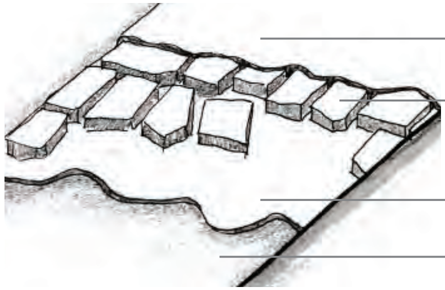
Foundation trench digging complete

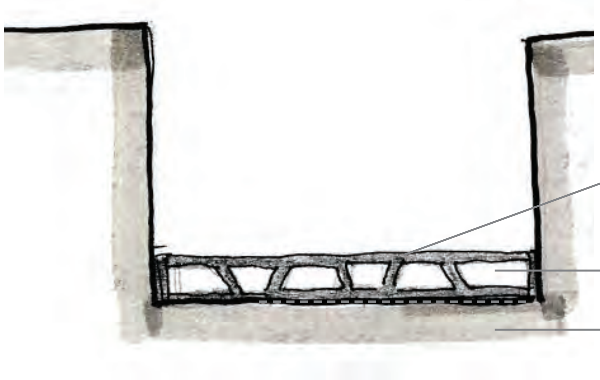
The earth that comes from digging the foundation trench should be placed inside the plot. The earth will be used to cover the gaps after the foundation beam is finished. Placing it there avoids extra work and spending on transport, also saving time.

In this manual we discuss the construction process for foundations using two different materials: stone and concrete. Both have different types of construction, and are suitable in different situations. First we explain the process for the stone wall foundation, and then for the concrete foundation.

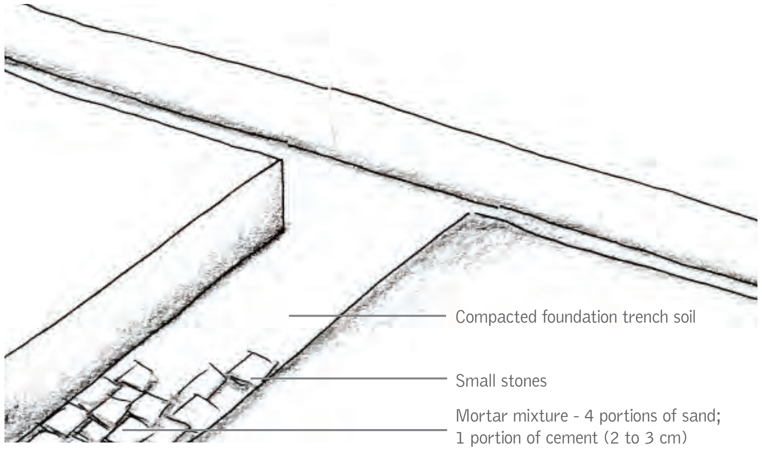
5.4.1 Stone wall foundation

After the foundation trench is dug, the next step is to create the bottom foundation layer. Only after compacting the soil in the foundation trench is it possible to create the first base layer of the foundation:

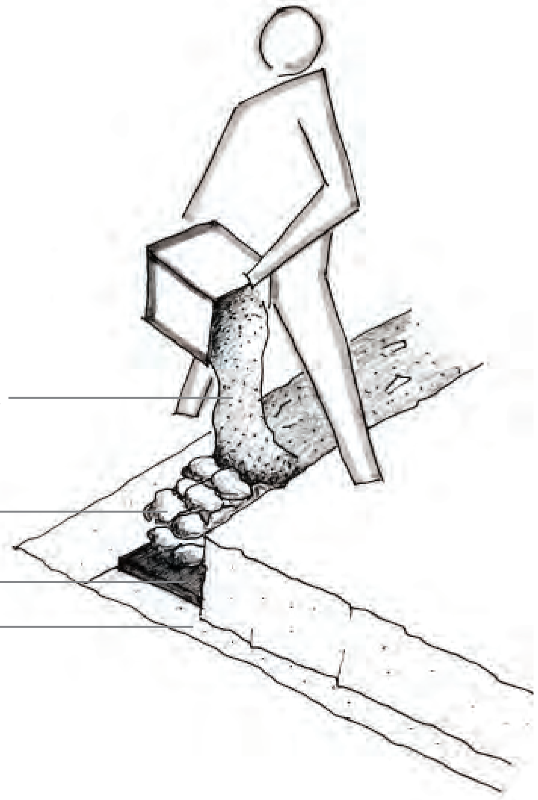




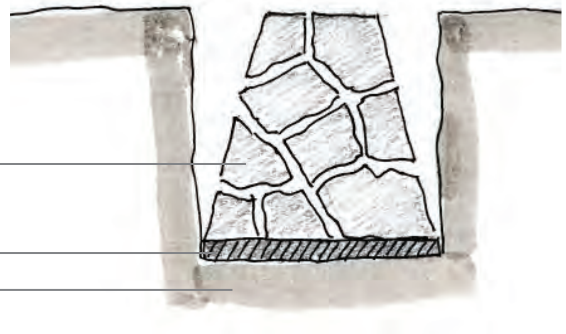
The base should have a height between 7 and 10 cm.



Make the foundation by filling the trench with stones and a mixture of cement and sand. The bigger stones should be placed on the bottom, the smaller ones at the top, to create a stable foundation wall.

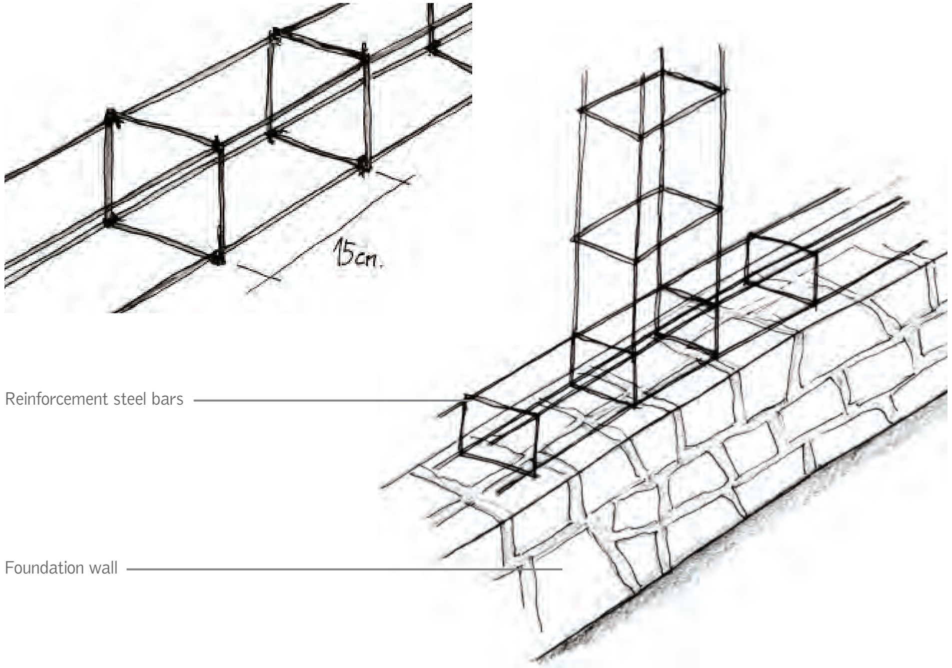


The mortar should be made of 4 portions of sand, and 1 portion of cement. Stones can be flat or round, and it is also possible to use bricks.

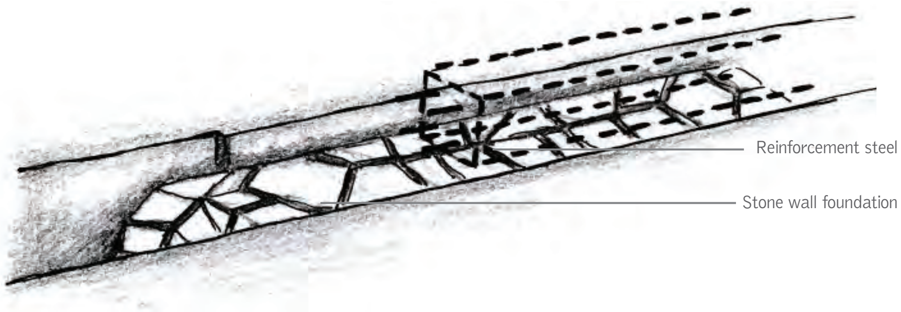


While doing the foundation, it is necessary to leave room for the water supply and drainage pipes. This sould be done while doing the foundation wall and never after the completion of it, to avoid having to destroy parts of it for the piping.

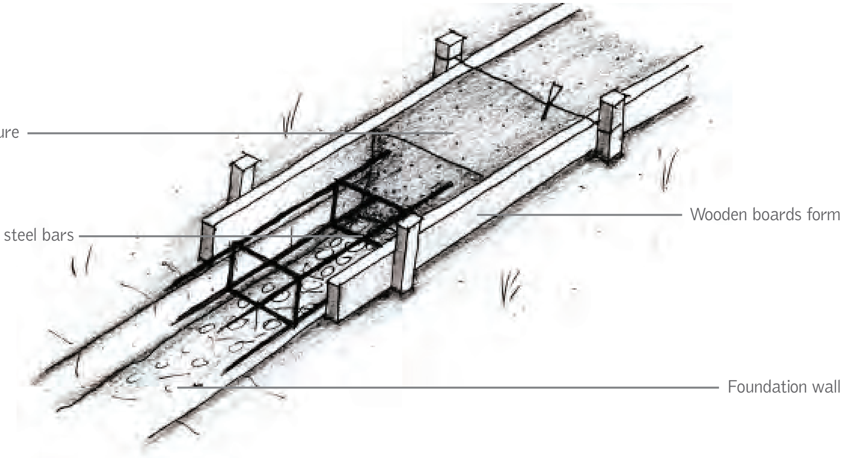
Once the foundation wall is complete, it is necessary to build the reinforced foundation beam. This is placed on top of the foundation wall. The process begins with placing the reinforcement bar cages that reinforce the beam.
Steel reinforcement bars with diameter number 3 should be used. The four bars are tied togheter by a steel belt. These belts should be placed no more than 15 centimeters apart.



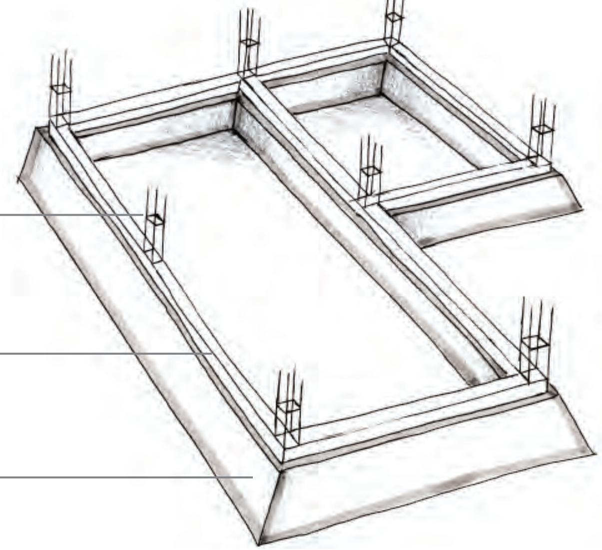
The reinforcement cages should be placed on top of the foundation wall.



Wood is used to place a form on top of the foundation wall, and around the reinforcement bars. This form should have the dimensions of the foundation beam. Concrete is poured, according to the mixture quantities described in chapter 4.3: Reinforced concrete. The reinforcement steel bars, have to be fully covered with the concrete mixture. After pouring the concrete, it should be vibrated within the form, so that there are no air bubbles left inside the mixture.



This process is done all along the foundations' perimeter. The surface of the foundation beam has to be smooth and straight.



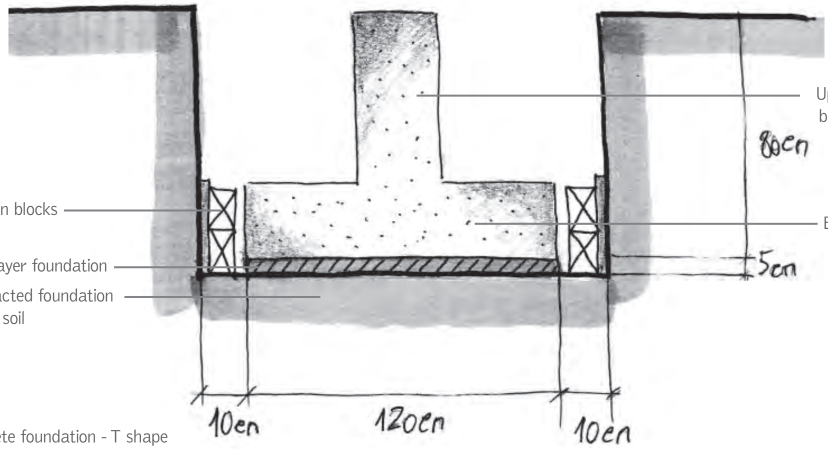
It is necessary to provide the initial steel connections between the foundation beam and the columns. This should always be done before pouring the concrete of the foundation beam, and taking into account the necessary overlap of the steel bars, as described in chapter 4.3.

5.4.2 Concrete foundation

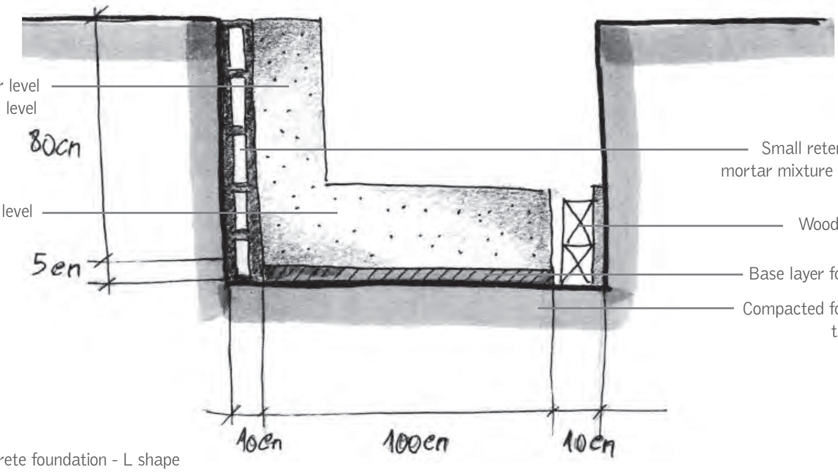
A concrete foundation is composed of two parts, the base level and the upper or beam level.

One can find two types of layout for a concrete foundation. One type to use when there are no surrounding buildings (T shape), and other to use when to build next to an existing building (L shape). Both types will be explained in this manual.

As with the stone wall foundation, it is necessary to create a base layer for the foundation. This is done by pouring a mixture of 1 bag of cement, and 6 buckets of sand over the compacted foundation soil trench. This layer should be placed across the width of the foundation trench, leaving an empty gap between it and the trench wall.



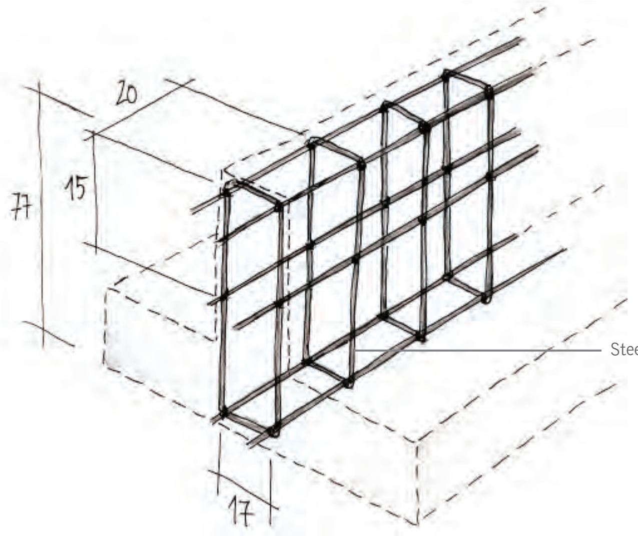
Concrete foundation - T shape



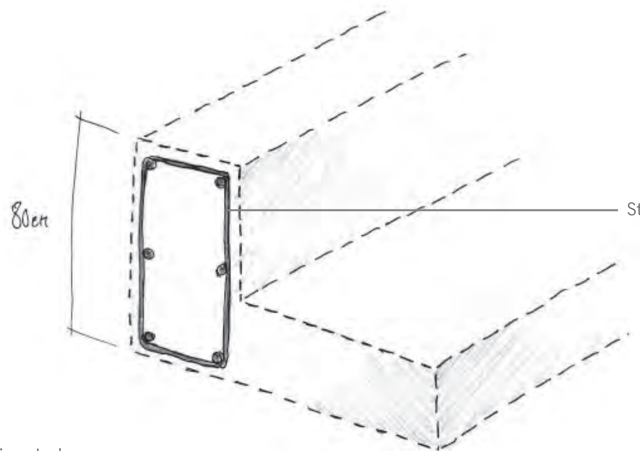
Concrete foundation - L shape

The construction process of concrete foundation follows three steps.

The first step is to create the steel reinforcements for the foundation. When doing the reinforcements, first do the base level of the foundation, and then the upper level. The reinforcement for the upper level of the T-shaped and the L-shaped foundation is the same.



Concrete foundation - T-shape

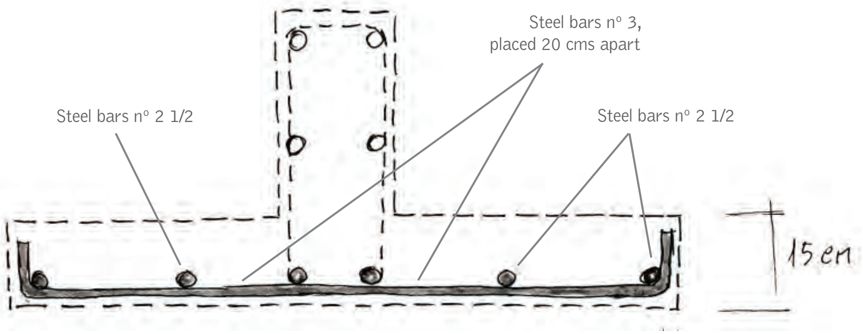


Concrete foundation - L-shape

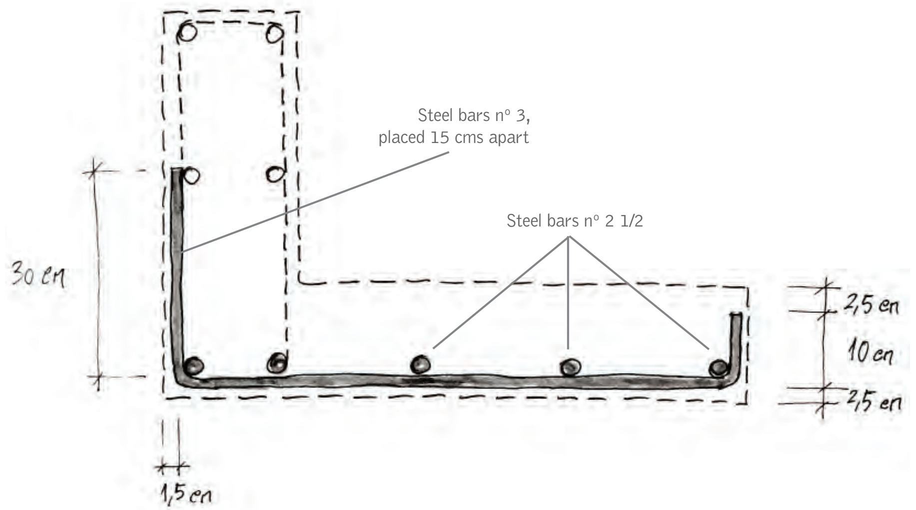
For the upper level of the foundation (the beam part), 6 bars of diameter number 3 need to be used, tied with steel ties 77 cm high, and 17 cm wide. The ties should be placed 20 cm apart.

In the case of the T-shaped foundation, for the lower level of the foundation 4 steel bars number 2 1/2 are placed in a longitudinal orientation, and for the remaining width, number 3 bars are placed 20 centimeters apart, in a transversal orientation.

In the case of the L-shaped foundation, for the lower level of the foundation 3 steel bars of diameter number 2 1/2 are placed in a longitudinal orientation, aand for the remaining width, number 3 bars are placed 15 centimeters apart, in a transversal orientation.

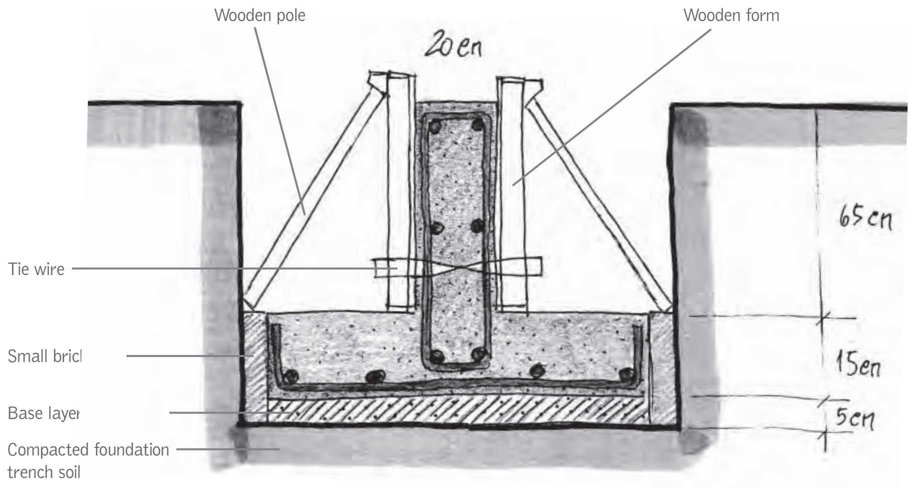


Concrete foundation - T-shape

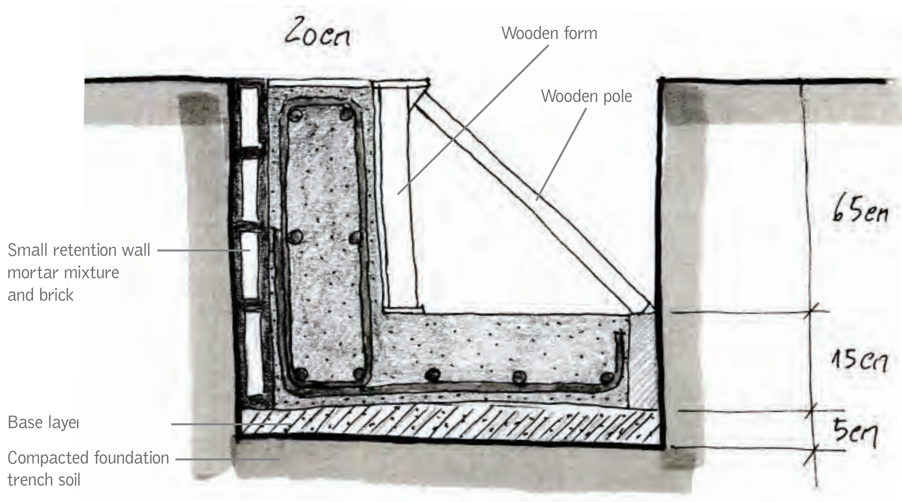


Concrete foundation - L-shape

After placing the reinforcement steel bars, it is necessary to create the form where the concrete will be poured. Wood is used for this, and it is extremely important to wet it before pouring the concrete mixture inside.



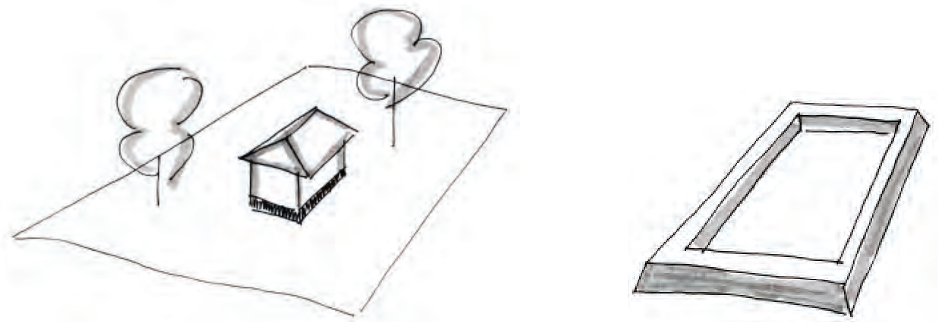
Concrete foundation - T shape



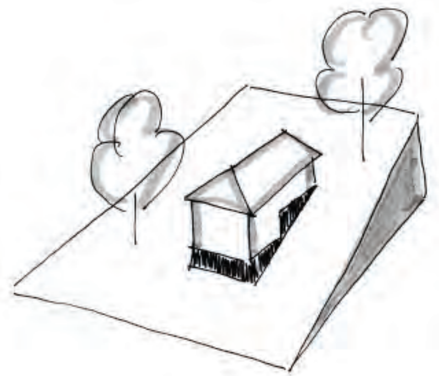
Concrete foundation - L shape

As with the stone wall foundation, it is necessary to create the initial steel connections between the foundation beam and the columns. This should always be done before pouring the concrete to the foundation beam.

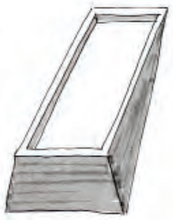
One should always divide the foundations into different levels when doing a foundation in a pitched plot, thus creating horizontal levels without having to dig too deep. The building's design will have to be adjusted to these different levels.



Stone wall foundation



Stone wall foundation - pitched plot



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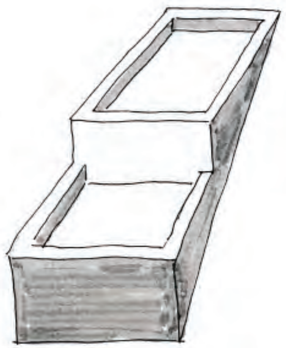
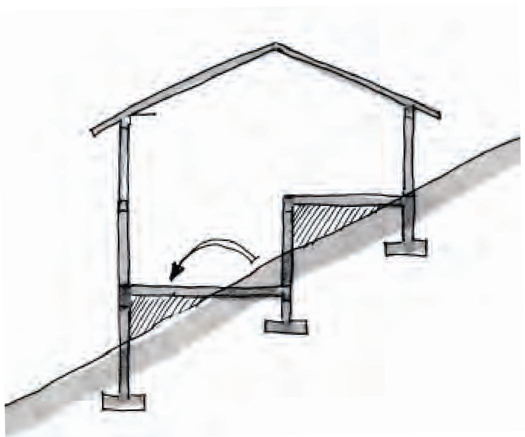


CORRECT



Concrete foundation - pitched plot

5.5 Walls

In this chapter we will talk about different ways of constructing the walls on top of the foundations. The walls of the building can be structural, taking the load of the roof and the stories above them. The walls can however also just act as an infill for a concrete beam and column structure, not taking any loads. In any case, they are necessary to separate the inside of the building from the outside, and to separate the rooms from each other.

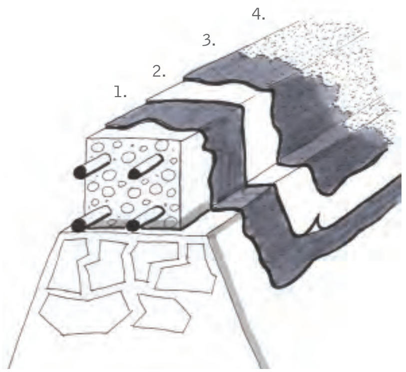
We will go into some different types of walls, depending on the structure, and on the available materials.

5.5.1 Waterproofing the foundations

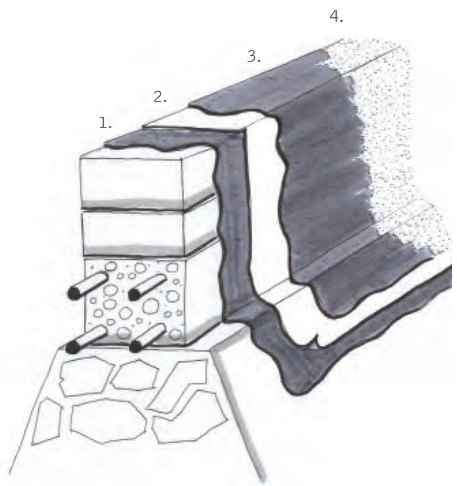
For all types of walls, the foundations need to be treated to prevent moisture from reaching the walls. The foundations are exposed to groundwater levels, and because they are made from porous materials, moisture will rise up through the foundations into the walls, which will damage the bricks and finishing in the long term. Therefore, we have to apply an impermeable layer between the foundation and the actual wall. In very humid terrains, or terrains where the soil is very salty, it is advisable to treat the first two layers of bricks of the wall as well.

The easiest solution to make the foundation waterproof is with subsequent layers of:

1. Asphalt
2. Polyethylene plastic sheeting
3. Another layer of asphalt
4. Fine sand



Waterproofing the foundation beam



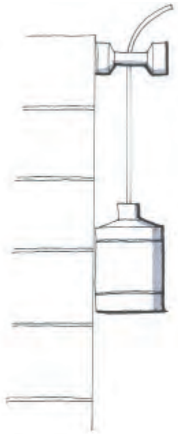
Waterproofing the foundation beam and first two layers of bricks

5.5.2 Constructing a brick masonry wall

In this section, we explain the different steps to construct a masonry brick wall. The bricks will be stacked on top of each other, using cement mortar as binder. For information on the mixing of the mortar we refer to chapter 3: Materials guidelines.

It is important to ensure that the walls are perfectly vertical when constructing them. This can be done both with a plumb-line or an air bubble level.

A plumb-line consists of an element holding a wire, and at the bottom of the wire a piece of lead is attached. The piece of lead has the same width as the wire-holder. To ensure if the wall is perpendicular, start at the top of the wall so far constructed. Place the wire-holder, to which the top of the wire is attached, on the wall. Now lower the wire with the lead element attached to it along the length of the wall, until it reaches the bottom of the wall. If the element is almost touching the wall, but not scraping it all the way down, the wall is perfectly vertical. If the element is not touching the wall, it means the wall is inclined outwards. If the element is touching the wall, and is still touching the wall when moving the wire holding element from the wall, the wall is inclined inwards.



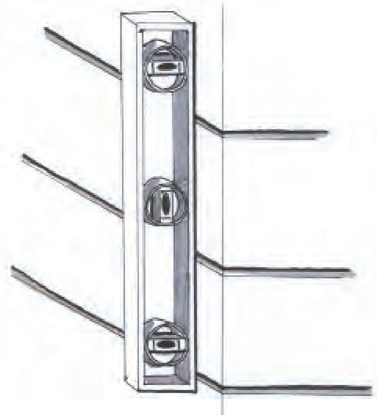
Using the plumb line

Wall inclined inwards

Wall inclined outwards

When using an air bubble level, it is recommended that the element to measure is no higher than 2 meters. When the wall to measure is longer than 2 meters, it is best to span a wire in between the top and bottom of the wall, and put the bubble level against the wire. This will increase the accuracy of the measurement. To measure whether the wall is perpendicular, simply place the bubble level vertically against the wall, and see if the air bubbles are between the marks on the level. If they are, the wall is perpendicular, if they are not, the wall is inclined.

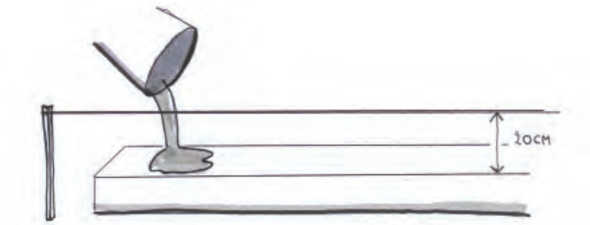
1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex



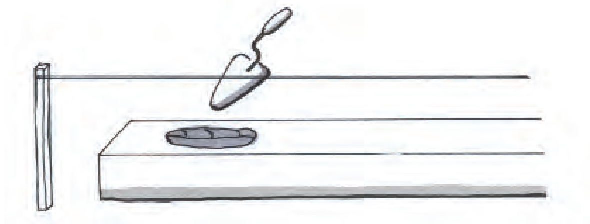
Using the bubble level; the bubbles are within the marks when perpendicular

When using clay bricks, the bricks need to be sprinkled with water before using them, to prevent them from absorbing the water of the mortar. With concrete blocks this is not necessary, as they are not so absorbent.

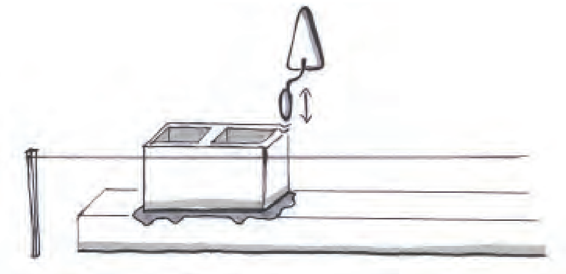
The surface to begin constructing the bricks on (the foundation beam) needs to be clean and moisturized. A wire needs to be spanned along the line where the wall needs to be, about 20 centimeters above the base of the bricks, as a guideline to construct a straight wall.



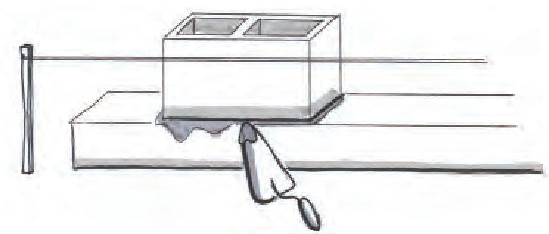
With a trowel, put some mortar on the base of the wall. Place the first brick, and make sure it is aligned with the wire.



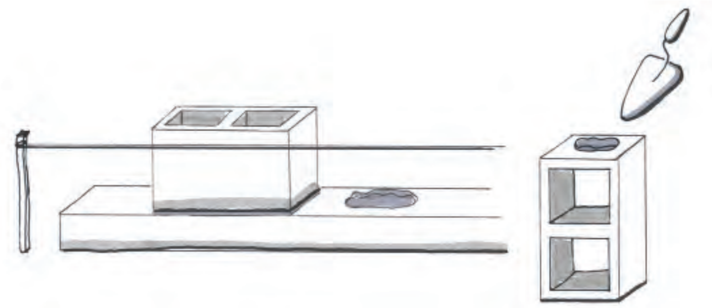
Tap it with the back of the trowel to put it horizontal. Assure that it is perfectly horizontal with the bubble level. If necessary, tap it some more with the trowel.



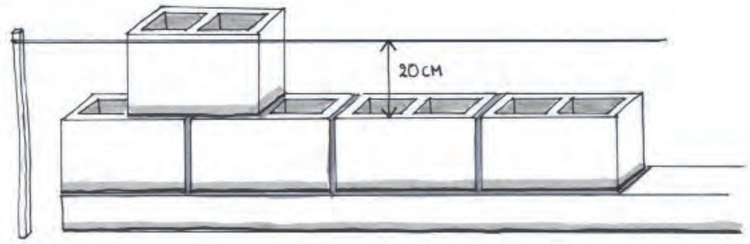
Remove the excess mortar from the sides with the tip of the trowel.



Put some mortar on the base, and also on the side of the second brick. Then place it next to the first brick, and repeat the steps.

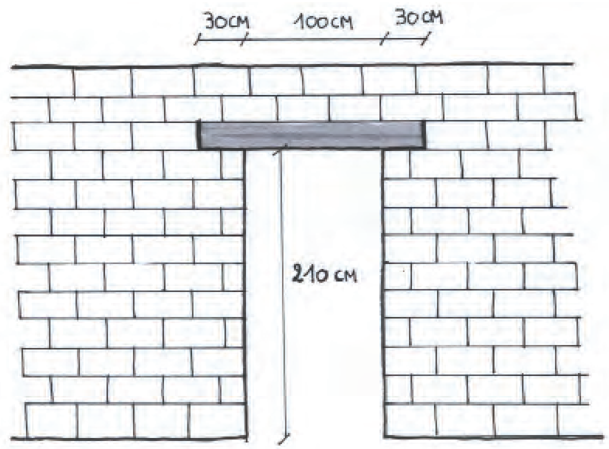


When the first level of bricks is complete, move the wire up, and construct the second level on top of the first. Repeat these steps for the entire wall, regularly checking if the wall is perfectly vertical with the line-plumb or bubble level.



5.5.3 Lintels for doors and windows

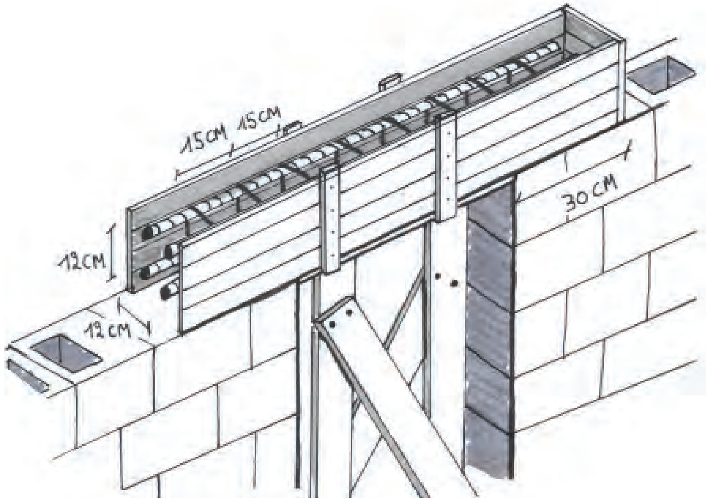
While constructing the walls, openings need to be made for doors and windows. Above these openings, there needs to be a lintel. This is a reinforced concrete beam that takes the weight of the bricks above the door or window opening, and distributes it to the bricks on either side of the opening. The lintel needs to extend 30 centimeters on either side of the opening.



Lintel above a door opening

The lintel can be prefabricated, but usually it is casted on site. The wall is built up until the height of the top of the opening. Next, a wooden formwork is constructed on the spot where the lintel should be, so that the bottom of the lintel is at the level of the top of the door or window. Usually, the width and height of the lintel is the same as the width and height of the bricks. Four reinforcement bars of diameter no. 2 or no. 3 are placed, 12 centimeters apart, and they are tied together by anchors in a square every 15 centimeters. Afterwards, the concrete can be poured into the formwork. For the mixing quantities of the concrete, we refer to chapter 4.3: Reinforced concrete. The construction of the rest of the wall can continue as soon as the lintels are dry and have developed their full strength.

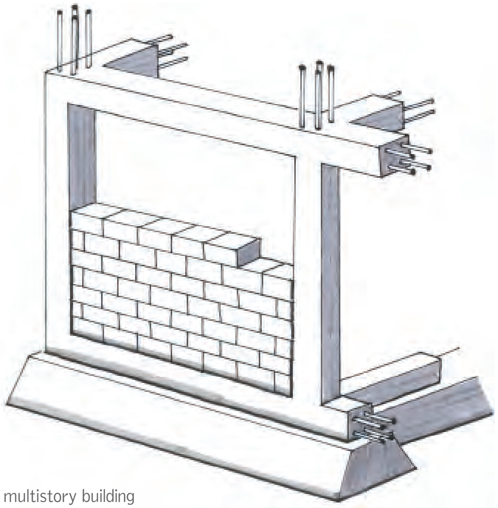
1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex



Casting a lintel on site

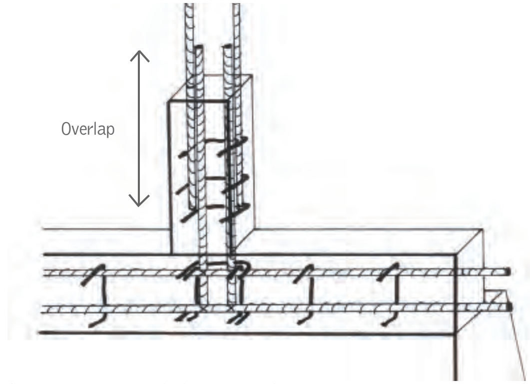
5.5.4 Vertical wall reinforcements

Walls need to be strengthened with reinforced concrete elements, because otherwise the resistance to lateral forces perpendicular to the plane of the wall is too low. They need to be reinforced both horizontally and vertically. Vertically, this is done with concrete columns, and horizontally with concrete beams. It is important that the reinforcement bars of the beams and columns are tied together, so that the beams and columns can function together as a rigid framework. This is especially important in earthquake-prone areas, where extra care needs to be taken.



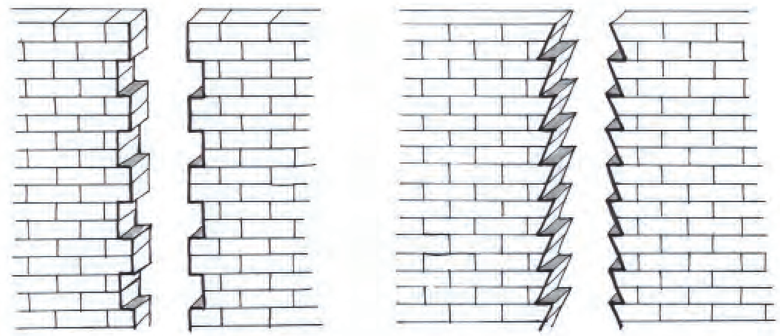
Beam and column structure for a multistory building

We begin with the columns, strengthening the wall vertically. They should be placed at the corners of the walls, and at the intersection of two walls. Additional columns should be placed every 3 or 4 meters along the length of the walls. When reinforcing the foundation beam, vertical reinforcement bars should be provided wherever the columns will be placed. These vertical bars have to be tied to the horizontal bars running along the beam. The vertical bars should overlap with the ones of the column according to the amounts specified in chapter 4.3.4: Reinforcing concrete.



Bars from the foundation beam overlapping with the column's bars

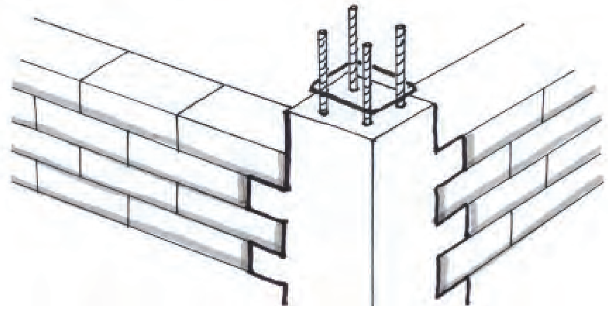
The columns can be made in two ways, depending on the type of bricks used.
The first method is mostly used when using solid clay bricks that don't have openings in them, and which are usually smaller. The width of the wall will determine the width of the column. The columns are formed by leaving a gap in the wall of at least 15 centimeters. The bricks have to be cut off in the way shown in the drawings, to make a mechanical connection between the column and the masonry.



Two ways of cutting off the bricks to make the connection with the column

When the masonry is completed, four reinforcement bars of diameter no. 3 will be placed along the height of the wall, overlapping with the reinforcement bars sticking out of the foundation beam, and tied together by square anchors every 20 cm. The reinforcement bars should be long enough to stick out

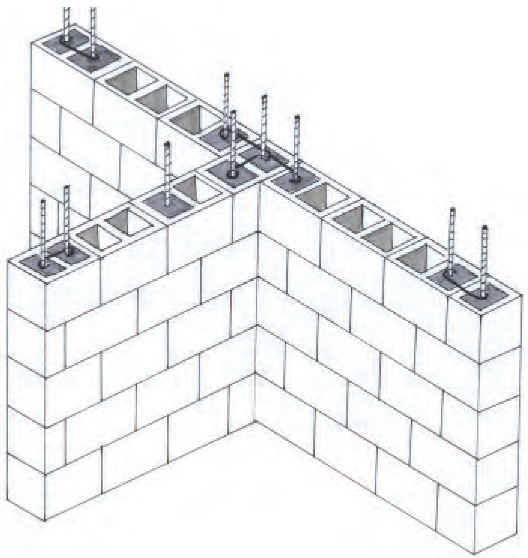
at the top of the wall, so they can later be tied together with the horizontal reinforcement bars in the beam at the top of the wall, or even more if it is a multistory building.
Next, a wooden formwork will be placed on either side of the wall, and fastened to the wall. Concrete will be poured into the form from the top, and be left to dry. It is important for the strength of the column to make enough concrete and pour it all at once. When the formwork is removed, the column is complete.



Column on the corner of two walls

The second method is only possible when the masonry is done with concrete blocks with openings in them. In this method, reinforcement bars of diameter no. 3 are placed through the holes in the concrete blocks, and the holes are afterwards filled with concrete.

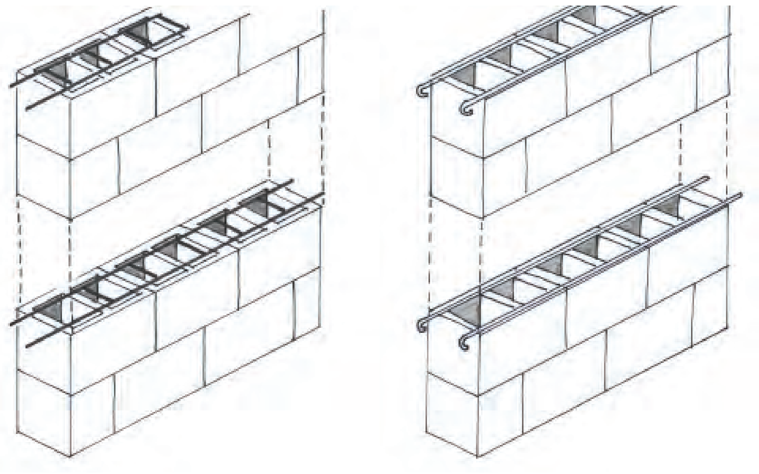
The bars should be placed at least at the ends of walls, at the intersections of two walls, when there are columns on the story above, and additionally every meter along the length of the wall. At the end of walls, two bars are usually placed, anchored together every layer of bricks. At the intersection of two



Reinforcements placed in the holes of concrete blocks

walls, four bars are placed, anchored together in every layer, in the way shown in the drawing. Every meter, one bar is placed.

When using this method, it is also important to include horizontal reinforcements in the masonry every two vertical rows, and tie them to the vertical reinforcement bars. These horizontal reinforcements consist of 'ladders' of wires welded together, or two narrow bars.



Horizontal reinforcements within the masonry

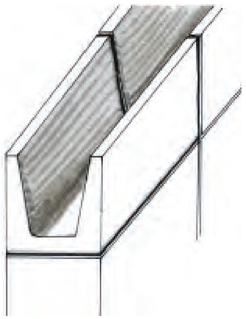
5.5.5 Horizontal wall reinforcements

At the top of the wall, where it connects to the roof structure in a single story building, or to the wall of the next story in a multistory building, it is necessary to create a horizontal bond beam. This bond beam connects all the walls of the building, and strengthens the entire structure. This is especially important in earthquake-prone areas, where the horizontal forces inflicted by the earthquake would otherwise make the walls fall over. With the bond beam all around the building, the walls will act together as a 'box', and the forces of the earthquake will be distributed over the entire structure, decreasing the risk of walls toppling down.

The bond beams are created with the same width of the wall, but should be at least 12 centimeters wide and 20 centimeters high. They consist of reinforced concrete, and can be created in several ways. We will discuss the easiest and most common techniques.

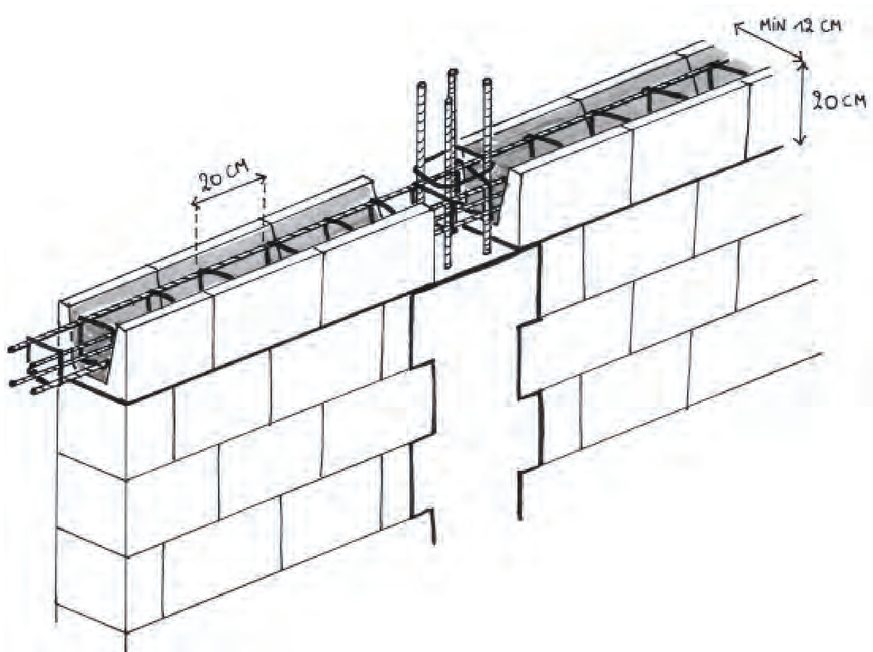
The most common technique to cast the bond beams is using a concrete formwork all around the walls. This technique is quite laborious and requires more wood for the formwork, but it may be the only option when the special U-shaped bricks are not available.

The second technique uses a type of U-shaped brick as a formwork for the beam. These bricks are used in the top layer of bricks, creating a kind of gutter. At the places where the reinforcement bars of the vertical columns are sticking out, the layer of bricks is interrupted, and a wooden formwork is used to complete the gutters.



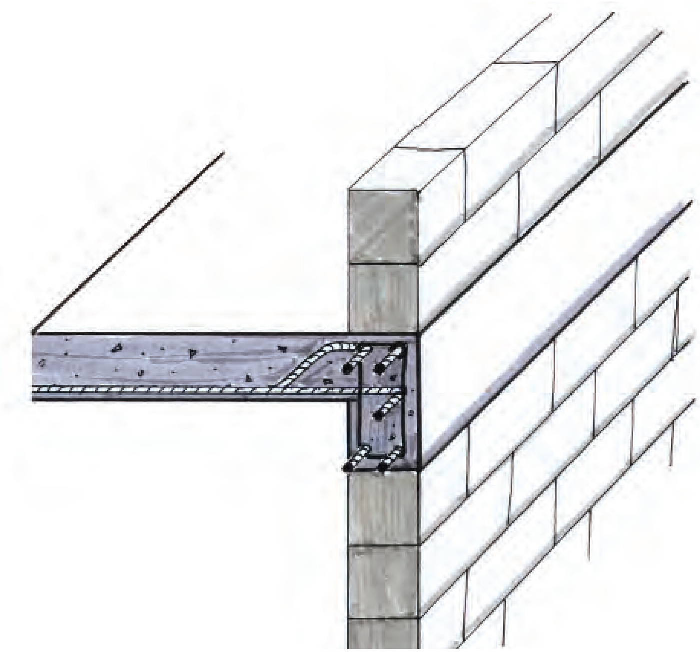
U-shaped bricks forming the gutter

Next, four reinforcement bars of diameter no. 3 are placed inside these gutters, archored by squared anchors every 20 centimeters, and tied together with the vertical reinforcement bars sticking out of the columns. Finally, concrete is poured into the gutters, and left to harden.



Reinforcing and casting the bond beam

A third possibility is that the bond beam is cast together with the concrete roof slab, or the floor slab of the next story. This applies only to buildings with concrete roofs or to multistory buildings. In this case, the reinforcements of the floor slab are tied to the reinforcements of the bond beam.

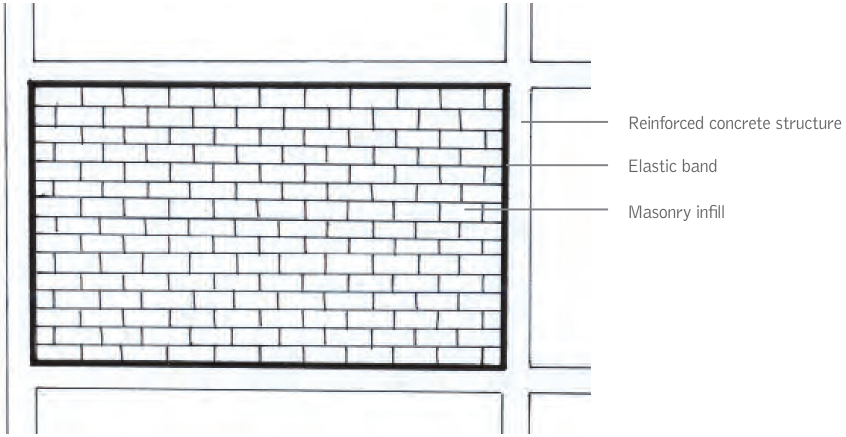


Casting the bond beam together with a concrete floor

5.5.6 Earthquake-prone areas

In earthquake-prone areas, extra precautions need to be taken when constructing the walls, columns and beams. For the columns for example, the method with leaving a gap in the masonry to cast the column will not be appropriate. In these situations, a concrete column and beam structure needs to be constructed first, and will afterwards be filled with masonry. However, a rubber or foam band of a few centimeters thick needs to be placed in between the structure and the masonry infill. This is because during an earthquake, the structure will move with a different frequency than the masonry infill. The elastic band between the two elements will absorb the difference in movement, and will prevent the masonry from cracking and falling over.

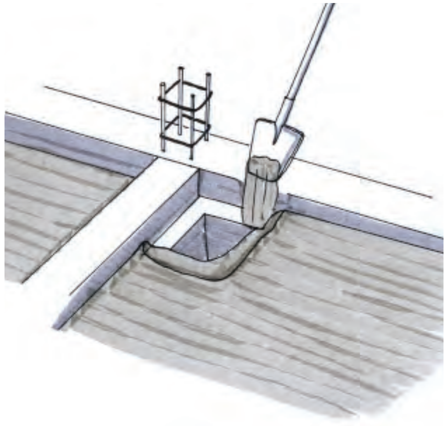
We don't provide instructions on how to construct this type of structure however, as for earthquake-prone areas, a specialized engineer should always be consulted for the construction.



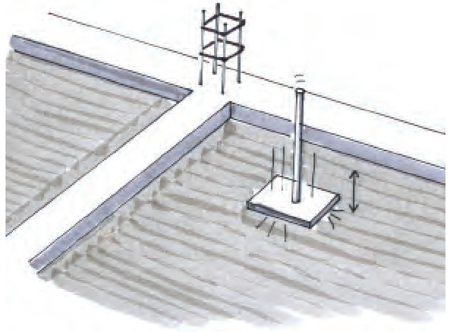
Earthquake-proof concrete beams and columns with masonry infill

5.6 Ground floors

For the construction of the ground floor, we have to make sure that the ground underneath is totally level. Any bumps or ditches in the soil have to be filled with sand, and a layer of fine sand has to be spread out and compacted by pressing it manually.



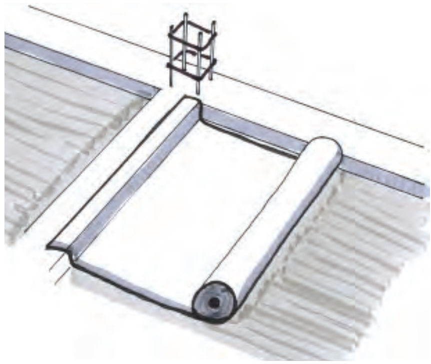
Filling holes and spreading an even layer of sand



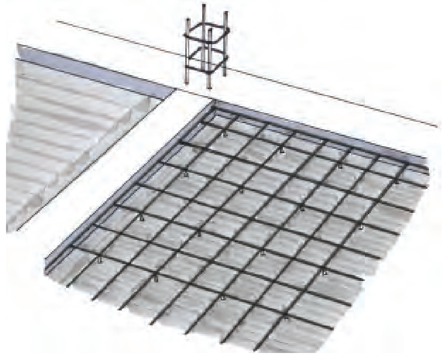
Compacting the sand layer manually

This compacted sand layer will form a solid base for pouring the concrete floor slab. The sand layer needs to be between 12 to 15 centimeters below the top of the foundation beam, so the concrete layer on top of it will be between 12 and 15 centimeters thick. Ensure that the sand layer is perfectly horizontal with the bubble level.

When working in an area where the ground water table will be very high (up to the level of the floor slab) for at least some time during the year, it is advisable to take a precaution against humidity. In this case, a plastic sheet is placed over the entire area of the floor, and fastened to the sheet covering the foundation beam. This sheet will prevent water from rising up through the concrete floor slab.

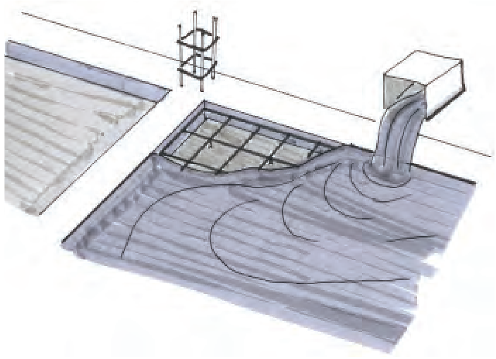


Covering the layer of sand with plasting sheeting

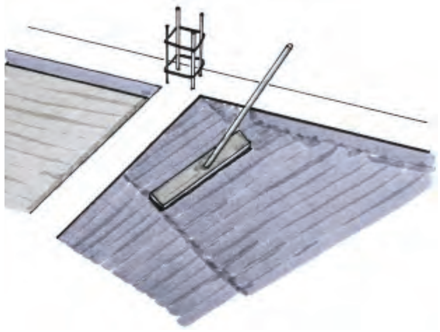


Placing a reinforcement net on retainers when applicable

When the floor needs to be able to take heavy loads, such as in the case of a storage area where heavy palettes of medical goods will be stored, it is advisable to reinforce the floor slab with a steel reinforcement net. This is to prevent the floor from cracking due to the heavy loads. The floor could also crack when drying too fast after casting it, in which case the reinforcement net is also useful. For other applications, it is not necessary. The reinforcement nets consist of a series of bars welded together to form a net. They are commercially available in different sizes and diameters. The net is placed on retainers in the bottom part of the floor slab, because this part will take the tension forces.

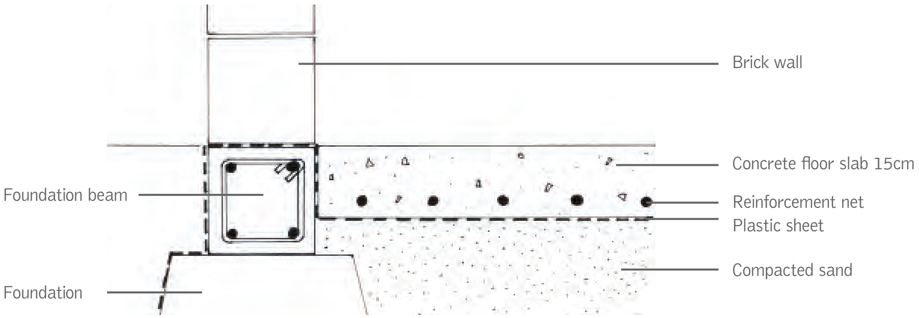


Pouring the concrete



Smoothing the concrete surface with a wooden plank

Next, the concrete can be poured. When pouring large surfaces, it should be cast in multiple phases, with a elastic joint in between the parts. For example a floor of 4 m by 7 m can be cast in two times 4 m by 3,5 m. This allows for contraction and expansions due to temperature differences, and prevents cracks. Remember that drainage and water pipes need to be put in place first where necessary. For this we refer to chapter 5.9: Installations.
The mixture of the concrete needs to have a strength of 150 kg/cm² for regular floors that will not carry especially heavy loads. For the corresponding mixture quantities we refer to chapter 4.3: Reinforced concrete. The concrete layer needs to reach up to the top of the foundation beam, so that the floor level is equal to the bottom of the first brick. This means that the floor slab will be 15 centimeters thick.
After pouring the concrete, the surface needs to be smoothed by going over it with a wooden plank.

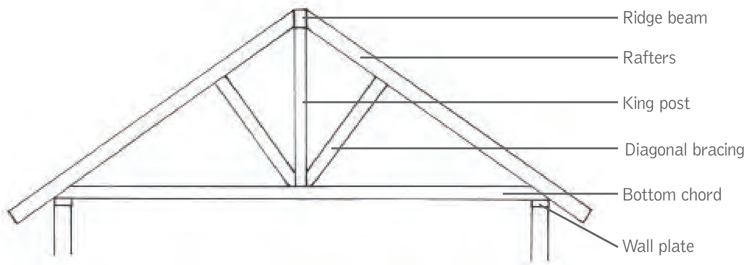


5.7 Roofs

In this chapter you will find a few variations on roof structures and roofing. It only covers slanted roof types, with easy to place roofing materials. Flat roof structures made out of concrete are possible, but require more technical expertise to execute properly. They are also more prone to leaking and other problems when not done correctly, and are more difficult to maintain. When constructing concrete roofs, it is mandatory to consult an expert.

5.7.1 Roof structures

We will discuss slanted roof structures made with wooden and metal rafters. Rafters are triangular roof elements made up of a number of straight elements, nailed or bolted together. They can form a simple triangle, or a small triangular truss, depending of the span of the roof. The angle of the roof has to be between 30° and 45°, to ensure a good rainwater runoff.

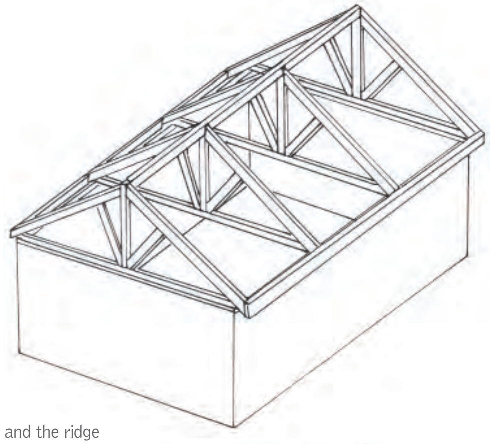


Truss with the names of the various elements

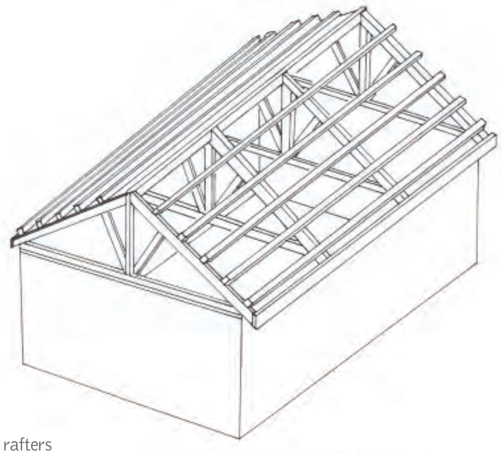
The shape of the structure is the same for metal and wooden structures, but the connections are different. For constructing these types of rafters, it is advisable to hire an experienced carpenter or metal worker.

When the rafters are complete, they are placed on the wall plates. These plates are placed on top of the wall, and distribute the weight of the rafters over the entire length of the wall, avoiding cracking or damaging the part of the wall on which the rafter is placed. Rafter should be placed at least every three meters along the length of the wall, but preferably closer together. The rafters are connected at the ridge of the roof by a beam, the ridge beam. At the eaves, they are also connected by a beam.

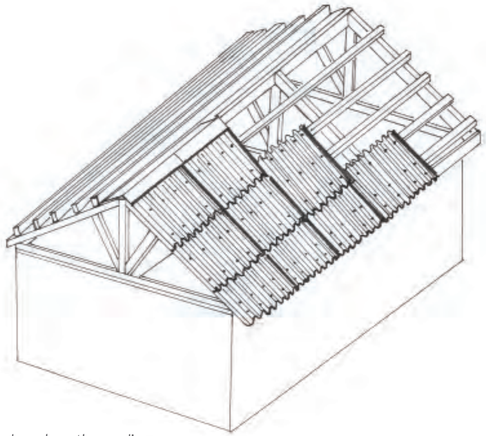
On top of the rafters, horizontal beams are placed, called purlins. The purlins take the load of the roofing, and distribute it over the rafters. The purlins are placed 85 centimeters apart. They are 5 centimeters wide, and 7 centimeters high.



Rafters, connected at the eaves and the ridge

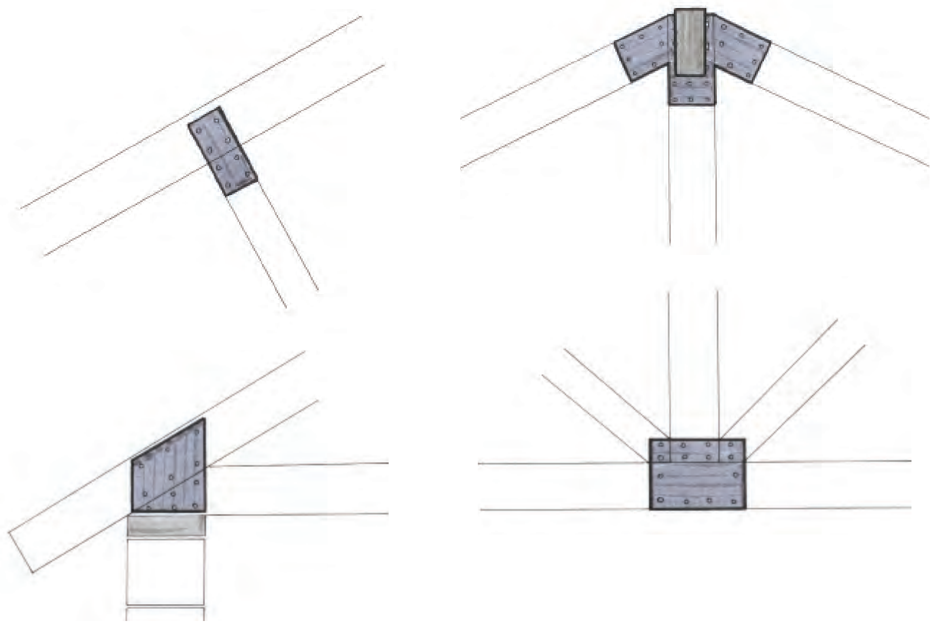


Purlins are placed on top of the rafters



The corrugated metal sheets are placed on the purlins

The connections between the different members of the roof structure can be done in different ways. In the case of a wooden structure, some of the members can just be nailed to each other, such as the purlins and the rafters. For bigger elements, such as the composing elements of the truss, a more solid connection is necessary. For this, we use a metal plate, through which the different members are bolted together. This forms a very rigid connection that can take the loads without deforming.



Connections with metal plates and bolts or screws

In the case of a metal structure, the members can be welded together, but it requires skill and experience to be able to make a strong welded connection. Alternatively, the same type of method as for the wooden members can be used, where a metal plate connects the different elements, and the elements are bolted or screwed to the plate. Again, this requires quite some experience, so it should not be applied unless a skilled craftsman or contractor can be hired.

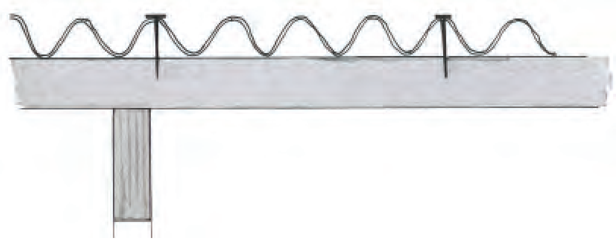
5.7.2 Roofing

For a detailed description of different roofing materials, and their advantages and disadvantages, we refer to chapter 4.6: Roofing materials. In this section, we will focus on the connections between the roofing material and the roof structure.

In the case of corrugated metal sheeting, the sheets can be bolted or screwed to the wooden or metal roof structure. Care needs to be taken that the bolts are always placed in the upper bend of the

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

corrugation, to prevent rainwater from entering the hole while running off the roof.



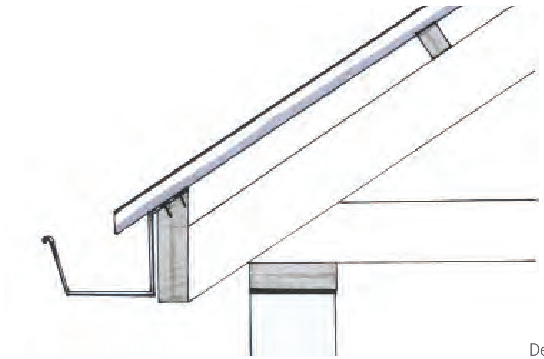
Nail or bolt connections of the corrugated sheets with the underlying tructure

The sheets need to be nailed to at least 3 purlins per sheet. They are placed beginning at the eaves and working upwards to the ridge. They have to be overlapping at least a few corrugations in the lateral direction. In the vertical direction they are placed overlapping at least 15 centimeters, the higher ones overlapping over the lower. This makes sure rainwater will run off without entering the building.
At the ridge, folded metallic sheets are placed overlapping with the upper layer of corrugated sheets on both sides of the slanted roof. This is to make the roof waterproof at the top.

5.7.3 Gutters

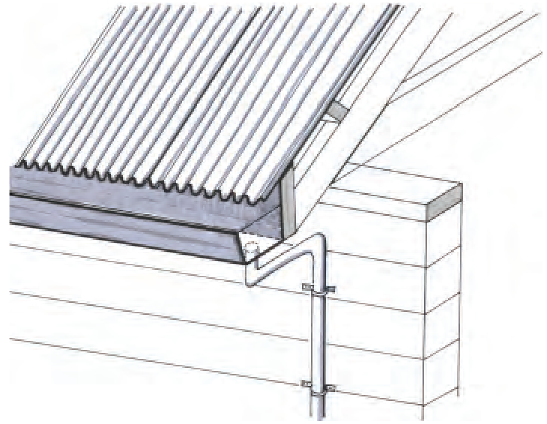
To prevent the surroundings of the building being flooded or muddy during heavy rains, the rainwater of the roof needs to be captured by a gutter, and transported through rainwater pipes. Eventually, the rainwater pipes can lead to an underground cistern or a plastic barrel, to be able to use the water afterwards for cleaning purposes, or to treat it further to use it as drinking water.

The gutters are usually made from zinc (metal), or aluminum. Increasingly, PVC gutters are also used. They are fastened to the roof structure by screwing or bolting them to the beam at the eaves. They need to be angled slightly over their length, towards the end where they are connected with the rainwater pipes, to ensure a good runoff. Care needs to be taken that the outer edge of the corrugated sheets coincides with the gutter, so all of the water is caught. The gutters need to be cleaned regularly, so that they don't become obstructed with leaves and dirt.



Detail of gutter connection

1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex

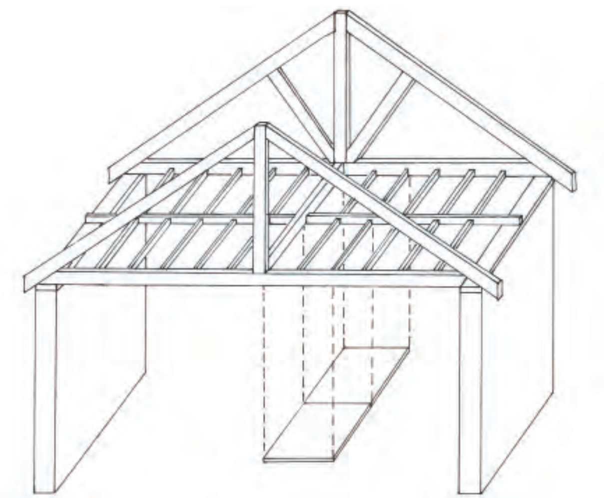


Connection of gutter and waterpipe to the facade

The rainwater pipes are usually made of the same material as the gutter, being metal or PVC. The pipe is connected to the gutter through a hole at the end of the gutter. The pipe itself is attached to the façade of the building with metal clams that are screwed into the façade.

5.7.4 Ceilings

For medical applications, it is important to provide a clean ceiling surface. This will contribute to the hygiene in the building, and will help isolate the interior from heat or cold. Especially when the sun is heating up the roof, ventilating the area between the roof and the ceiling will help decrease the temperature significantly. Furthermore, lighting and electric wires can be easily fixed to the ceiling.

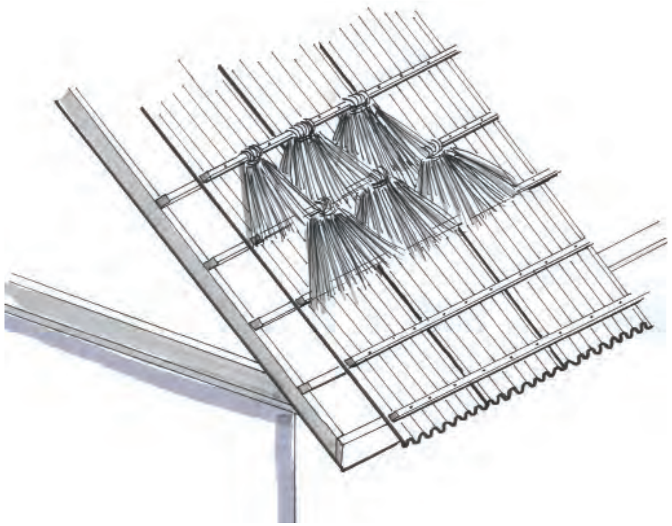


Nailing the plywood to the supporting joists

In the case of slanted roofs made up of rafters, there are joists in between the rafters. Onto these joists, plywood, OSB (Oriented Strand Board) or MDF (Medium Density Fiberboard) panels can be nailed or screwed. This is a quick and cheap solution for a horizontal ceiling surface. Afterwards, light fixtures can be easily screwed into the panels.

When using corrugated metal sheets as a roofing material, extra insulation against heat or cold is necessary. It is possible to use natural local materials such as dry leaves or grasses, which are placed on the top of the roof itself. This prevents the sun from heating up the roof, and eventually the entire

building. They are tied to a series of wooden supports, which are nailed through the metal to the roof structure underneath. The advantage of these is that they are environmentally friendly and often locally available. The disadvantage is that they degrade over time, and have to be replaced regularly. They can also house insects and small animals, which is a concern for the hygiene.



Insulation fastening on top of the corrugated metal sheeting

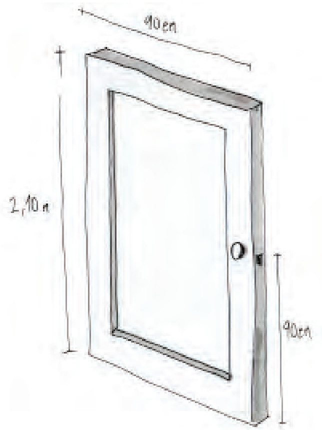
5.8 Doors and windows

When constructing a new building one should take care of the location of the doors and windows. Their location should help and improve the ventilation of the building and its natural lighting. For this it is extremely important to be aware of their best orientation, regarding sunlight and predominant winds.

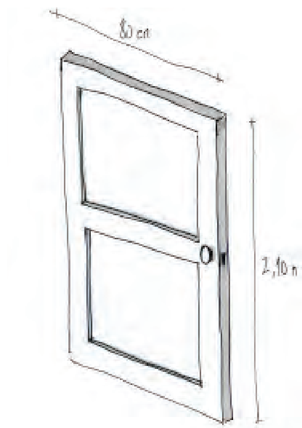
There are several types of doors and windows, and also several types of material out of which they can be made. In this manual you will find the general description of these, going through an explanation of the materials, the types of doors and windows, and their general process of construction.

Doors and windows are composed by a frame, with inside of it a panel. The frame is the part connecting the door to the building.

Usually exterior doors are a little wider than interior doors.



Exterior door dimensions



Interior door dimensions

Wood has the advantage that it is widely available and easy to adjust or repair with simple carpentry tools. Wooden doors and windows provide good thermal insulation for cold climates (when placed properly). Disadvantages are that wood contracts and expands with varying moisture content, which means doors and windows may be difficult to open or shut when expanded, and creaks occur when contracted. Also, it needs to be maintained regularly by painting or treating the wood to prevent degradation.

Wooden doors are normally based on a core of wooden planks, called the frame, lined on both sides with plywood, which can be 3 or 6 mm. This type is mainly used as interior doors.
It is also possible to have doors made of solid timber, or even of several wooden poles placed together. These type of doors are more durable, and are mainly used as exterior doors.

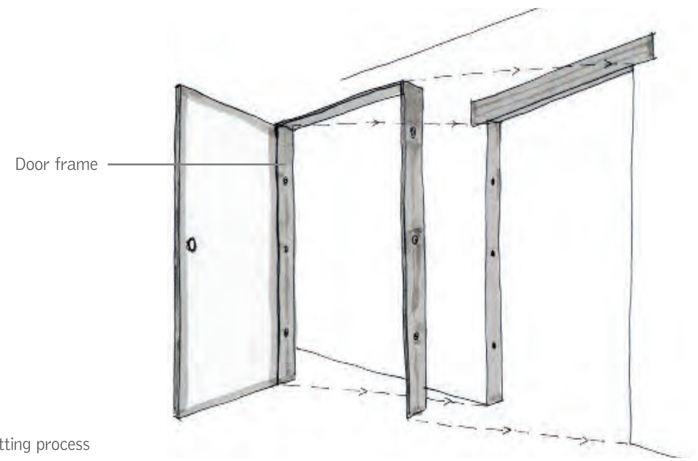
Iron and steel doors have the advantage that they are durable and solid. They offer a higher level of protection from natural elements, and more security. The disadvantage is that they may be harder to obtain in remote areas, and are more difficult to adjust or repair with simple tools. Also, they don't provide any thermal insulation, unless using specially designed profiles. Treatment against corrosion, such as painting, is also necessary.

Aluminium can also be used, although it is more expensive and less strong than steel. This can be alleviated if a reinforcement is applied. The main advantage of aluminium is its lightness and low maintenance requirements.

When choosing a type of door or window one should be aware of the climate and orientation, in order to decide the best type and material to use.

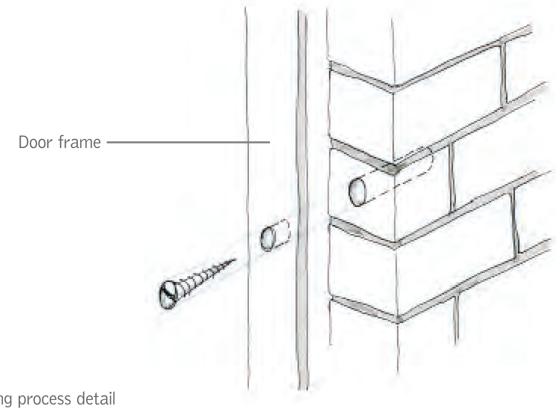
Before buying or producing the doors and windows, it is necessary to carefully verify the span of the masonry where the frame will fit. Both dimensions should be equal, to assure a good fit without too many gaps. Gaps would make wind and rain enter, and deteriorate the thermal insulation.

The setting of a door in a building wall starts with drilling holes within the masonry frame. These holes (usually three) have to be at the same height as the ones in the door frame.



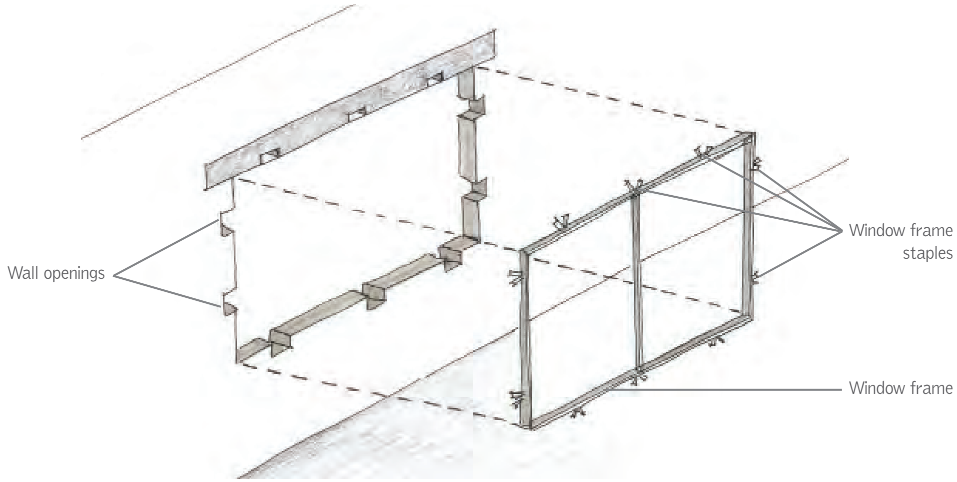
Door setting process

After this is done, place the door frame within the masonry and screw them together. This will fit the door frame to the wall. Is then possible to place the door panel inside the door frame. They are connected at one side with metal hinges, which allow for the movement of the door. At the other side, the connection is made with the door handle and locking mechanism. This finalizes the door setting process.



Door setting process detail

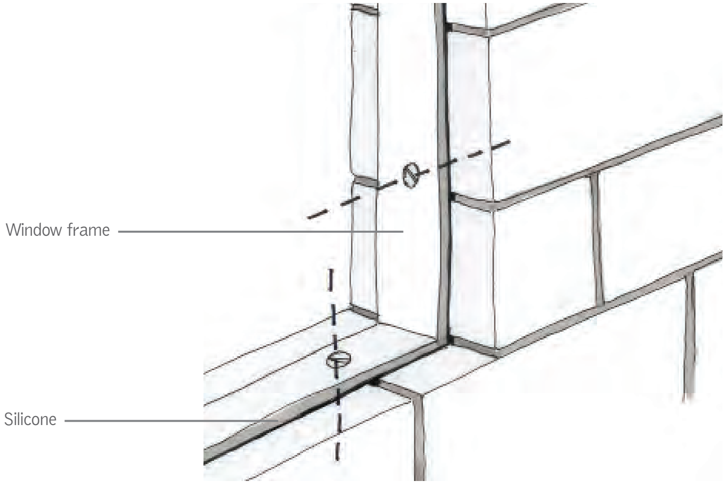
The process of setting a window to the wall is very similar to the one for the doors. Openings are made in the masonry to fit the window frame. The window frame is then placed within the masonry, fitting it with staples into the openings previously made.



Window setting process with staples

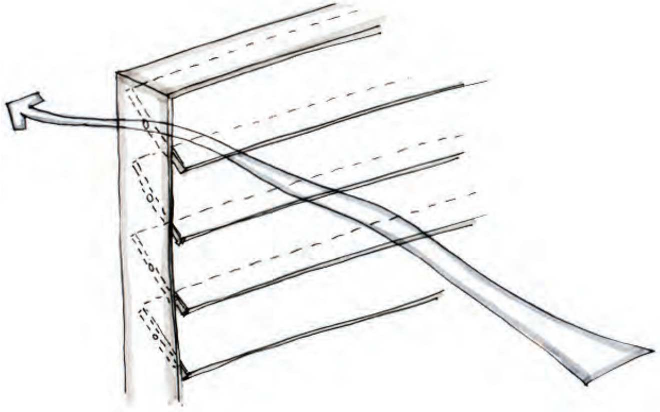
These staples are opened, attaching the window frame to the wall. In the end cement mortar is poured over the staples to seal the connections.

Another possibility for setting a window to the wall, is to use a combined method with screws, and silicone.



Window setting process with screws

In both cases, it is advisable to cover the gap between the window frame and the wall with a seal material, such as silicone. This will prevent wind, dust, moisture and other elements from coming in . In the end, the window panels are placed into the window frame. These can be attached with hinges, so the windows can be opened, or with solid connections for fixed windows.



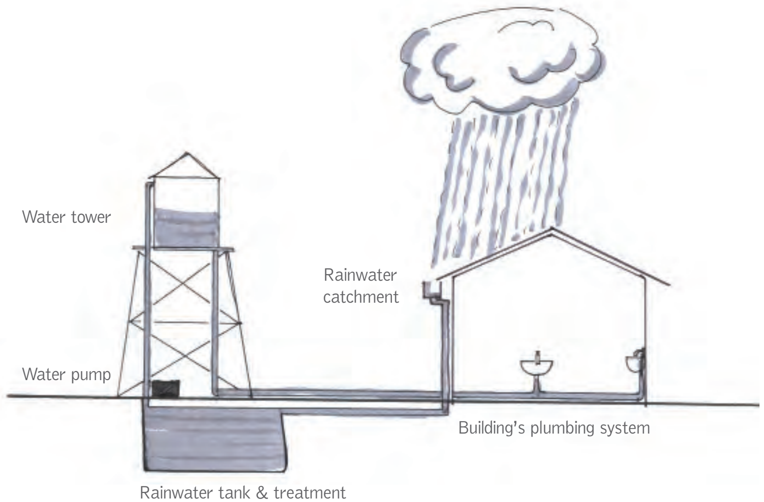
Window louvres

The same type of window frame can be used to create ventilation openings with movable louvres. In this case, the louvres are fixed to the frame with an axis that allows them to turn. This way, they can be opened and closed, depending on the need for ventilation. Mosquito nets should be placed in this case where necessary.

5.9 Installations

5.9.1 Water supply

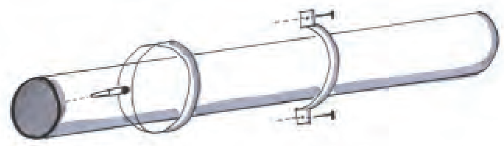
The water supply of the building will usually come from locally obtained water, rainwater or from a well, which is pumped to the water tower on the site. Due to the gravity, the water from the water tower has sufficient pressure on it to make it flow through the pipes and into the taps.



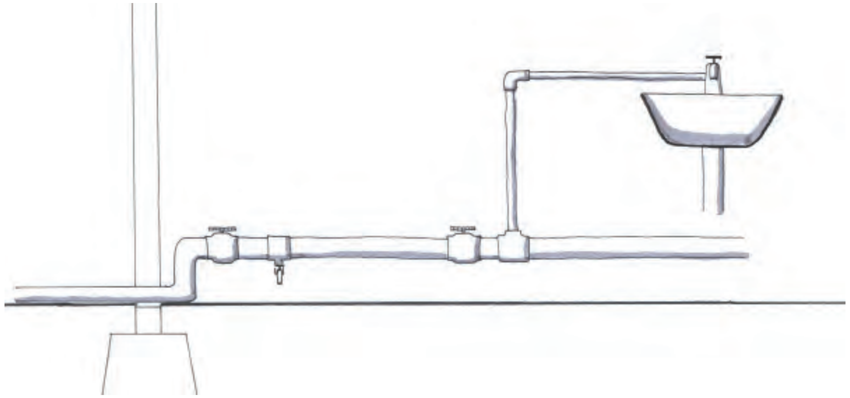
From the water tower to the taps, the water is transported through water pipes. Formerly, leaden pipes were used, but this is not recommended anymore because the lead dissolves in the water, and can cause lead poisoning when drinking the water. Nowadays, copper, galvanized steel, Polyethylene (PE) or PVC pipes are used. The pipes feeding the taps have a diameter of about 13 mm. The central pipe from the tower to the building will be larger. It is important to use the same type of metal throughout the whole installation, including connections, valves and taps. Otherwise, the two metals in combination with the water will start to corrode very fast due to an electrochemical reaction.

Usually, there are valves to close off the pipe at the beginnings and the endings, and a small tap to deplete the pipe. This is useful to be able to replace defective parts.

In regard to repairs, it is advisable to place the pipes visible on the surface of the walls, and not hide them inside the walls. They are fastened to the walls by metal clams and screws. They do often have to be put through a wall into an adjoining room. To do this, a small hole is cut into the wall, the pipe is put through it, and the edges of the hole are sealed again with cement or mortar.



Types of pipe fastening clams



Water piping system with valves and taps

5.9.2 Drainage & Sewage

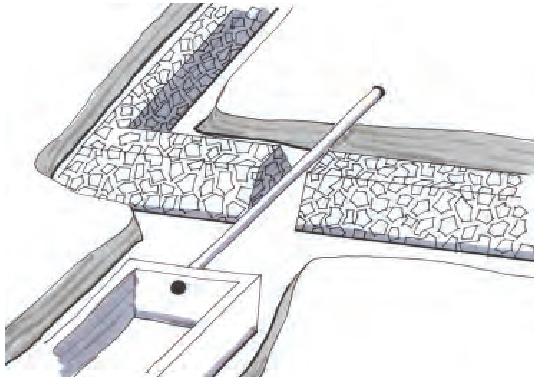
The drainage system for a building with all kinds of equipment such as can be found in a kitchen and a bathroom can become quite complex. All the piping has to be connected to each other in a tree-like structure, and in the end be collected. It is important to ALWAYS keep wastewater from household activities, called greywater, and sewage from toilets, called blackwater, separated.

The greywater will have to pass through a grease trap before infiltration. For the construction of a grease trap, we refer to chapter T.B. 4.0.4 in the 'Public Health Engineering in Precarious Situations' manual on the DVD-LOG/13 WHS LOG/Ebooks. After having passed through the grease trap, the water can be infiltrated into the soil through a soak-away pit or infiltration trench. For their construction, we refer to chapters T.B. 4.0.6 & T.B. 4.0.7 of the same manual.

The blackwater will be led to a septic tank. For the construction of a septic tank, we refer to chapter T.B. 3.11 in the manual 'Public Health Engineering in Precarious Situations'.

In the 'Public Health Engineering in Precarious Situations' manual the construction of various stand alone facilities such as latrines and washing areas are described. In this manual, we will focus on the drainage installations inside of a permanent building. It is recommended when possible to consult a plumber or a specialized contractor, as the construction of a drainage system can be quite tricky.

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

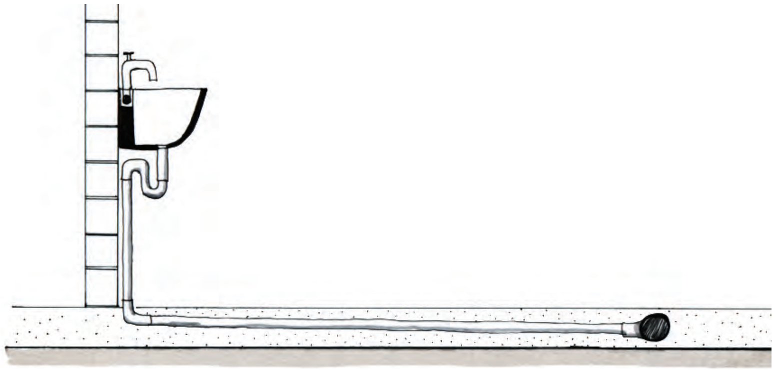


Construction of grease trap and central collector pipe during foundation contruction

During the construction of the foundations, it is important to determine the space where the grease trap will be built. It is a good idea to build the grease trap on the plot, close to the building, and close to the infiltration area, but outside of the building's interior space.

The central collector pipe should be provided before constructing the foundations. When constructing the foundation, the pipe should be integrated into the foundation wall. Take care that the pipe is inclined towards the grease trap, so that the wastewater will run off correctly. The same goes for the blackwater collection pipe that runs of towards the septic tank.

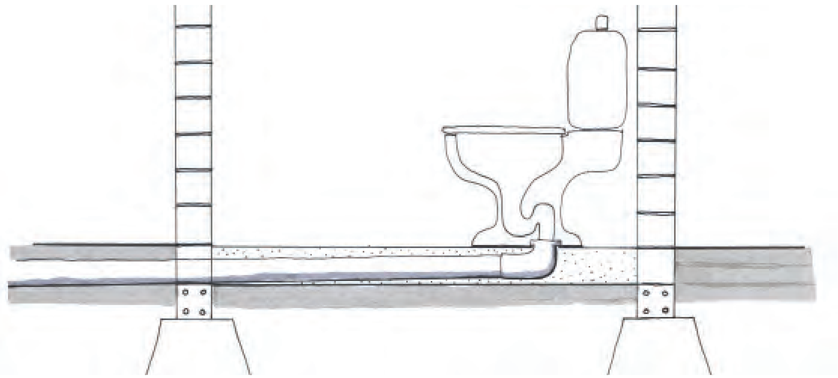
Before constructing the concrete floor slabs, the drainage pipes leading from the installations such as sinks should be put in place, and connected to the main collector pipe. These pipes are usually made from PVC, and are about 40mm diameter. It is important to incline the pipes at least 2 centimeters every meter, towards the main collector pipe, to ensure the wastewater runs off correctly. The pipes



Drainage pipes from sink to central collector pipe should make a 90° turn upwards where they will later be connected to the sink. It is also possible to integrate the pipes into the thickness of the walls, but we will not discuss this, as this is more complex, and is more difficult to fix when a pipe needs to be replaced.

When the shell of the building is complete, the actual installations such as the sinks can be put in place. They are connected to the drainage pipes that were provided when casting the concrete floor slab. The connection has to include a waste water trap. This consists of a U-shaped bend of 180° in the pipe in which some water always remains. This water will prevent odors from the drainage system from entering the building.

The blackwater sewage system for toilets consists of PVC or concrete pipes of 100mm diameter, so considerably thicker than the greywater pipes. They make a 90° bend at the connection with the toilet, and just as with the greywater pipes, they need to be inclined towards the septic tank. The toilet includes a U-bend before the connection with the pipes. In this U-shaped water trap, some water always remains to prevent odors from the sewage system from entering the building.



Blackwater drainage pipes towards the septic tank

5.9.3 Electricity

It is important to hire an expert such as an electrician when implementing an electrical system, because it can be dangerous when you don't know what you are doing. For an extensive explanation of the entire electrical installation, we refer to the 'MSF Electrical Safety Guidelines'. (5) However, we will provide some basic knowledge in this chapter to allow for a basic understanding of all the different electrical components. This will allow the logistician to keep an eye on the correct execution of the electrical installations. We will focus on the parts that have to be installed during the building construction.

The electricity supply used for the building can come from the distribution net of an electricity company, or can be locally supplied by a generator in the absence of such a distribution net. In both cases, the interior installations of the building are practically the same.

The electricity comes into the building, and is first led through the distribution board. This distribution board distributes the power over different circuits throughout the building, and houses all of the protective devices for the circuits. It should be installed in a dry place, out of the reach of children, but accessible when needed. It should not be more than 3 meters from the grounding peg, which is discussed later on. The distribution board also includes a 'main switch' to switch the main power of the building on and off.

The distribution board contains a protective fuse or Miniature Circuit Breaker (MCB) for each circuit. These will cut the power when too much current flows through the circuit. This happens when there is a short circuit, when the circuit is overloaded, or when a device malfunctions. By cutting the power, the fuse prevents the temperature in the circuit's wires to become too high, which could lead to fires. A fuse simply consists of a wire that melts when the current is too high, thus cutting the power, and has to be replaced afterwards. MCB's operate with a switch that automatically switches off, and can be switched on again after removing the cause of the problem. According to MSF guidelines, MCB's are preferred because they are safer. They come in different sensitivities, which cut the power at different levels of current, corresponding with the allowed current through the circuit (10 Ampères (A) for lighting circuits, 16 A for outlet circuits).

The distribution board in a building is also connected to a so-called grounding connection, which is an essential prevention mechanism to electrocution. According with the electrical safety guidelines of MSF, a copper peg of 2 meters long is used, which is buried into the ground. The grounding device is eventually connected to the electric circuits and all exposed metallic surfaces in the building (called 'ground for masses'). It must be at least 20 meters removed from the ground of the generator or transformer of the power supplier (called 'ground for neutral'). For the correct installation of a grounding kit, we refer to the 'Electrical safety' guidelines. (5)

The grounding provides a low impedance path to the earth, to prevent hazardous voltages from appearing on appliances. For example, an electrical appliance could malfunction, and a dangerous electrical current could appear on its metal casing. If the appliance is connected to the ground wire through the electrical circuit, the dangerous current will go through the ground wire into the earth, instead of through the body of a person touching the appliance, thus preventing electrocution. Of course, both the power outlet and the plug have to have a grounding connection.

A distribution board also needs to contain a Residual Current Device (RCD) for every circuit, an additional protection from electrocution. This is a device that detects a leakage current, and shuts off the power within a few milliseconds. A leakage current occurs for example when a person accidentally touches an electrical wire which carries a current. The current flows through the body of the person to the earth, thus 'leaking' current to the earth. The device detects this, and shuts of the power almost instantly, thus preventing the person from being electrocuted. The sensitivity needs to be 10 or 30 mA (milliAmperes) for normal circuits, and there is a main RCD for the entire installation of 300 mA. RCD's have a button to test their correct functioning, which should be done once a month.

5. Electrical Safety Guidelines. Medicos Sin Fronteras, 2010

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex
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1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

The diameters of the electrical wires depend on the amount of power to transport, and of the distance to transport it. The more lights, outlets or appliances are connected to the circuit, the larger the power, and the larger the diameter of the wire must be. For the correct diameters in each case, we refer to the 'MSF Electrical Safety guidelines'. The insulated wires consist of a conducting copper core, with an insulating cover around it. A cable consists of multiple insulated wires together in a secondary protecting insulating layer. ([5])

For wires of circuits feeding only lighting (10 A), the minimum diameter is 1,5 mm^2, with a maximum of 8 lighting points. For wires of circuits which feed electrical sockets as well (16 A), the minimum diameter is 2,5 mm^2. The maximum number of outlets for each circuit is 8. For circuits powering appliances such as stoves, ovens and washing machines, the minimum diameter of the wires is 4 mm^2 (20 A) or 6mm^2 (32 A). When using thinner cables, there is a danger of overheating, thus creating a fire hazard. If additional sockets are needed, an additional circuit needs to be made. ([5])

When using insulated wires, they have to be installed onto the walls inside conduits for extra protection. These are plastic tubes that protect the wires from water, mechanical rupture, and do not propagate fire. Cables can be placed onto the walls without conduits. They can be hidden inside the walls, floors and ceilings of the building, but this complicates things when adjustments or repairs need to be made. Therefore, the conduits need to be placed onto the walls with plastic or metal clams.

5. Electrical Safety Guidelines. Medicos Sin Fronteras, 2010

5.10 Finishing's

In this chapter you will find the explanation for the wall and floor finishings that are advisable to use on MSF buildings.

5.10.1 Walls finishing

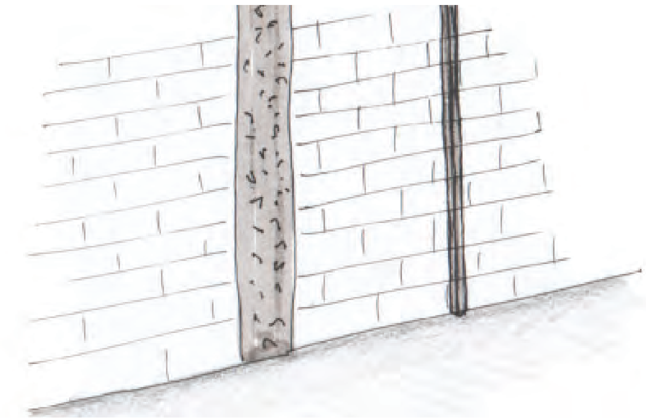
In this section you will find an explanation of the plastering of the walls, both for interior walls and the exterior façades. This is always advisable for the purpose of MSF buildings, because it avoids problems regarding hygiene, prevents the gathering of dust and also prevents gaps and holes for insects to breed as in an unfinished brick wall. A finished plastered wall also provides an extra layer of insulation and protection from the elements.

Although the method of plastering the walls is the same for the interior and exterior, the plaster mixture to use in each case is different. The plaster mixture used on the interior walls makes a smoother and cleaner surface, while the exterior mixture is more water resistant. For the mixtures, please consult chapter 4.2: Mortar.

Some tools are necessary to apply the plaster, such as a metal rectangular finishing trowel, a 'hawk', which is a board with a handle used to hold the plaster before applying it, a plumb line to verify the level of the wall, and a wood or metal board to smooth out its surface.

When applying the plaster, it is important to get a smooth surface in order to avoid unnecessary spending of paint when painting the wall.

To ensure that the plaster surface will be smooth and straight, it is advisable to first create and place wooden guides. These are small wooden rulers, placed no more than 1,5 meters apart, and which have the same height as the necessary thickness of the plaster. The plaster layer should be no more than 1 to



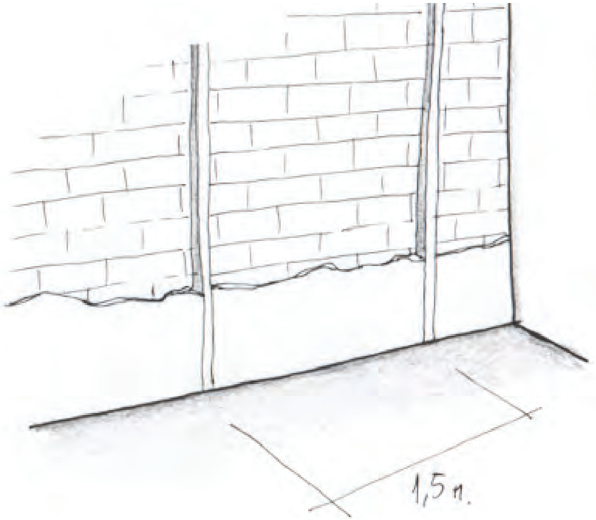
Placement of wooden rullers

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

1,5 centimeters thick, because it will start to peel. Don't try to even out an uneven wall with too thick a layer of plaster.

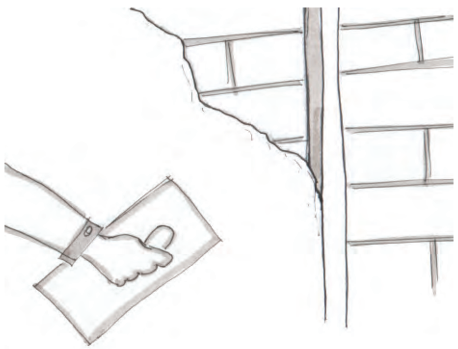
The rulers will afterwards act as a support for the wooden board when using it to smoothen and straighten the surface, and provide the plaster with the correct thickness.

The paste is then placed onto the wall from bottom up, using the hawk to hold the plaster in the one hand and applying it with the finishing trowel with the other hand. It is extremely important to be fast and accurate when applying it, because the plaster tends to harden fast.



Applying the plaster from bottom up

The surface is then smoothed out with a wooden or metal board, using a finishing trowel when necessary for the small details.



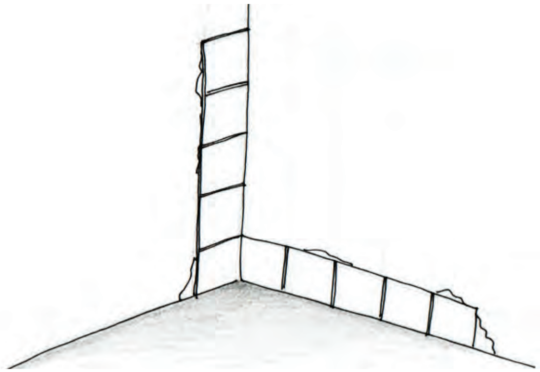
Applying the plaster with the finishing trowel

Use the same method to apply the exterior plaster. The mixture used for this differs from the one used for the inside walls. This plaster will be exposed to the natural elements, and will work as the first protection layer for the building.

It is necessary to wet the walls before applying the mixture, to prevent them from soaking up all the plaster's moisture. Any concrete surface, such as the columns and beams, needs to be made rough and irregular with a hammer and chisel, to ensure a good connection between the concrete and the plaster. After the plaster is dry, it is necessary to cure it with water avoiding any possible cracks.

When painting the plastered walls, it is necessary to make sure that the plaster mixture is already dry. It is advisable to use water based paints instead of oil based paints. This allows the walls to 'breathe' which means that it allows humidity to pass through, preventing the accumulation of humidity and fungus within the building. Acrylic based paints are advisable when the walls need to be washable.

Ceramic tiles are also a possibility for the wall's finishings. It is preferable to used glazed tiles, because their surface is easier to clean. This solution enables to have a smooth and easier to clean surface, especially if one is building a room wiht special need regarding hygiene. The method of placing the tiles follows the same procedure as the placement of tiles for floors., which is explained in the next section You make the tile mortar, wet the tiles, and start to place them starting from the corners, up until the desired height. With the wall tiles, small plastic spacers need to be placed at the corners, to make the joints all the same width, and ensure straight rows of tiles. When the mortar is dry, the spacers are removed and the joints are filled with white cement and water mixture.



Wall tiles placing

5.10.2 Floor finishing

The most common materials for the floor finishing are cement and tiles.

The cement floor is probably the most advisable to apply on the MSF buildings. It provides a smooth surface, easy to clean, hygienic, and durable. First it is necessary to create the cement mixture.

Before pouring the mixture onto the floor, it is necessary to clean it and wet it slightly, in order to improve the binding.
The process to apply this floor follows the same principles as plastering the walls. Place small wooden rulers with the desired layer height, that will work as guides, according to the necessary height. The mixture is then poured and smoothed with a wooden or metal board.

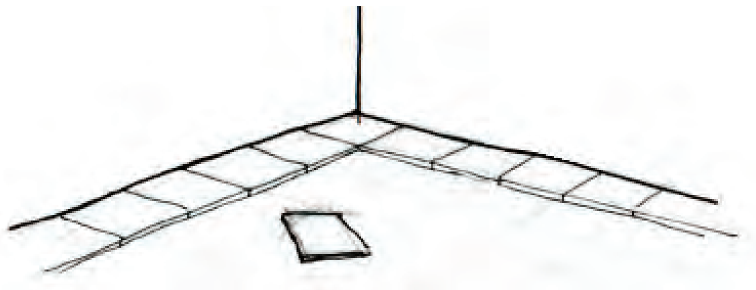
When the surface is almost dry, it needs to be washed with a brush and water, which removes the biggest grains from the surface. This will create a very smooth final surface, which is easy to clean and maintain.

Ceramic tiles can be used for the floor finishing's. It is preferable to used glazed tiles, because their surface is easier to clean. This is also quite a durable solution, although their placing needs to be done properly and carefully to achieve a smooth surface. The mortar joints between the tiles need to be as narrow as possible, because these gather dirt more easily than the tile surfaces. It is advisable to use specialized labor for placing the tiles.

Before placing the floor tiles it is necessary to create the mortar binder. You can use the mixture for indoor plastering, but there are also specialized binder mixtures available on the market. Before placing the tiles, it is necessary to wet them, improving the binding.

Wet the tiles before placing them

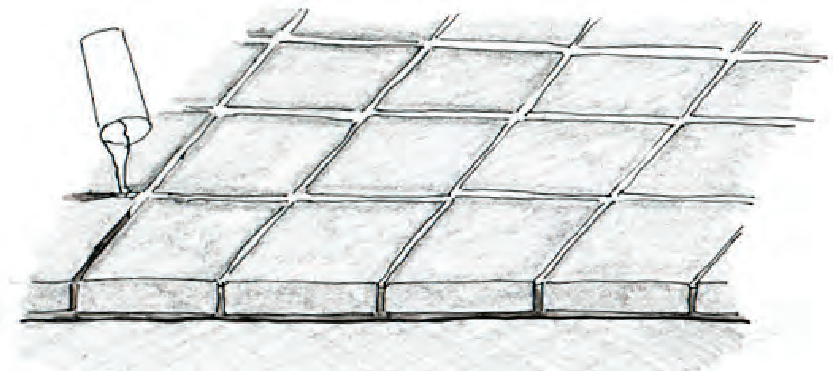
The mortar is placed and spread out with a trowel on the surface that will be covered with the tile. The tile is carefully placed onto the surface, and put perfectly horizontal using a bubble level and tapping it with a rubber hammer or the back of the trowel.



Tiles placing - starting from the corners

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

When all the tiles are placed, it is necessary to fill the small joints between them, in order to get a smooth and uniform surface. For this, use a mixture of white cement and water that is poured into the joints. Before the joints' cement is completely dry, is necessary to clean the tiles with a humid rag, to avoid any white cement stain on the tiles.



Filling the small joints

1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex

6. EXTENSIONS TO EXISTING BUILDINGS

This chapter covers the issues related with possible extensions to existing buildings. When doing an extension, it is necessary to perform a study of the building's existing construction techniques and structure. This is done to prevent future complications when dealing with structural building connections, and also regarding installations such as water, electricity and sewage. Although the construction techniques to use on the new building will not necessary match the ones applied on the existing one, it is mandatory to perform this study, so that it is possible to know and evaluate the existing situation. After the study is done, the extension can be done with more certainty. In this chapter there is an explanation of the process of extensions regarding the various building components. Reference is only made to specific issues that influence the extension's construction. When the process does not differ, we will refer to the previous chapter.

6.1 Foundations

Just as for the new building construction, when building a foundation for an extension, one has to study the type of soil present on the plot, as explained in section 5.4. It is most likely to be the same type of soil as found when constructing the original building, but it is important to verify this.

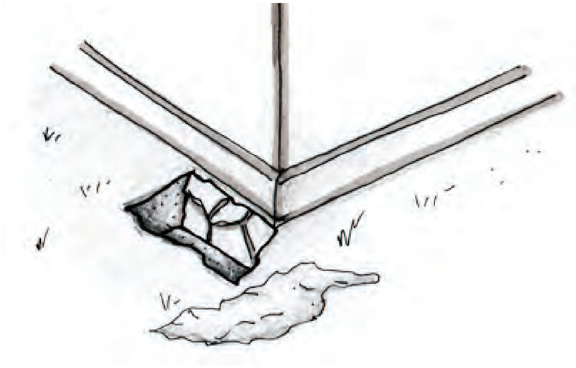
When doing an extension one should be aware of the issues regarding the foundations. If the extension is located right next to an existing building, the type of foundation to use should be the concrete L-shape model, regardless of the soil. Please consult chapter 5.4, for more details about it.

The foundation of the extension should be independent from the one of the existing building. The same foundation technique could be applied, but this decision should be made regardless of the existing building, to avoid repeating past mistakes. An analysis of the existing foundations, and their behavior over time, give us indications on the correct use of the foundation technique. If the existing building had foundations problems, like settling that might create cracks, a different foundation technique should be considered.

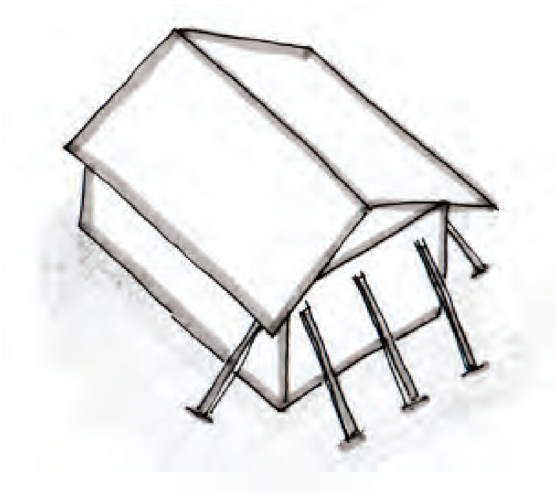
When building the foundation for the extension, one should be aware of the necessity to stabilize the existing building and its foundation. To investigate the type of existing foundation used on the old building, one should use extreme caution. Dig a hole to investigate the existing foundation. The hole should be made as small as possible, in order to not disturb the soil around the existing foundation. The objective of this investigation is to find out the type of existing foundations, and their depth.

Before initiating the works for the foundation of the extension building, is necessary to secure the existing building's façade. This is done by placing wooden poles from the top of the façade into the ground around the building. The poles are secured in holes created in the façade.

It is extremely important to avoid any kind of disturbance to the existing foundation and to the soil under and around it. This avoids new problems regarding possible sudden settling of the existing building.



Digging the existing foundation

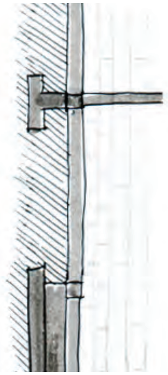


Securing the existing building façade

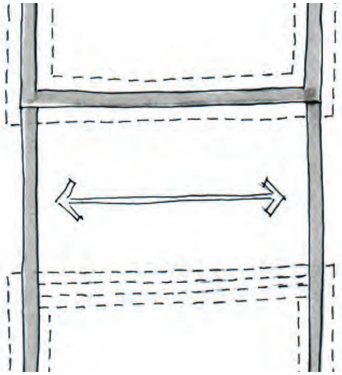
The extensions' foundations have to be placed with their bottom level situated above the existing foundation wall. This prevents digging and disturbing the soil next to and underneath the existing foundation. This is done regardless of whether the existing foundation is made of stone wall or concrete. At a safe distance from the old building, around 1,5 to 2 meters, normal foundations can be placed again at the original foundation's depth.

To bridge the gap between the existing buildings perimeter and the safe zone for normal new foundations, a foundation slab is constructed. This slab takes the weight of the new walls directly attached to the

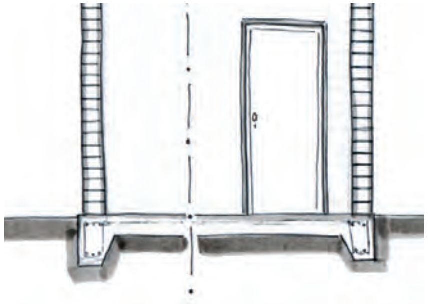
1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex



Extension slab section

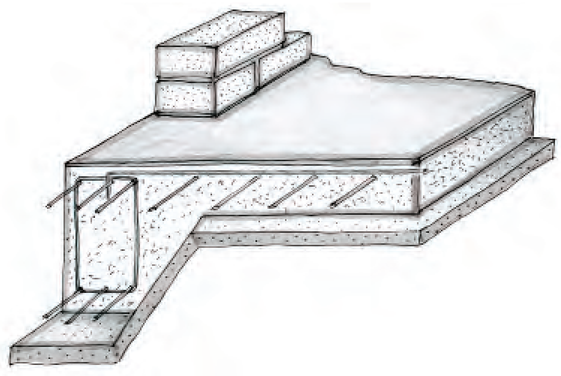


Extension slab plan



Extension slab and extension walls section

existing building, and divides this weight over the entire floor surface area, instead of over a narrow foundation slab. This way, the foundation does not need to be so deep, avoiding disturbance of the existing foundation. The slab is placed over the compacted soil, at a higher level than the existing building foundation. Its reinforcements allow the distibution of the weight of the wall over the entire slab, and over the soil. For the foundation building procedure please consult the chapter 5 "new building, 5.4 foundations".

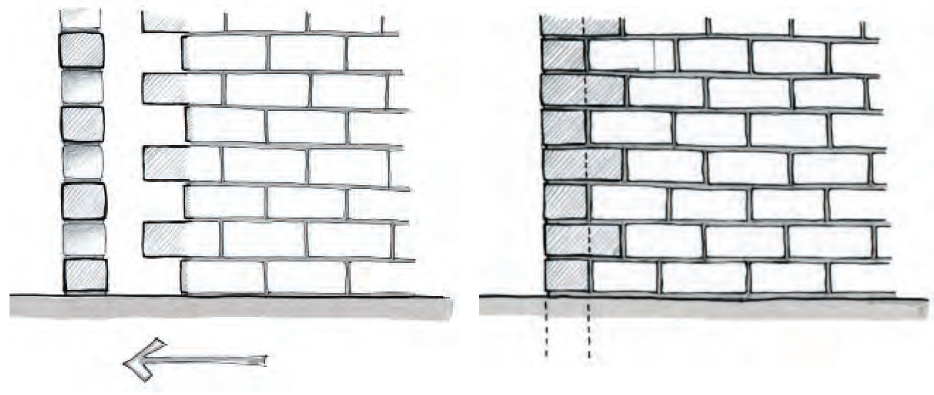


Slab extension reinforcment detail

When in the presence of earthquake risk, is advisable to set the two buildings completely apart. This allows the two buildings to move independently when an earthquake happens.

6.2 Walls

The connection of walls between the extension and the existing building should be done according to the structural elements. If the structural system uses reinforced concrete, the extension wall should end on a column right next to the existing wall. If the wall is made of structural masonry, it should end next to the existing wall, weaving the existing and the new brick wall together as shown below.



Wall extension connection

Once again, when there is an earthquake risk, is advisable to set the two buildings a considerable distance apart. This allows the two buildings to move independently when an earthquake happens.

6.3 Floors

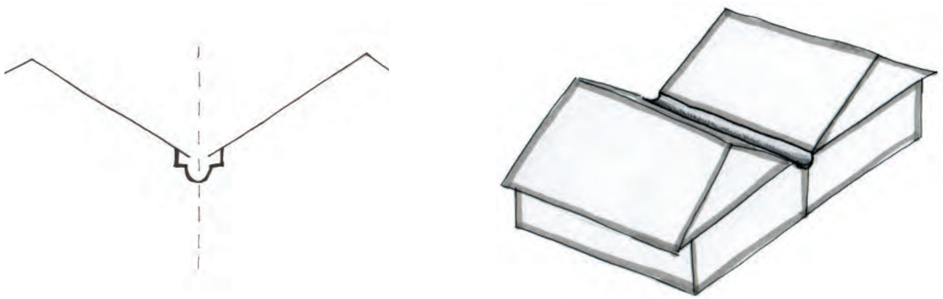
The floors of the existing building and the extension are completely independent, because the floor slabs are cast independently from each other.

If a door opening between the two buildings is necessary, the concrete slab within that door opening will be the only floor element connecting the two areas. For the finishing of this, a variety of materials can be used. It is important to ensure that the floor level between the two buildings is equal. So before pouring the concrete slab, you have to be aware of the thickness of the floor finishing as well. If tiles will be used, one has to make sure that the thickness of the floor slab + mortar + tiles will reach the same level as the existing floor level. If this is impossible, the door opening can be equipped with a step made out of concrete, tiles, or natural stone. Be aware however, that it will make the building less accessible, especially for medical purposes.

6.4 Roofs

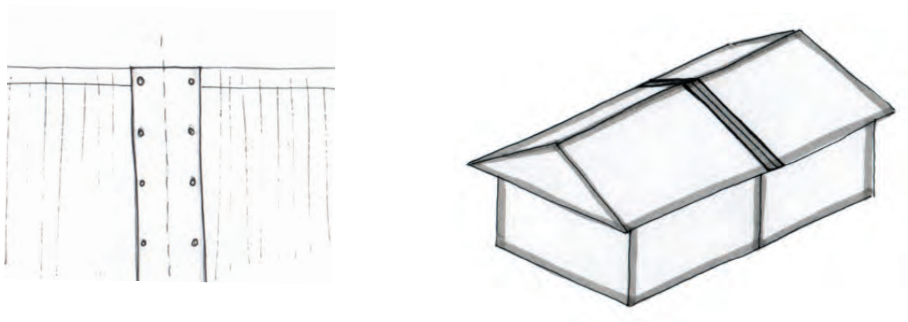
Roofs are one of the most sensitive elements when doing an extension. One should pay special attention when building the roofs of the extension building. The connection between the two roofs has to be done properly, and this is one of the most important issues to address when doing an extension.

When the slopes of the roofs run towards each other, a gutter needs to be provided as the connecting element. This way drainage is assured for the two roofs, preventing water infiltration on the buildings. Special care should be taken with this gutter, and when possible, this type of connection should be avoided, because it is likely to cause leakage problems during heavy rains. Preferably, the new roof's slope is directed away from the existing building.



Extension roof - gutter connection

When the ridge and the eaves of the roofs connect to each other, it is advisable to use the same type of roofing as on the existing building, and provide metal sheets at the intersection, to ensure good rainwater runoff, and prevent infiltration. When possible, this type of connection is preferable over the previous one, because it is easier to do, and less prone to mistakes.



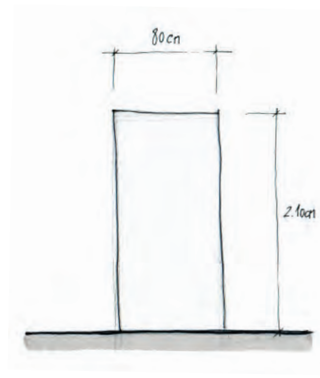
Extension roof - metal sheets connection

Be aware of dangerous materials when making roof extensions, such as asbestos, or others that might contain harmful chemicals. Materials that are harmful to the users' or workers' health should not be used.

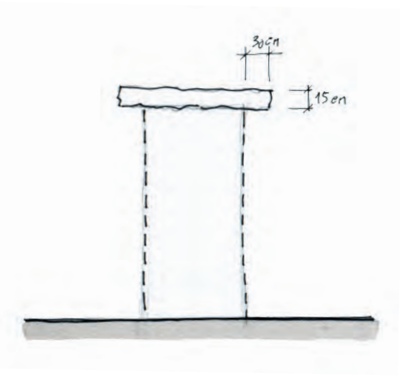
6.5 Doors and windows

If necessary, a door opening should be made in the existing building, providing a connection between the extension and the existing building.

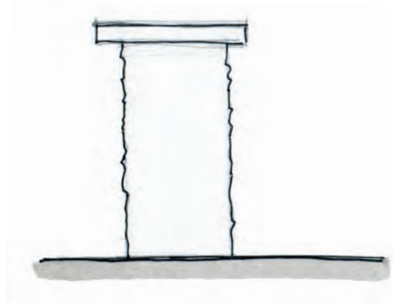
Special care is necessary when doing this, and the process follows the following steps:



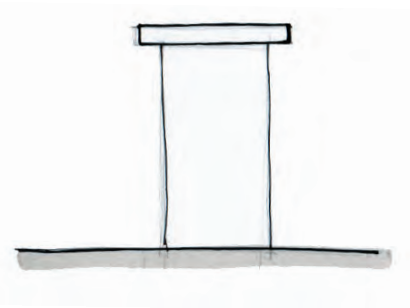
Trace the outline of the door on the wall



Brake a slot in the top of the door outline
Place a stone, or a wooden beam with the same dimensions



Brake the outline of the door



Define the outline of the door using mortar to fill the bigger holes, and then plaster.

7. REHABILITATION OF DAMAGED BUILDINGS

Special care needs to be taken when doing a building rehabilitation. It is necessary to perform a detailed assessment of the building, in order to identify and analyze its pathologies, and its current state of conservation. This procedure allows to determine the course of action to take.

If the building suffers from a high level of degradation, demolition could be the only option, due to the impossibility of rehabilitating it, or due to the cost and time involved in rehabilitating it. If it is possible to rehabilitate the building, then it is necessary to proceed with the identification of the techniques to apply. It is EXTREMELY IMPORTANT to always aknowledge the the building's state of conservation. Special attention is necessary regarding the building's structure, to assess if it is structurally sound, or if it needs profound rehabilitation. If profound structural rehabilitation work is necessary, this is usually very expensive, and in many cases demolition will be the best option. Special attention also needs to be paid to the roof (structure and roofing), and to the existing installations. These can be considered as a priority. Though it is also necessary to evaluate the remaining elements, such as doors, windows, and the finishing. If the assessment to be done involves technical skills, for instance in the case of structural problems, this has to be done by qualified staff. These issues have to be reported to the MSF HQ, expressing the concerns and the need for a structural assessment done by a consultant.

When the assessment of the existing building is done, and all of the existing problems and pathologies are clearly identified, the next step is to proceed with the identification of the elements to rehabilitate. The best techniques to use for each building component need to be determined.

In this chapter you will find the identification and explanation of the process to follow in rehabilitation, starting with the building's assessment, identifying the causes of the problems, and going through the possible treatments of each building component. The most commonly reported pathologies on MSF buildings are related to humidity and corrosion, and cracks and structural concerns that originate in building settling.

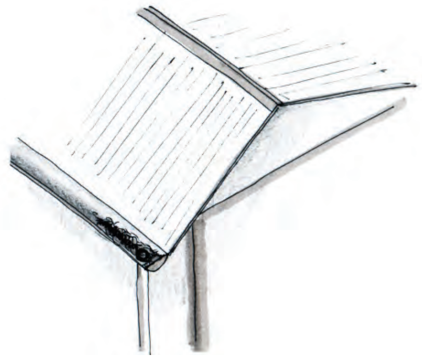
7.1 Roof and roofing material

When there are problems with the roof and the roofing, this usually also creates other problems on other building components. The roof works as the first layer of protection of the building, mainly from rainwater. When this protection becomes compromised and no longer functions properly, this results in water infiltration, which manifests itself as leaking during heavy rains, presence of humidity on the walls and corrosion of the reinforcements. It may also give rise to rotting of the wooden roof structure, due to the presence of water, compromising the roof's structural stability.

To assess and discover the location of the problem, one should perform a test to see if the roof is waterproof. This is done by heavily sprinkling the roof with water for a certain period of time, while observing the top and the bottom of the roof to check for holes or leaks. You should also check if all the rainwater drainage is functioning properly. Doing this, it should be possible to identify any existing defects on the roof and roofing, and to choose the right rehabilitation procedure.

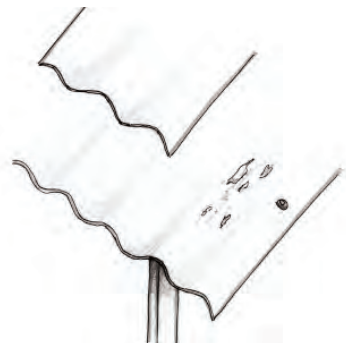
Roof waterproof testing

Sometimes the problem may only be clogged gutters, and then it is simply necessary to remove all the dirt from the gutters and rainwater pipes.



Clogged gutters

If the problem is the roofing material, it is necessary to remove and replace the section that is causing the problem. Alternatively, when there is only a small leak or hole somewhere with the rest of the roofing material intact, it may be cheaper to place a small metal (zinc) plate over the leak to fix it.



Roofing material replacement

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions **7. rehabilitation** 8. bibliography 9. annex

If the problem is the roof drainage system, and it is not due to rubbish accumulation, one should replace the section that is deteriorated.

If during the roof inspection one finds that (part of) the wooden structure is rotten or deteriorated by termites or other problems, one should remove these sections and replace them. If the problem was caused by water infiltration, this should be only done together with fixing the cause of the problem. If the problem was caused by termites, one should consider treating the wood to prevent this in the future.

7.2 Humidity

Humidity can present itself in various forms in the building (walls, floors, roof structure):

- Difference in colour between the dry and wet building part
- Degradation and eventually peeling and falling down of the plastering off the wall
- Stains of all kinds, left behind by the dirt in the water
- Fungi appearing on the parts that are frequently exposed to humidity

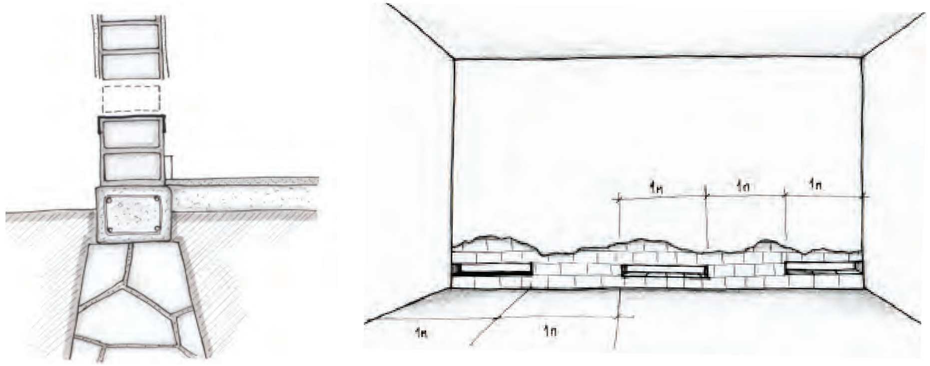
When these kinds of pathologies are observed, one should start by assessing and identifying the origin of the problem:

Problem: When the humidity comes from the ceiling or the top of the walls, it is likely that there is a problem with the roof or the drainage.
Solution: If this is the case, proceed with the process of identifying the existing problems on the roof described above in section 7.1.

Problem: When the humidity comes from the sides of the building, like the middle of the walls, there may be a problem with rain coming in sideways because the eaves are not big enough, in combination with cracks in the walls. Also, there may be openings or cracks in the connections between the doors and windows and the walls, which may cause humidity to enter the building.
Solution: The solution is this case is to increase the overhang of the eaves, so that rain will not touch the façade of the building. The cracks at the connections with doors and windows also have to be filled with mortar. For solving the problem of the cracks in the walls, please consult the next section.

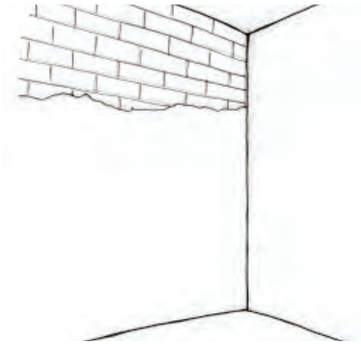
Problem: When the humidity seems to come from the bottom of the building, such as the bottom of the wall, or through the floor, it is possible that there is infiltration from the foundations or from the soil around the walls, or through the floor due to constant water pressure. When the building procedures for impermeabilization of the foundation beam and floor slab have been used, this should not be a problem.
Solution: For the walls, a possible treatment is to open and clear holes within the base of the walls, no less than 1 meter apart. The holes should be no more than 1 meter wide. After the initial holes are created, one should place an asphalt sheet over the bricks. After this, it is possible to close the holes again with brick and mortar masonry. When the initial holes are taken care of, the process should be repeated for the wall sections that were previously left intact.

Impermeabilisation of the floor is also possible, but much more expensive and difficult.



Wall humidity at bottom treatment

After taking away the cause of the humidity problem, it is then possible to perform the rehabilitation and treatment of the building elements that were deteriorated by the moisture.
First begin by peeling all the plaster of the walls using a chisel, until you reach the bricks. You should leave the wall to rest like this for a period of at least 2 weeks. This will allow evaporation of the moisture that is contained within the wall. After the wall is dry, you should plaster it again.



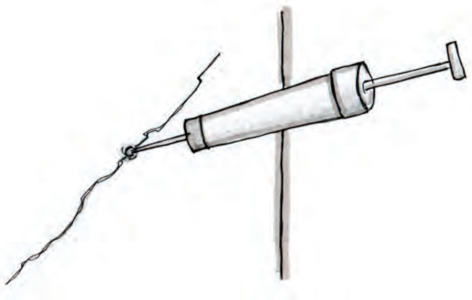
Treatment of humidity at the top of the wall

It is extremely important to do this process in a time of year when it doesn't rain, and when there is a low humidity rate.

7.3 Wall cracks

Problem: Normally when a building is finished, there is the possibility that it will settle within the soil. This is normal behaviour, resulting from the weight of the building which compacts the soil underneath. This settling is not seen as such, but it may result in very small cracks, especially in the plaster, only seen when looking up close. However, this should not happen on a large scale.

Solution: If the cracks are small and relatively harmless to the structural integrity of the building, the procedure to take is the following: Drill a 5 mm – 10 mm diameter hole into the crack every 100 mm, through the whole thickness of the wall. Inject a resin appropriate for these issues, which should be easy to find, until it exudes from the next hole. Alternatively, mortar can be used. This will fill the crack, preventing water infiltration.



Wall cracks filling

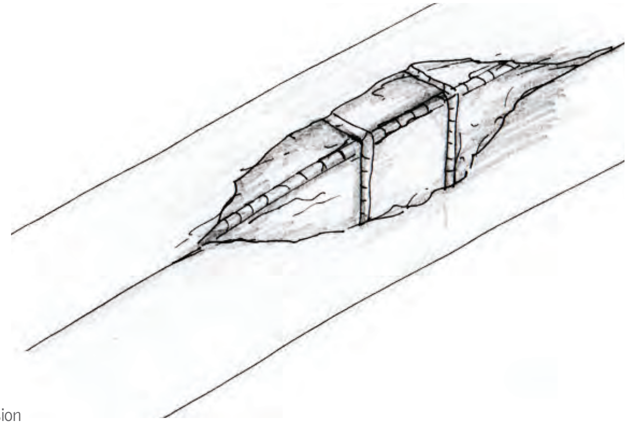
Problem: On the other hand, if the building shows big cracks, this may be the result of severe settling. In this case it is necessary and mandatory to closely monitor the behaviour of these cracks. If the cracks continue to open, this means that the building is still moving, and that profound work is necessary.
Special technical equipment exists to monitor the cracks, but it is expensive and not easy accessible. The best way to monitor the cracks in a practical and easy way is to use a piece of glass. Place a rectangular piece of glass of 20 x 10 x 0,5 cm over the crack. Ask a glazing merchant to drill a hole in each corner. Use plastic plugs or resin and rubber washers to fix the glass across the crack. Take care not to turn the screws too tightly or the glass will break. If the crack opens further after placing it, the glass will break.

Solution: If the cracks continue to open, further investigation of the foundations is needed. One should inspect the foundation, digging along it. This has to be done with extreme caution, always securing the building and its foundation. This procedure can ONLY be done by a specialized technician. In this case please ask for approval and guidance to the national MSF office.

In the case that the cracks resulted from an earthquake, or any other natural disaster, this may indicate that the whole structure has been compromised In this case, a profound evaluation of the structure has to be done by a structural engineer.

7.4 Reinforcements corrosion

Problem: A common problem with reinforced concrete elements is the corrosion of the reinforcement bars over time. This manifests itself through cracking of the concrete, and eventually the full exposure of



Reinforcement corrosion

the reinforcement bars. This happens because the corrosion of the steel makes it expand, which causes the cracks. There are a number of possible causes for the corrosion:

The first reason may be a bad concrete mixture. If the water or the sand made to mix the concrete contained too much salt, or other corrosive elements, this will start corroding the steel immediately after the casting. This will result in a rapid degradation of the concrete.

Another possibility is when the concrete is used in a very aggressive environment (salty and humid for example), and the concrete cover is insufficient to protect the reinforcement bars. In this case, the corrosion happens in two stages. In a first stage, the aggressive elements, such as chloride or carbon dioxide present in the surrounding, penetrate into the concrete. This is the initiation stage. The second stage is propagation, which starts when these aggressive bodies reach the reinforcements in high concentrations. This corresponds to rust growth, which means a volume expansion, and therefore breaks the concrete cover, further aggravating the corrosion.

Solution: If corrosion has been identified in the reinforcements, there is no easy treatment for it. Depending on the spread of it, and on the structural elements where is present, one may demolish that section and rebuild it.
Prevention, by using correct concrete mixtures, reinforcements and concrete cover, is the only real solution to this problem. For more information on good concrete construction, we refer to chapter 4.3.

As conclusion to this chapter, it is extremely important to transmit the idea that the best way to prevent costly and time consuming rehabilitation works on a building is to perform regular maintenance. This prevents the building's degradation, and prolongs its life. Special attention needs to be paid to the roof, and one should clean the gutters every 2 months, especially before the rainy season. When a problem appears, it should be immediately addressed and treated, preventing the problem from deteriorating the building further.

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1. introduction
2. project management
3. preliminary
4. materials
5. new buildings
6. extensions
7. rehabilitation
8. bibliography
9. annex

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9. ANNEX

9.1 Contract (example - guidelines)

Between MSF, of the one part and (designation of the other party)

A. GENERAL

1. Definitions *(Designation and definition of the different parties and components of the contract)*

(a) Owner *(means the owner of the building or the construction work)*

(b) Project Director *(means the Construction Project Director for MSF, and her authorised representatives, referred to as "Project Manager" or "Supervision")*

(c) Contractor *(means the construction enterprise or organisation responsible for the construction work)*

(d) Contract *(is the agreement entered between MSF and the Contractor for the execution of works)*

(f) Works *(comprises all those items that are to be constructed under the terms of the contract and the specifications)*

2. Object of the Contract
(Explanation of the object of the contract – new building construction; rehabilitation; expansion; etc – and the purpose of the construction, explaining in a very brief way its program)

3. Location of Works
(Indication of the location of the works – country; province; district; etc)

4. Type of Contract
(Designation and explanation of the type of contract)

The present contract is for the whole Works based on the prices stated in the signed Tender material including all documents related to the tender procedure and contract negotiations.

Anything mentioned in this contract and not shown on the drawings or specified in the Specifications or, on the other side, shown on the drawings or stated in the Specifications but not mentioned in this contract, shall have the same effects as if shown on or stated in both. In case of difference between drawings/specifications and this contract, this contract shall govern.

5. Documents Forming the Contract
(Designation and explanation of the documents that compose the contract and which are recognized when signed by the parties)

The documents forming the contract shall be interpreted in the following order of priority:
- The present Contract
- The Bill of Quantities
- Project Specifications
- Specifications of Works
- Drawings
- The Work Schedule of Construction.

6. Supervision of Works
(Designation and explanation of the responsibilities of the project manager in charge of doing the project supervision)

The supervision of works is under the Project Manager and/or his/her authorised representatives. The Contractor will obey all written and verbal advices of the Project Manager and will notify him/her in writing within 2 working days of his observations or claims, if any.

7. Instructions/orders
(Designation and explanation of the project manager's responsibilities)

The function of the Project Manager or his/her authorised representative is to supervise the works and administer the contract. The Contractor shall only take instructions from the Project Manager or from his authorised representative.

8. Possession of the site
(Identification and explanation on the issues about site possession)

9. Contractor to Conform to Government Regulations
(Designation and explanation of the regulations and laws that the contractor is obliged to respect)

The contractor shall ascertain and conform in all respects with the provisions of any general or local Act of Government and such Regulations and Laws, which may be applicable to the Works. This shall in particular apply to the:

(a) Conditions of employment of local labour. The Contractor is bound by the labour regulations and social legislation, which are in force in the country. In particular, he shall comply with the following rules: hours and conditions of works, wages and benefits, general health regulations, safety and health precautions. The Contractor shall provide a first aid kit.

(b) Traffic, regulations, including provision of adequate warning sign, and traffic barriers.

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

(c) Environmental protection. The Contractor shall carefully plan and conduct his works in a manner, which will minimise their effect on the environment. In particular the Contractor shall take care not to interfere with or pollute in any way irrigation channels or watercourses. Borrow pits shall only be worked at the location and to the extent agreed by the Project Manager and, in particular, the pits shall be left in a condition that it is not a safety or a health hazard due to stagnant water collection.

10. Responsibilities

(Designation and explanation of the liabilities and responsibilities of the contractor, towards his own workers and towards third parties)

The Contractor is responsible during the implementation of the works for the following risks:

(a) Third party liability (including any employee of the MSF present on the site), and covering injuries to persons and damage to property, losses and any prejudice which might result from the execution of works.

(b) Work accidents and injuries, which might befall his own staff.

11. Equipment/Machinery

(Explanation of responsibilities regarding the necessary machinery for the completion of the work)

The contractor will seek the agreement of the Project Manager on the adequacy of the Contractor's Equipment/Machinery to carry out the works. However the Contractor is fully responsible for the use of his equipment.

12. Settlement of Dispute

(Definition of the procedure to take in case of a dispute between the two parties)

(a) In the course of the execution of the works, if any conflict or difference of any kind whatsoever arises between MSF and the Contractor, the latter shall submit a memorandum to the Project Manager that explains the reasons for the disagreement and, possibly the amount in dispute. It should be accompanied by any supporting documents needed to examine the case.

(b) These issues should be shared and send to MSF headquarters, for record and analysis.

B. TIME CONTROL

(Designation and explanation of the issues related with the timetable of the implementation of works)

1. Commencement of Works/ Implementation Period

Signature of the contract will constitute the Project Manager's notice to commence the works. The date of commencement of the implementation period is 4 calendar days after the signature of the present contract and after receiving a "Letter to Proceed".

2. Planning of Works

(Explanation of the procedures and necessary elements for the planning of the works, and its implementation – related with the project supervision process – issues about the work log book)

(a) Within 5 working days after signature of the contract, the Contractor will present to the Project Manager the detailed implementation plan for the works including site organisation and materials to be used.

(b) Before starting the implementation of works, the Contractor and the Project Manager will agree on a weekly basis on the location, type and volume of works that will be implemented during the week, and analyse the work done in the previous week. The corresponding decisions (location, type, and volume) will be accepted in writing by the Project Director or his representatives and recorded in the daily site log book.

(c) The daily site log book will be opened by the Contractor and the Project Manager to report on a daily basis, what is happening on the site (such as visits of the Project Manager or other authorities, verbal orders given by the Project Manager, climatic condition, number of workers, works done, material used, site-work incident and any other relevant facts related to the works). The weekly reports of evolution of the works elaborated by the project supervision (project manager), are also to be copied in the work log book.

(d) In case of an apparent problem, verified by both parties, which may cause delay in the works or affects the contractor performance, the Contractor shall communicate through writing to MSF at the shortest possible time for an immediate solution. This should also be discussed at the weekly meetings between the project manager (MSF) and the contractor.

C. QUALITY CONTROL

(Explanation of the responsibilities of the different parties related with the quality control issues. This includes issues about the project; quality of works and materials; possible adjustments to the project and works; and sub-contracting)

1. Drawings

Drawings and other Engineering documentation are indicative of the scope of work. Field alterations may be decided by the Project Director and communicated to the Contractor through change orders, as conditions may warrant and as dictated by acceptable Engineering practice, without altering the object of the contract.

2. Quality of Works

Works shall comply with the Specifications of Works and the Bill of Quantities, which describe the particular technical requirements of the works to be performed under each activity. These Specifications of Works are to be followed by the Contractor unless instructed by the Project Manager. The Project

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

Manager shall decide as to the quality and acceptability of materials to be used and work to be performed.

3. Variations

(a) The Project Manager may authorise variations in quantities, without modifying unit prices, of up to a maximum of 50 % of the total Contract Price without amending the contract.
(b) Such variation does not allow the Contractor any additional claim or release him from any of his obligations. Additional works shall be valued at the marked rates in the tender documents.
(c) The Project Manager may agree to extend accordingly the completion deadline.

4. Sub-Contracting of the Works

(Identification of the procedure for sub-contracting, and explanation of the relation between the contractor and the project manager regarding these issues)

The Contractor shall not, without the written consent of the Manager, sub-contract any part of the Works. In the event the Project Manager approves the sub-contracting, such consent shall not relieve the Contractor of his obligations under the Contract.
The Project Manager may demand the contractor to sub-contract parts of particular works, if it is proven that the contractor cannot deliver the works in accordance to the Specifications of Works or to the satisfaction of the Project Manager. The sub-contractor shall form a part of the contractor organisation.

D. COST CONTROL

(Identification and explanation of the issues about the monetary compliance with the contract)

1. Contract Price

(identification and explanation of the contract price, and issues about the taxes regulation on the country)

2. Procedure for Payment

(Identification and explanation of the payment procedure. Establishment of the payment timetable, and each party's responsibilities)

3. Place of Payment

(Designation and explanation of the payment method and location)

Amounts due to the contractor shall be made payable in form of check to be collected from MSF office by the Contractor. All bank or other charges incurred in such transaction shall be at the expense of the Contractor.

4. Time for Payment

(Explanation on the time for payment to the contractor)

Payments to the contractor shall take place at the latest 7 days after the approval by the Project Manager.

5. Advance

(Explanation on the advance payment, establishing values and percentages)

20% of the amount agreed minus 10% retention money will be paid in advance immediately upon signature of this contract.

6. Penalties

(Explanation on the possible penalties to the contractor, regarding delays and non-compliance of works)

(a) Failure by the contractor to complete the works within the implementation period, or any extended period granted by the Project Director, shall render the Contractor liable to forfeit (defined value) per calendar day of time overrun.

(b) The maximum sum which will be forfeited shall be 10 % of the original value of the Contract or the equivalent of 14 days of work, whichever is less; after which, MSFmay rescind the contract.

7. Retention Money

(Designation and explanation of the procedure regarding retention money. This value is used as a warranty that there will be monetary means available to have any defects found on the works after their completion corrected)

(a) From each amount due for payment, MSF will deduct 10 % thereof as retention money. Such deductions will be made until the completion of the works. 50% of the retention money will be paid upon signing the hand-over protocol. The remaining amount of the retention money shall serve as a guarantee that any defect discovered in the defect liability period will be corrected. Upon the expiration of the defect liability period, which is 3 months later after the handing-over protocol has been signed, the remaining balance of the retention money shall be released to the contractor after the issuance of the Final Certificate of Completion.

8. MSF Default

(Explanation of the possible procedure to be followed by the contractor if MSF's payment were to be delayed)

If payment to the contractor is delayed more than 14 days after presenting the approved Certificate of Valuation, the Contractor may suspend work until such time as the payments are normalised and a return to work agreement satisfactory to both parties is agreed upon.

E. FINISHING THE CONTRACT

(Explanation on the procedures to take when the contract is finished, after the completion of the works)

9. Hand-over

(Designation and explanation of the hand over procedure after the construction is complete)

(a) When the Contractor shall consider that the whole of the Works has been substantially completed he shall give notice to that effect to the Project Manager.

(c) The notice must be accompanied by an undertaking to finish any outstanding work as expeditiously as possible and to rectify any defects, which might become apparent for the period following the date of issuance of the Hand-over Protocol.

(d) The Project Manager shall within 14 calendar days of receiving the Contractor's notice, prepare and carry through the hand-over procedure.

10. Defects Liability Period

(Establishment of the period for possible work rectifications, after the hand over process)

The Contractor shall be responsible for rectifying any defects in his works, including all costs due to the defects, which become apparent for a period of 3 months following the signature of the Hand-over Protocol. Contractor agrees to complete all defects and agrees that should he not be able to do so that MSF shall have the right to have the works completed by deduction from the retention money.

11. Final Certificate of Completion

(Establishment of the Certificate of completion, establishing the finalization of the construction and the end of the liability period)

(a) Upon expiration of the Defect liability Period and when all outstanding and defective work has been completed or rectified, the Project Manager or his representative shall issue a Certificate of Completion, which shall state the date on which the Contractor shall have completed his obligation to the Project Manager's satisfaction.

(b) The Project Manager or his representative and the contractor will inspect the works 14 calendar days before the expiration of the Defect Liability Period and will issue at this time a list of any defects required to be rectified prior to issuance of the Certificate of Completion.

12. Termination of Contract

(Designation and explanation of possible situations that may give reason for the termination of the contract on both parts)

(a) The contract is terminated automatically and without compensation in the following cases:

- in the event of a Force Majeure situation occurring in the country, herein defined to include civil commotion, armed conflict, insurrection, floods, government's order, or other events beyond MSF control; this contract shall immediately and automatically terminate, and MSF shall be obliged to pay only for services up to the date of Force Majeure, on a pro rata basis, and no further liability shall exist between MSF and the Contractor.
- Death or legal incapacity of the Contractor;
- Bankruptcy or judicial liquidation of the Contractor's business;
- Subcontracting of part of the works (with the exception of hauling of material) to another enterprise without the Project Manager's authorisation; or
- Major delays in the execution of the works , i.e. when the contractor has exceeded the time for completion allowed for in the contract by 25% of the total time to carry out the works, or by 45 calendar days, whichever is less.

(b) If the Contractor does not comply either with the clauses of the Contract or the notices received, the Project Manager, shall issue a formal notice requesting compliance within 28 calendar days or less in case of emergency. Beyond that period of time, if the Contractor has not complied with the request, the Project Manager may declare the contract to be terminated at the Contractor's expenses.

(c) In case of termination, the Project Manager shall, in the Contractor's presence, draw up a list of all works carried out and inspect the material supplied. The Contractor shall vacate the site within the time indicated by the Project Manager. An account will be draw up for payment of the works completed and material supplied by the Contractor. Deduction will be made for accounts already settled, advances made, retention money paid, and for additional expenses to be incurred in preparing a new bid and awarding a new contract for the remaining works.

F. FINAL AGREEMENT

(Recognition and signature of the contract by all parties involved, addressing and recognizing all the topics and elements included in it. Identification and designation of representatives of all parties included in the contract. Identification of the date, local, and witnesses is obliged)

This contract contains the entire understanding, representations and agreements of the parties and there are no other agreements, oral or written, between the parties other than those contained in the present Contract, the Bill of Quantities, Project Specifications, Specifications of Works, Drawings and the Work Schedule of Construction.

The parties hereto have caused this Contract to be executed the day and year first written in accordance with their respective law.

Date:	Date: ....
For MSF, (name and designation)	For the Contractor, (name and designation)
________________________________	________________________________
Head of Mission, (name)	Contractor, (name)

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

MEDICOS SIN FRONTERAS

Construction Project Director, (name)

Contractor, (name)

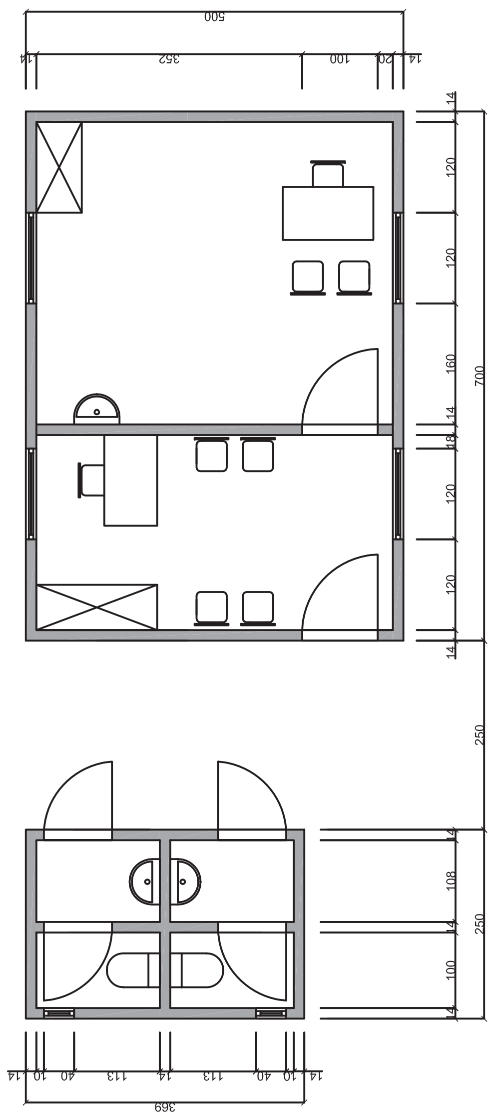
and witness by:

(name and designation)

9.2 Sample building

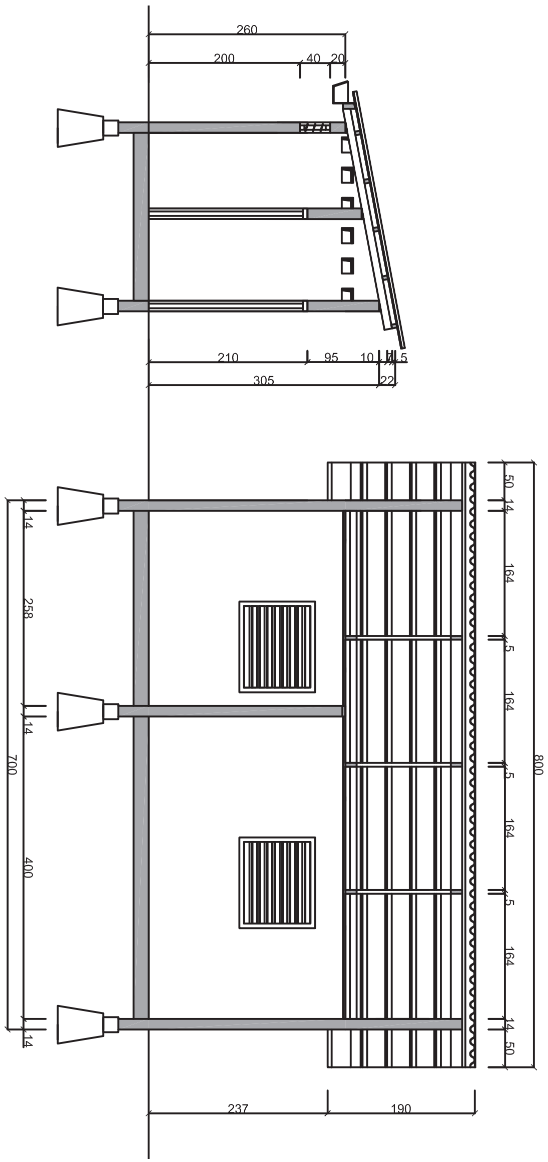
Sample building plans

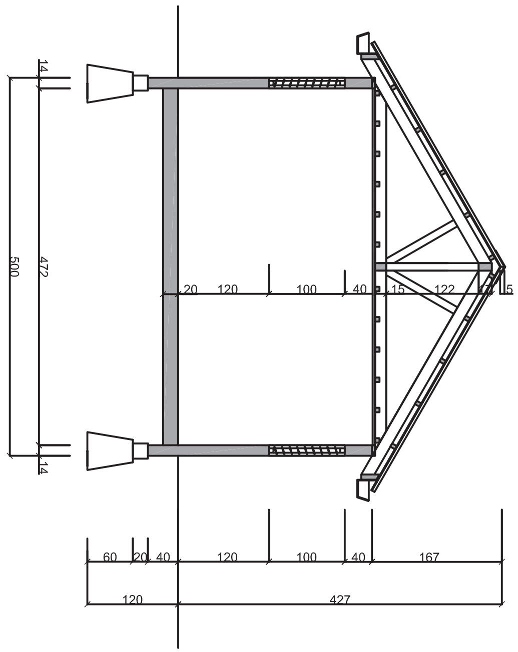
Scale 1:100



Sample building sections

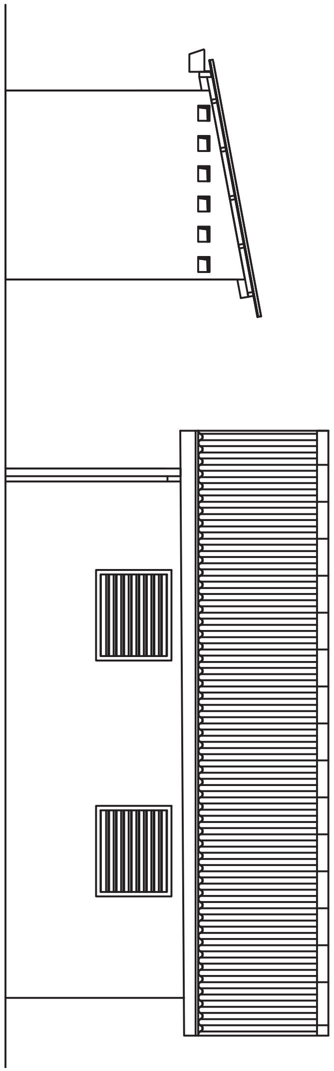
Scale 1:100

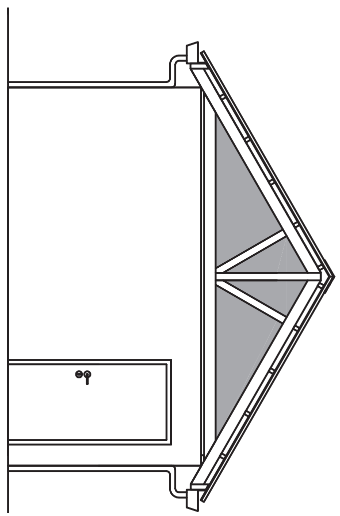




Sample building elevations

Scale 1:100





9.3 Bill of quantities

MEDICOS SIN FRONTERAS . MSF		
BILL NO. 1: PRELIMINARIES		
ITEM	**DESCRIPTION**	**VALUE (country currency)**
A.	**GENERAL PRELIMINARIES**	
1.	**PRICING OF ITEMS OF PRELIMINARIES AND PREAMBLES** Prices will be inserted against items of Preliminaries in the Contractor's priced Bills of Quantities and Specification. The Contractor must include in his prices or rates for the various items in the Bills of Quantities: all costs involved in complying with the requirements for the proper execution of the whole of the works in the Contract.	
2.	**ABBREVIATIONS** (description and explanation of the abbreviations and terms used throughout the boq - this is done so that everyone involved in the process understands in the same way all the used abreviattions)	
3.	**EXCEPTION TO THE STANDARD METHOD OF MEASUREMENT** (description of any exception on the stantard method of measurement, if so exists)	
4.	**EMPLOYER** (identification and designation of the employer)	
5.	**PROJECT MANAGER** (definition of the term Project Manager - P.M. - as the person authorised to represent the employer) (identification and designation of the employer - MSF)	
6.	**ARCHITECT/PROJECT MANAGER** (identification of the architect responsable for the project - IF EXISTENT)	
7.	**QUANTITY SURVEYOR** (identification of the quantity surveyor responsable for the project materials qantifications - IF EXISTENT)	
8.	**ELECTRICAL ENGINEER** (identification of the electrical enginner responsable for the electricity project - IF EXISTENT)	
9.	**MECHANICAL ENGINEER** (identification of the mechanical enginner responsable for the installations - IF EXISTENT)	
10.	**STRUCTURAL ENGINEER** (identification of the structural enginner responsable for the structural calculations and project - IF EXISTENT)	

11.	**PLANT, TOOLS AND VEHICLES** Allow for providing all scaffolding, plant, tools and vehicles required for the works, except in so far as may be stated otherwise herein. No timber used for scaffolding, formwork or temporary works of any kind shall be used afterwards in the permanent work.	
12.	**TRANSPORT** Allow for transport of workmen, materials, etc., to and from the site.	
13.	**MATERIALS AND WORKMANSHIP** All materials and workmanship used in the execution of the work shall be of the best quality and description unless otherwise stated. The Contractor shall order all materials to be obtained from overseas immediately after the Contract is signed and shall also order materials to be obtained from local sources as early as necessary to ensure that they are onsite when required for use in the works. The Bills of Quantities shall not be used for the purpose of ordering materials.	
14.	**SIGN FOR MATERIALS SUPPLIED** The Contractor will be required to sign a receipt for all articles and materials supplied by the PROJECT MANAGER at the time of taking deliver thereof, as having received them in good order and condition, and will thereafter be responsible for any loss or damage and for replacements of any such loss or damage with articles and/or materials which will be supplied by the PROJECT MANAGER at the current market prices including Customs Duty and V.A.T., all at the Contractor's own cost and expense, to the satisfaction of the PROJECT MANAGER	
15.	**STORAGE OF MATERIALS** The Contractor shall provide at his own risk and cost where directed on the site weather proof lock-up sheds and repair damaged or disturbed surfaces upon completion to the satisfaction of the PROJECT MANAGER. Nominated Sub-Contractors are to be made liable for the cost of any storage accommodation provided especially for their use.	
16.	**SAMPLES** The Contractor shall furnish at his own cost any samples of materials or workmanship including concrete test cubes required for the works that may be called for by the PROJECT MANAGER for his approval until such samples are approved by the PROJECT MANAGER and the PROJECT MANAGER, may reject any materials or workmanship not in his opinion to be up to approved samples. The PROJECT MANAGER shall arrange for the testing of such materials as he may at his discretion deem desirable, but the testing shall be made at the expense of the Contractor and not at the expense of the PROJECT MANAGER. The Contractor shall pay for the testing in accordance with the current scale of testing charges laid down by the relevant authority The procedure for submitting samples of materials for testing and the method of marking for identification shall be as laid down by the PROJECT MANAGER The Contractor shall allow in his tender for such samples and tests except those in connection with nominated sub-contractors' work.	
17.	**ACTS REGARDING WORKPEOPLE, ETC** Allow for complying with all Government Acts, Orders and Regulations in connection with the employment of Labour and other matters related to the execution of the works. In particular the Contractor's attention is drawn to the provisions and his tender must include all costs arising or resulting from compliance with any act, order or regulation relating to insurances, pensions and	

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. Annex

	holidays for workers or the safety, health and welfare of the workers. The Contractor must make himself fully acquainted with current acts and regulations, including police regulations regarding the movement, housing, security and control of labour, labour camps , passes for transport, etc. It is most important that the Contractor, before tendering, shall obtain from the relevant authority the fullest information regarding all such regulations and/or restrictions which may affect the organisation of the works, supply and control of labour, etc., and allow accordingly in his tender.	
18.	**SECURITY OF WORKS, ETC** The Contractor shall be entirely responsible for the security of all the works' stores, materials, plant, personnel, etc., both his own and sub-contractors' and must provide all necessary watching, lighting and other precautions as necessary to ensure security against theft, loss or damage and the protection of the public.	
19.	**PUBLIC AND PRIVATE ROADS** Maintain as required throughout the execution of the works and make good any damage to public or private roads arising from or consequent upon the execution of the works to the satisfaction of the local and other competent authority and the PROJECT MANAGER	
20.	**EXISTING PROPERTY** The Contractor shall take every precaution to avoid damage to all existing property including roads, cables, drains and other services and he will be held responsible for and shall make good all such damage arising from the execution of this contract at his own expense to the satisfaction of the PROJECT MANAGER	
21.	**VISIT SITE AND EXAMINE DRAWINGS** The Contractor is recommended to examine the drawings and visit the site the location of which is described in the Particular Preliminaries hereof. He shall be deemed to have acquainted himself therewith as to its nature, position, means of access or any other matter which, may affect his tender. No claim arising from his failure to comply with this recommendation will be considered.	
22.	**ACCESS TO SITE AND TEMPORARY ROADS** Means of access to the Site shall be agreed with the PROJECT MANAGER prior to commencement of the work, and the Contractor must allow for building any necessary temporary access roads for the transport of the materials, plant and workmen as may be required for the complete execution of the works, including the provision of temporary culverts, crossings, bridges, or any other means of gaining access to the Site. Upon completion of the works, the Contractor shall remove such temporary access roads; temporary culverts, bridges, etc., and make good and reinstate all works and surfaces disturbed to the satisfaction of the PROJECT MANAGER	
23.	**AREA TO BE OCCUPIED BY THE CONTRACTOR** The area of the site which may be occupied by the Contractor for use of storage and for the purpose of erecting workshops, etc., shall be defined on site by the PROJECT MANAGER	
24.	**WATER AND ELECTRICITY SUPPLY FOR THE WORKS** The Contractor shall provide at his own risk and cost all necessary water, electric light and power required for use in the works. The Contractor must make his own arrangements for connection to the nearest suitable water main and for metering the water used. He must also provide temporary tanks and meters as required at his own cost and clear away when no longer required and make good on completion to the entire satisfaction of the PROJECT MANAGER. The Contractor shall pay	

	all charges in connection herewith. No guarantee is given or implied that sufficient water will be available from mains and the Contractor must make his own arrangements for augmenting this supply at his own cost. Nominated Sub--contractors are to be made liable for the cost of any water or electric current used and for any installation provided especially for their own use.	
25.	**SANITATION OF THE WORKS** The Sanitation of the works shall be arranged and maintained by the Contractor to the satisfaction of the Government and/or Local Authorities, Labour Department and the PROJECT MANAGER	
26.	**SUPERVISION AND WORKING HOURS** The works shall be executed under the direction and to the entire satisfaction in all respects of the PROJECT MANAGER who shall at all times during normal working hours have access to the works and to the yards and workshops of the Contractor and sub-Contractors, or other places where work is being prepared for the contract.	
27.	**MATERIALS ARISING FROM EXCAVATIONS** Materials of any kind obtained from the excavations shall be the property of the Employer. Unless the PROJECT MANAGER directs otherwise such materials shall be dealt with as provided in the Contract. Such materials shall only be used in the works, in substitution of materials which the Contractor would otherwise have had to supply with the written permission of the PROJECT MANAGER Should such permission be given, the Contractor shall make due allowance for the value of the materials so used at a price to be agreed.	
28.	**PROTECTION OF THE WORKS** Provide protection of the whole of the works contained in the Bills of Quantities, including casing, casing up, covering or such other means as may be necessary to avoid damage to the satisfaction of the PROJECT MANAGER and remove such protection when no longer required and make good any damage which may nevertheless have been done at completion free of cost to the Employer	
29.	**REMOVAL OF RUBBISH, ETC** Removal of rubbish and debris from the buildings and site as it accumulates and at the completion of the works and remove all plant, scaffolding and unused materials at completion.	
30.	**WORKS TO BE DELIVERED UP CLEAN** Clean and flush all gutters, rainwater and waste pipes, manholes and drains, wash (except where such treatment might cause damage) and clean all floors, sanitary fittings, glass inside and outside and any other parts of the works and remove all marks, blemishes, stains and defects from joinery, fittings and decorated surfaces generally, polish door furniture and bright parts of metalwork and leave the whole of the buildings watertight, clean, perfect and fit for occupation to the approval of the PROJECT MANAGER	
B.	**PARTICULAR PRELIMINARIES**	
1.	**PRICING ITEMS OF PRELIMINARIES** Prices **SHALL BE INSERTED** against items of "preliminaries" in the tenderer's priced Bills of Quantities. The Contractor must include in his prices or rates for the various items in the Bills of Quantities or Specification: all costs involved in complying with all the requirements for the proper execution of the whole of the works in the Contract. The contractor is advised to read and understand all preliminary items.	
2.	**DESCRIPTION OF THE WORKS**	

1. introduction 2. project management 3. preliminary 4. materials 5. new buildings 6. extensions 7. rehabilitation 8. bibliography 9. annex

	The works to be carried out under this contract involves construction to completion of **the ………………… project including the accociated Electrical and Mechanical Works, Civil works and External works.**	
3.	**MEASUREMENTS** In the event of any discrepancies arising between the Bills of Quantities and the actual works, the site measurements shall generally take precedence. However, such discrepancies between any contract documents shall immediately be referred to the PROJECT MANAGER.	
4.	**LOCATION OF SITE** The site is located at ……………………………………………………………………… The Contractor is advised to visit the site, to familiarize with the nature and position of the site. No claims arising from the Contractor's failure to do so will be entertained.	
5.	**CLEARING AWAY** The Contractor shall remove all temporary works, rubbish, debris and surplus materials from the site as they accumulate and upon completion of the works, remove and clear away all plant, equipment, rubbish, unused materials and stains and leave in a clean and tidy state to the reasonable satisfaction of the Project Manager. The whole of the works shall be delivered up clean, complete and in perfect condition in every respect to the satisfaction of the Project Manager.	
6.	**PAYMENTS** The tenderer's attention is drawn to the fact that the Eployer **MAY/MAY NOT MAKE ADVANCE PAYMENTS**	
7.	**PREVENTION OF ACCIDENT, DAMAGE OR LOSS** The Contractor is notified that these works are to be carried out on a restricted site where the client is going on with other normal activities. The Contractor is instructed to take reasonable care in the execution of the works as to prevent accidents, damage or loss and disruption of normal activities being carried out by the Client. The Contractor shall allow in his rates any expense he deems necessary by taking such care within the site.	
C.	**WORKING CONDITIONS**	
1.	**TRANSPORTATION OF WORKERS** The Contractor shall not be allowed to house labour on site. Allow for transporting workers to and from the site during the tenure of the contract.	
2.	**MATERIALS FROM DEMOLITIONS** Any materials arising from demolitions and not re-used shall become the property of the Employer. The Contractor shall allow in his rates the cost of transporting the demolished materials to the Employer	
3.	**PRICING RATES** The tenderer shall include for all costs in executing the whole of the works, including transport, replacing damaged items, fixing, all to comply with the said Conditions of Contract.	
4.	**PAYMENT FOR MATERIALS ON SITE** All materials for incorporation in the works must be stored on site before payment is effected, unless specifically exempted by the Project Manager. This is to include materials of the Contractor, nominated sub-Contractors and nominated suppliers.	

5.	**EXISTING SERVICES** Prior to the commencement of any work, the Contractor is to ascertain from the relevant authority the exact position, depth and level of all existing services in the area and he/she shall make whatever provisions may be required by the authorities concerned for the support, maintenance and protection of such services.	
D.	**TOTAL PRELIMINARIES CARRIED TO GRAND SUMMARY**	

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BILL NO. 2 : BUILDING WORKS

ITEM	DESCRIPTION	QTY	UNIT	RATE	VALUE (country currency)
	ELEMENT NO.1: SUBSTRUCTURES				
	(this table section is intend for the brief description and explanation of the necessary work related with the plot - clearing and preparation)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	Clear the site of all bush scrub undergrowth and small trees grub up roots and cart away or burn all arising	x amount	Time (hours)	price/hour	
	Excavations and earthworks				
	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
B.	Excavate oversite average 200mm deep to remove vegetable soil load up wheel and deposit away and later spread and level on site where directed	x amount	m2	price/m2	
	Carried to Collection				-
	(this table section is intend for the brief description and explanation of the necessary work related with foundations and structure)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	Foundation beam 200x200mm	x amount	m3	price/m3	
	Quantity calculation procedure: measure the total lenght of the walls, and then multiply it by the surface area of the foundation beam's section				
	example: foundation dimensions 200mmx200mm; total length of walls 50m;				
	*0,02 m*0,02 m = 0,004 m2 0,004 m2* 50m = 0,2m3*				
	Steel reinforcement				
B.	Supply and fix bars reinforcement				
C.	reiforcement bars diameter nº 3	x amount	kg	price/kg	
	Quantity calculation procedure: Take the total length of the walls, as this is also the total length of the reinforcement bars in the foundation beam underneath.				
	Multiply this length by the weight of the bars per unit length (can be found through manufacturer). Multiply this number by the number of bars in the beam.				
	This gives you the total weight of the reinforcement bars in the foundation beams.				
	example: total length of walls 50m; weight per unit length of bars (no. 3): 0,561 kg/m, number of bars per beam: 4				
	*50 m * 0,561 kg/m = 28,05 kg; 28,05 kg/bar * 4 bars = 112,2 kg*				
	The weight of the ties also needs to be included into the weight of the reinforcement steel. For this, the number of ties is multiplied by the weight of each tie.				
	The number of ties is found by dividing the total length of the beam by the space in between two ties.				
	example: 50 m walls; 150 mm in between ties; 0,05 kg per tie				
	*50 m / 0,15 m = 333 ties; 333 ties * 0,05 kg/tie = 16,67 kg*				
	Carried to Collection				-
	Foundation walling				
A.	200mm stone walling bedded and jointed in cement and sand	x amount	m3	price/m3	
	Quantity calculation procedure: calculate the volume of the foundation wall in the same way as caculating the volume of the foundation beam.				
	Carried to collection				
	TOTAL FOR ELEMENT NO. 1: SUBSTRUCTURES ***CARRIED TO SUMMARY***				
	ELEMENT NO.2: REINFORCED CONCRETE FRAME				
	(this table section is intend for the brief description and explanation of the necessary work related with reinforced concrete frame)				

A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	Ring Beam	x amount	m3	price/m3	
B.	Columns	x amount	m3	price/m3	
	Steel reinforcement				
C.	reinforcement bars diameter nº4	x amount	kg	price/kg	
	TOTAL FOR ELEMENT NO. 2: REINFORCED CONCRETE FRAME				
	CARRIED TO SUMMARY				-
	ELEMENT NO. 3: WALLS				
	(this table section is intend for the brief description and explanation of the necessary work related with external walling)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	150mm Thick concrete blocks	x amount	m2	price/m2	
	Quantity calculation procedure: Take the total length of all the walls, both interior and exterior, and multiply this number by the height of the walls.				
	Take care when some walls have a different height. This number is the total surface area of the walls.				
	example: total length of walls: 50m; height of walls: 2,60m				
	*50 m * 2,60 m = 130 m2*				
	TOTAL FOR ELEMENT NO.3: EXTERNAL WALLING				
	CARRIED TO SUMMARY				-
	ELEMENT NO 4: ROOF STRUCTURE, ROOFING AND RAIN WATER DISPOSAL				
	(this table section is intend for the brief description and explanation of the necessary work related with roofing and rain water disposal)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
	Roof structure				
B.	Metal connection plates for roof structure	x amount	units	price/unit	
C.	Rafter beams 150 mm x 50 mm	x amount	m	price/m	
D.	Rafter truss beams 100 mm x 50 mm	x amount	m	price/m	
E.	Ridge beam 100 mm x 175 mm	x amount	m	price/m	
F.	Eaves beams 70 mm x 200 mm	x amount	m	price/m	
G.	Joists 60 mm x 60 mm	x amount	m	price/m	
H.	Purlins 50 mm x 70 mm	x amount	m	price/m	
I.	Wall plate 150 mm x 40 mm	x amount	m	price/m	
	Roofing				
J.	metal sheets nailed and bolted on timber trusses	x amount	m2	price/m2	
	Rainwater disposal				
K.	Gutters 250 mm x 150 mm galvanized steel, bolted	x amount	m	price/m	
L.	Rainwater pipes, 70 mm diameter, galvanized steel, bolted with clams	x amount	m	price/m	
	TOTAL FOR ELEMENT NO. 4: ROOFING AND RAINWATER DISPOSAL				
	CARRIED TO SUMMARY				
	ELEMENT NO. 5: EXTERNAL WALL FINISHES				
	(this table section is intend for the brief description and explanation of the necessary work related with external wall finishes)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	12mm thick plaster	x amount	m2	price/m2	
B.	paint	x amount	m2	price/m2	
	TOTAL FOR ELEMENT NO. 5: EXTERNAL WALL FINISHES				
	CARRIED TO SUMMARY				-
	ELEMENT NO. 6: INTERNAL WALL FINISHES				
	(this table section is intend for the brief description and explanation of the necessary work related with internal wall finishes)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	apply 12mm thick lime plaster in two coats	x amount	m2	price/m2	
B.	paint	x amount	m2	price/m2	
	TOTAL FOR ELEMENT NO. 6: INTERNAL WALL FINISHES				
	CARRIED TO SUMMARY				
	ELEMENT NO. 7: FLOOR FINISHES				
	(this table section is intend for the brief description and explanation of the necessary work related with floor finishes)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
	Floor finishes				

A.	40mm Thick cement finished smooth	x amount	m2	price/m2	
B.	tiles				
	TOTAL FOR ELEMENT NO. 7: FLOOR FINISHES				
	CARRIED TO SUMMARY				-
	ELEMENT NO. 8: CEILING FINISHES				
	(this table section is intend for the brief description and explanation of the necessary work related with ceiling finishes)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	30mm thick plywood ceiling	x amount	m2	price/m2	
	TOTAL FOR ELEMENT NO.8: CEILING FINISHES				
	CARRIED TO SUMMARY				-
	ELEMENT NO. 9: WINDOWS				
	(this table section is intend for the brief description and explanation of the necessary work related with windows)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	Wood casement louvre windows				
B.	Window overall size	x amount	units	price/unit	
	Carried to collection				-
	Glazing				
	5mm Thick clear sheet glazing:				
A.	in panes	x amount	m2	price/m2	
	Carried to collection				
	TOTAL FOR ELEMENT NO.9: WINDOWS				
	CARRIED TO SUMMARY				-
	ELEMENT NO. 10: DOORS				
	(this table section is intend for the brief description and explanation of the necessary work related with doors)				
A.	(brief description and explanation of the necessary work)	(amount)	(measurement unit)	(unit price)	total (=qty*unit price)
	EXAMPLE:				
A.	50x50mmx3mm wooden Frame	x amount	units	price/units	
	Doors				
B.	45mm thick wooden door	x amount	units	price/units	
	Carried to Collection				-
	TOTAL FOR ELEMENT NO.10: DOORS				
	CARRIED TO SUMMARY				
	STAFF COMPOUND				
	SUMMARY				
		PAGE	NO		
1	**SUBSTRUCTURES**				-
2	**REINFORCED CONCRETE FRAME**				-
3	**WALLS**				-
4	**ROOF STRUCTURE, ROOFING AND RAIN WATER DISPOSAL**				-
5	**EXTERNAL WALL FINISHES**				-
6	**INTERNAL WALL FINISHES**				-
7	**FLOOR FINISHES**				-
8	**CEILING FINISHES**				-
9	**WINDOWS**				-
10	**DOORS**				-
	TOTAL FOR BILL NO. 2 BUILDERS WORKS CARRIED TO GRAND SUMMARY				-

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