

# 03

# A

# CONSTRUCTION

# MANUAL ON HOW

# TO BUILD

# A ROWLOCK BOND

# HOUSE

RowLock Bond  
CONSTRUCTION PROCESS



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Agency for Development  
and Cooperation SDC

**skat** Swiss Resource Centre and  
Consultancies for Development

**PROECCO** PROmoting EMPloyment through  
CLimate Responsive COnstruction



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## INTRO

This **CONSTRUCTION MANUAL** is a comprehensive step-by-step practical guide for construction supervisors, masons, builders, architects and engineers on how to build a multi-story building using the Rowlock Bond (RLB) technology. The manual is presented in three volumes, covering the **01 RLB principles**, the **02 Structural principles** and **03 construction process**. Each volume includes a comprehensive list of annexes covering quality control, specifications and useful tools, to be used to verify the design, structural calculations or construction works against the set standards.

# TABLE OF CONTENTS

01	Team structure	4
02	Tools	6
03	Construction preliminary works	8
04	Foundations	14
05	The Ground floor	20
06	General brick wall constructions	22
07	Windows and Doors	36
08	Plumbing and electrical installations	38
09	Timber Floor	40
10	MaxSpan slab	44
11	Partition walls	50
12	Stairs	52
13	Roof	54
14	Finishing	56
15	Construction Appendix A - Safety in Construction	58
16	Construction Appendix B - Quality control checklist	60

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# 01

## TEAM STRUCTURE



**Architects** Project design



**Engineers** Project structures and civil, MEP design



**Construction Managers** Logistics, finances, supplies, HR management



**Masons** Manpower



**Electricians** Electrical systems



**Plumbers** Water supply, waste water and rain water management



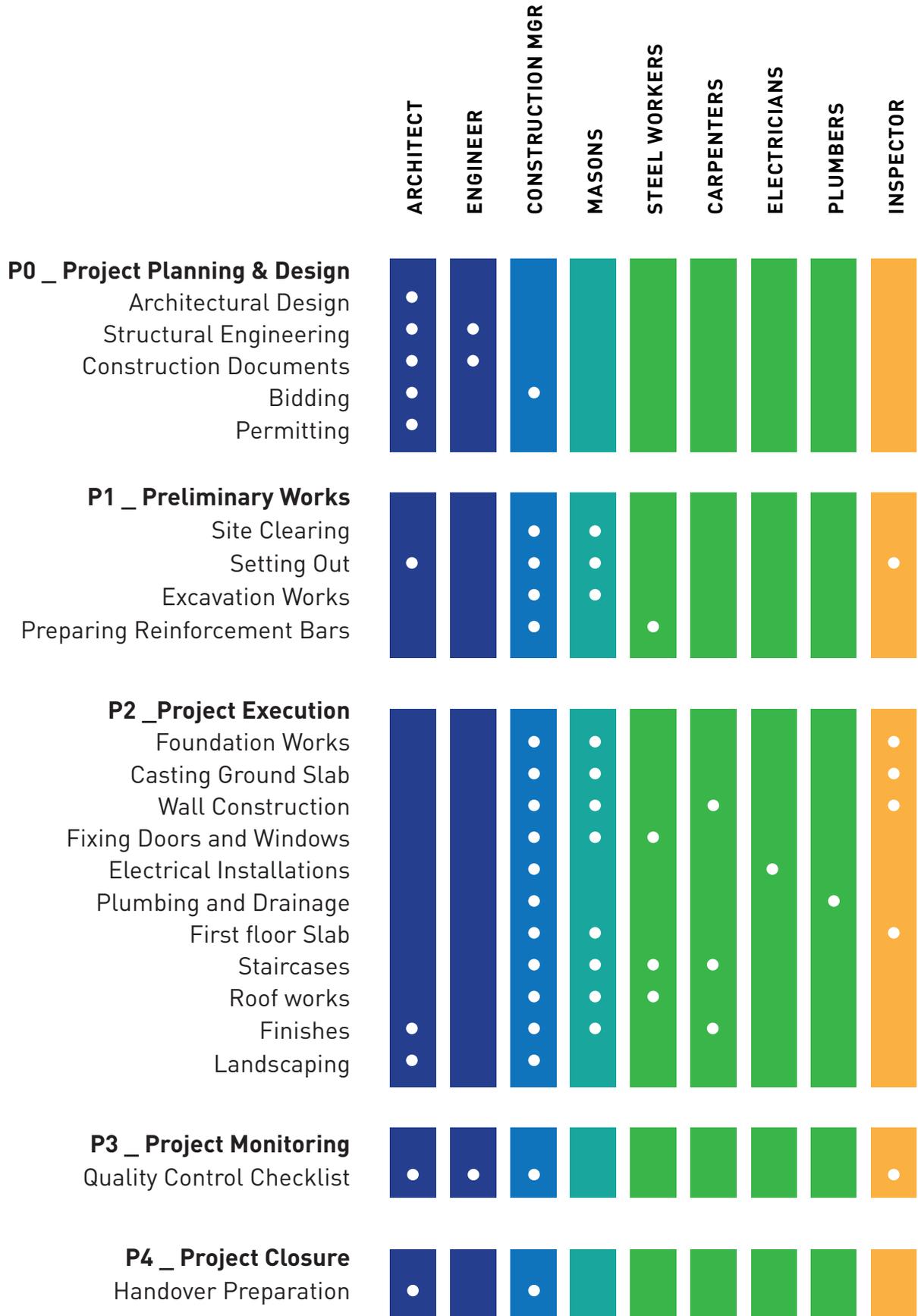
**Carpenters** Timber works, slabs, stairs



**Steel Workers** Concrete reinforcements, windows and doors



**Inspectors** Quality assurance



# 02

## TOOLS

## SAFETY EQUIPMENT

## TOOLBOX



Helmet



Overall



Safety boots



Gloves



Mask



Goggles



First aid kit



Tape measure



Strings



Spirit level



Water hose level



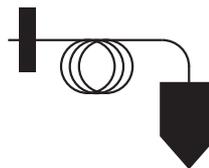
Trowel



Hammers



1cm re-bar



Plummet



Timber boards



# 03

## CONSTRUCTION PRELIMINARY WORKS

The basic design principles for an efficient RLB construction

### The building components

A building is a fixed structure that provides protection from natural elements such as rain, sunshine, wind, cold and heat. Different buildings are required for different use such as schools, markets, shops, offices, hospitals or factory buildings. A building can provide privacy, protection and a secure working environment. A basic building is made up of the components illustrated in this chapter.

### ROOF

- Provide cover to the building to protect occupants from rain and sun
- Provide extra living space especially for flat roofs

### WALLS

- Enclose space
- Divide or partition the building into rooms
  - Allow for openings (doors, windows)
  - Support floor slabs and roofs

### FLOOR

- Provides the working area where most activities take place and can be solid or light weight

### STAIRCASE

- Provide ascent and descent from one floor to the other.
- Provide an escape route in case of fire.

### OPENINGS

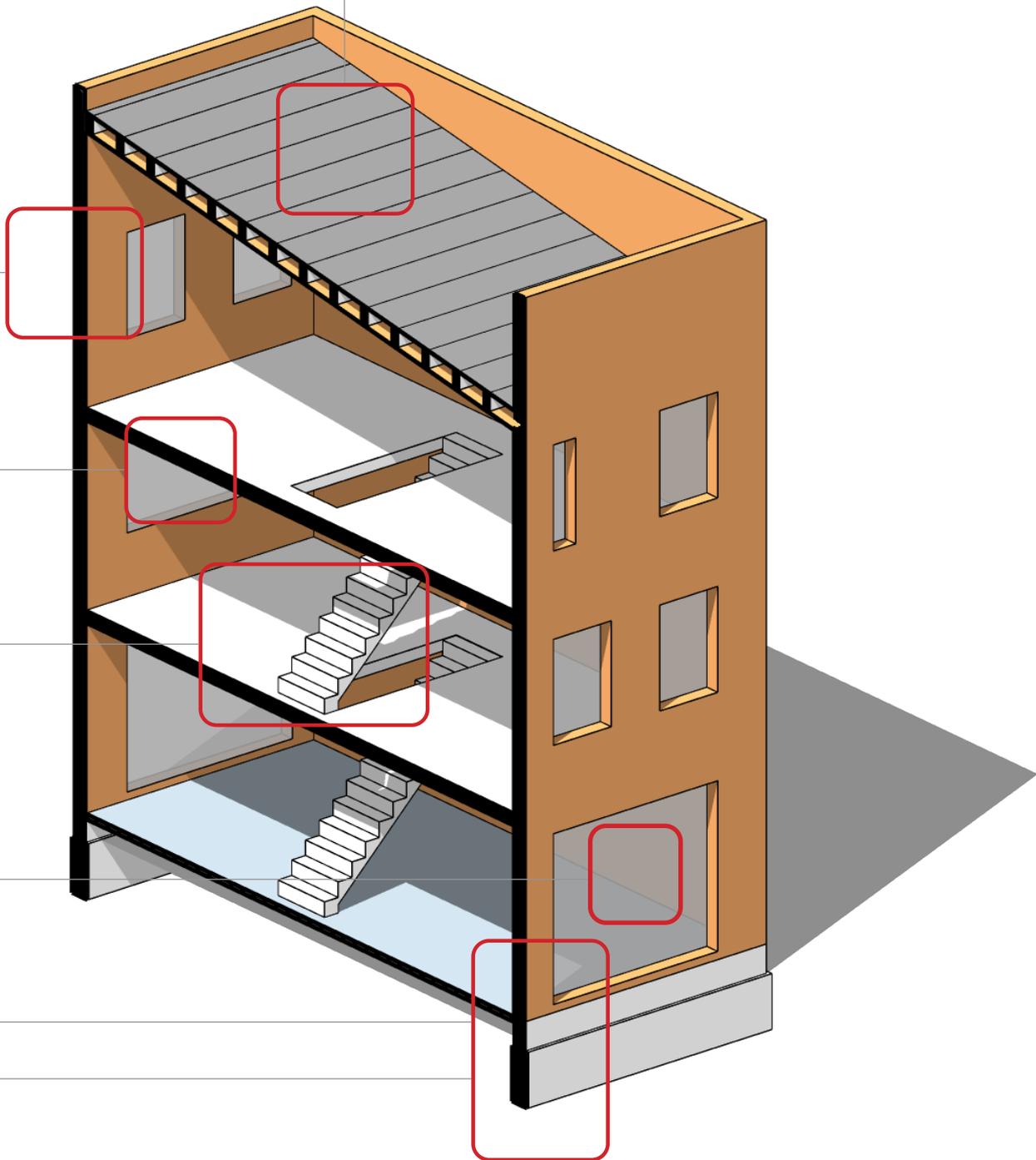
- Provide access, light and ventilation.

### RING (TIE) BEAM

- Ties the entire building at the ground level.
- Provides a level base for the brick wall.

### FOUNDATIONS

- Constitutes the base of the building.
- Carries both dead and live loads of the building, transmitting them to the ground

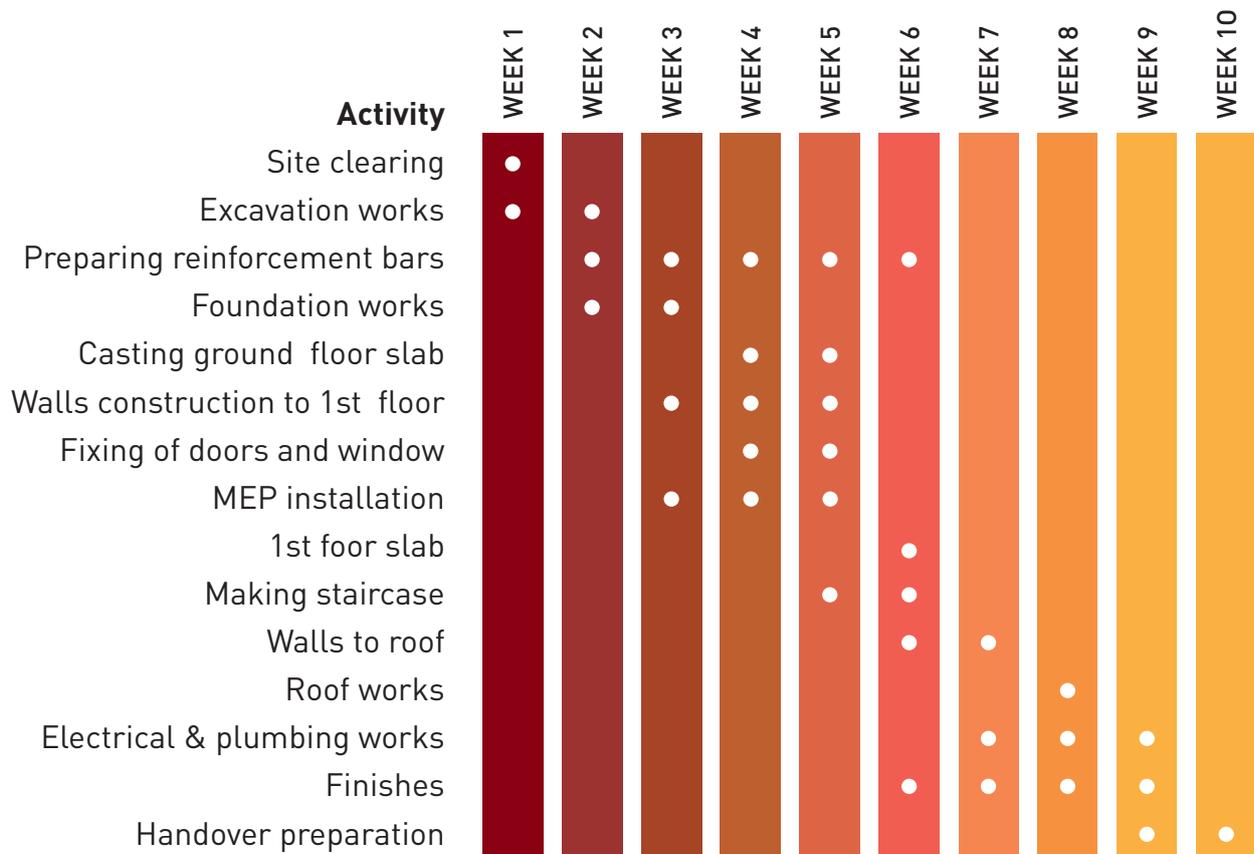


## PLANNING

The construction of any building involves many activities performed by different people. Construction requires clear communication and effective coordination amongst all the players. It requires well-coordinated teamwork and before construction begins a well- devised plan of the works should be designed to ensure the building is built within the time and budget provided.

### Planning and scheduling of construction activities

This involves preparing schedule of the construction activities. Each activity should be allocated a realistic construction time and labor force. The construction schedule helps in planning and determining when specific materials, special construction equipment and sub-contractor services will be required on site.



Example of an activity schedule. The construction of the Swiss Cube (2-storey) or similar size should not take more than ten (10) weeks with all materials ready.

### Building a site diary

This is an important document kept by the site foreman or supervisor, for recording important daily occurrence which may be required for future reference.

Some of the crucial information recorded on a site diary may include:

- Daily progress made on various construction activities.
- Instructions from architects or other superiors.
- Site visits by members of the building team such as structural engineers.
- Delays caused by late deliveries or other circumstances.
- Occurrences such as accidents, loss or theft of materials or tools, weather events.

## Assembling the construction team - time allocation.

This involves determining how many construction workers will be required for specific construction activities, and for how long. This activity helps in setting up an efficient and effective team. The construction workers include skilled tradesmen such as carpenters, masons and unskilled workers who do manual jobs.

	Estimated days	Masons	Painters	Carpenters	Steel Workers	Unskilled workers	Total man/days
							
Site clearing	3	-	-	-	-	3	9
Excavation works	3	-	-	-	-	3	9
Foundations	5	3	-	-	-	2	25
Floor slab	3	2	-	-	-	3	15
Walls to 1st floor	7	3	-	-	-	2	35
Bar bending	2	-	-	-	2	-	4
1st floor slab	1	2	-	-	-	4	6
Staircase	2	-	-	2	-	2	4
Walls to roof	2	-	-	2	-	2	8
Roof works	1	-	-	2	-	2	4
Doors & windows	3	-	-	2	-	0	6
Floor finishes	3	3	-	0	-	2	15
General finishes	5	-	-	2	-	2	20
Painting	5	-	2	0	-	1	15
Making good	2	-	-	0	-	3	6
<b>Totals</b>	47	13	2	10	2	31	181

An example of a labor allocation schedule

## Procurement of Building Materials

A variety of building materials will be required at different construction stages. It is the work of the construction management team to prepare procurement schedules indicating when specific building materials will be delivered on site.

No.	Activity	Cement	Sand	Gravel	Bricks	Timber	Steel	Roofing sheet
	Unit	Bags	m <sup>3</sup>	m <sup>3</sup>	#	Lm	Lm	#
1	Foundations	20	0.5	1.5	1000	-	15	-
2	Floor	15	1	1	-	-	-	-
3	Walls	15	0.75	-	9000	-	17	-
4	Ring Beam	5	0.5	1	-	-	15	-
5	Roofing	-	0	-	-	25	-	12
6	General finishes	5	0.25	-	-	-	-	-
	<b>TOTALS</b>	65	3.5	3.5	10,000	77	47	12

Key: m<sup>3</sup>\_cubic meters Lm\_linear meter #\_pieces

An example of a materials procurement schedule.

# SITE PREPARATION

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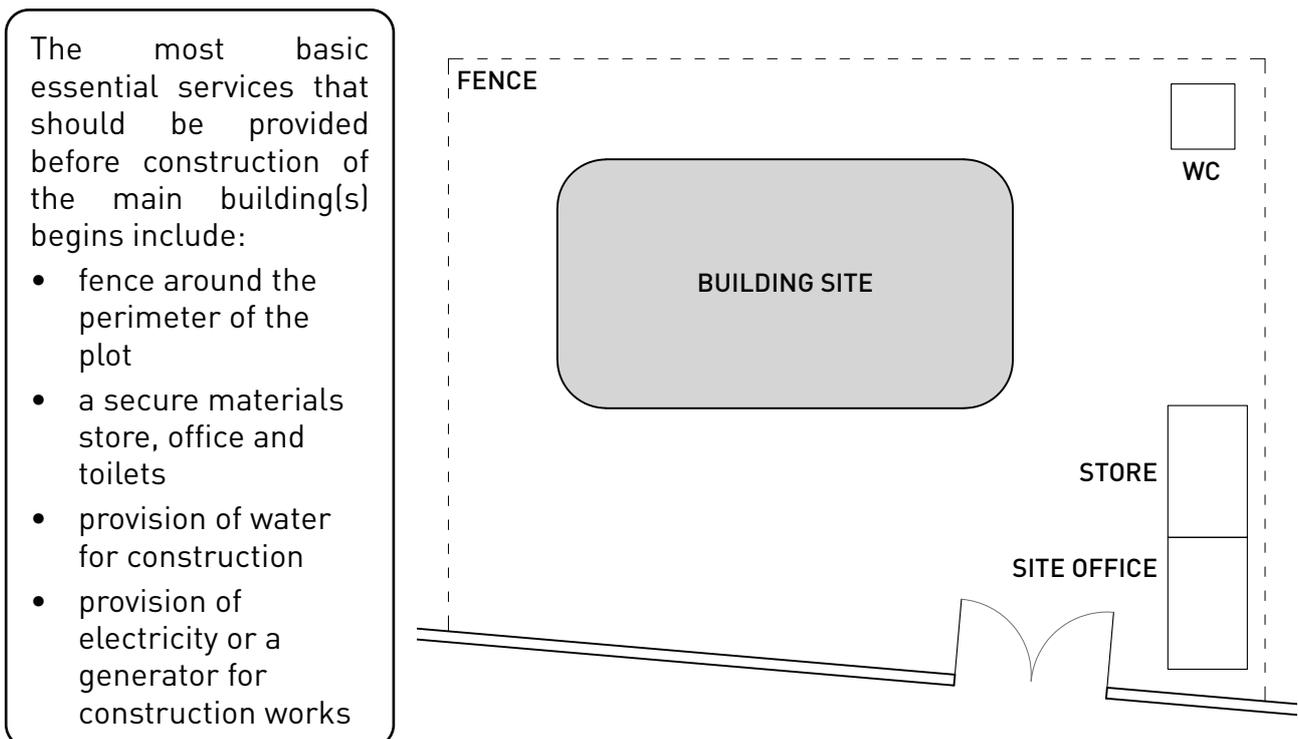
Site preparation involves making the construction site ready for construction works to commence.

Key activities under site preparation include:

1. Demolition of buildings or other structures that may be an obstacle to the new building.
2. Cutting trees on the construction site. Consideration should be given to retaining trees that are not an obstacle to the building.
3. Clearing and disposing all loose soils and demolition debris.
4. Removing electrical power lines that may be on the way. This will require engaging the electrical power authority.
5. Establishing the datum point. In building construction, a datum point refers to a point of reference from where measurements and levels are taken. In relation to the new construction. This can be the highest or lower point on the construction site. A floor level of an existing building can be used as the datum point. A datum point can also be established by fixing a concrete spot at the lowest or highest level of the site

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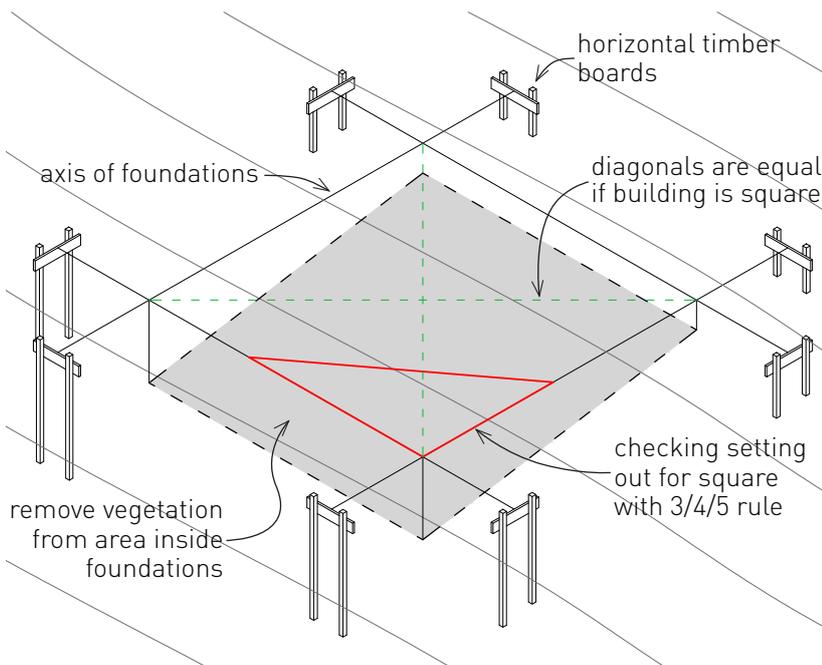
Once the site has been prepared, the **essential services** required during the construction must be put in place. The construction of a building may take several weeks, months or even years, depending on the size of the building. Therefore, there is a need to provide certain services on during the construction period such as fencing, toilets, materials storage facilities, site office and, in some cases, accommodations for workers.



# SETTING OUT

The setting out the Building is the process of setting or mapping out on the ground the building plan to be constructed. For a simple, square or rectangular building, the process followed is as explained below:

1. Establish a baseline from where to take all the measurement. This should be the front or rear of the building, leaving safe and adequate distance from roads, rivers, slopes, electrical power lines and according to any applicable building regulations.
2. Use the 3, 4, 5 method to set out corners at right angles (90°). For this exercise, a minimum of two people and two tape measures are needed:
  - Mark out the front baseline of the house, with the real length dimensions of the building and drive 2 pegs to the ground. Label the two pegs as A & B. Tie a line (string) joining pegs A&B.
  - Along the base line from peg A, drive a peg at a 3-meter mark. Mark this peg as C.
  - From peg A stretch one tape measure to a 4-meter mark towards where you want to establish the 90° corner. From peg C stretch the other tape measure to a 5-meter mark, until the 5-meter mark meets with the 4-meter mark. Mark this as point D and



drive a peg to the ground. This establishes 90° angle at corner

- Repeat the same process at point B to establish the 90° mark.
3. Verify the accuracy of the setting out by using diagonal measurements. Check if the diagonals are equal.
  4. Once the 4-corners of the building are accurately established, you can fix profile boards where you will mark the width of the trenches, columns and walls.
  5. Transfer the building setting/layout on the ground using lime or sand.
  6. The load bearing capacity of the soil will need to be tested to ensure that it will be able to support the load of the building. This will require the services of a soil expert.

N	What to check	Observations
1	In case of a rectangular or square building, are the diagonals equal?	Yes / No
2	Are all the wall measurements as per the drawings?	Yes / No
3	Are the profile boards fixed 1-meter away from the foundation trenches?	Yes / No

# 04

## FOUNDATIONS

### A. EXCAVATION FOR FOUNDATION

#### TEAM members involved



Masons



Unskilled workers

#### Construction tip

The foundation depth is always determined by a combination of soil load bearing capacity and the size or weight of the building.



Excavation of trenches and holes for foundation starts after the setting out of the building process is complete. A structural engineer will, according to the type of sub-soil and the size of the building, determine the depth and width of the foundation trenches and holes.

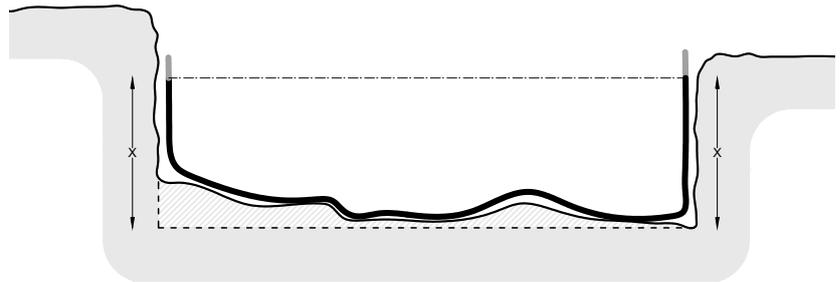
Once the setting out is done, the excavation of trenches and holes involves the following steps:

- Excavation of trenches or holes for foundations following the marks of the setting out and the depth agreed.
- Leveling of the trench bottom. This requires the use of a transparent hosepipe filled with water to transfer levels from one end to the other, in order to ensure that the

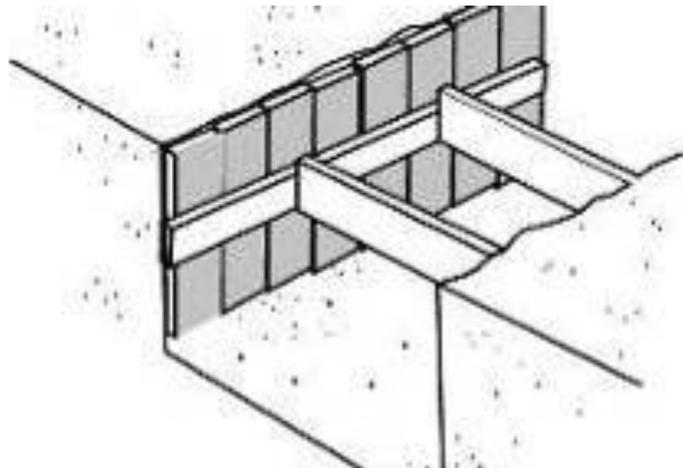


bottom of the trench is flat and level.

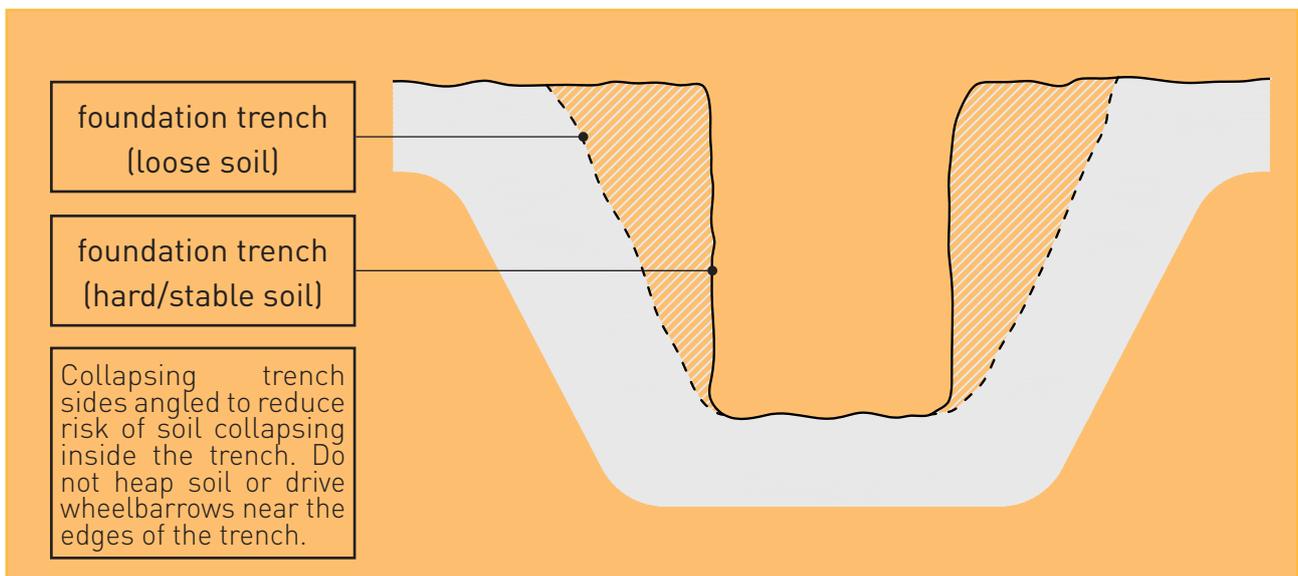
- Clearing the leftover excavated soil and disposing it to an approved site.
- Protecting the sidewalls of trenches from collapsing by digging sides at an angle or placing wooden planks and bracing them. (For more details see the illustration above).
- Prepare the bottom of the trench with lean cement concrete or gravel (if the budget allows) before starting the construction of the foundation.



Trench leveling with the water hose method.



Collapsing trench sides protected with wooden planks.



## C. FOUNDATION WALLS

### TEAM members involved



Masons



Unskilled workers

### Construction tip

Stone rubble is one of the most commonly used material for underground foundations as it is a perfect water and mineral resistant material, as well as extremely hard and durable.

The depth of foundation walls is normally a minimum of 0.6M deep. Depending on the subsoil load bearing capacity, and the size of the building, the foundation wall can be as deep as 2-3 meters.

Foundation walls must be built using strong materials that will not be damaged by water, salts or minerals found underground.

**A. Select hard stones that cannot be damaged by water, salts and minerals found underground.**

**B. Mix the mortar:**

- Mix the cement/sand mortar using a ratio of 1:3, unless otherwise specified.
- Use a clean surface such as a concrete base, plywood or sheet metal for mixing.
- Use a bucket to batch out the mix
- Turn over the cement/sand 3 times dry, until a uniform color is achieved before adding water.

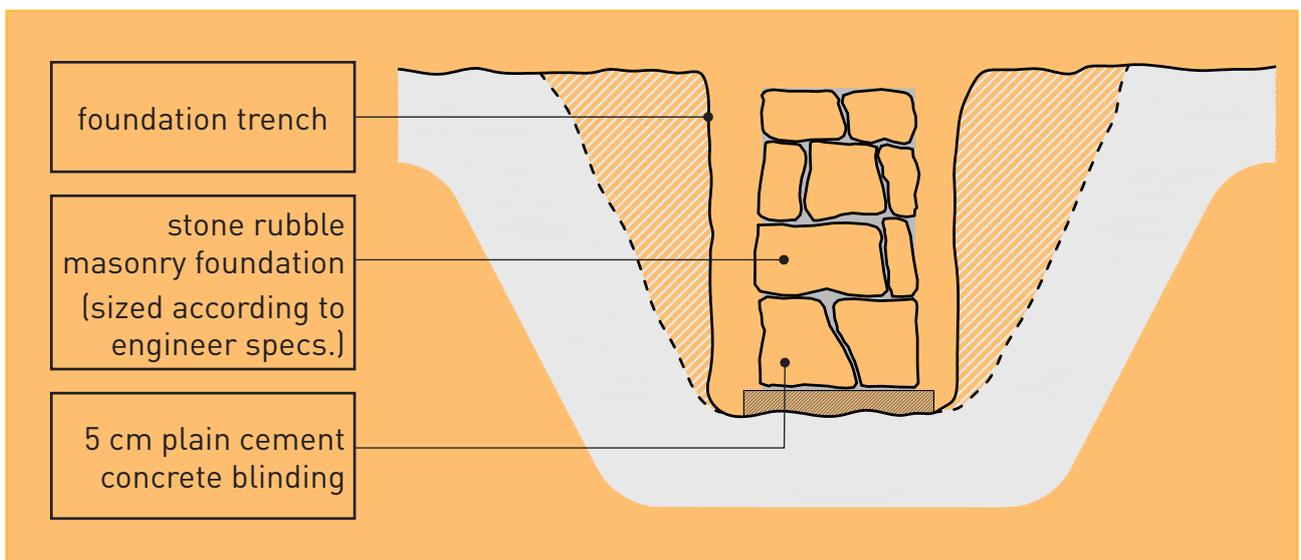
**C. Lay the stones:**

- Soak the stones in water before laying them.
- Overlap the joints as much as possible, avoiding straight vertical joints





Construction of a stone masonry foundation wall.



## C. GROUND TIE BEAM

### TEAM members involved



Masons



Unskilled workers



Steel Workers

### Construction tip

The vertical re-bars connecting the RLB masonry reinforcement to the ground beam below must be placed at precisely design locations as per structural details BEFORE basting the concrete of the ground beam.

### The Ground Tie Beam

The plinth or ground tie beam is made of reinforced concrete, cast on top of foundation wall, just above the ground level. It can be the width of the entire foundation wall or the width of the brick wall to be built on top of it. The plinth beam reinforces and ties the entire building together at the ground level.

#### A. Making the ground beam reinforcement cage

- Use the size of steel bar specified and space the stirrups at as per specifications.

#### B. The concrete / reinforced steel spacer

- This is a device that secures the reinforcing steel in place prior and during the pouring of concrete, it ensures the correct space is left between reinforcement and the edges of the poured beam. The concrete spacers are left in place after pouring the concrete to keep the steel reinforcement in place. They become a permanent part of the structure.

#### C. Making the ground beam formwork. Use straight plywood or timber planks.

- Tie the formwork on top with 60x40mm timber ties spaced at 0.6m intervals. This prevents the formwork from bulging out under concrete pressure.

#### D. Placing the concrete spacer

- Concrete spacers must be placed and spaced at 0.6m intervals throughout the formwork.

#### E. Casting the ground beam concrete

- Water the inside of the formwork before pouring concrete.
- Pour the concrete.
- Vibrate the concrete with a poker vibrator or compact it by using a metal rod and tapping the outside of the formwork with a hammer.



Examples of a plinth beam reinforcement cage.



Ground beam and vertical waiting re-bars.

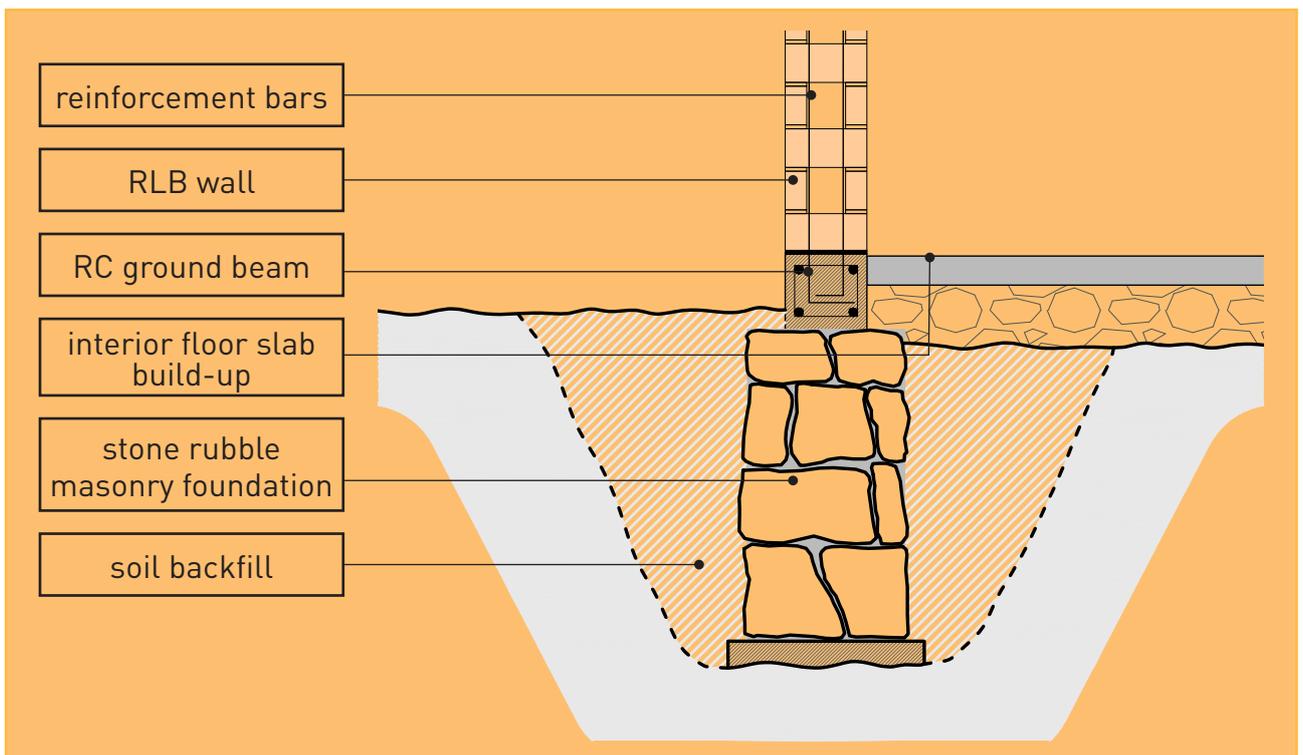


Concrete spacer to be used in all RC works.

Typical ground beam reinforcement.



Ground beam and stone masonry foundation before backfilling



# 05

## THE GROUND FLOOR

### TEAM members involved



Masons



Unskilled workers



Steel Workers

### Construction tip

Isolating the building from the ground damp through the careful and meticulous installation of a damp proof membrane is essential for both the comfort of the future users and for the duration of the building through the years.



The ground floor is made of four components, these are:

#### A. The sub floor:

The sub-floor is made of compacted and well-arranged hard, waterproof materials such as rubble stones or broken burnt bricks. The top, of the rubble stones or broken bricks, is sealed with gravel or appropriate soils such as laterite to blind the big gaps in between the stones.

#### B. A Damp Proof Membrane (DPM):

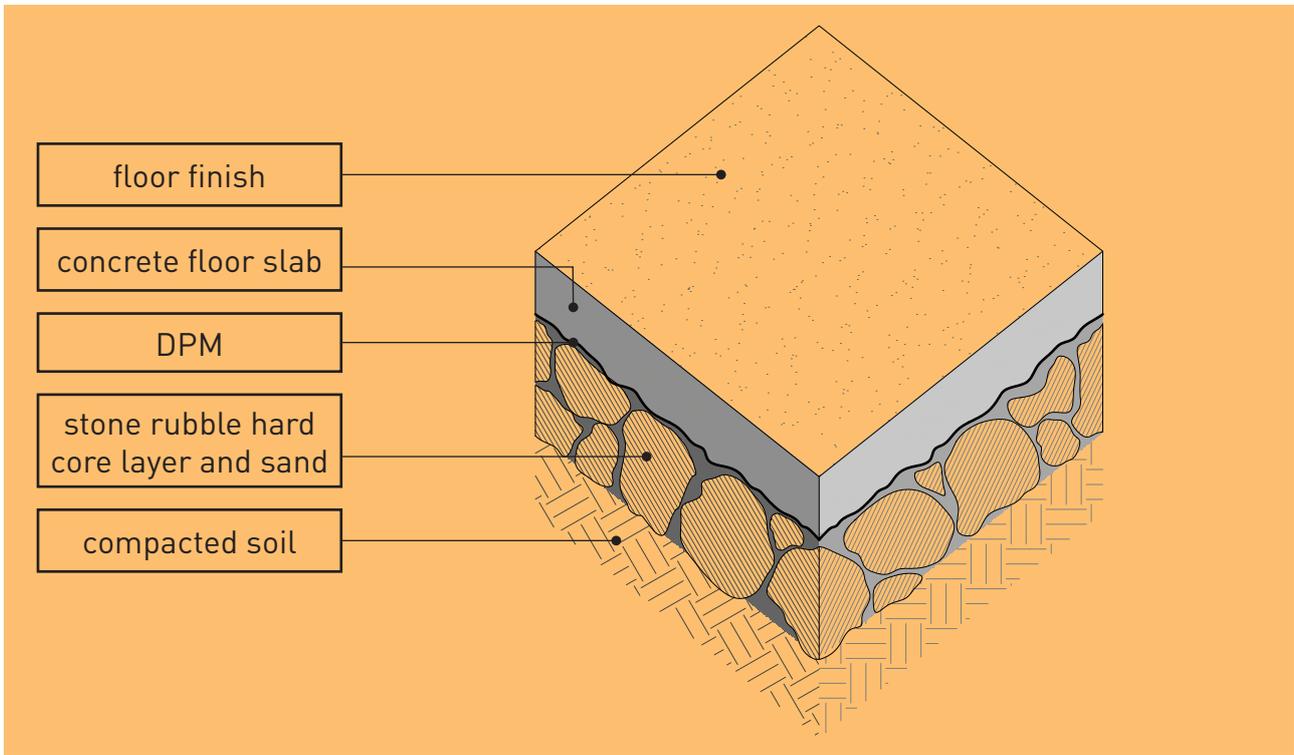
The DPM commonly used is heavy gauge polythene sheet. The DPM role is to prevent moisture rising through to the floor slab, making the house damp and damaging the floor finish.

#### C. Floor slab:

The floor slab is made from either plain or reinforced concrete. The thickness of the floor slab ranges from 50-200mm (2"-8") depending on the use of the floor or building. Domestic buildings can have a thin floor section of only 50mm (2") while factories or public buildings will have floor section of 100-200mm (4"-8") thick.

#### D. Floor finish:

The internal floor finish can be made from a smooth cement/sand screed, ceramic or PVC tiles. The internal floor finish is applied when the main construction of the entire building is complete.



Damp proof membrane laid over the hardcore layer



Above and below: concrete pouring and flattening activities



#### Procedure for laying the ground floor:

- Compact the soil, leveling and flattening the ground top.
- Arrange the rubble stones or broken burnt bricks tightly and level
- To form a firm, strong and stable under surface to receive the floor slab, this is the sub-floor. The thickness of the sub-floor compacted stones or broken burnt bricks is 150-200mm (6"-8").
- Seal the big gaps between the rubble stones with gravel or other approved sealing materials. This is known as blinding.
- Spread the heavy gauge polythene sheet on top of the sub-floor. This forms the Damp Proof Membrane (DPM) layer.
- Place the steel reinforcement mesh on top of the DPM if the floor slab is to be reinforced.
- Pour the concrete slab on top of the DPM as per thickness and concrete grade specified. For large floors, it's advisable to lay the slab in sections of 3Mx3M bays, creating expansion joints in between. This reduces shrinkage and eliminates the chances of having cracks on the floor later.
- Cure the concrete slab by watering it daily for a minimum of 14 days, or covering the concrete with sand to keep it damp for the 14 days.
- Apply the specified floor finish after the whole building is complete and there is no risk of damage due to construction works

# 06

## GENERAL BRICK WALL CONSTRUCTIONS

General guidelines to build any kind of brick wall.

### TEAM members involved



Masons



Unskilled workers

### Construction tip

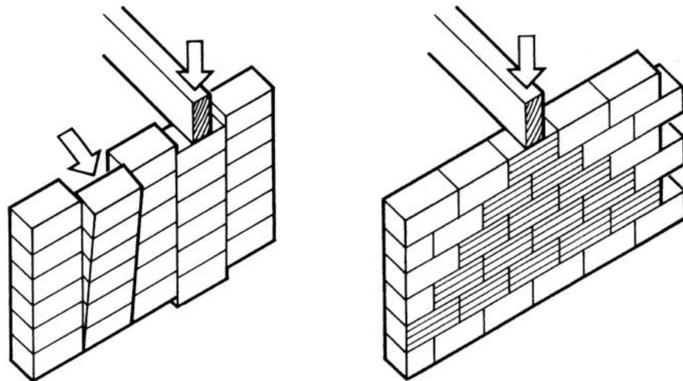
Start selecting bricks and separate them in different categories (i.e. regular, partially defected, discarded) already during the truck offloading activities in order to reduce time and further breakages by having to go through all the bricks again at a later stage.

### General guidelines to build any kind of brick wall.

This chapter describes in detail the key principles to be observed when building with bricks. The chapter covers the different types of brick bonds and the essential elements of bricklaying in mortar to conform to set standards in terms of strength and appearance. The strength of the wall depends on the quality of bricks, the bond, and the mortar used, while appearance is dependent on the quality of bricks and workmanship of the bricklayer. There are many rules for bricklaying depending on the brick bond used. The brick laying bonds commonly used are Stretcher, English, Flemish and the Row Lock Bond.

#### A. Bonding

Bonding is the arrangements of bricks in such a way that there are no vertical straight joint on the wall. This means that the bricks are laid in a staggered way that overlap joints with bricks below. An un-bonded wall with continuous vertical joints is weak and unstable.



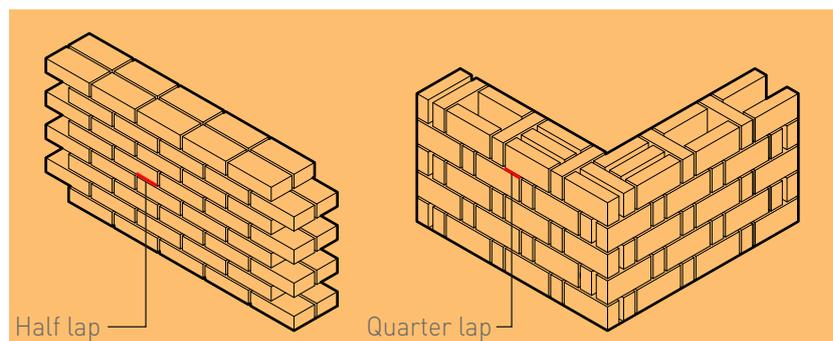
Un-bonded brick wall resulting in vertical straight joints that result in weak walls. Staggering bricks eliminates vertical straight joints and enhances uniform distribution of loads.

#### B. Brick overlap

The length of overlap between bricks is  $\frac{1}{2}$  or  $\frac{1}{4}$  the length of a brick. The minimum overlap allowed is  $\frac{1}{4}$  the length of the brick.

#### C. Rules for joints

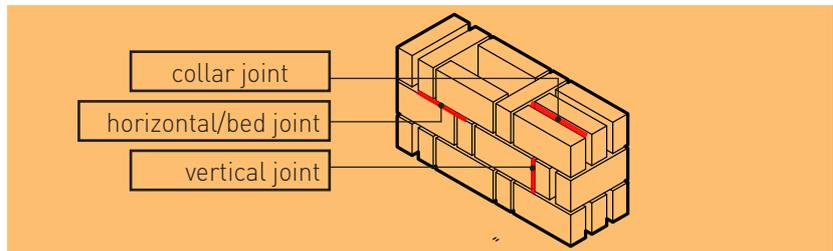
Basically, the mortar joints are the weakest and the most expensive part of the masonry wall. Therefore, care must be





taken to be as economical as possible with all type of joints so as not to make the masonry wall weak and expensive.

- Horizontal joints: horizontal joints are known as “bed joint”. The maximum thickness recommended in brick work is 10mm. If the horizontal joints are too thick (more than 10 mm) the result is a waste of expensive mortar as well as building a weak wall.
- Vertical joints: vertical joints refer to the cross and collar joints. The maximum thickness recommended is 10 mm. Care must be taken to ensure that the entire vertical joint is filled with mortar.
- Collar joints: collar joints are the internal mortar joints not visible from the out side and can vary in thickness according to the type of bond.



#### D. Selection of bricks

Once the bricks are delivered on the construction site, workers should take time to select and separate good bricks. Bad bricks are the ones with defects such as cracks, twists and other deformities, and over-burned. Only the good bricks (even in size, dimensions and color) should be used for main wall construction. Bricks with minor defects (small deformities and over-burned) can be used for hidden works such as sealing bottom courses before pouring concrete for sealed beams. Bricks with cracks should not be used.

Bricks with defects should not be used as facing bricks.  
Bricks with surface defects used for hidden works



#### E. Soaking bricks in water

Bricks should be soaked in water before laying them. This helps in a strong bonding between the brick and mortar. The bricks should be soaked in water for a minimum of 1-hour before laying them. Bricks laid dry will soak water from the mortar, resulting in poor bonding. Dipping the brick into a water bucket just before placing is not adequate as the brick may still absorb more water from mortar, resulting in a weak bond, cracking of the joints and weak walls.

The soaking of bricks is done for two reasons:

- to remove dust and dirt: the surface of the brick is always covered with dust, sometimes even dirt. If this dust or dirt is not removed, the bonding between the brick and the mortar will not be effective, hence the entire brick masonry wall will be weakened and development of

cracks will likely happen.

- to prevent the brick from seeping water from the mortar.

#### **F. Maximum height of brick wall to be built in a day**

The recommended maximum height of any brick wall to be laid in a day is 9 layers or courses. This is because the added weight by each new brick layer needs to be carried by the wet mortar below.

The mortar needs time to harden so as to be able to carry the 9 layers per day without developing cracks under the heavy load. These cracks usually cannot be seen, and will reduce the total strength of the brick wall.

In RLB, the recommended number of courses to be laid in a day is maximum 6 courses corresponding with the sealed beam course that is cast on every 6th course (explained later in this chapter).

#### **G. Curing**

A brick wall should be cured for 7 days minimum. Watering the wall 2-3 times in a day during 7 days does the curing. The walls are exposed to wind and sunshine and the water in the wall dries fast. This fast drying results in a weak wall due to the fast hydration of cement.

#### **H. Main type of brick bonds**

The most commonly use bonds for laying bricks are:

- **Stretcher bond:**

This is normally used for partition walls where a single brick, referred to ½ brick wall is used. The stretcher bond maintains a ½ lap bond.

- **English bond**

English bond is used for main load-bearing wall. It is laid in what is known as 1-brick thick wall, where the length side (Stretcher) of the brick, forms the thickness of the wall. The English bond alternates stretcher and header course, on every other course. A special half brick known as queen closer is used in the corners to create a ½ lap bond.

- **Flemish bond**

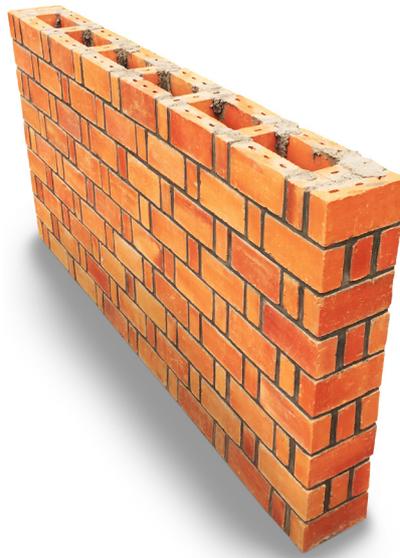
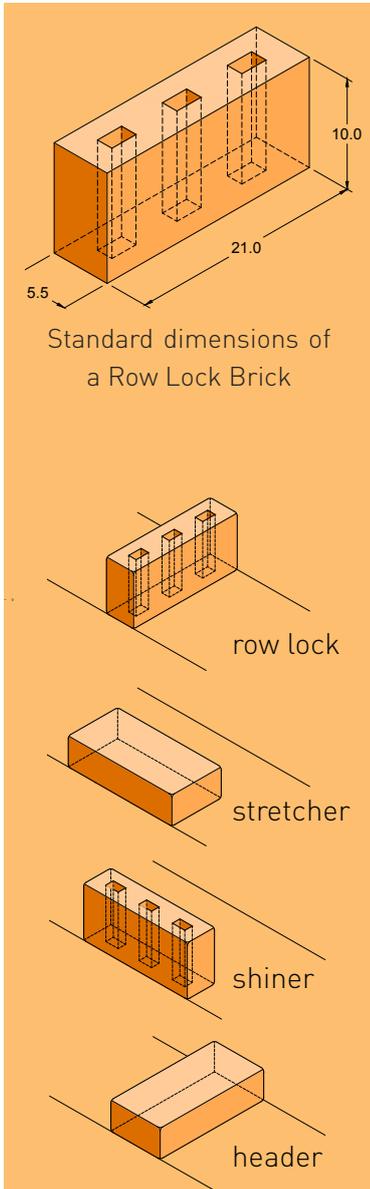
Flemish bond is a 1-brick thick wall, combining both header and stretcher on the same course. Flemish bond provides a decorative pattern of bricklaying. A queen closer is used at the corners to help maintain a ¼ lap bond.

- **Rowlock bond**

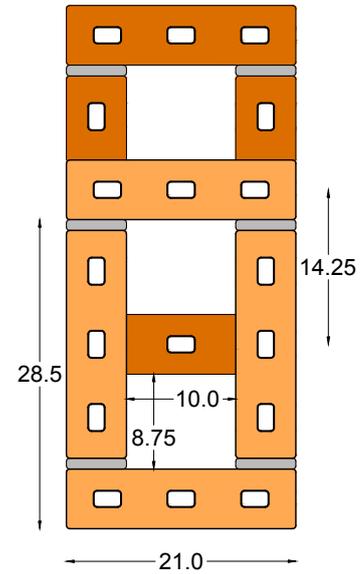
Rowlock bond is also known as the Rat-trap bond. It uses special bricks, normally used for facing. The Rowlock bond creates a cavity between the bricks. More details on how to build a Rowlock bond are covered separately.

## RLB WALL CONSTRUCTION

Specific guidelines to build a Row Lock Bond brick wall.



Example of a Row Lock Bond wall



Basic Row Lock Bond layout

Row Lock Bond (RLB) is a type of brick laying technique for the construction of walls. RLB is also known as the Rat-trap bond and it uses special bricks, normally used for facing brick masonry walls. In RLB, bricks are laid vertically, making visible both the shiner and row lock bricks, on both sides of the wall. By this laying process the walls have a cavity (gap) in the middle, improving the wall's thermal and sound proofing properties.

This cavity improves the wall thermal insulation and sound proofing properties as well as reducing the weight of the building. The stretcher faces of the brick appearing on both sides of the wall. The header face of the wall appearing on both sides of the wall. In RLB construction, the walls are not plastered but the joints are finished with key-pointing. This makes the wall cheaper in saving plastering costs.

### A. The RLB Brick Features

The brick is produced industrially or semi-industrially, therefore it comes in consistent dimensions. It is perforated to allow heat to reach the brick core during the firing process and guarantee and even firing temperature throughout the brick body. This results in a high and reliable compression strength of at least 10MPa.

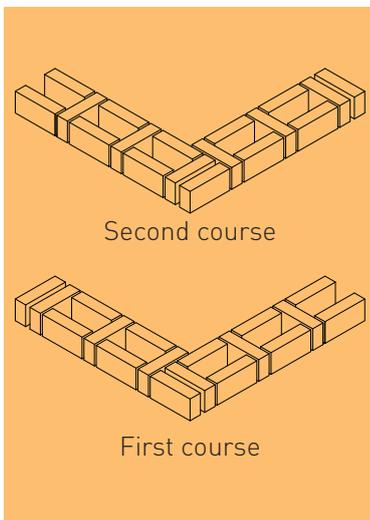
The standard size of a RLB brick is:

L (Length)210mm x W (Width)55mm x H (Height)=100mm

### B. Advantages of the RLB

The main advantages of using RLB for construction are:

- Cheaper than other bonds, as the RLB uses 35% fewer bricks compared to traditional brick bonds such as the English and Flemish bonds.
- Sound and thermal insulation. The cavity (gap) created in the middle improves the thermal properties of the

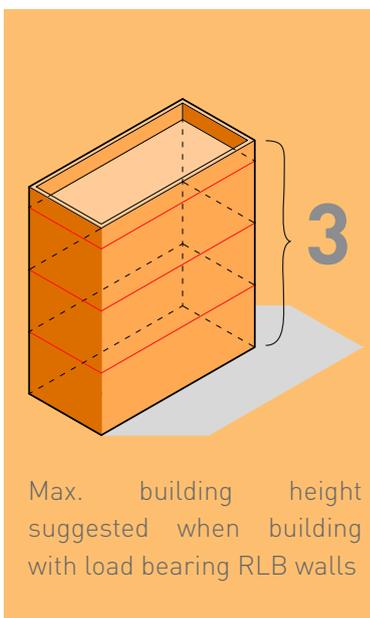


wall making it cooler in summer and warm in winter. The cavity also helps to sound proof the wall.

- Plastering can be avoided on both sides of the walls making further savings on the overall construction cost.
- The dead loads of the walls are reduced by 20%, hence cheaper and lighter foundations can be adopted.
- Concrete works for columns and beams can be concealed, with final finish of the wall being facing brick, which is also maintenance free.
- Saves the cost of formworks as the bricks serve as formwork when casting concrete for concealed beams and columns.
- Installation of vertical electrical conduits and plumbing works can easily be done during the wall construction, concealing them with brickwork.



Row Lock Bond masonry wall construction



### C. Disadvantages of the RLB

The main disadvantages of a RLB construction are:

- Only well-fired bricks of same size and without cracks can be used.
- Construction of RLB houses is limited to 3-story buildings, where the RLB walls are load bearing. However more stories can be built by using RLB as infill.
- Masonry strings must be used on both sides of the wall, to maintain proper alignment of the masonry.
- The first courses after the DPC, sill level, and lintel level, as well as the last/top courses must be built solid or closed. Bricks with surface defects can be used in the interior cavity for this purpose.
- Specially trained masons are required for good RLB construction. The bricklaying requires very high standard of workmanship so as to achieve a beautiful finish.



Mason verifying brick dimension



Row Lock Bond masonry wall construction

#### D. Guidelines when building with RLB

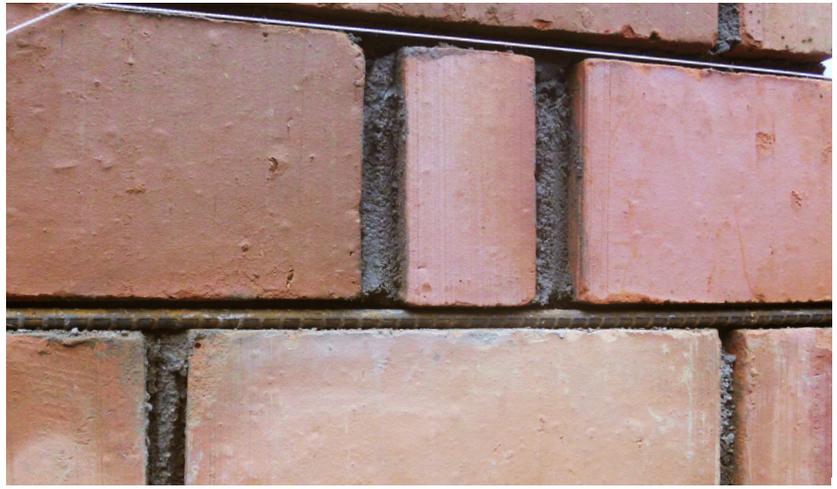
- **Building dimensions and brick module:** the total wall height must be divided into an appropriate number of brick courses in order to maintain a consistent 1cm high horizontal mortar joint thickness. Accordingly, the height and width of openings must be in multiples of the RLB course height and width to avoid unnecessary cutting of bricks.
- **Soaking bricks in water:** bricks must be cleaned and soaked in water before laying them. This enables create a good bond between bricks and the cement mortar.
- **Solid courses:** the first course after DPC, sill level, lintel level and the last course of the building must be built solid. Courses at sill and lintel level are made solid by casting a concealed concrete beam.
- **Bricks alignment on both sides:** when bricklaying, masonry strings must be used on both sides of the wall, to maintain proper alignment of bricks.. All joints are to be maintained at 10mm maximum.
- **Joints thickness:** uniform joints of 10mm both vertically and horizontally must be

Soild first RBL brick course



Re-bar used as gauge to control the joint thickness and alignment strings





Re-bar used as gauge to control the joint thickness

maintained. This is achieved using 10mm steel rods to gauge the joints.

- **Defective bricks:** defective bricks should be used where the side with defects is hidden, such as the bottom of the concealed beam.
- **Concrete mix:** a concrete mix of 1:1.5:3 is poured in the column holes and every 6th course, creating a stable concealed corner column.
- **Keeping the bricks clean:** the bricks should be cleaned immediately there is cement paste on them. Use clean water. Where the cement stain cannot be removed by water, vinegar added to water removes such stains.

Mpazi project built with RLB walling technology



## TESTING THE RLB LAYOUT

Dry test the first two brick courses to verify dimensions and layout.

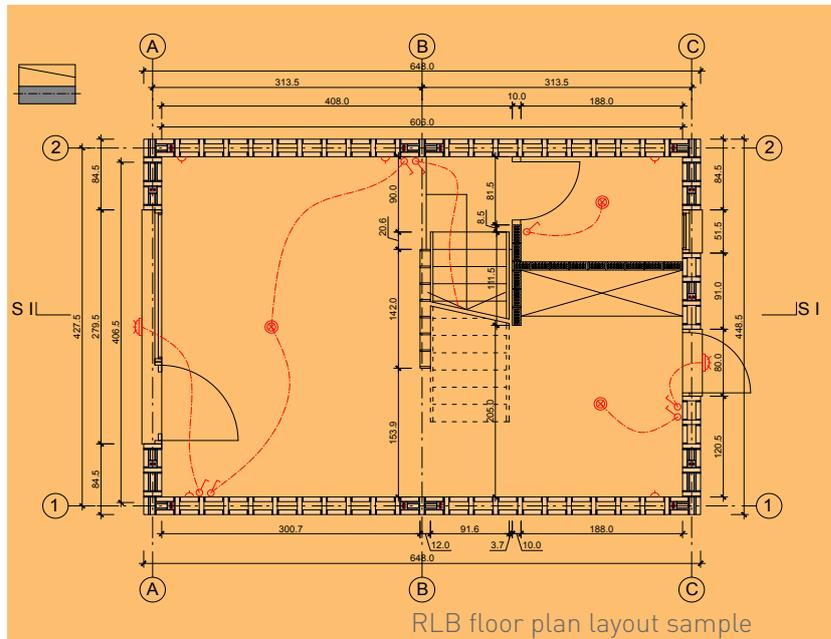
### TEAM members involved



Masons

### Construction tip

The RLB uses a repeated pattern with consistent dimensions. Follow carefully the supplied architectural or structural drawings to lay out the first rows of bricks by counting them and visually compare the layout to the drawings. If the procedure is followed correctly you won't even need a meter tape.

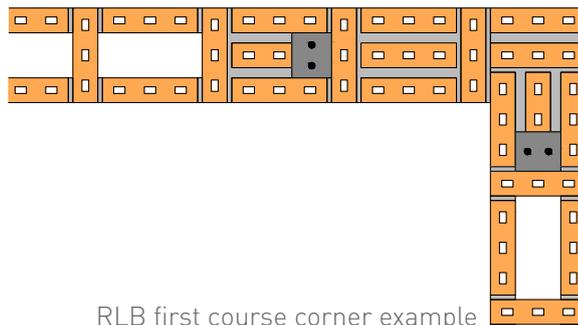


RLB floor plan layout sample

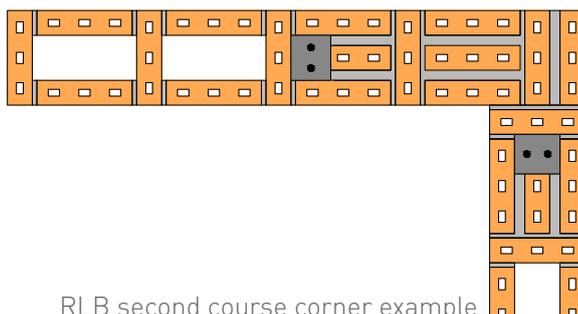
### Testing the RLB arrangement

When building with RLB, an initial test of the bond arrangement should take place. The 1st and 2nd courses will be dry-stacked (laid out without mortar), leaving 1cm vertical joints between the bricks. This test will help in working out where doors and window openings will be so that adjustments can be made if necessary in order to avoid unnecessary cutting of bricks.

Once this is done accurately, and the position of the brick has been recorded, masons can restart placing the first two courses with mortar and it will be easy to build the rest of the wall as all other courses are replicas of the first two courses.



RLB first course corner example



RLB second course corner example



A supervision team verifying the RLB first course layout

Dry stack of a RLB wall sample



First RLB course construction



## REINFORCED CON- CRETE FRAME

The embedded anti-seismic frame bracing the RLB masonry.

### TEAM members involved



Masons



Unskilled workers



Steel Workers

### Construction tip

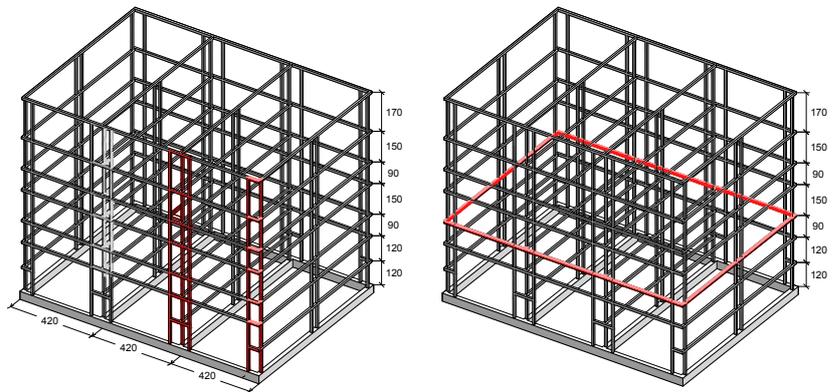
Always keep the cavities sealed with some pieces of leftover paper or fabric in order to prevent debris and mortar to fall inside and occlude them during the construction of the walls elevations.

### Reinforced concrete elements.

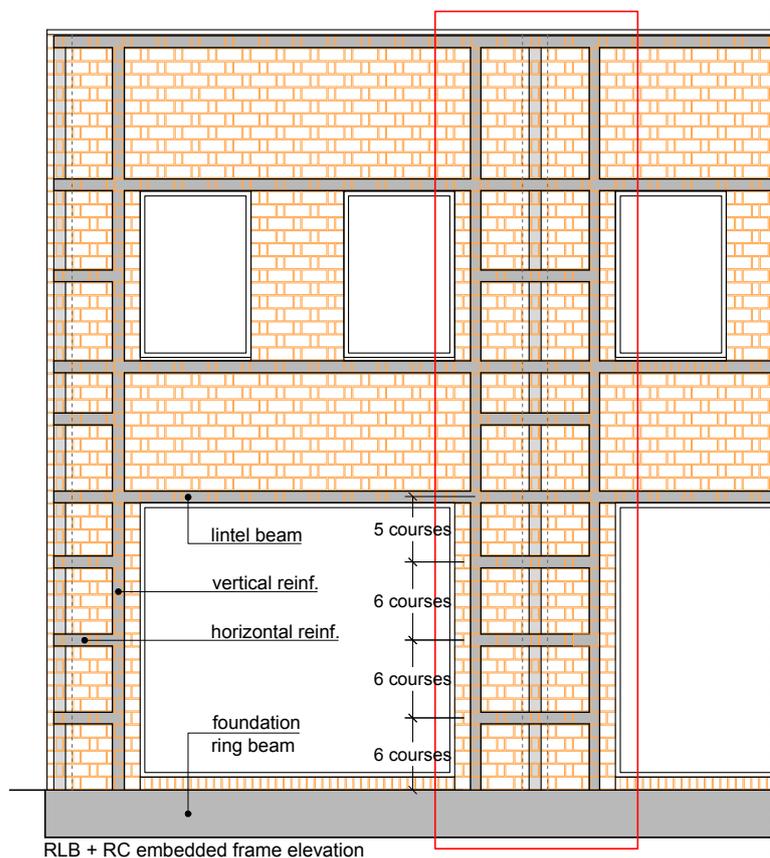
In order to make the brick masonry earthquake resistant, a concrete frame is built and concealed within the masonry. The quantity, size and location of the vertical and horizontal reinforcement must be calculated and designed by a certified engineer.

The basic structural and earthquake principles will be covered in the following chapters.

Vertical steel reinforcements are inserted at the corners, at the walls intersection and junctions to reinforce the walls connection. These RC elements connect with the horizontal tie beams. Reinforced concrete horizontal beams, or tie beams, are cast at crucial sections of the wall. They are



RLB embedded RC frame - the intersection/corner/horizontal reinforcement elements.





Rebars protruding from the ground beam and the RLB masonry

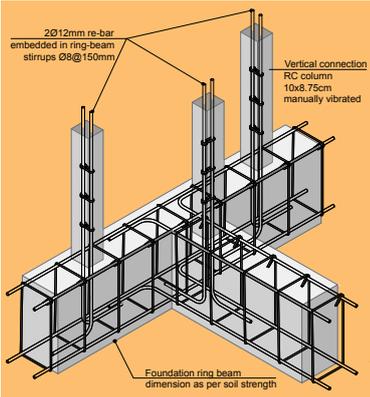


Diagram of the RC columns to ground beam connection



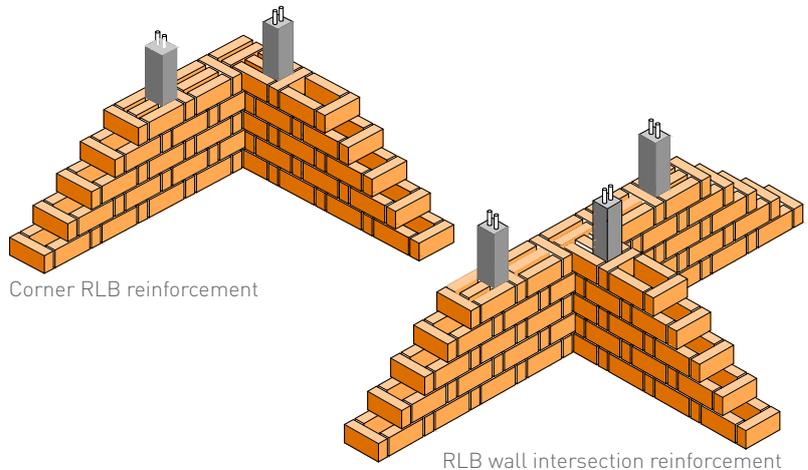
placed every 6 courses and at sills, lintels and at the last course before the roof. These tie beams are concealed in the wall as the reinforced concrete is poured in the gap created between the outside and the inside brick layers of the wall.

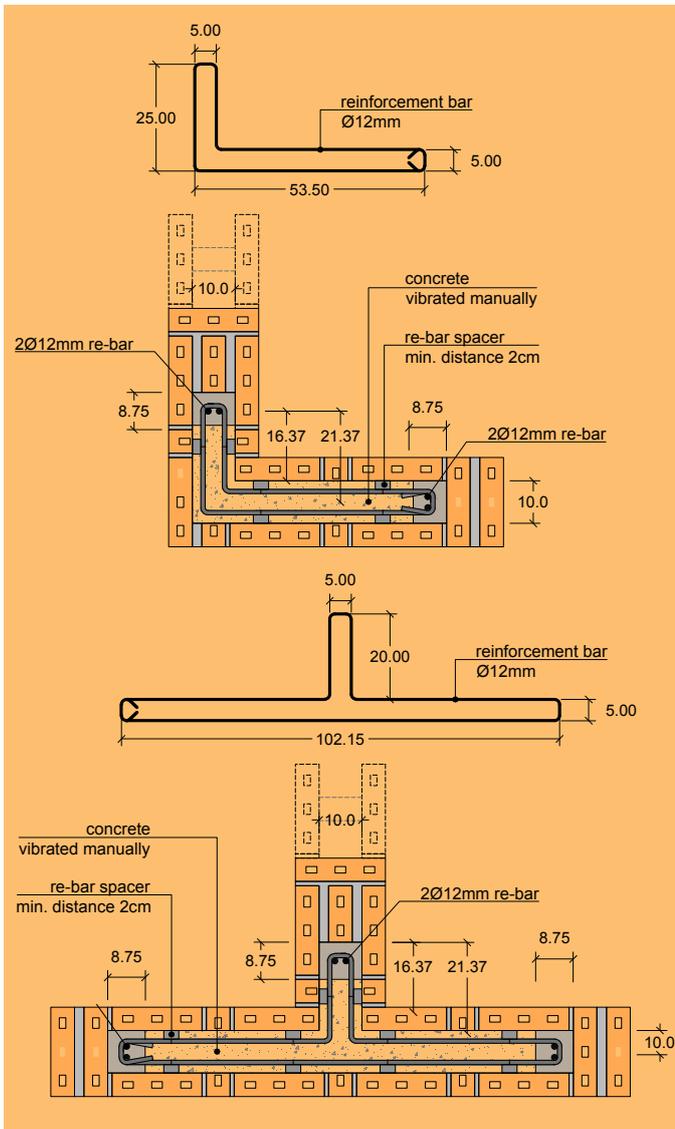
**A. Corner columns and Wall intersection columns:**

In every corner and wall intersection, two steel bars per column are placed as shown below to stabilize the corner and create RC columns.

Typically, corners are reinforced with two columns, while intersections are reinforced with three columns:

- The diameters of the re-bars varies between 10 and 14mm.
- The vertical steel bars are connected with a 6-8mm stirrup as shown below, on every 6th course where they will be connected with the hidden tie beam in RC.
- A concrete mix of 1:1,5:3 is poured in the column holes and every 6th course, creating a stable concealed corner column.
- The concrete is poured at intervals of 5 courses, within the cavity left for that purpose and it is compacted by hand with a metal rod.
- The 6th course is reserved to the horizontal reinforcement tie.





## B. RC reinforcement tie beams

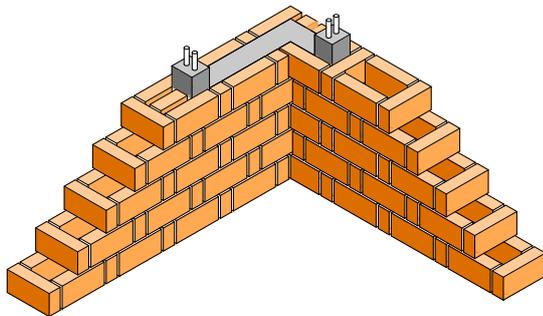
These beams are built at the corners, wall intersections and within long single walls. They can be found every six brick courses (unless otherwise specified by the structural engineers).

The width and depth of the tie beam is equivalent to the RLB cavity (10x11cm). Two steel bars tied with stirrups (spaced every 200mm) are used to reinforce the tie beams.

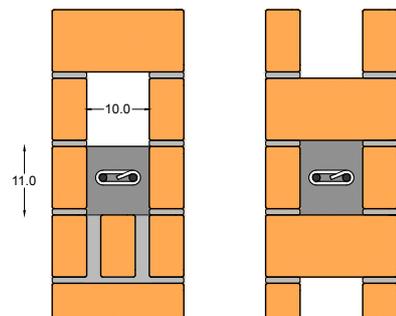
Before casting the concealed beam, the last course should be sealed with bricks that have surface defects to form the base of the beam.

Bricks are then laid both internally and externally to form the channel and tie beam formwork.

The steel reinforcement is then placed as per the specifications. The concrete is poured and compacted manually, forming the concealed beam. The concrete mix is 1:1.5:3. The compaction and vibration should be carried out by hand, to prevent damaging the brick wall.



Corner RC tie beam



Wall section sample at the lintel level



Corner reinforcement bars connecting with the columns.

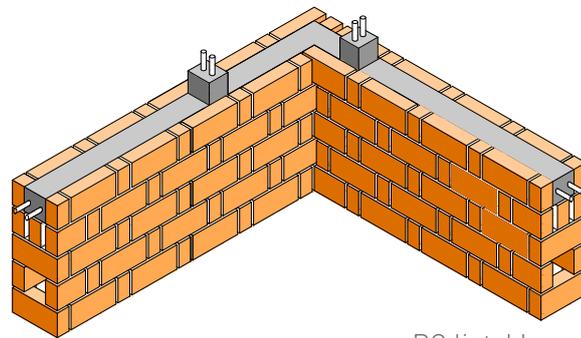


Corner reinforced concrete tie beam



## CONSTRUCTION TIPS

- fill the RLB cavities below the Lintel or Tie beams course with with discarded bricks and mortar to create a flat surface where to pour the concrete
- wait for the mortar of the bricks forming the “in-built formwork” to dry for at least one day before pouring the concrete
- compact and vibrate the poured concrete manually with a timber or metallic rod, in order to prevent the “in-built formwork” bricks to displace.



RC lintel beam

### C. Lintel beams

A concealed reinforced concrete tie beam that ties the entire building and serves also as lintel for the openings. It is built every 12 courses and at every floor level. Before casting the concealed beam, the last course should be sealed with bricks that have surface defects to form the base of the beam.

The next RLB course is then built to form a channel (U-shape) where the concrete will be poured to form the lintel beam. In this course, all the Row Lock (header) bricks are cut to 55mm so that they only act as face bricks on both sides of the wall, forming the channel formwork for the lintel beam.

The lintel beam base over doors or window openings is formed by setting a timber base supported by wooden props. Steel reinforcement is then placed within the cavity as per specifications provided. Concrete spacers are placed at the bottom of the steel reinforcement.

The concrete is poured and compacted manually, forming the concealed beam. The concrete mix is 1:1.5:3. The compaction and vibration should be carried out by hand, to prevent damaging the brick wall.

# 07

## WINDOWS AND DOORS

Installation and details

### TEAM members involved



Steel  
Workers



Masons

### Construction tip

Make sure that the anchoring brackets are welded along the metal frame in correspondence to the brick that has been removed to allow for their installation.



A typical RLB masonry elevation with doors and windows of different sizes

Door lintel beam supported by scaffolding before concrete is cast

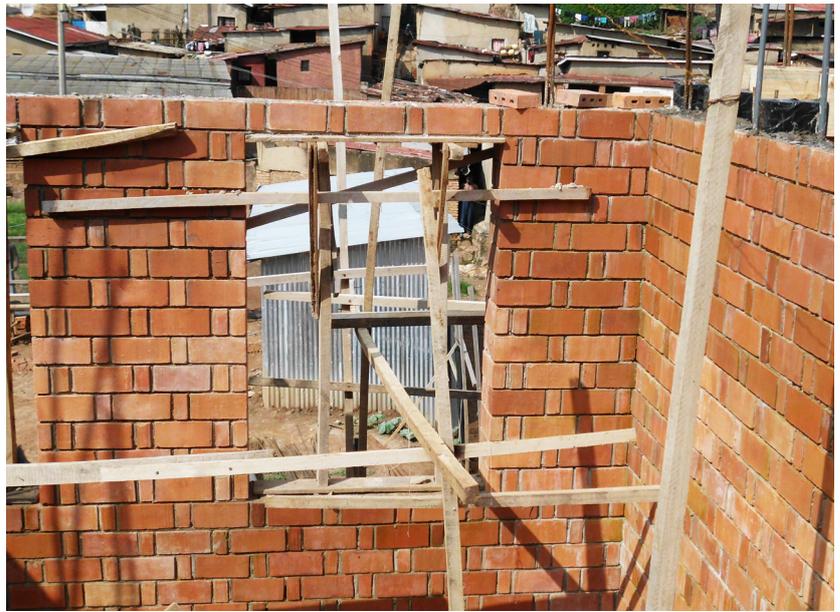


Doors and window frames are generally manufactured in metal workshops or any other production facility that is able to follow the specifications supplied by the project team. These elements follow the dimensions dictated by the Row Lock Bond masonry pattern, both in width and height, while the material and finishing level is instead related to the available construction budget.

Doors and windows are best fixed as the wall construction progresses, by embedding the frames brackets within the masonry in a seamless way. Fixing the frames after the walls have already been built necessitates the breaking of the brick wall, weakening the corner and requiring repair works to re-establish a fair finish of the wall.



RLB wall side before a door installation



Doors and windows manufactured in a metal workshop



Several openings on the main elevation of a RLB building

Frame bracket positioned within the brick wall pattern



Masonry completed and pointed



# 08

## PLUMBING AND ELECTRICAL INSTALLATIONS

MEP systems and their interaction with the RLB masonry system

### TEAM members involved



Electricians



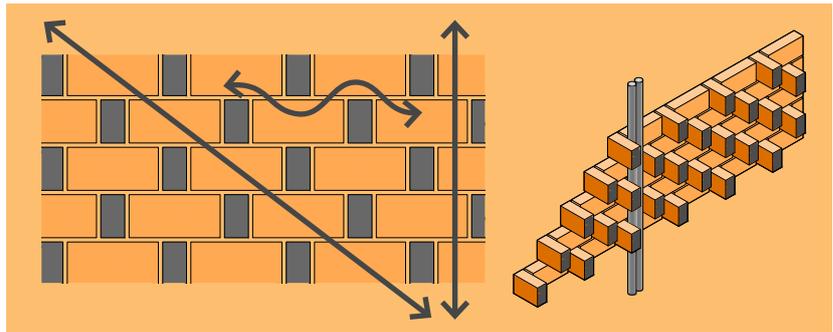
Plumbers

### Construction tip

Retrofittings are not possible once the lintels are cast. Therefore always allow for multiple electrical provisions through the horizontal RC elements for future alterations of the services systems.



An electrician installing a light switch on a RLB masonry wall



RLB construction has the advantage of using the cavities created within the wall to insert pipes for plumbing works and electrical conduits, without raking or chiseling the brickwork.

Proper planning of the Electrical and Plumbing systems and drafting of their layouts should be carried out at the design stage and then carefully implemented at the construction stage. Placeholders should be inserted within the horizontal RC tie beams crossing the path of the conduits and pipes to facilitate their installation without having to brake these structural elements at a later stage and compromise the structural integrity of the building.

Electrical junction/distribution boxes, switches and sockets as well as plumbing faucets and waste water outlets should be positioned during the masonry construction according to the plans provided on site, although alterations and adaptations within each floor level are easily conducted by exploiting the masonry cavities.



Sockets and switches installed on a RLB masonry wall



An electrician working on conduits installation within the RLB cavities



Electrical conduits and cables routed through the RLB cavities

Mix of regular and RLB masonries and the different MEP integration solutions



The picture on the right demonstrate how easy and convenient is to fit plumbing or electrical systems within the RLB masonry cavity in comparison to a traditional brick masonry, where chiseling and braking is required.

# 09

## TIMBER FLOOR

A lightweight and cost effective suspended flooring solution.

### TEAM members involved



Carpenters



Masons



Unskilled workers

### Construction tip

The contractor should purchase and store the timber in a well ventilated area during the first phases of the construction process, in order to allow for extra drying time in case the wood has been harvested and cut recently.

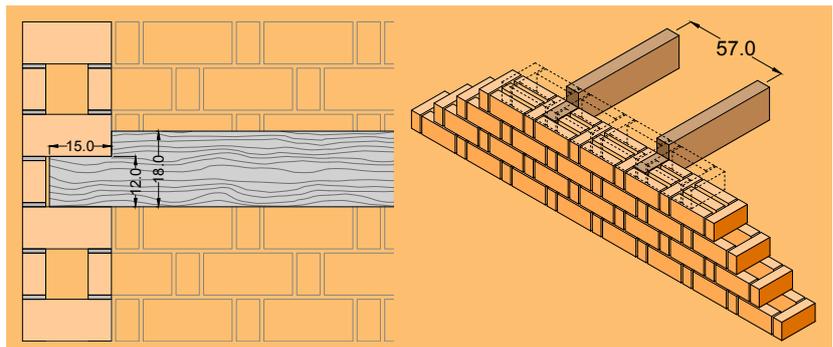
**Upper floors** in multi-story buildings are suspended floors; sometimes these are used in single story buildings, just above the ground level when separation is needed from the ground. Suspended floors can be made amongst other materials from timber and reinforced concrete.

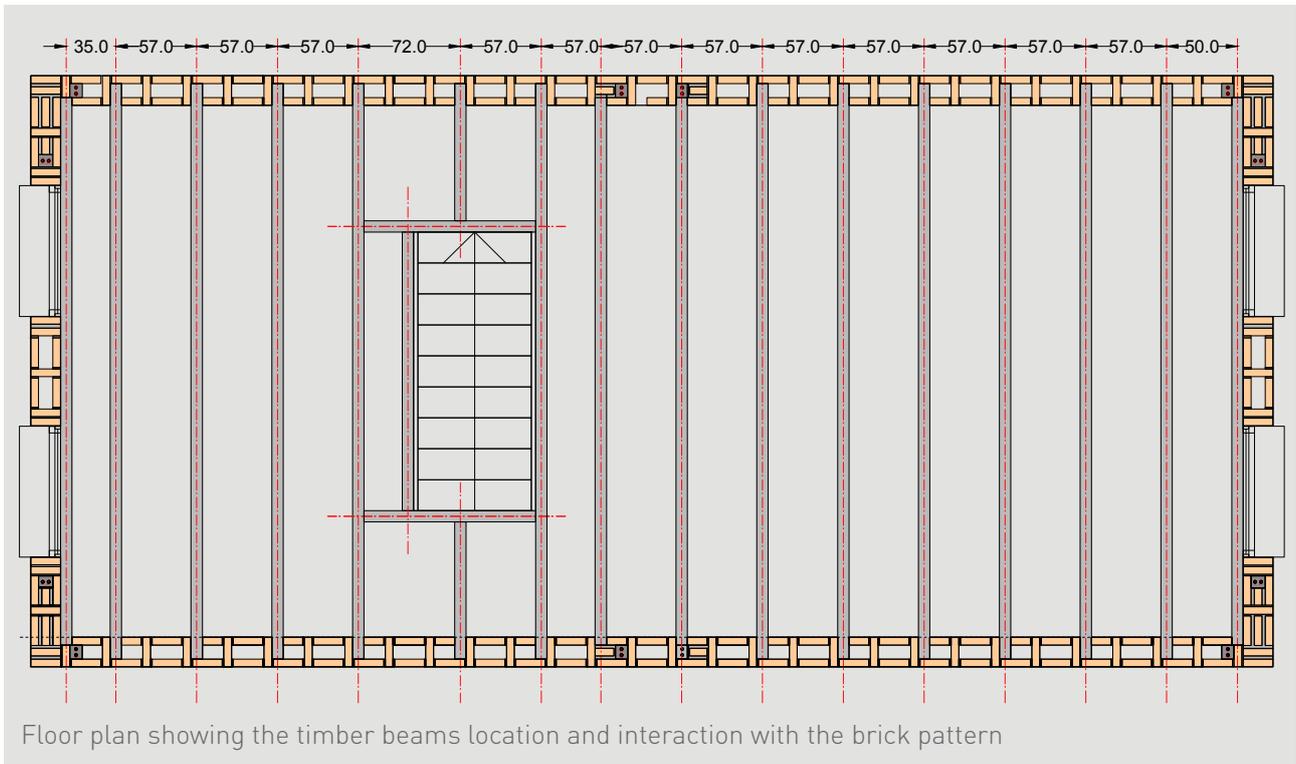
### A. Components of a timber suspended floor

- Beams: these are timber of various section sizes spanning between the two supporting walls. The beam size and spacing is determined by the thickness of the floor planks to be used, the span between the two supporting walls and the pattern of the Row Lock Bond. Unless otherwise specified by the engineer, the following guidelines should be followed:
  - As much as possible, full size beams without joints should be used. Where joints must be used, the engineer should guide on the type of joint to use.
  - The minimum section size of timber that can be used for hardwood timber beams of 4-meter spans is 15cmx5cm.



Timber beams being sanded and treated before the installation





Waterproofed beam head



Detail view of the timber beam and RLB wall connection.

### Construction tip

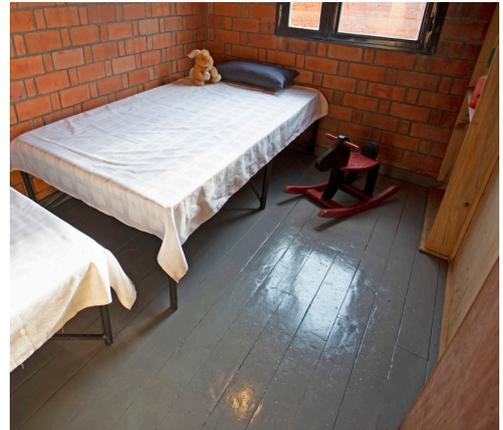
It is good practice to wrap the timber beams with polythene sheet to protect them from damage, dust and rain during construction. The timber beams must be dry and pre-treated against termites and bugs before installing and wrapping them, in order to prevent fungus and mold from forming underneath the PVC sheets.



- Floor planks: these are timber boards with tongue & groove (T&G) joints. The planks should be minimum 25mm (1") thick, well dried and pre-treated for fungus and termites. Once installed, they can be either varnished or painted in order to increase the durability and match the level of finishing of the project.



A suspended Pinus beams and Pinus T&G planks floor



Varnished floor planks

### **B. The process of making timber floors with beams and floor planks is as follows**

- The timber floor beams or joists are placed on top of the concrete tie beam concealed within the RLB wall. The timber beam spans from wall to opposite wall covering the whole span of the room to be covered. The space between any two supporting walls can vary according to the maximum length and structural section of timber beams available on the market (generally speaking between 3,5 and 4,5m).
- The timber beam heads should be wrapped with a water resistant layer to protect them from the wall damp during the construction.
- The spacing of the timber beams is determined by the timber structural section sizes specified by the engineer and the availability of timber, and in any case the maximum spacing should not exceed 60cm. The timber beams must always rest on the Shiner brick and not the Row Lock, this will condition their spacing.
- Once the timber beams are placed on top of the tie beam, brick laying will proceed up to the roof or next suspended floor.
- The timber planks that form the floor walkable surface are fixed to the beams once the roof protects the building from the rain. The floor planks are fixed with nails or screws to the beams from one end of the room to the other. If using the T&G (Tongue & Groove), the boards must be tightly fitted by using clamps during the installation.

Below and right: T&G floor being installed





Above and below: examples of suspended timber floor in a RLB built project in Bukavu



# 10

## MAXSPAN SLAB

The IN SITU and PRECAST semi-dry suspended concrete floor solutions.

### TEAM members involved



Steel Workers



Masons



Unskilled workers

### Construction tip

Always fit a piece of pvc sheet (same as the DPM) between the in-situ ribs reinforcement and the bottom formwork to allow for an easy detachment of the last once the concrete has cured.



MAXSPAN block

The MAXSPAN technology combines a fired clay block and reinforced concrete to create a semi-dry suspended slab. The clay blocks, or MAXSPAN blocks (or pots) are light and with a very open structure. They are used to reduce the overall weight of the slab (in comparison to a solid reinforced concrete slab) by filling the space between the structural beams (or ribs) with air. It is an effective and fast solution to cover a floor span at a lower cost than solid RC. There are two typologies of MAXSPAN slab: the in-situ version and the pre-cast version, that we will discover in detail in the following chapters.

### MAXSPAN TECHNOLOGY MAJOR ADVANTAGES:

- Weight reduction by removing parts of solid concrete and replacing it with hollow blocks
- Suitable for medium spans 4/5m with moderate life load (mainly residential)
- Cheaper than a solid RCC slab (for spans between 4 and 5 meters)
- Good sound proofing and excellent fire resistance

#### A. Precast beams Maxspan

- Beams need to be cast 28 days in advance.
- Uses minimal formwork support.
- Reduces construction time
- Requires high precision when casting and placing beams.
- Requires significant manpower to hoist the beams to the floor level

#### B. Cast in-situ Maxspan

- Requires sizeable formwork support.
- Can accommodate irregularities in brick laying.
- Increases construction time.
- Concrete poured is of uniform strength and age.
- No need to hoist the beams to higher floors

# IN-SITU MAXSPAN SLAB



In-situ Maxspan in the works

## A. Components of an in-situ Maxspan concrete floor:

- Slab ribs (in-built beams) reinforcement properly tied to the ring beam waiting bars.
- Maxspan blocks as per specified size placed in between the ribs.
- Steel reinforcement mesh placed on top of the Maxspan bricks, once the ribs and Maxspan blocks are placed in position.
- A concrete layer of minimum 40mm cast on top of the Maxspan blocks and inside the ribs to complete the slab structure.

## B. The process of making an in-situ concrete floor using Maxspan blocks is as follows:

- Place the scaffold and formwork support for the slab.
- Bend the ribs re-bars to the specified shape and length and place them over the formwork respecting the spacing and anchoring requirements indicated by the structural engineer.
- Lay down the Maxspan blocks in between the ribs, accurately aligning them to the inside face of the walls underneath.
- Place the top steel mesh (dimensions as per structural design) and tie it to the ribs reinforcement. Use spacers to maintain a minimum gap of 2cm between the Maxspan blocks and the mesh.
- Pour concrete over the entire construction, forming the ribs and top screed at the same time.
- Apply the required level of finishing to the slab to concrete surface (rough finish to bond to further finishing layers or polished for final use).

In-situ Maxspan rib reinforcements positioned over the formwork



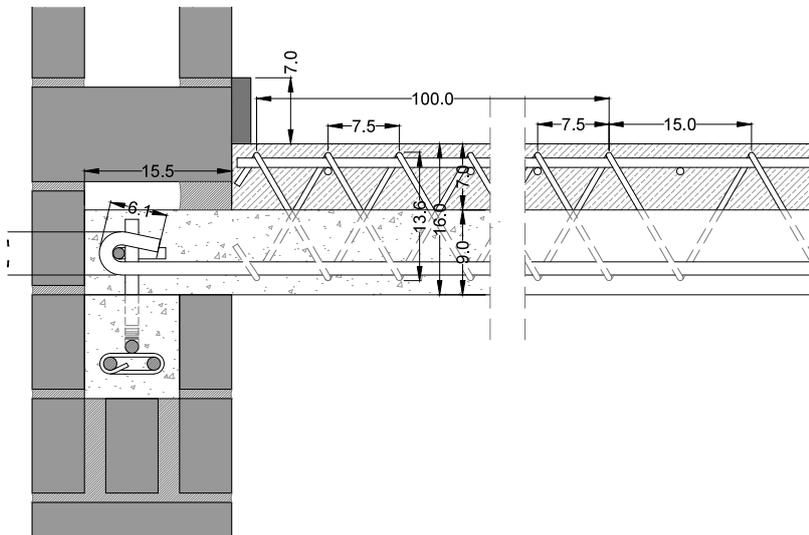
Detail of the in-situ Maxspan ribs reinforcement and blocks



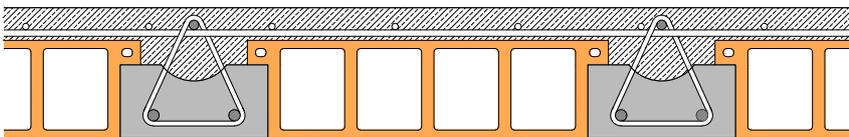
# PRE-CAST MAXSPAN SLAB

## A. Components of a pre-cast Maxspan concrete floor:

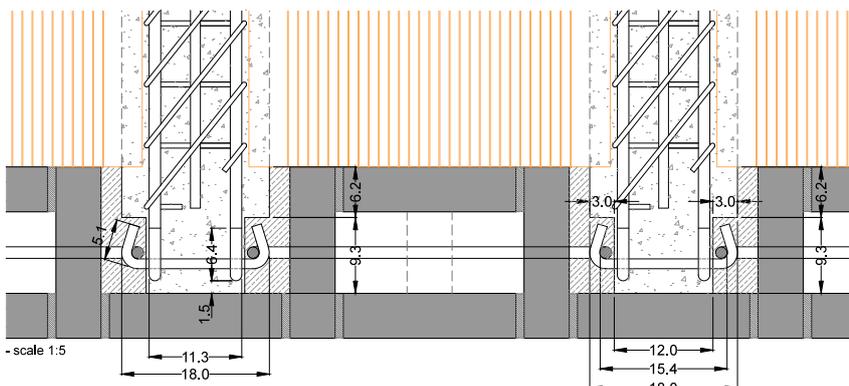
- The peculiarity of this technology is the presence of pre-cast beams (or ribs) that are built on site at the feet of the building with reusable steel molds. This allows for consistent beam sizes, the quality is controlled and guaranteed by the in-situ production, there is no need to transport the beams with motorized vehicles, and one beam can be hoisted to the floor level by a team of 4/6 workers.
- The beams are shaped to allow for an easy and effective structural connection with the tie beam that they are sitting on. Two waiting re-bars, previously embedded in the tie beam concrete, engage with the ribs ends to form a solid bond.
- The beams must cure for at least 28 days before being used. Therefore the construction team casts them well in advance (normally while the foundations are being built) before they are capable of withstanding the slab loads.



Longitudinal section of a pre-cast Maxspan slab and RLB wall



Cross section of a pre-cast Maxspan slab



Detail plan of the pre-cast beams connection with the lintel beam waiting bars



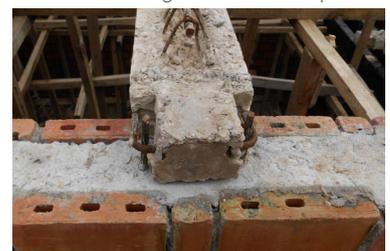
Tie beam waiting bars detail



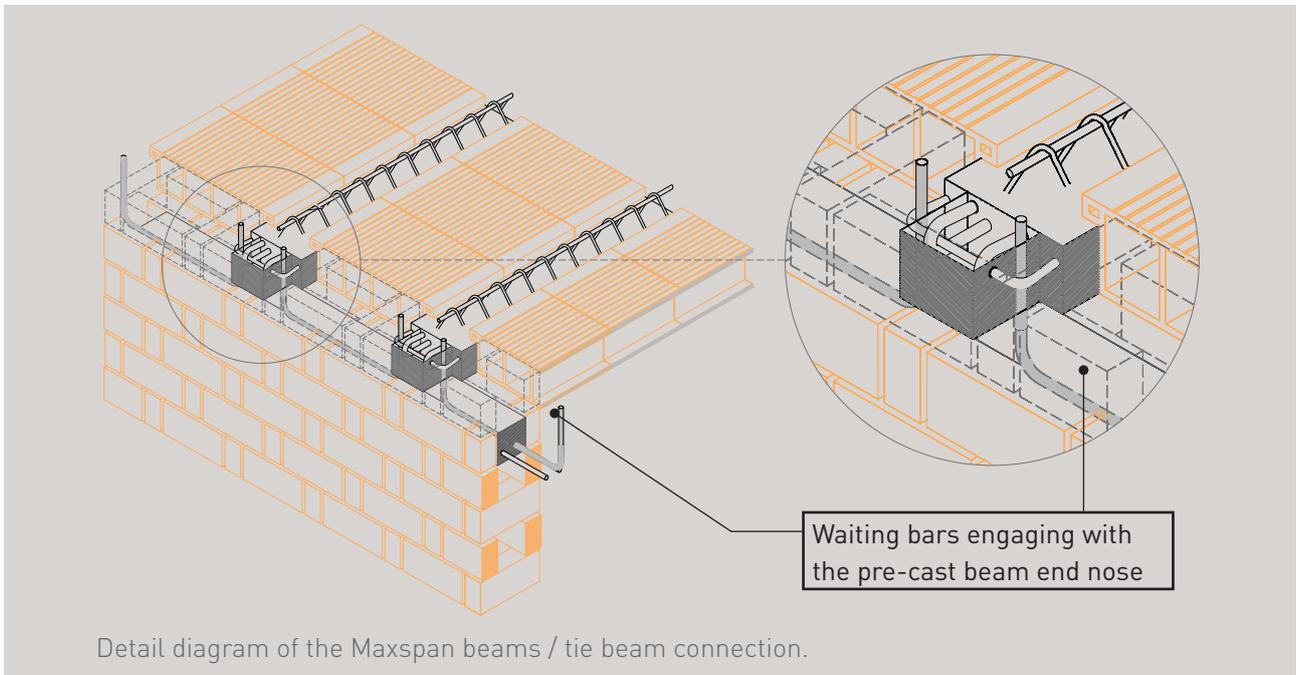
Pre-cast beam nose end detail



2cm high concrete spacer



Maxspan/tie beam connection detail



Maxspan ribs formworks



Maxspan ribs curing on site



Maxspan rib being hoisted to position



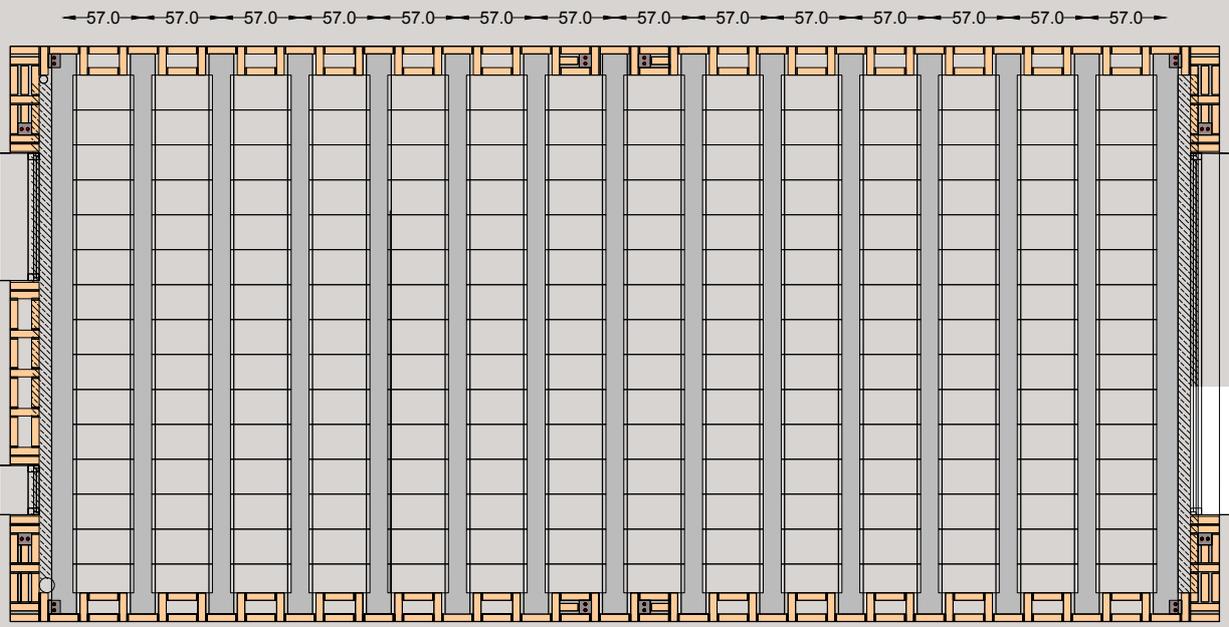
Maxspan blocks placed in-between ribs

#### A. Components of a pre-cast Maxspan concrete floor:

- Pre-cast reinforced concrete beams (ribs) spanning from wall to wall and properly tied to the ring beam waiting bars.
- Maxspan blocks as per specified size placed in between the ribs.
- Steel reinforcement mesh placed on top of the Maxspan bricks, once the ribs and Maxspan blocks are placed in position.
- A concrete layer of minimum 40mm cast on top of the Maxspan blocks and inside the ribs to complete the slab structure.

#### B. The process of making a suspended pre-cast concrete floor using Maxspan blocks is as follows:

- Place the scaffold and formwork support for the slab.
- Manufacture the pre-cast reinforced concrete beams following the specifications provided by the structural engineer. Make sure that the beams have been curing from at least 28 days.
- Once the walls reach the correct height, hoist the beams to the suspended floor level and place them over the waiting bar to make sure that the structural connection tie beam/rib is ensured.
- Lay down the Maxspan blocks in between the ribs.
- Place the top steel mesh (dimensions as per structural design) and tie it to the ribs reinforcement. Use spacers to maintain a minimum gap of 2cm between the Maxspan blocks and the mesh.
- Pour concrete over the entire construction, forming the ribs and top screed at the same time.
- Apply the required level of finishing to the slab to concrete surface (rough finish to bond to further finishing layers or polished for final use).



Floor plan showing the Maxspan pre-cast beams location and interaction with the brick pattern



↑ Maxspan blocks placed in-between ribs



Top concrete layer casting and vibration ↗

Top screed finishing works →



↓ Maxspan blocks placed in-between ribs



Concrete layer wire mesh reinforcement

Maxspan bare slab underside

Maxspan plastered slab underside



# 11

## PARTITION WALLS

Masonry or timber interior partition walls

### TEAM members involved



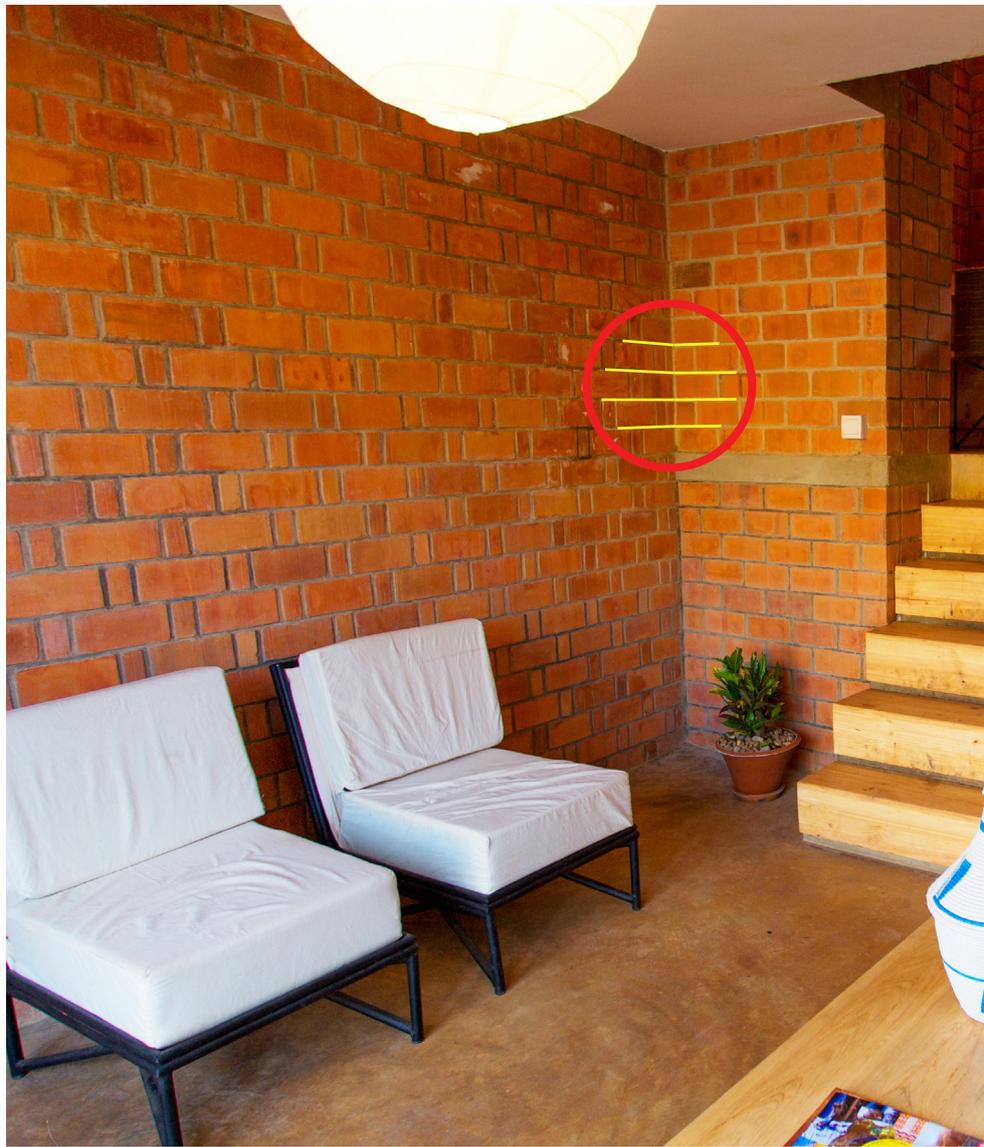
Masons



Carpenters

### Construction tip

To avoid delays in the construction of the interior partition walls, the contractor should place an order for the 10x10x21cm size bricks at the same time as the regular RLB bricks and store them on site.



Interior 10x10x21cm brick partition wall (right) matching the RLB wall (left)

Partition walls are used to sub-divide or separate interior spaces into different rooms. They can be built using 10cm or 5,5cm wide brick masonry walls or timber partitions. The material used is determined by the client or architect according to the requirements of sturdiness, soundproofing, privacy and budget.

#### A. Brick partition walls

These should be used in all wet areas such as bathrooms or kitchens, and in partitions between apartments.

The brick masonry partition walls should be built with 10x10 x21cm bricks in order to match the regular RLB masonry row height or alternatively with a regular RLB brick (5,5x10x21cm), with particular attention to its design and stability (adding buttresses). They must all be well connected with the load bearing RLB wall, avoiding straight vertical joints.

#### B. Timber partition walls

These can be used to subdivide rooms where there is no



Interior 5,5x10x21cm brick partition wall with buttresses and in-built shelves



Timber frame partition under construction

Timber frame partition with in-built shelves and desk

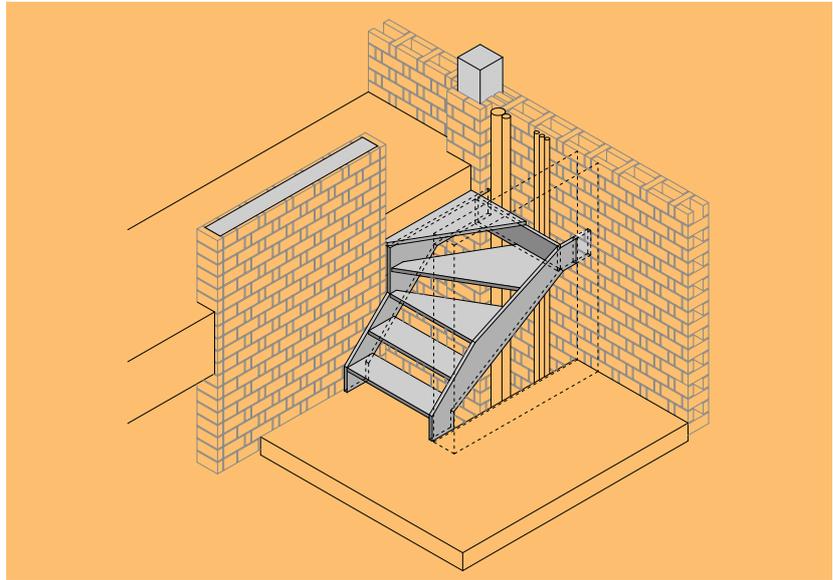


possibility of water damage. To build a timber partition wall, the following procedure is followed:

- Timber partition walls can only be built when the roof and all the timber or concrete floors are complete.
- A base timber framing with section 7/8cmx2cm or as specified is first fixed to the floor and roof or ceiling.
- The frame vertical timber posts and horizontal planks are nailed at specified spacing of approximately 0.6-1M.
- Plywood (triplex) is then nailed on the timber framework formed, completing the partition wall.
- Shelves can be created on either side of the partition wall.

# 12

## Stairs



Staircases can either be made from reinforced concrete, timber or metal according to the building use, level of fire resistance, slabs where it anchors to and budget.

### A. Timber staircase:

PROs: Timber stairs are lightweight, can be anchored to any floor slab and they are easy to build and install. They are the cheaper solution.

CONs: They are not fire resistant and sound insulating.

### TEAM members involved



Masons



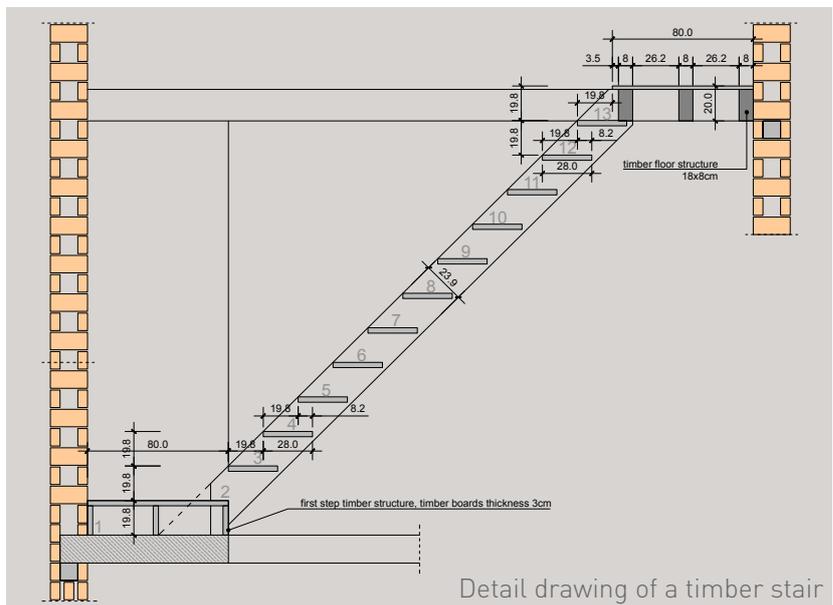
Carpenters



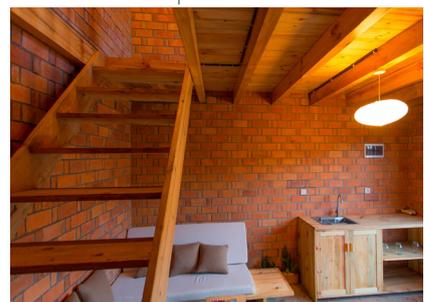
Steel Workers

### Construction tip

For reinforced concrete stairs on Maxspan slabs, always make sure that special pre-cast beams and dedicated waiting re-bars are placed within the slab to allow for a proper anchoring of the two elements.



Two examples of timber stairs





# 13

## ROOF

The basic principles for the construction of a timber structure and metal sheet roof

### TEAM members involved



Carpenters



Masons



Roof timber beams in position before the wall construction continues



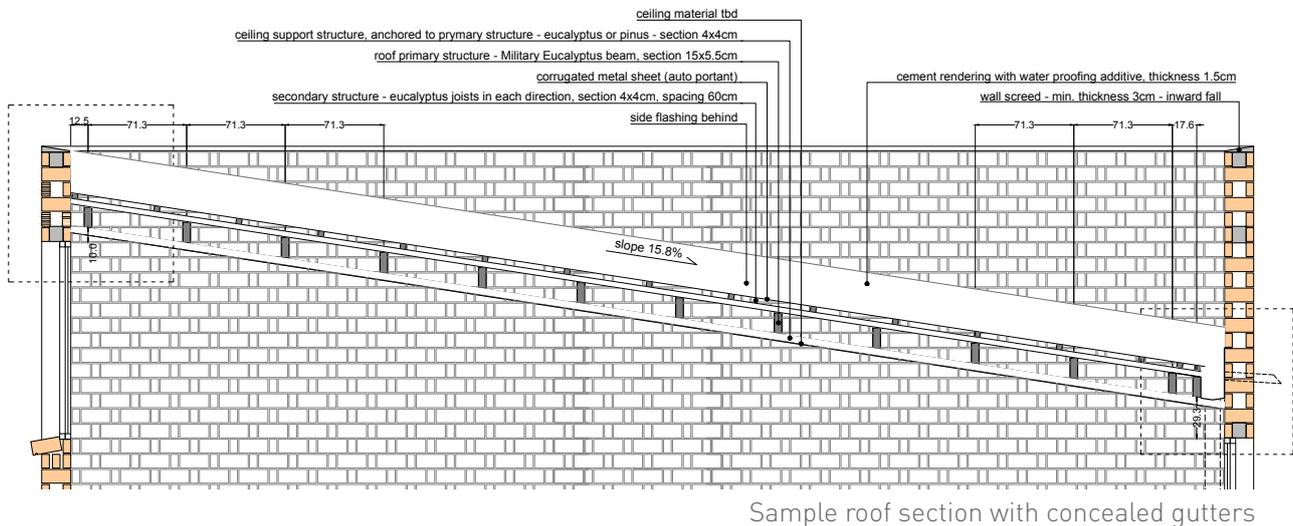
Detail of the roof beams



The roof structure completed with 6x4cm timber joists

### A. Components of an iron and timber roof:

- Understructure: a roof with iron sheet covering requires a structure made from timber or steel. The timber or steel structure is firmly anchored to the brick wall by means of anchor bolts or metal brackets anchored with concrete into the brick wall. For spans (wall to wall distances) of less than 4 meters trusses may not be necessary. As a reference for a timber roof structure, a minimum beam section size of 150x50mm (6"x2") can be used for spans of up to 4 meters, (depending on the timber type and once confirmed by a structural engineer.
- Cover: Corrugated metal sheets with a minimum gauge of G28 and custom bend metal sheet flashing with a minimum thickness 1,5mm.
- Rainwater drainage: box gutters are custom built in a square section, overlap with iron sheet cover of at least 20cm. The specific design of the gutter profile depends from the roof design, the presence of a roof eave or not and the rain catchment surface size. It is



normally painted with anti-rust and a project color.

- PVC downspout of a minimum diameter of 110mm.
- Overflow pipe: custom cut metal pipe with the same material and finishing as the gutter to prevent the gutter from overflowing towards the inside of the building when the gutter is concealed

## B. Building process

- Mount the prescribed the timber structure within the RLB pattern. The spacing between the timber beams is determined by their length (span), the spacing of the purlins (if used) and the gauge of the iron sheets to be used. The spacing usually ranges between 0,6m and 1.2m. The procedure followed to fix the timber beams is as follows:
  - Tie two lines at both ends of the roof, stretching from the lower to the upper levels. These guide lines will inform the position of the intermediate beams.
  - Spacing the intermediate beams at the spacing specified by the engineer
  - On the lower roof end two beams are mounted to offer a wide support to the gutter overlap with the roofing sheets. The gutter overlap is then nailed to both those beams.
- Once the beams have been placed the gutter is fixed to the beams and embedded on the wall when necessary. The slope for the gutter should be a 1/4 of the span covered unless differently specified. Place the downspouts as per specifications and drawings. These must be anchored to the walls with metal or plastic brackets every 2m min.
- Place the iron sheets by nailing them with roofing or umbrella nails directly to the beams

with a minimum side and longitudinal overlap of 15 cm. The longitudinal overlap should coincide with the beam underneath. Start fix the corrugated metal sheet roofing from the lower end and move towards the upper end.

- Install the flashing embedded within the brick wall (before the wall has been built) to avoid cutting bricks.



Corrugated metal sheets installed with a minimum 15cm overlap

# 14

## FINISHING

The basic design principles for an efficient RLB construction

### TEAM members involved



Masons

### Construction tip

Don't leave the cleaning to the end of the construction. Cleaning, especially of the RLB masonry, should be carried out constantly during the construction to make sure that the facing bricks retain their fair surface until the building handover.



**The finishing** works refer to the last activities on the construction site, in preparation of handing over the building to the Client.

The three major activities which are:

- Fixing and correcting any construction defects.
- Cleaning up the building and the compound.
- Landscaping.

### A. Fixing and correcting any defects

The construction supervisor or building foreman should inspect the entire building with a checklist to ensure that every component of the building is functioning properly. Any defects or malfunctions noted should be corrected or fixed. An example of the handing over checklist is shown appendix of this manual.

Common defects likely to be observed include:

- Poor filling and pointing of brick wall joints.
- Bricks with surface defects should be replaced.
- Bricks stained with cement mortar.
- Sagging doors not closing properly or with defective locks.
- Leaking gutters, plumbing and drainage systems.

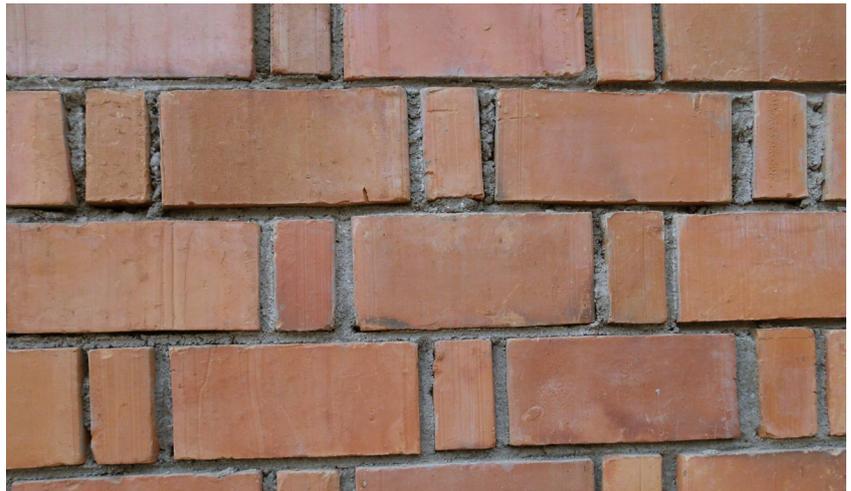
Once the defects have been fixed, the whole building



RLB wall pointing works

### Finishing works on RLB walls

- RLB brick walls do not require plastering like other masonry walls. The joints require pointing so as to achieve a quality neat and attractive finish.
- The brick wall should be thoroughly cleaned with water to remove all cement stains, so as to leave an attractive natural brick color finish.
- Stubborn cement mortar stains and sometimes the green moss/algae can be removed by mixing water with some vinegar and thoroughly scrubbing the wall with some steel wool.



RLB wall before pointing.

RLB wall pointing works

should be visited again and tested before the final hand-over.

### B. Cleaning up the building and the compound

The building compound should be handed over to the Client in a perfect condition. The activities of cleaning up involve:

- Cleaning all the rooms and wiping out dust from all components such as doors and windows, thresholds, sills, shelves and floors.
- Cleaning up the compound by removing all temporary structures that are no longer required and equipment such as scaffolds.
- Clearing the compound from debris, dust, extra soil and garbage.

### C. Landscaping

Landscaping may involve bringing in a sub-contractor specialist. However, the contractor should ensure the following activities: leveling footpaths and other pathways, compact the soil and remove leftovers. Re-planting grass where it has been damaged during construction.



RLB wall cleaning works with water and vinegar



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# 15

## CONSTRUCTION APPENDIX A - SAFETY IN CONSTRUCTION

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### Safety on a building construction site

“Accidents do not just happen, they are caused to happen”.

The main reasons for construction related accidents are carelessness, technical faults, in appropriate use of tools, abuse of alcohol, and most important no proper awareness about potential sources of accidents.

A construction site is the place where people come to work together mainly to earn money to support their families. A place where people come to make a living must be safe. No economical consideration justifies an accident. It's a great tragedy for a family, if for a preventable reason an accident happened resulting to no more income for the family. Worse still is if an accident turns to be fatal or resulting in significant injuries such as breaking a leg or an arm.

Knowing the sources of potential and predictable accidents means that we can prevent them. It is the duty of a construction supervisor to know the potential sources of accidents and to prevent them as far as possible.

Safety on a construction site is also every individual's concern, and everyone must do everything possible to prevent accidents from happening.

The major causes of accidents on a building site are:

- Untidy and unsafe sites.
- Workers welfare and safe working conditions.

Use of poor construction equipment.

### A. Untidy and unsafe sites

Untidy and unsafe sites are characterized with conditions such as:

- Walkways obstructed with stones and dangerous timber with nails.
- Unprotected holes and trenches where an unsuspecting person can fall in.
- Materials poorly stored or stacked to unsafe heights where they can collapse on workers.

The site supervisor should appoint one worker to be responsible for the site tidiness and safe working condition for all workers.

#### - Working in excavations

While working in trenches, always wear a helmet to protect falling objects hitting your head. Open trenches with loose soils should be protected against collapsing especially during a rainy season.

#### - Working with electricity

All electrical equipment such as drills should be regularly checked ensuring that they have safe cables, which are not worn out and can possibly cause electric shocks. Repair of any electrical equipment or movements of electrical cables should be handled by an electrician.

#### - Working with formwork

Formworks support wet concrete, the workers and equipment used when pouring concrete. Poorly made formworks can be major causes of accidents. To prevent

accidents happening when working on formworks, the foreman responsible for site operations must always check the stability and safety of the formwork before pouring of concrete begins.

- **Working with cement**

Cement burns bare hands and can cause skin disease. While working with cement, wear hand gloves and dust masks.

- **Working on roofs**

Only competent carpenters or other workers should climb on a roof under construction. Safety measures while working on a roof include:

- Erecting scaffolding under the roof to facilitate safe movements when fixing the roof.
- Walking on boards which will help spread loads when moving up and down the roof.

- **Materials storage**

- Combustible materials such as petrol and paints must be stored separately from materials such as timber in case of an accidental fire.
- Bricks and blocks should not be piled up to heights exceeding 1meter

- **Fire Extinguishers**

- Fire extinguishers should be placed in strategic places near the storage facilities.
- A carbon dioxide fire extinguisher or buckets full of sand should be placed near a store where fuel or other combustible materials are stored
- A drum/barrel full of water should always be kept near timber stores.
- There should be a designated smoking place on site to avoid accidental fires

**B. Workers welfare and safe working conditions**

Every site worker must wear protective clothing as the following illustration:

-  Helmet
-  Overall
-  Safety boots
-  Gloves
-  Mask
-  Goggles
-  First aid kit



- **Cleanliness, health, hygiene, and rest place**

Cleanliness on a construction site will help eliminating potential causes of accidents and contributing to the general hygiene and health of workers.

Some of the basic health and hygiene requirements on a construction site are:

- Provision of clean toilets, separate for both male and female.
- Provision of washing hands facilities.
- Provision of a safe, sheltered place from rain and sun for resting during lunch breaks.
- Provision of safe and clean drinking water.

- **First Aid**

Every site must have a first aid box with the basic first aid medicine and items such as:

- Bandages and topic disinfectants to treat open wounds.
- Basic elements to temporarily fix broken fingers.
- Pain killers

There should also be at least one person on site trained in the administration of first aid.

# 16

## CONSTRUCTION APPENDIX B - QUALITY CONTROL CHECKLIST

A construction quality control checklist is an important monitoring tool that is used by the construction foreman to check crucial construction stages, ensuring that the building is built to specifications made by the Architect or Engineers.

The checklist must be used and filled on a daily basis, or every time the supervisor visits the site, or when crucial activities such as pouring of concrete are taking place.

### General construction checklist

N	Construction stage	What to check	Performed	Recommendations / observations
1	Site selection	<ul style="list-style-type: none"> <li>- Is the site topography flat?</li> <li>- Does the soil/load bearing capacity require testing?</li> <li>- Is there vegetation/trees that need to be removed?</li> <li>- Is the site accessible by road?</li> <li>- Is water &amp; electricity available?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
2	Setting out	<ul style="list-style-type: none"> <li>- Are all the building dimensions set out accurately?</li> <li>- Are all the angles accurately set?</li> <li>- Are the diagonals equal if the building is square/rectangular?</li> <li>- Are the profile boards firmly fixed to the ground, 1M away from excavation?</li> <li>- Has the building layout accurately transferred to the ground?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
3	Excavation	<ul style="list-style-type: none"> <li>- Is the subsoil stable?</li> <li>- Is the bottom of the trench well leveled?</li> <li>- Are the foundation trenches and holes dug to correct width and depth?</li> <li>- Is excavated soil kept 1M away from the trenches?</li> <li>- Do the sides of the trenches require shoring support to prevent collapsing?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	

N	Construction stage	What to check	Performed	Recommendations / observations
4	Concrete preparation and pouring	<ul style="list-style-type: none"> <li>- Is there a clean base for mixing concrete &amp; mortar?</li> <li>- Is there a bucket or a batch box for measuring cement, sand and gravel?</li> <li>- Is mixing done 3-times dry?</li> <li>- Is concrete prepared in small quantities that can be poured within 45minutes?</li> <li>- Is the poured concrete protected from evaporation or damage by rain water?</li> <li>- Is the concrete cured for a minimum of 14days?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
5	Stone foundation	<ul style="list-style-type: none"> <li>- Have stones of an approximate regular shape been selected?</li> <li>- Are the stones soaked in water before laying them?</li> <li>- Are joints maintained to 3cm thick maximum?</li> <li>- Are the stones overlapped to avoid straight vertical joints?</li> <li>- Are the joints are fully filled and sealed with mortar?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
6	Making reinforcement cage for ground-tie beams	<ul style="list-style-type: none"> <li>- Are the bar sizes used as specified ?</li> <li>- Have overlapping of bars maintained as specified where two bars overlap?</li> <li>- Are the stirrups spaced at specified spacing?</li> <li>- Have the stirrup hocks bent inside at 45° and a minimum of 50mm?</li> <li>- Are the stirrups alternated forming a spiral?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
7	Making concrete spacers	<ul style="list-style-type: none"> <li>- Have the concrete spacers been made 3-7 days ahead of concrete pouring?</li> <li>- Has a cement/sand mix of 1:2 is used?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
8	Mating form works	<ul style="list-style-type: none"> <li>- Is the formwork: made from straight timber?</li> <li>- Reinforced with 5cmx2cm on the sides and top every 60cm.</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
9	Placing concrete spacers	<ul style="list-style-type: none"> <li>- Check if the concrete spacers have been placed before concrete pouring:</li> <li>- At bottom of the formwork?</li> <li>- On both sides of the reinforcement cage in case of a beam?</li> <li>- On all sides of the reinforcement cage in case of the columns?</li> <li>- Are spaced at 0.6-1M c/c?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	

N	Construction stage	What to check	Performed	Recommendations / observations
10	Concrete pouring	<ul style="list-style-type: none"> <li>- When pouring concrete, check the following:</li> <li>- Has the formwork been watered?</li> <li>- Is the concrete vibrated either manually or mechanically?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
11	Placing the DPL	<ul style="list-style-type: none"> <li>- Check if the DPC has been placed:</li> <li>- At 150mm (6") minimum above the ground level?</li> <li>- The top of the foundation wall/tie beam is well leveled?</li> <li>- Approved DPC material is used?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
12	Setting out the first two courses	<ul style="list-style-type: none"> <li>- Have bricklaying being tested by first dry-stacking the first 2-courses of brick work?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
13	Brick selection	<ul style="list-style-type: none"> <li>- Are bricks without surface defects being used?</li> <li>- Have cracked or bricks with defects being used?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
14	Bricklaying with mortar	<ul style="list-style-type: none"> <li>- Are the bricks soaked in water before laying them?</li> <li>- Are both the vertical and bed joints maintained at 10mm maximum?</li> <li>- Are the joints fully filled with mortar?</li> <li>- Are the bricks kept clean?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
15	Corner details	<ul style="list-style-type: none"> <li>- Are the reinforcement bars accurately positioned as per specifications?</li> <li>- Is concrete poured every 6-courses of bricklaying, the following day when the bricks have reasonably set?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
16	Wall intersection details	<ul style="list-style-type: none"> <li>- Are the reinforcement bars placed as per specification?</li> <li>- Is concrete poured every 6th course of bricklaying, the following day when the bricks have reasonably set?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
17	Hidden beam details	<ul style="list-style-type: none"> <li>- Has the cavity in the last course been sealed with bricks of lower quality?</li> <li>- Are the bricks laid on the next course to form a U-section that will form the concealed beam?</li> <li>- Have reinforcing bars been placed in the cavity as specified?</li> <li>- Is the concrete well compacted?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	

N	Construction stage	What to check	Performed	Recommendations / observations
18	Hidden column details	<ul style="list-style-type: none"> <li>- Have the hidden column concreted as follows?</li> <li>- Erecting the reinforcing bars right from the foundations.</li> <li>- Building brick work around the column</li> <li>- Pouring concrete on every 6th course.</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
19	Fixing doors and windows	<ul style="list-style-type: none"> <li>- Are the doors and windows frames positioned next to a hidden column?</li> <li>- Are the metal brackets that connect the frames to the wall well connected to the hidden column reinforcement?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	
20	Plumbing and drainage works	<ul style="list-style-type: none"> <li>- Has a plumber been engaged at an early stage to fix pipe work?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
21	Placing electrical conduits	<ul style="list-style-type: none"> <li>- Has an electrician been engaged at an early stage to fix electrical conduits?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
22	Fixing wooden floors	<ul style="list-style-type: none"> <li>- Are the floor beams/joists well anchored inside the wall without exposing them outside?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> </ul>	
23	Fixing concrete Maxspan floors	<ul style="list-style-type: none"> <li>- Are the precast beams correctly spaced?</li> <li>- Are Maxspan blocks tightly packed?</li> <li>- Are all the reinforcement bars of specified size and placed as per specifications?</li> <li>- Is concrete poured evenly spread?</li> </ul>	<ul style="list-style-type: none"> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> <li>- Yes / No</li> </ul>	

### Partition walls checklist

N	Partition walls	What to check	Performed	Recommendations / observations
1	Bricks	<ul style="list-style-type: none"> <li>- If using 10cm bricks, are they the same height as the RLB bricks?</li> </ul>	<ul style="list-style-type: none"> <li>Yes / No</li> </ul>	
2	Joints	<ul style="list-style-type: none"> <li>- Are both vertical &amp; horizontal joints maintained at 10mm?</li> </ul>	<ul style="list-style-type: none"> <li>Yes / No</li> </ul>	
3	Fixing of timber	<ul style="list-style-type: none"> <li>- For timber partitions, is the timber framework firmly fixed with screws to the floor and ceiling?</li> </ul>	<ul style="list-style-type: none"> <li>Yes / No</li> </ul>	
4	Timber joints	<ul style="list-style-type: none"> <li>- Are timber joints neatly connected with no gaps?</li> </ul>	<ul style="list-style-type: none"> <li>Yes / No</li> </ul>	

## Electrical and plumbing checklist

N	Electrical and plumbing	What to check	Performed	Recommendations / observations
1	Specs	- If using 10cm bricks, are they the same height as the RLB bricks?	Yes / No	
2	Positioning	- Are both vertical & horizontal joints maintained at 10mm?	Yes / No	
3	Overlap with structural elements	- For timber partitions, is the timber framework firmly fixed with screws to the floor and ceiling?	Yes / No	
4	Fixing	- Are timber joints neatly connected with no gaps?	Yes / No	

## Staircases checklist

N	Staircases	What to check	Performed	Recommendations / observations
1	Design compliance	- Have the steps and risers set out accurately as per drawing specifications?	Yes / No	
2	RC Reinforcement	- In case of concrete staircase, has the formwork and steel reinforcement been placed and certified as per drawing?	Yes / No	
3	RC mix quality	- Has the right concrete mix been used and well compacted with a vibrator?	Yes / No	
4	RC curing	- Has curing been done for 14days minimum?	Yes / No	
5	Design compliance	- For timber staircase, has all the steps and risers accurately marked on the stringer before cutting and fixing?	Yes / No	
6	Structural compliance	- Is the stringer firmly anchored to the wall or floor as specified?	Yes / No	
7	Installation compliance	- Have the steps and risers been firmly fixed with glue and screws to the stringer?	Yes / No	

## Materials quality checklist

N	Materials quality	What to check	Performed	Recommendations / observations
1	Cement	– Is the cement fresh, well stored and protected from absorbing moisture?	Yes / No	
2	Sand	– Is the sand used evenly graded with clay content less than 10%?	Yes / No	
3	Gravel	– Is the gravel as per specified size, free from clay and dust <10%.	Yes / No	
4	Steel	– Is the steel of specified size and free from rust?	Yes / No	
5	Bricks	– Are the bricks free from defects, with good surface finish?	Yes / No	
6	Timber	– Is the timber free from warps & twists and is well seasoned and stored?	Yes / No	

## Safety on site checklist

N	Electrical and plumbing	What to check	Performed	Recommendations / observations
1	Workers welfare	<ul style="list-style-type: none"> <li>– Protective clothing &amp; First aid:</li> <li>– Are workers wearing protective clothing such as helmets?</li> <li>– Is there a well-equipped First Aid box?</li> </ul>	Yes / No	
2	Site tidiness	<ul style="list-style-type: none"> <li>– Are walkways kept clear with no obstacles?</li> <li>– Are all the excavated soils well leveled out, and holes filled?</li> </ul>	Yes / No	
3	Safe equipment	<ul style="list-style-type: none"> <li>– Safe ladders and scaffolds:</li> <li>– Are the ladders and scaffolding used safe or do their pose danger to workers?</li> </ul>	Yes / No	
4	Material storage	<ul style="list-style-type: none"> <li>– Are materials such as cement stored in a protected environment?</li> <li>– Are bricks and timber stored stacked up at safe heights?</li> </ul>	Yes / No	

## Handover checklist

N	Handover	What to check	Performed	Recommendations / observations
1	Walls	<ul style="list-style-type: none"> <li>- Are all the joints completely pointed and sealed?</li> <li>- Have all the bricks been thoroughly cleaned, removing all stains?</li> </ul>	Yes / No	
2	Windows and doors	<ul style="list-style-type: none"> <li>- Are all the doors and windows opening and closing without hitches?</li> <li>- Are all hinges fixed with all the screws?</li> </ul>	Yes / No	
3	Roof	<ul style="list-style-type: none"> <li>- Are there any leakages detected and repaired?</li> <li>- Is the rainwater flowing fast and drained through the gutters and down pipes with no leaks?</li> </ul>	Yes / No	
4	Floors	<ul style="list-style-type: none"> <li>- Are the concrete floors, smoothly cemented?</li> <li>- Are timber floors well sanded and treated with wood preservative?</li> </ul>	Yes / No	
5	Staircase	<ul style="list-style-type: none"> <li>- Have the specified staircase finish such as timber finish or smooth cement been applied?</li> </ul>	Yes / No	
6	Clean-up	<ul style="list-style-type: none"> <li>- Have all the scaffold been removed?</li> <li>- Has the general compound been cleaned, removing all waste materials and debris?</li> <li>- Is the compound well leveled, filling up valleys and leveling the uneven ground?</li> </ul>	Yes / No	
7	Services	<ul style="list-style-type: none"> <li>- Are the electrical services operational?</li> <li>- Is water flowing through all pipes without leaks?</li> <li>- Is the drainage system working without blockage or leakage?</li> </ul>	Yes / No	
8	General	<ul style="list-style-type: none"> <li>- Have all the above checked and certified by the Architect or an independent building inspector.</li> </ul>	Yes / No	

## Quality Control Construction Checklist (QCCC)

### Guidelines:

- Take a picture for each construction detail.
- Discuss observations and recommendations made with construction supervisor.
- Leave a copy of instructions with the construction supervisor.
- Check and record improvements made on follow up visits.

Name of supervisor			
Construction stage			
Date of 1st inspection		...../...../20....	
Date of 2nd inspection		...../...../20....	
Date of 3rd inspection		...../...../20....	
No	1st visit Observations & recommendations	2nd visit Observations & recommendations	3rd visit Observations & recommendations

To:			
From:			
Date:		...../...../20....	
Construction stage:			
No	Instructions given:		
Name of Supervisor:		Signature:	Date: ...../...../20....
Received by:		Signature:	Date: ...../...../20....

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