

01

A

CONSTRUCTION

MANUAL ON HOW

TO BUILD

A ROWLOCK BOND

HOUSE

RowLock Bond
DESIGN PRINCIPLES

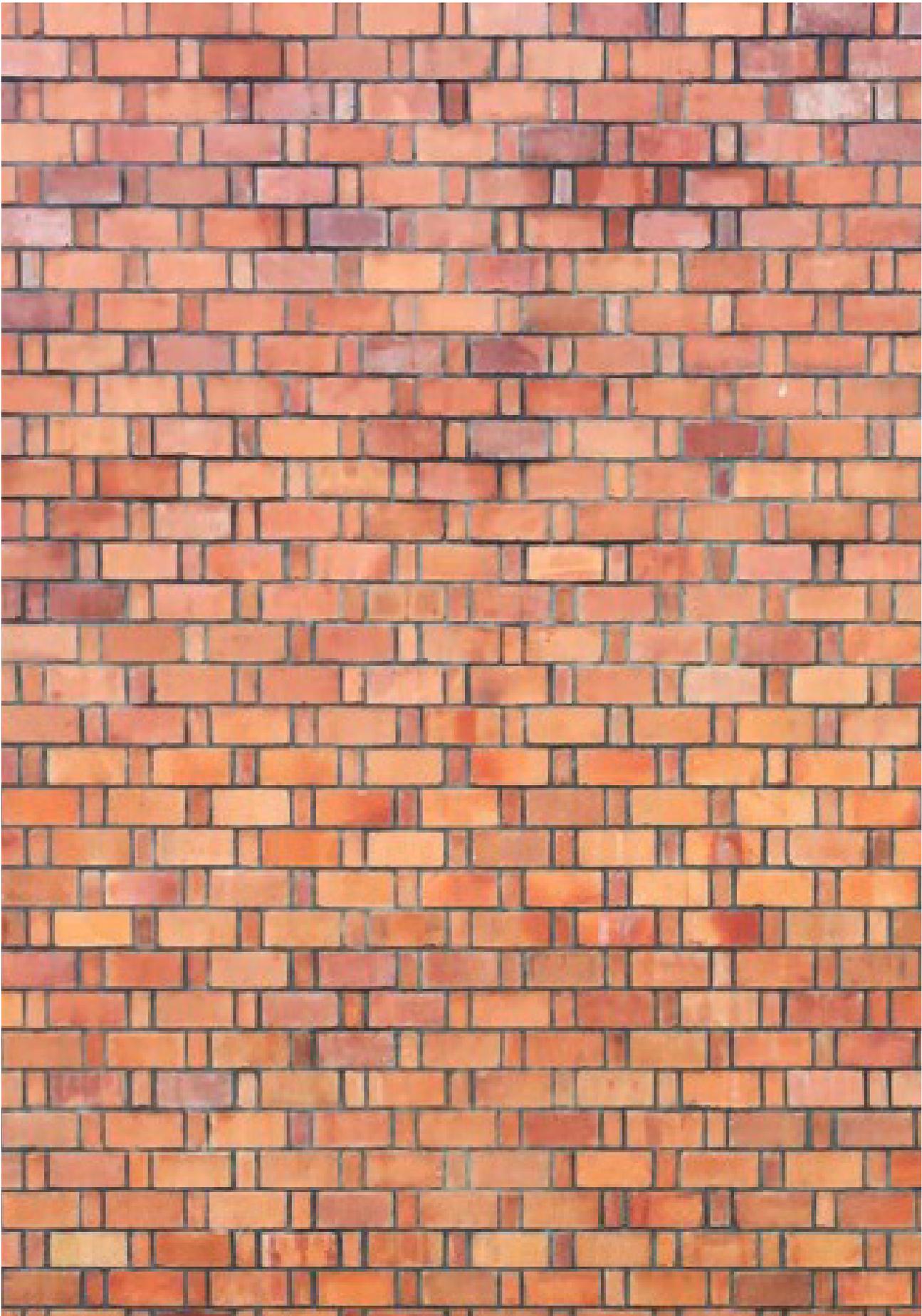


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PROECCO PROmoting Employment through
Climate Responsive Construction



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.

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01

HISTORY

Historical background and references

Rowlock Bond walling is a cost-effective walling system for houses up to 2.5 stories. It was popular during the industrial revolution in both the UK and United States. In the last three decades, the system has made a resurgence in South Asia. A damage assessment after the Kathmandu Earthquake (Nepal 2015) proved the strength and good para-seismic performance of the Rowlock Bond walling system. The system has now been officially endorsed by the Nepalese government.



Henlow, UK, **1801**



Ontario, CANADA, **1856**



Holsman, Holsman, Klekamp, Taylor, Chicago, USA, 1949



Holsman, Holsman, Klekamp, Taylor, Chicago, USA, 1949



Skat, Katmandu, Nepal, 2011



Verduzco Villegas, S.L. Rio Colorado, Mexico, 2016

02

ROWLOCK BOND DESIGN PRINCIPLES

The basic design principles to build with RLB technology efficiently and cost effectively

02_A

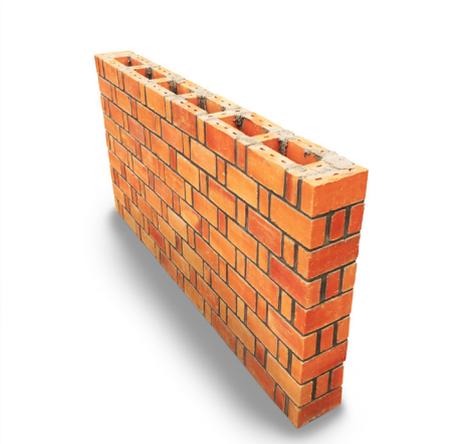
THE ROWLOCK BRICK



An industrially or semi-industrially produced brick with consistent sizes and reliable compression strength.

02_B

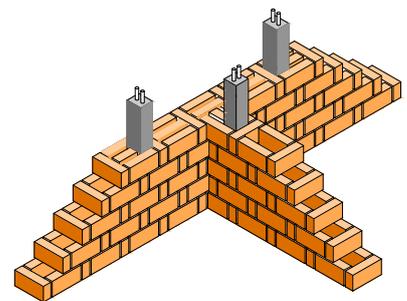
THE RLB WALL



The Row Lock Bond wall is a load bearing wall featuring cavities within the bond, saving in overall use of cement and bricks and allowing or integration of structural reinforcement and MEP.

02_C

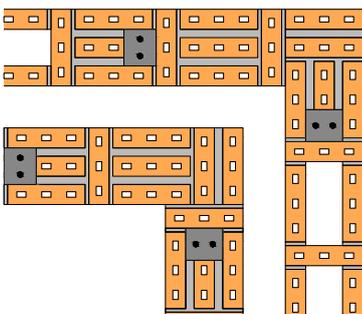
LOAD BEARING WALLS AND ANTI-SEISMIC REINFORCEMENT



The cavities within the Row Lock Bond allow to integrate vertical and horizontal reinforced concrete bracing. These reinforcements add anti-seismic properties to the RLB masonry.

02_D

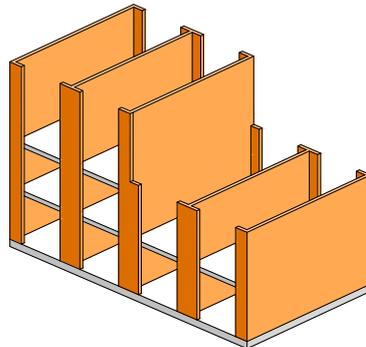
RLB CONNECTIONS



The RLB walling patterns, both for load bearing walls and internal partitions.

02_{E/F}

THE SLABS

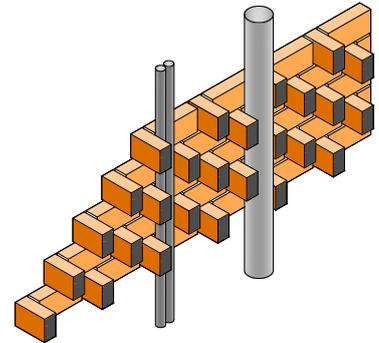


Several slab options are available. The most efficient solutions are timber slabs and Maxspan slabs (hourdis).

The choice of material is informed by the budget, geometrical constraints of the building and required structural and insulating performances.

02_G

MEP INTEGRATION



Mechanical, electrical and plumbing installations can be integrated and concealed within the masonry exploiting the cavities.

02_A

THE ROWLOCK BRICK



The Row Lock Bond brick:
Low carbon brick production,
features and advantages

Construction costs in Rwanda are higher than in most other countries in Africa. This is mainly due to its land-locked geographic position and the resulting high transportation costs of imported material, namely steel and cement. Rwanda's abundant clay deposits are of excellent quality and the massive demand of the country's fast-growing cities are fertile grounds for the construction industry to produce and build with Modern Brick Technologies. For several years Rwandan SME's, with the support of the Swiss Agency for Development and Cooperation, have started to produce machine-made Modern Bricks that allow for the construction of green and cost-effective buildings. These technologies have the potential to significantly reduce the cost of housing and construction and bring tens of thousands of jobs back to Rwanda that were lost to the foreign cement industry.

Current Situation: Concrete blocks are mostly composed of imported cement (Cimerwa production is sufficient for concrete work and mortar only). The capital

spent for concrete blocks is mainly lost to the foreign cement industries and does not further circulate in the country or create local jobs.

Modern Bricks Replace Concrete Blocks:

The introduction several new modern brick facilities in proximity to Kigali and the secondary cities reduces the need for imported cement. With more production facilities in operation, the number of local jobs available in the building material and construction sector increases exponentially. The capital remains in-country, the job growth translates to higher demand.

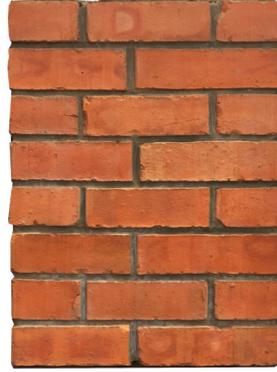




CEMENT BLOCK WALL



TRADITIONAL BRICK WALL



INDUSTRIAL BRICK WALL



SMART BRICK WALL

CEMENT MORTAR



325 kg



206 kg



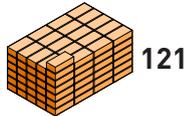
98 kg



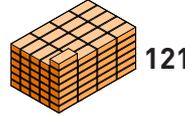
41 kg

BRICKS

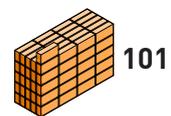
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121



101

Traditional production degrades the environment. In the Great Lakes Region, the traditional building material sector significantly contributes to deforestation.

Improved quality equals energy savings. These archaic brick firing methods consume up to 4 times more energy than modern brickyards and leave 30-40% of all bricks underfired and weak.

Significant energy savings achieved. Modern brick kilns are well insulated, and therefore bricks are fired with a homogeneous high quality and oblige the brickmaker to use legal alternative fuels such as bio-waste - namely sawdust, coffee and rice husk. With the shift to modern brickmaking, the overall energy consumption can be reduced by 50%, while the brick production can actually be doubled.

Clay consumption reduced. Perforated modern bricks consume less clay than solid traditional bricks, contributing to an additional energy savings of 20-30% and better quality products. Less clay also means lighter bricks, facilitating transport.

KEY FACTS:

Walling material cost:

30-50% lower

Cement mortar*:

Reduced by 70%

*Cement for mortar and blocks is mostly imported, due to the limited production capacities if the local cement factory and the limits of locally available raw material (lime)

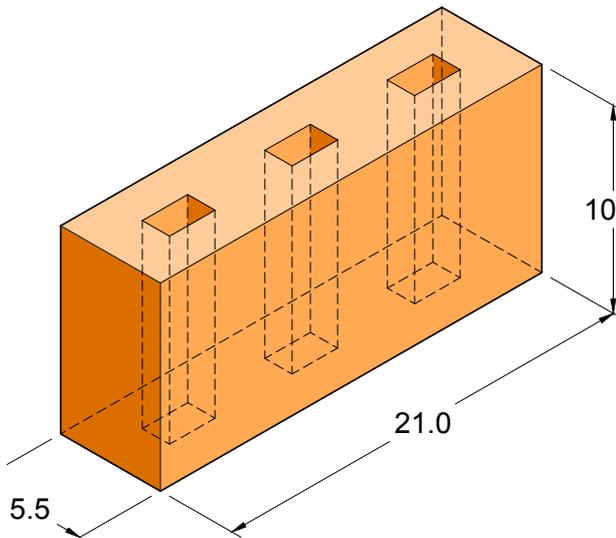
Fuel Consumption*:

Reduced by →75%

*for the brick firing alone alone, not yet taking into account the cement related reduction of embodied energy and CO2 emissions



the Row Lock Brick



Standard dimensions of a Row Lock Brick

PRODUCED INDUSTRIALLY
or SEMI-INDUSTRIALLY

EXTRUDED ► PRECISE DIMENSIONS
PERFORATED ► EVENLY FIRED

▼
RELIABLE PERFORMANCE

minimum
compressive
strength

10MPa

traditional brick
3/5 MPa

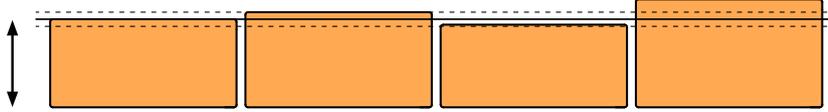
Increased building height and reduced construction time.

Used in combination with the RL bricks for the construction of RLB walls, it allows for:

- a higher overall height of the building thanks to its added load bearing strength.
- to reduce the masonry construction time by increasing the brick laying speed, thanks to its larger size.
- to reduce the masonry construction cost as it replaces 3 standard bricks without need for mortar joints.

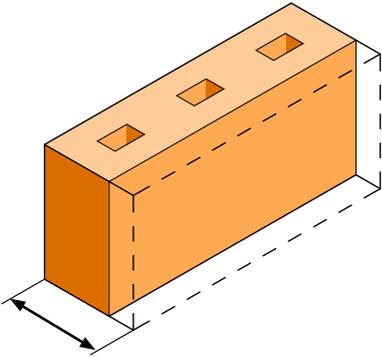


Brick size tolerance



Brick size tolerance:

+/-4mm

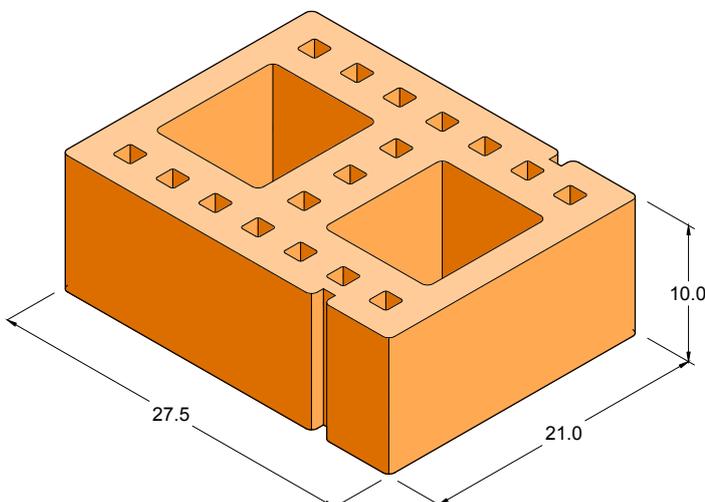


Verify the actual dimension of every brick before use and select only those respecting the prescribed dimensions.

the Plan Fill Block

The Plan Fill is large fired block that perfectly integrates with the RLB masonry and equals to three standard Row Lock bricks. It is produced industrially, thus it benefits from the same features of the RL Brick in terms of consistent size.

The plan fill block is extruded to resemble the characteristic RLB pattern and its resistance is higher than three equivalent RL Bricks, due to the absence of mortar joints.



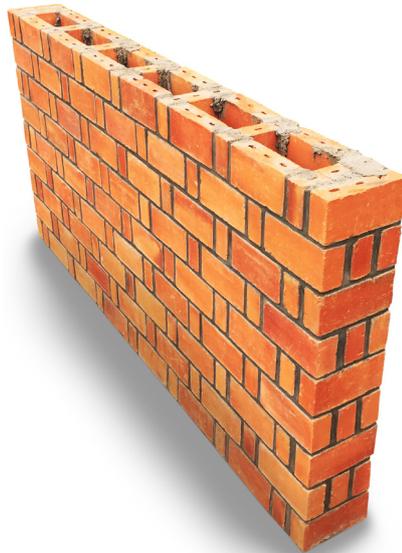
Increased building height and reduced construction time.

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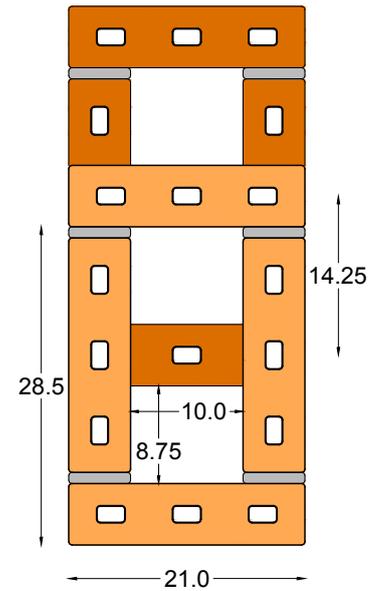
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02_B

THE ROWLOCK BOND



Example of a Row Lock Bond wall

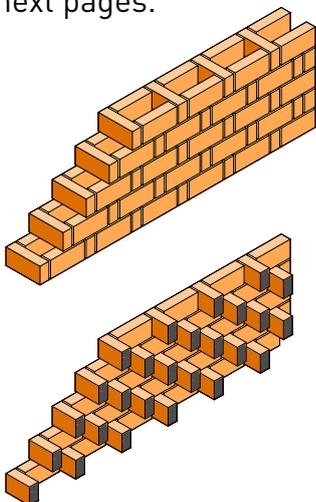
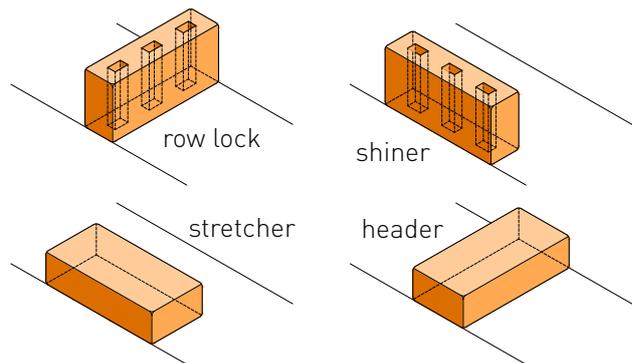


Basic Row Lock Bond layout

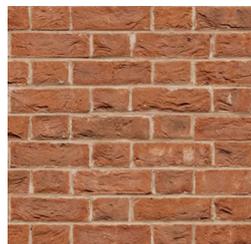
the Row Lock Bond

This type of wall makes use of the modern perforated brick by laying it in a vertical position rather than horizontal. Thus a stretcher becomes a shiner and a header becomes a row lock.

This is possible thanks to the compressive strength of the modern brick, that allows for a load bearing wall with a reduced amount of bricks. The vertical use of the brick inherently creates central cavities in the masonry, that are a key feature of this bond and can be exploited as explained in the next pages.



RLB structure/cavities diagram



Flemish bond wall

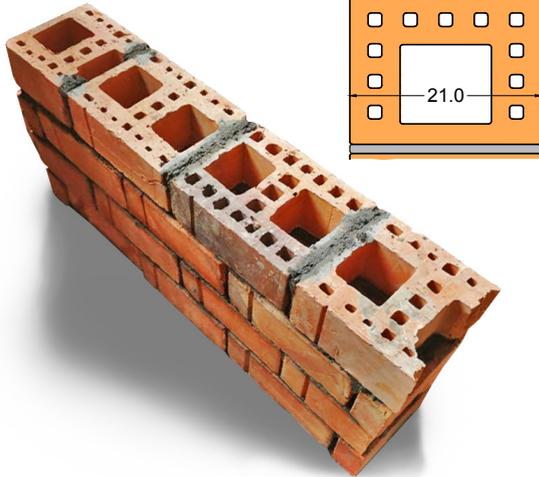


Row Lock Bond wall



Masons laying the first row of RLB bricks

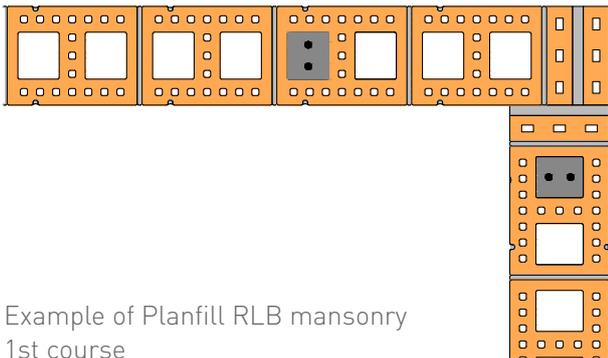
RLB variations



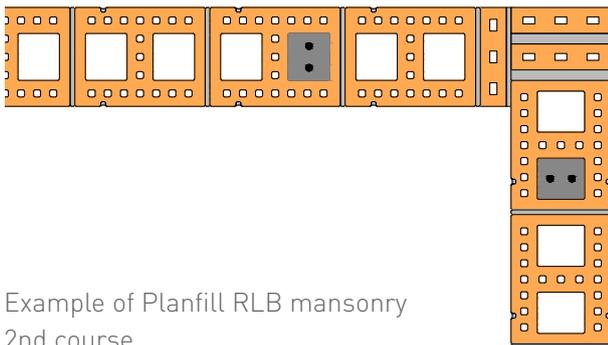
PLANFILL block RLB layout

PLAN FILL RLB

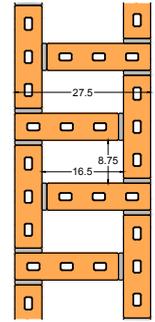
The PLANFILL Row Lock Bond masonry has the same width of the standard RLB and integrates single Row Lock type bricks within the pattern to complete corners and connection to partition walls. It is faster to build in comparison to the standard RLB masonry thanks to the larger blocks size and has a higher compression strength. The cavities are the same of the RLB masonry.



Example of Planfill RLB masonry
1st course



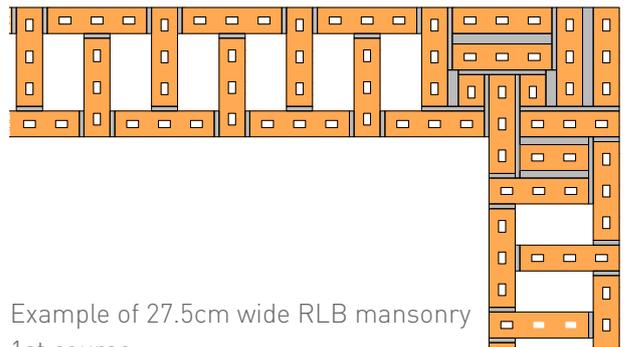
Example of Planfill RLB masonry
2nd course



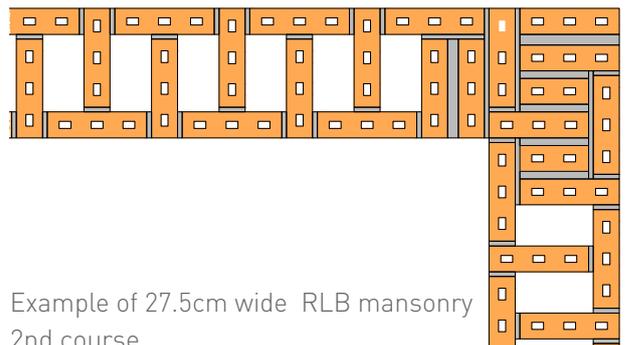
27,5cm wide RLB layout

27.5 cm wide RLB

The 27.5 cm wide RLB masonry makes use of the standard Row Lock Brick using it in a “T-shape” bond that allows for a wider wall footprint, increasing its compression strength and allowing for larger cavities (16.5 x 8.8 cm), hence larger RC reinforcement or more space for MEP integration. It also allows for a seamless integration of a classic RC frame (pillars and beams) within its thickness.



Example of 27.5cm wide RLB masonry
1st course



Example of 27.5cm wide RLB masonry
2nd course

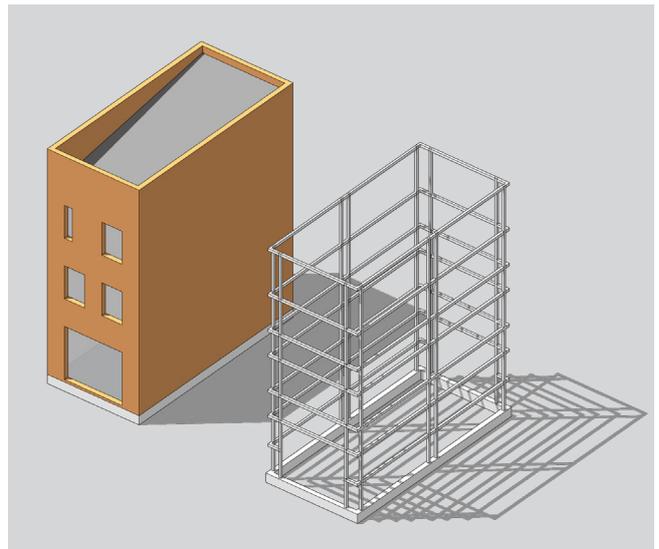
02c

LOAD BEARING WALLS AND THE ANTI-SEISMIC REINFORCEMENT

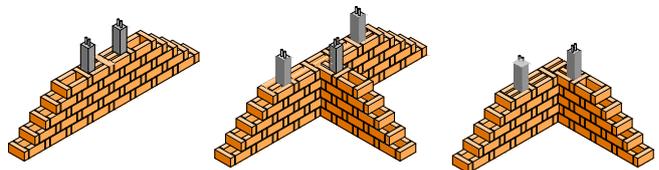


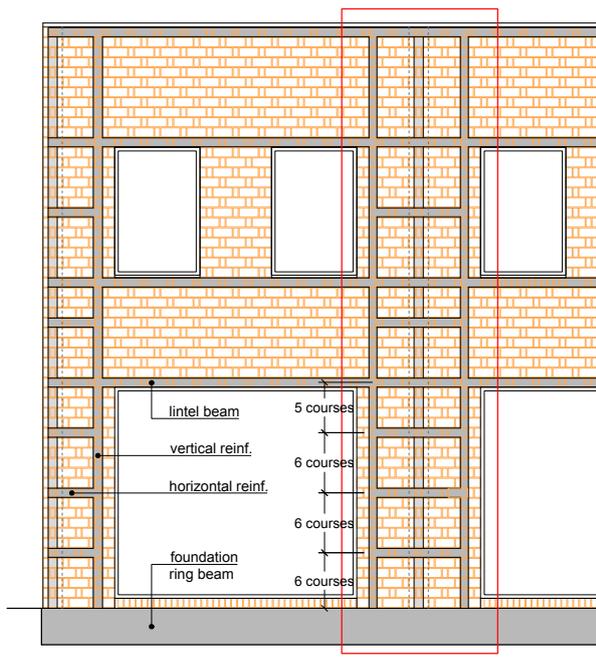
The Swiss Cube built with RLB anti-seismic technology

The Modern Brick RLB Construction System is a “strong box” held together by concrete reinforcement (tie beams). The result is a structural frame within which flooring and walling elements can be adjusted and modified at will. The reinforcement is anchored to the bottom ground beam, and “grows” with the masonry, embedded vertically within the RLB cavities and horizontally every (approx) 12 brick courses, creating a three-dimensional frame that braces the building and, compounding with the RLB masonry, creates a very efficient anti-seismic construction system.



Exceptions to the frame pattern allow for opening on the short ends of the “box”, while the long sides are considered the main load bearing sides, supporting the slabs and roof beams. All typologies and building geometries are suitable for Maxpan floor slabs, or timber floor slabs. Both systems can be applied without modification to the structural “box.”

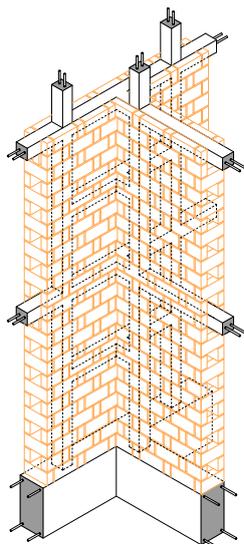




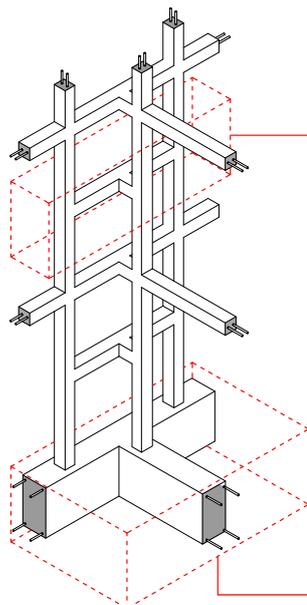
EMBEDDED CONCRETE REINFORCEMENT

- 2X12mm re-bars
- stirrups 8mm @ 20cm

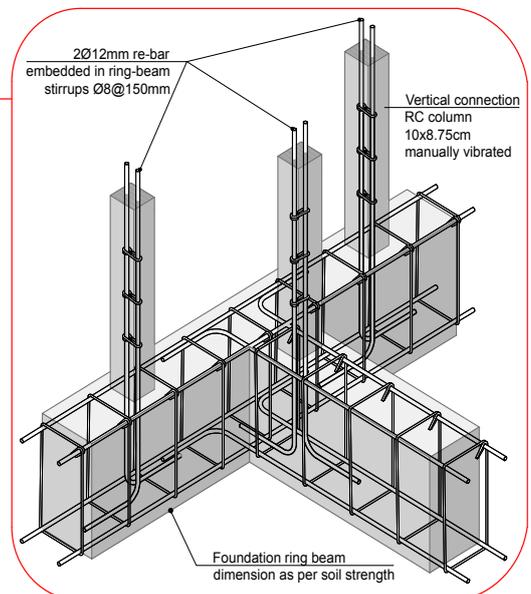
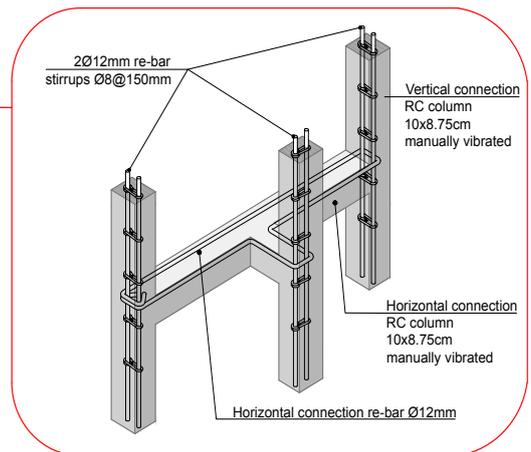
both for vertical and horizontal elements



RLB masonry



RLB embedded reinforced concrete frame



The embedded concrete system is reinforced with 12mm and 8mm diameter re-bars, available in any construction materials market. The steel workers can quickly and easily bend and assemble the reinforcement. The RLB masonry acts as form-work, reducing the quantity of timber need for the construction. Furthermore, it allows for a very tight bond between the load bearing bricks and the anti-seismic RC frame.

02_D

UPPER FLOORS TIMBER



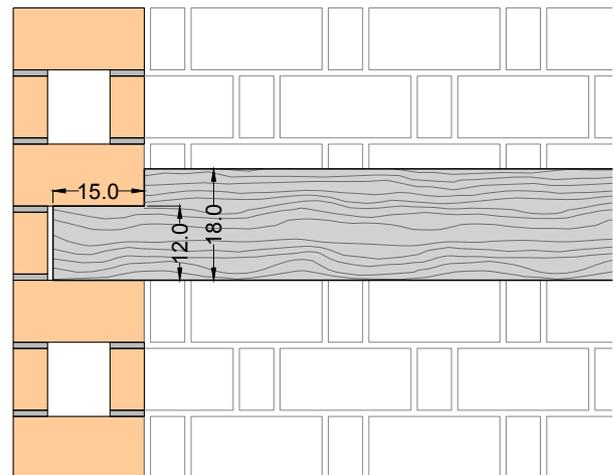
Example of a dwelling unit featuring a timber slab.

The timber floor is the ideal solution to provide an efficient, cost effective and aesthetically pleasing solution for projects with limited budget or that don't require special insulation performances for the floors above ground.

Timber beams are generally available on the market, although can be limited in size and availability. This could influence the span size between load bearing walls, and it is advisable to verify what is readily available on the market before finalizing any design.

The timber floor is a very flexible solution, as the beams are inserted within the masonry and can easily be dismantled or their position shifted.

Each beam is placed at regular intervals: the distance between beams is derived by the RLB pattern. We could say that each beam "replaces" a brick in the fabric of the masonry.



Detail section of a timber beam "nose" size and position within the RLB masonry.

PROS:

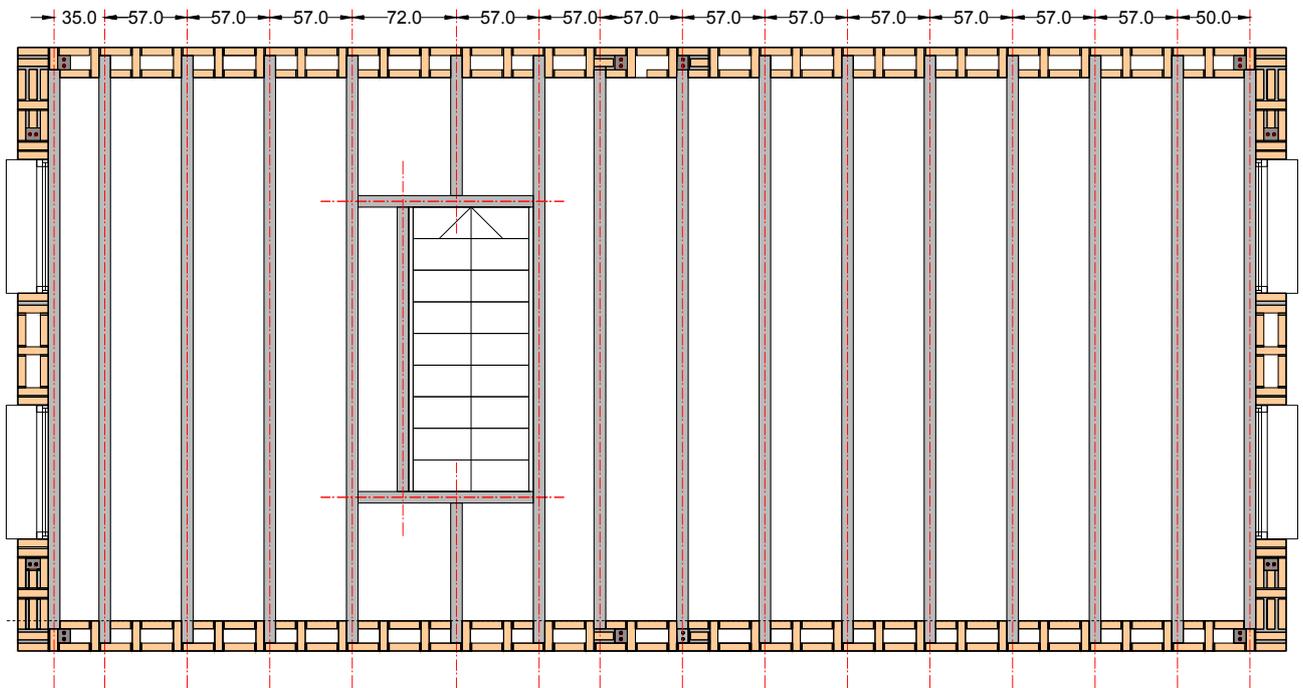
- cost effective
- easy to build
- good para-seismic (lightweight)
- flexible (modifications possible any time)

CONS:

- supply challenges
- size constraints (limited span)
- non fire resistant
- less sound insulating



Example of a timber beams floor being installed on a RLB masonry wall system.



Floor plan showing the spacing of the timber beams spanning between load bearing walls.

02_E

UPPER FLOORS MAXSPAN SLAB IN-SITU VERSION

The in-situ Maxspan slab is a semi-dry technology that uses hollow clay blocks to create a lightweight RC concrete slab. It allows to cover spans ranging from 3.5 to 5.2 meters (different Maxspans clay modules to be used according to the span size). It requires roughly the same scaffolding of a solid RX slab but utilizes 60% less concrete, replacing it with the Maxspan clay modules, making it a fast and more affordable solution.

The construction process requires the steel benders to fabricate and position the reinforcement directly on the form-work. The reinforcement is anchored to the perimeter lintel underneath. The Maxspan blocks are then placed in-between the steel reinforcements. A final 4cm thick cement concrete screed is poured to complete the construction.

This slab typology, similarly to the pre-fabricated Maxspan slab, or a solid RC slab, is an excellent fire retardant and it has good sound insulation properties.



In-situ reinforcement positioned on the timber form-works.



Maxspan blocks positioned in-between the reinforcements.



Detail view of the connection between the steel reinforcements and the tie beam underneath.



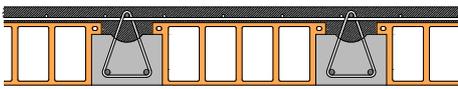
Finishing works after the final cement concrete layer is cast.

02_F

UPPER FLOORS MAXSPAN SLAB PRE-FABRICATED VERSION



Pre-castslab - 12cm high Maxspan blocks



Pre-castslab - 16cm high Maxspan blocks

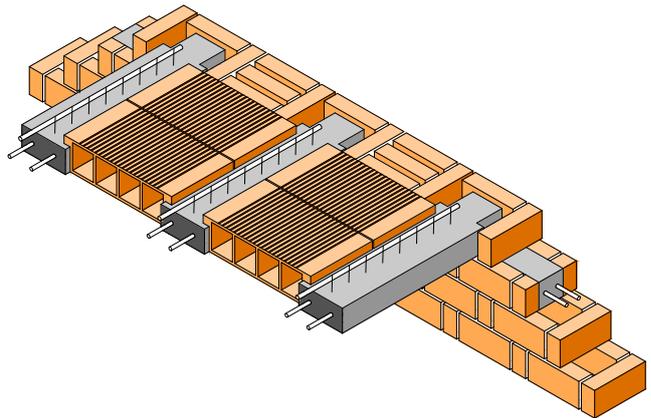
The pre-fabricated Maxspan slab is a cost effective solution that reduces significantly the construction time. The structural elements are pre-fabricated and stored on site ready to be installed as per the construction schedule. The beams are hoisted at the required level and anchored to the RC tie beam underneath. The position and spacing of the beams is dictated by the RLB pattern (57cm axis to axis), ideal to house the Maxspan blocks.

The required scaffolding is significantly reduced if compared to the in-situ version, as the beams need to be supported only in few points, in order to reduce the sag and vibrations during the casting of the top 4cm thick RC screed.

This solution allows to cover spans ranging from 3.5 to 5.2 meters (different Maxspans clay modules to be used according to the span size). This slab typology, similarly to the in-situ Maxspan slab, is an excellent fire retardant and it has and good sound insulation properties.



Maxspan formworks ready for concrete to be poured.



Cut out model of the pre-cast Maxspan slab assembly.



Maxspan blocks placed within the pre-cast beams.



Detail of the Maxspan beam connection to the tie beam underneath.



Maxspan blocks playing within the pre-cast beams.



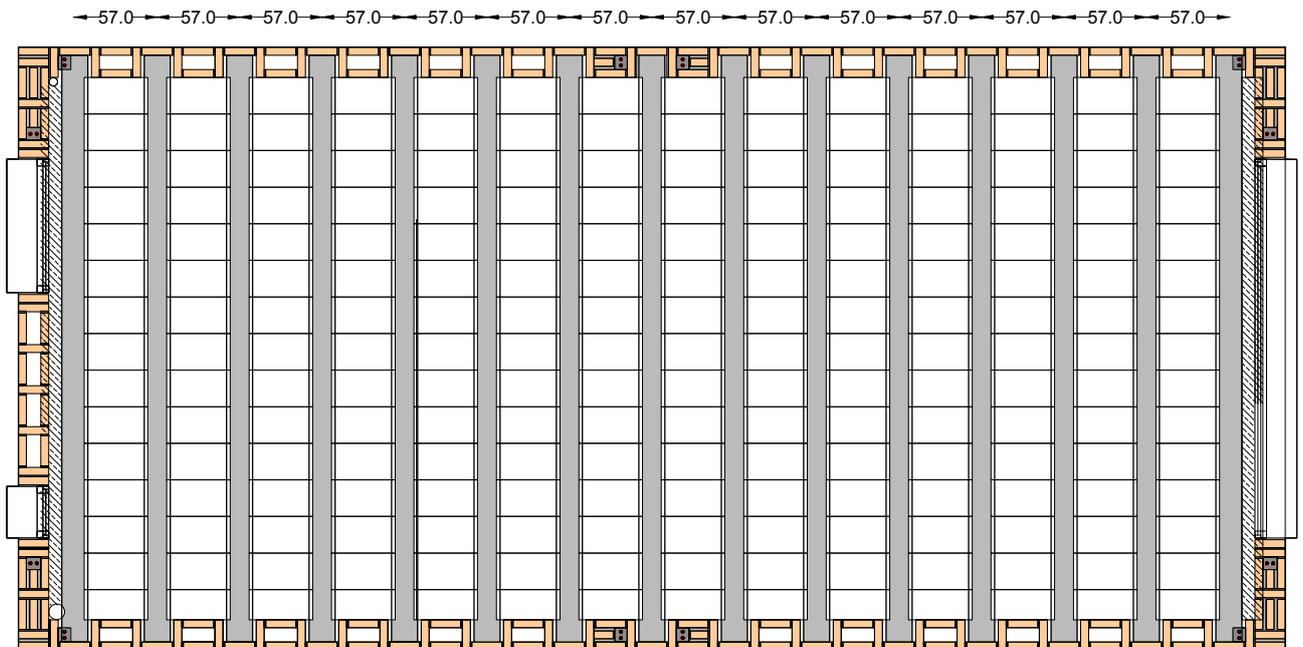
Top screed reinforcement mesh anchored to the pre-cast beams.



The Maxspan slab bottom surface without finishing.



The Maxspan slab bottom surface plastered and painted.



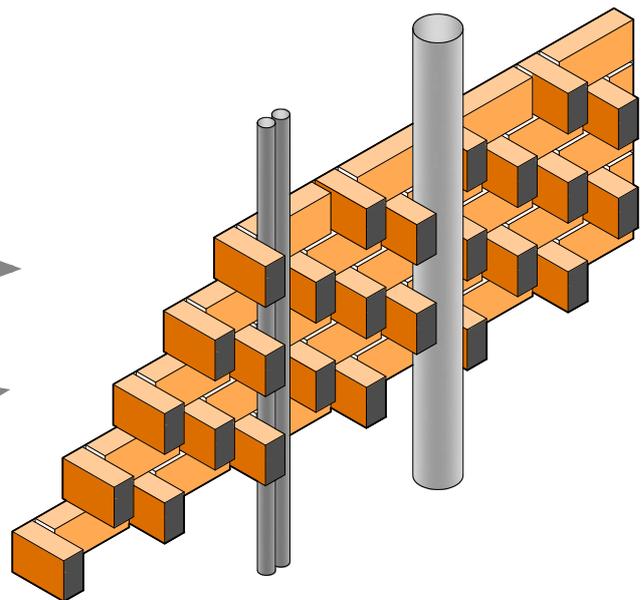
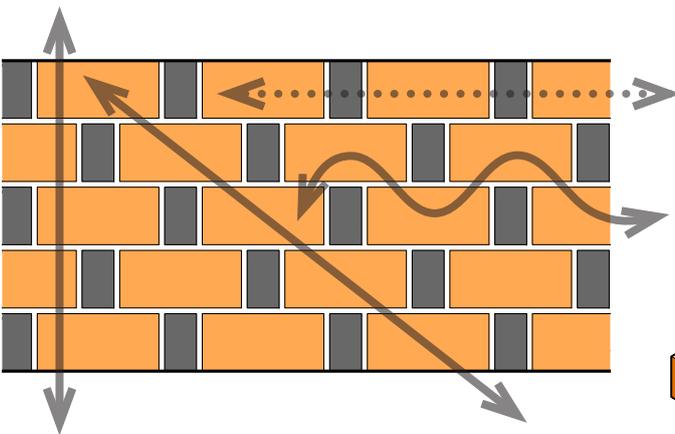
Floor plan showing the spacing of the pre-fab. beams spanning between load bearing walls.

02_G

THE MEP INTEGRATION

The Row Lock Bond walling system features central cavities (for a standard 21cm wide wall the cavity size is 8.8x10cm) running for the entire length and height of the wall. Mechanical, electrical and plumbing pipes and conduits that respect the max cavity size can be embedded in the masonry from the early stages of the construction process. The only interruptions are the tie beams and reinforcement columns, where pipes can be routed through with adequate planning at the design stage and by including provisions during the construction phase. MEP maintenance and adjustments are possible after the building completion with simple masonry interventions.

The Row Lock Bond cavities run uninterrupted vertically and diagonally, while the horizontal ones are possible in a non linear way or by modifying the masonry.



Electrical conduit passing through vertical cavities.



Electrical conduit and wires embedded in the a RLB wall.



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