

02

A CONSTRUCTION MANUAL ON HOW TO BUILD A ROWLOCK BOND HOUSE

RowLock Bond
STRUCTURAL PRINCIPLES



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development
and Cooperation SDC

skat Swiss Resource Centre and
Consultancies for Development

PROECCO **PR**o**MO**ting **E**mployment through
Climate Responsive **C**onstruction

THE ROW LOCK BOND SYSTEM

- 1 The RLB Structural Principle
- 2 The Design Flow Chart
- 3 The structural Design Guidance
- 4 The worked example
- 5 The RLB calculation tool



THE ROW LOCK BOND SYSTEM

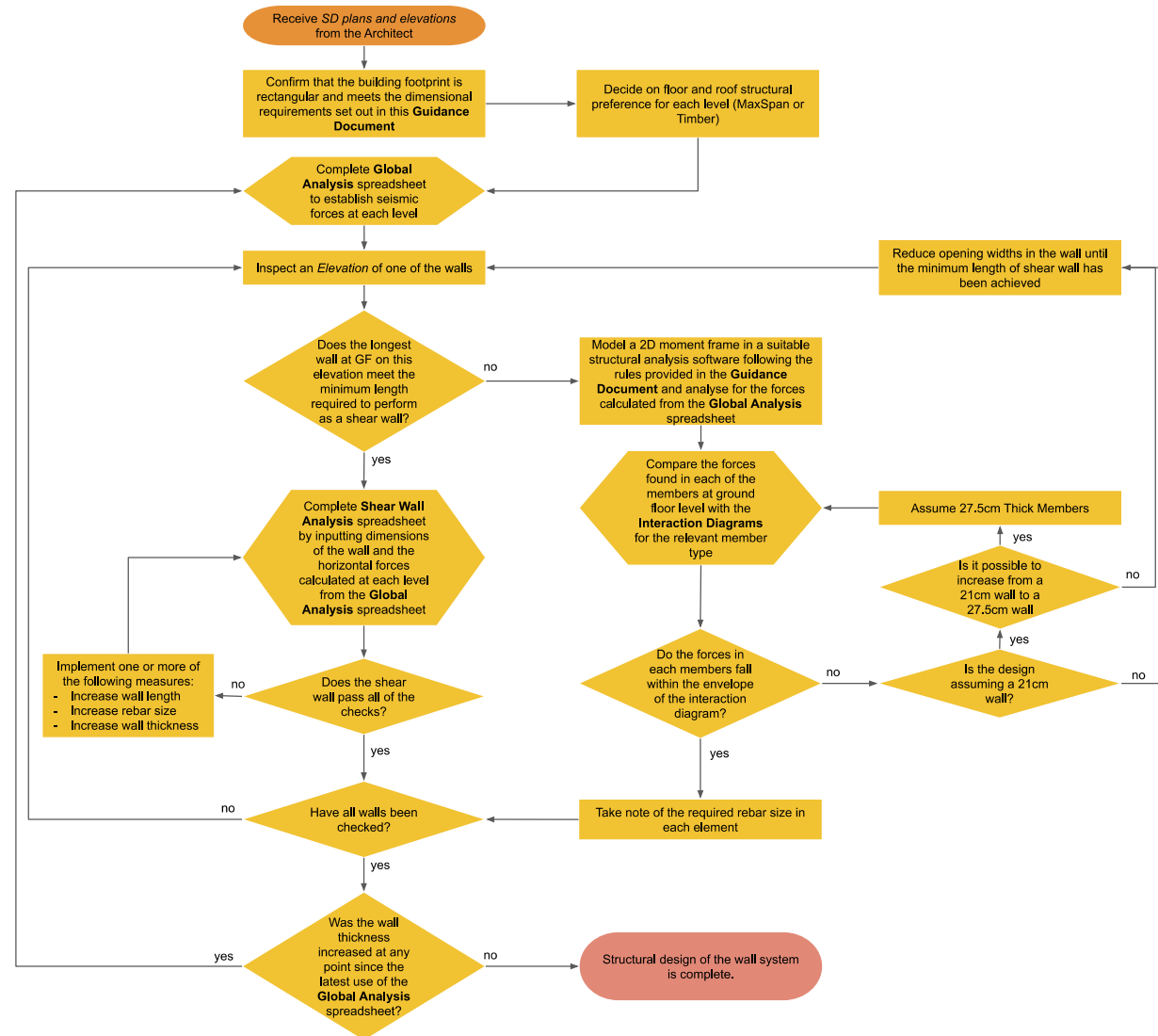
1 The RLB Structural Principle

2 The Design Flow Chart

3 The structural Design Guidance

4 The worked example

5 The RLB calculation tool



THE ROW LOCK BOND SYSTEM

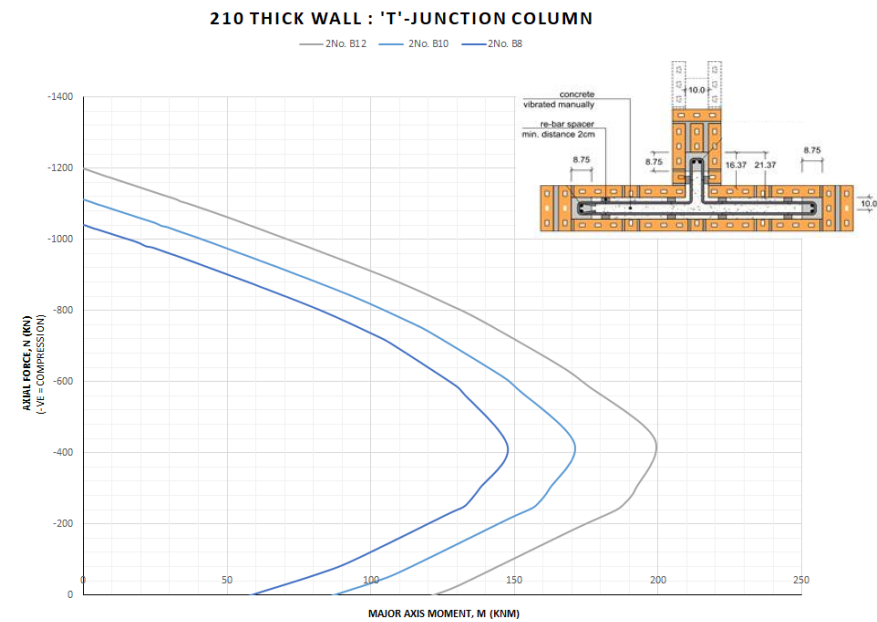
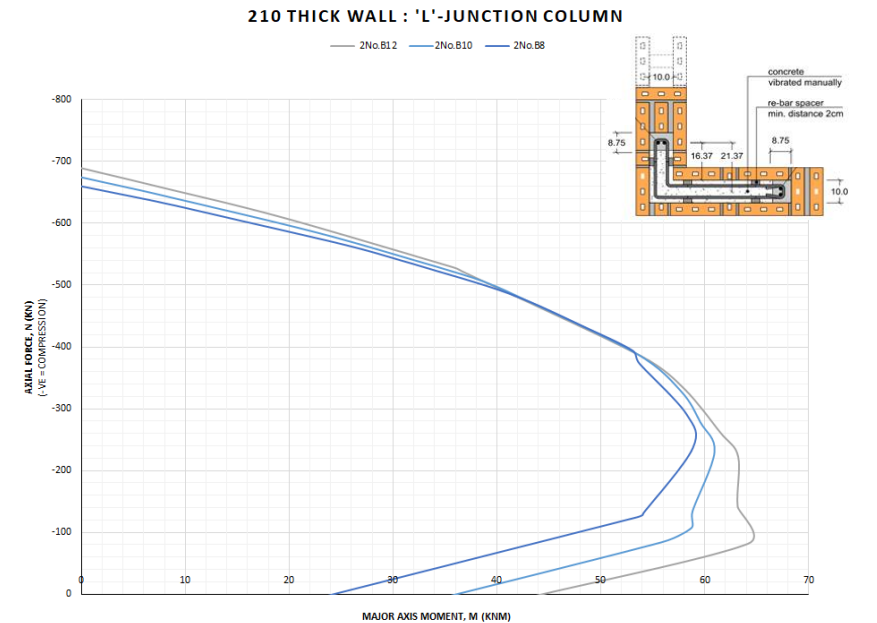
1 The RLB Structural Principle

2 The Design Flow Chart

3 The structural Design Guidance

4 The worked example

5 The RLB calculation tool



THE ROW LOCK BOND SYSTEM

1 The RLB Structural Principle

2 The Design Flow Chart

3 The structural Design Guidance

4 The worked example

5 The RLB calculation tool

GLOBAL ANALYSIS - WORKED EXAMPLE

This worked example is based on the design of the existing SKAT Rowlock Bond housing located at Mpazi, Nyabagogo, Kigali, Rwanda.

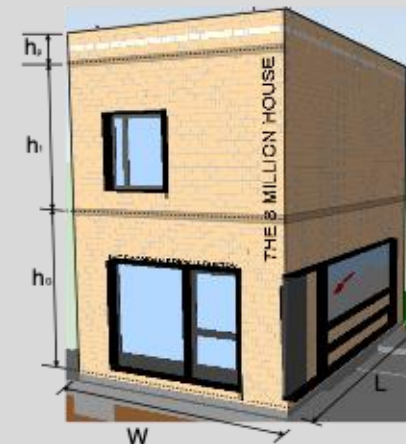
Seismic Design Parameters

Rwanda is considered a region of moderate seismicity given its location adjacent to the East African Rift System. The following seismic parameters are considered appropriate for the site based on the Rwanda Building Code, Global Earthquake Model (GEM) and the requirements and values set out in Eurocode 8 (where Response Spectra Type 1 is assumed for the purposes of this design).

RBC / GEM	Peak Ground Acceleration (PGA)	$a_g = 1.6 \text{ m/s}^2$
$g = 9.81 \text{ m/s}^2$	Ratio of PGA to Gravity	$\alpha = a_g / g = 0.16g$
EC8, Table 3.1	Soil Factor - Assume Spectrum Type 1, Soil Type C	$S = 1.15$
EC8, Table 4.3	Importance Factor - Assume Importance Class II	$\gamma_i = 1.0$
EC8, Table 4.4	Ductility Factor - Reinforced Masonry	$q = 2.0$
EC8, Eqn 3.14	Design Seismic Acceleration	$S_d = 2.5 \alpha S \gamma_i / q = 0.234g$

Building Geometry

The units are rectangular in plan and the footprint of an individual unit is 4.5m x 6.5m and there are four units constructed in a single terrace. 210mm thick RLB structural walls exist on the 4 sides of each unit, and there is no spine wall. The units are 2storeys tall and each storey has a different height. The masonry walls extend above roof level to form a parapet around each individual roof.



THE ROW LOCK BOND SYSTEM

- 1 The RLB Structural Principle
- 2 The Design Flow Chart
- 3 The structural Design Guidance
- 4 The worked example
- 5 The RLB calculation tool

RBC / GEM
g=9.81 m/s²
EC8, Fig 3.2 & 3.3
EC8, Table 3.1
Table 3.2 & 3.3
EC8, Table 4.3
EC8, Table 4.4
EC8, Eqn 3.14

SKAT RLB
Construction
Manual

EC8, Eqn 4.6

Spreadsheet key

Input cells to be completed by user

Instruction, must be followed

Output Cell

Introduction

This calculation spreadsheet calculates the seismic force acting along each structural wall line in a single or group of simple housing units built with Skat Rowlock Bond Masonry Technology.

Limitations of the spreadsheet include - Refer to Construction Manual for more information:

- The housing unit must be rectangular in plan, with no re-entrant corners.
- SKAT RLB junction elements to be continuous over height of the building.
- The unit may have a single additional transverse wall (Spine Wall) centred on the plan
- The housing unit can be single storey, two storey or three storey.
- Each storey of the unit must have the same building footprint i.e. no step backs.
- A structural diaphragm is achieved at each floor level and the roof level.
- All diaphragms are considered to be flexible.
- Up to 5no. identical units can be considered to act as a single building.
- The overall building footprint should not exceed a Length to Width ratio of 4.0

Inputs

Seismic Design Paramaters

ag

Peak ground acceleration

1,6 m/s²

α

Ratio of pga, gravity

0,16 g

Response Spectrum Type

1

Soil Type

D

S

Soil factor

1,35

ya

Importance Facor

1

q

Ductility Factor

2

Sd

Design seismic acceleration on plateau

0,275 g

Geometry

L

Unit Length

9 m

W

Unit Width

4 m

A

Area of Unit Footprint

36,0 m²

h_v

h_t

h₁

h₂

h₀

number of storeys, n (up to 3)

n

Number of storeys

2

h_G

Ground Floor Height

2,5 m

h₁

First Floor Height

2,5 m

h₂

Not Used, Set as 0.0m

2,5 m

h₀

Parapet Height, maximum 1m height

1,0 m

H

Building Height

6,00 m

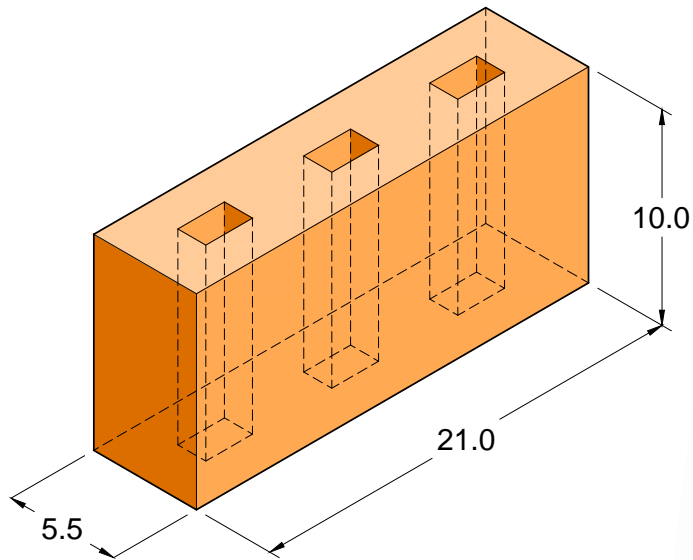
T1

Fundamental Period

0,29 s

THE ROW LOCK BRICK

MAIN FEATURES



10 Mpa

minimum
COMPRESSIVE
STRENGTH

Traditional brick
3/5 MPa



**PRODUCED INDUSTRIALLY
or SEMI-INDUSTRIALLY**

EXTRUDED

PRECISE
DIMENSIONS

PERFORATED

EVENLY FIRED

**RELIABLE
PERFORMANCE**

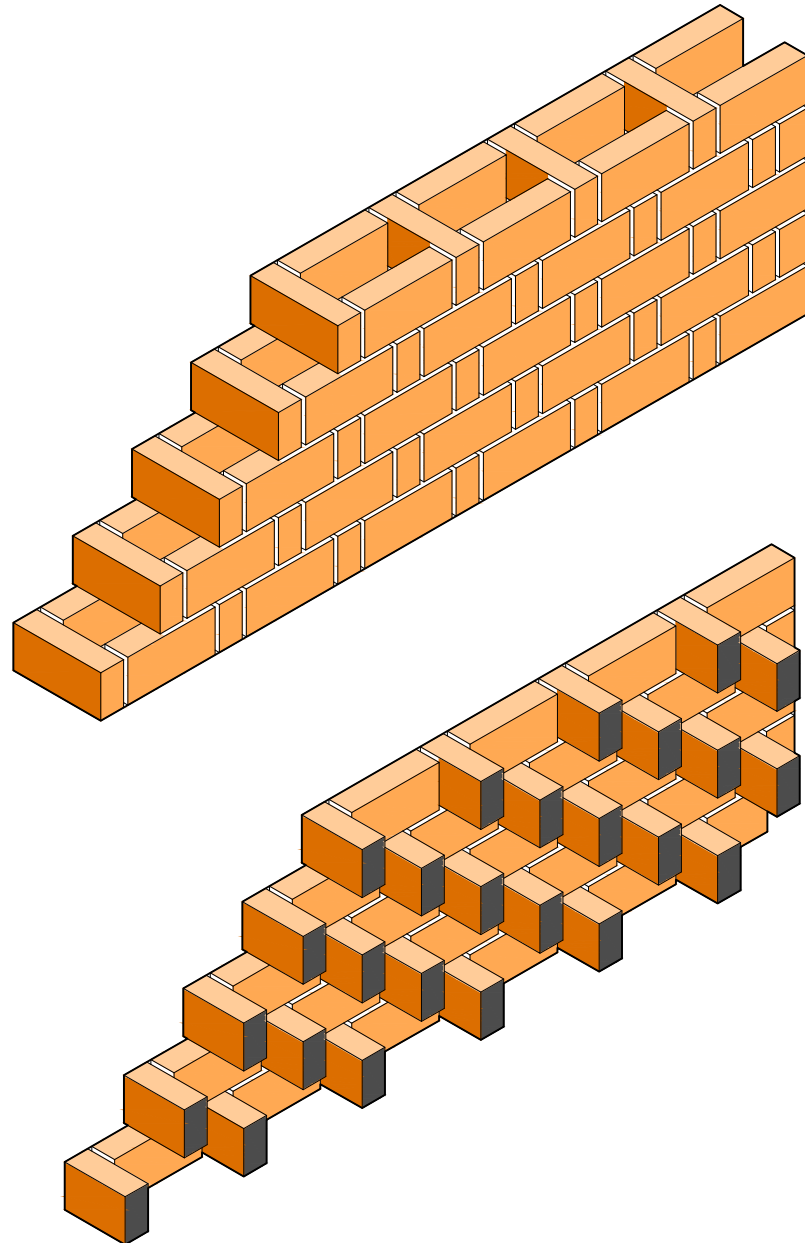
Smart Brick Houses
require up to
6-8 times less energy
for brick firing than a
traditional brick wall

THE **ROW LOCK BOND**

cavity



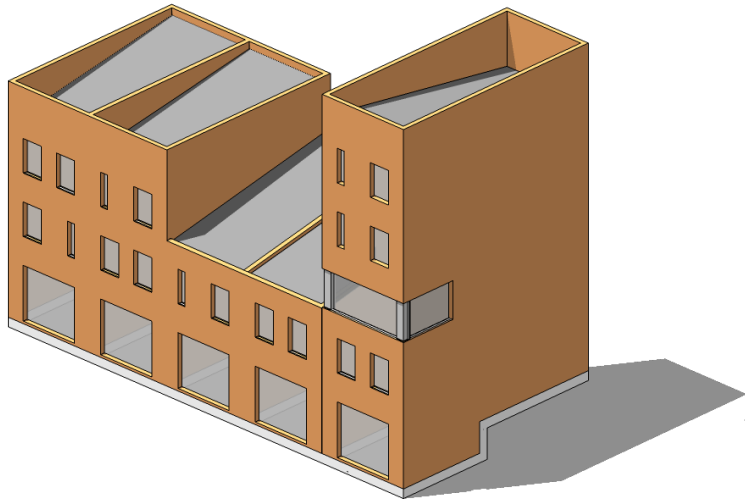
30% AVERAGE LESS MATERIAL USED
25% FEWER BRICKS USED
40% LESS MORTAR USED





THE **ROW LOCK BOND STRUCTURAL PRINCIPLE**

Earth quake resistant properties

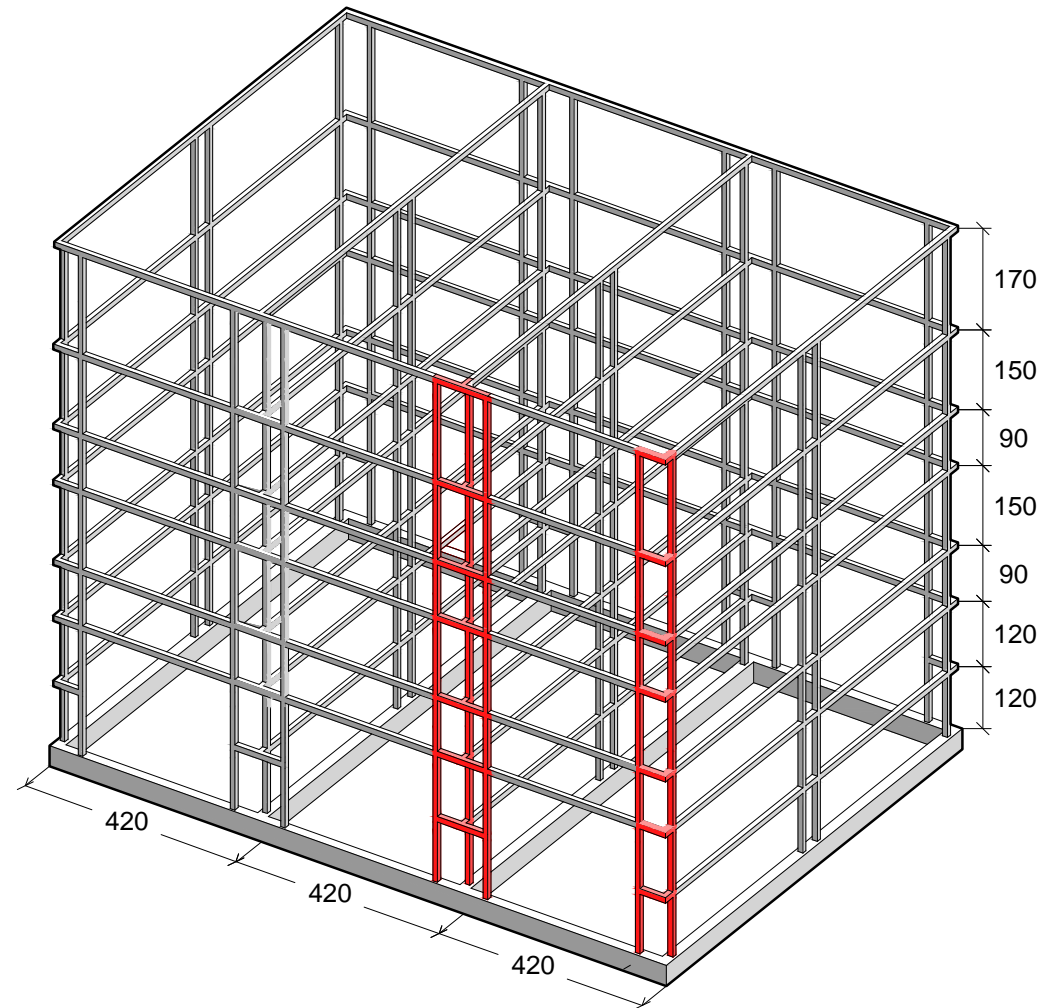
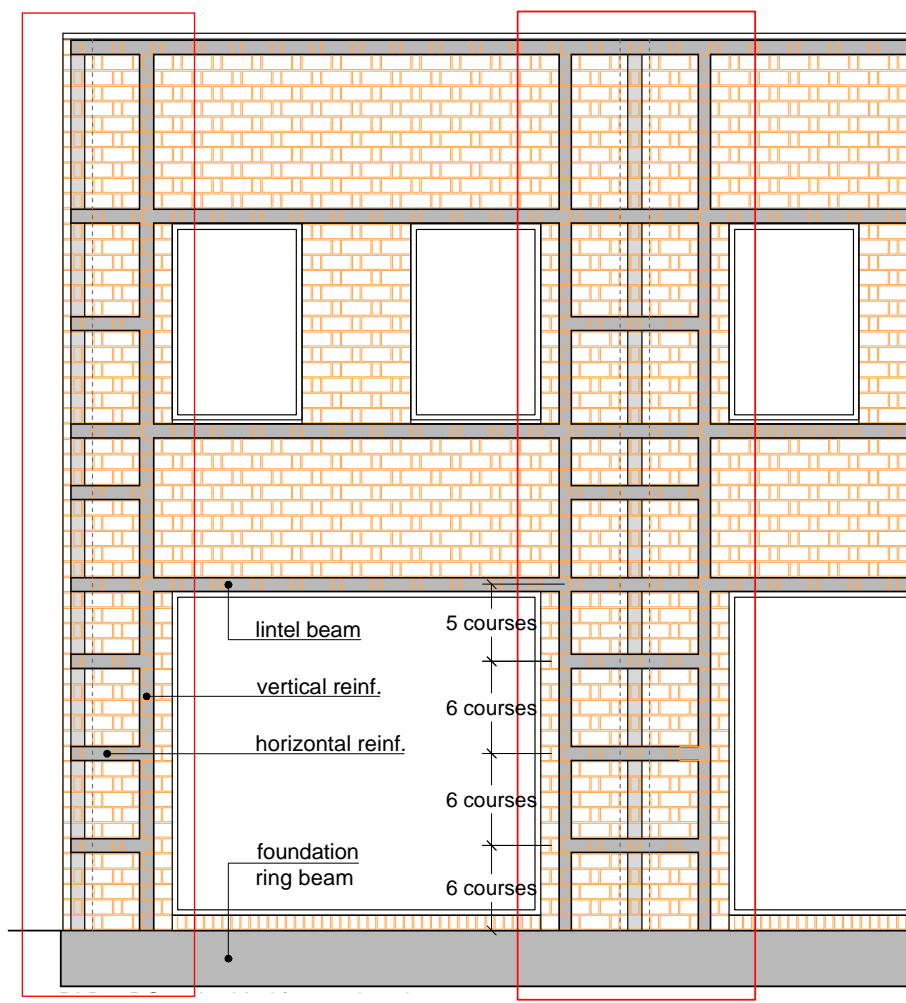


VERTICAL LOADS
are supported by the
load bearing brick walls

SEISMIC LOADS
are supported by the
reinforced concrete
embedded frame

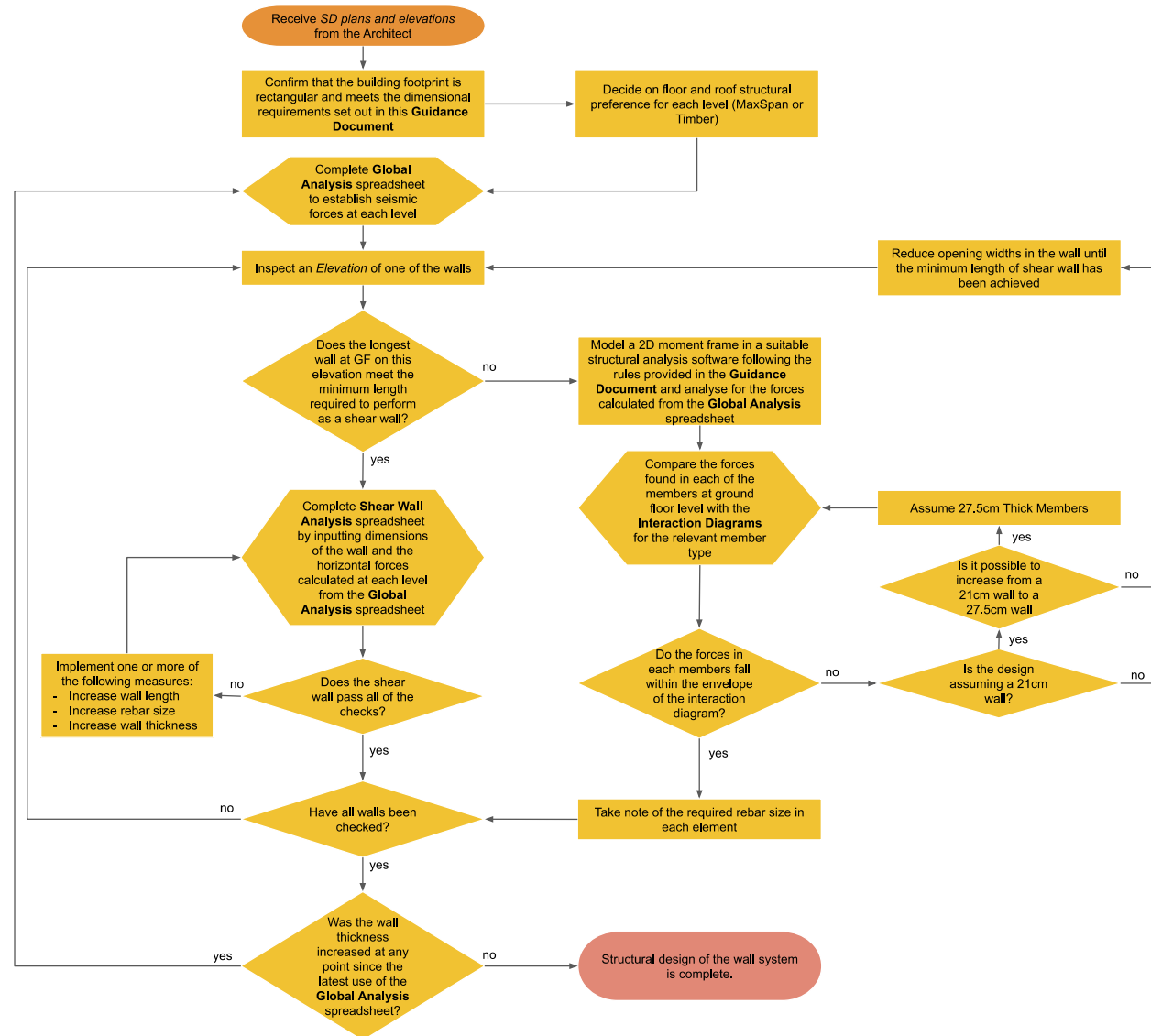
THE ROW LOCK BOND STRUCTURAL PRINCIPLE

T-shape and corner reinforcement



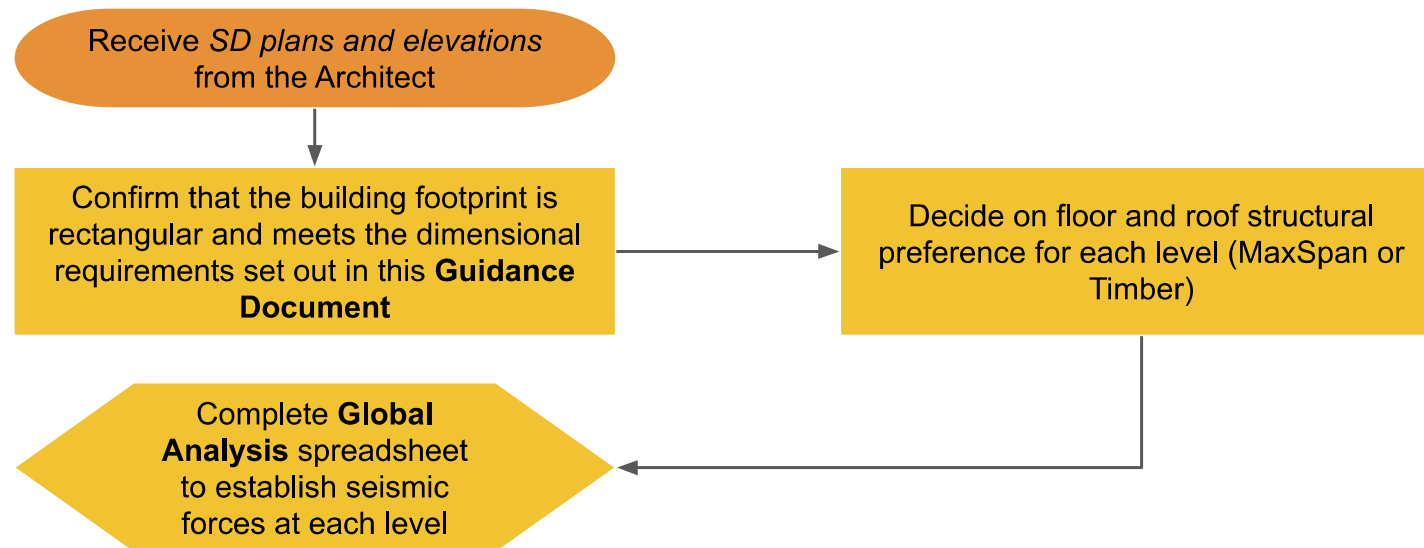
THE ROW LOCK BOND DESIGN FLOW CHART

Sequential RLB structure design steps



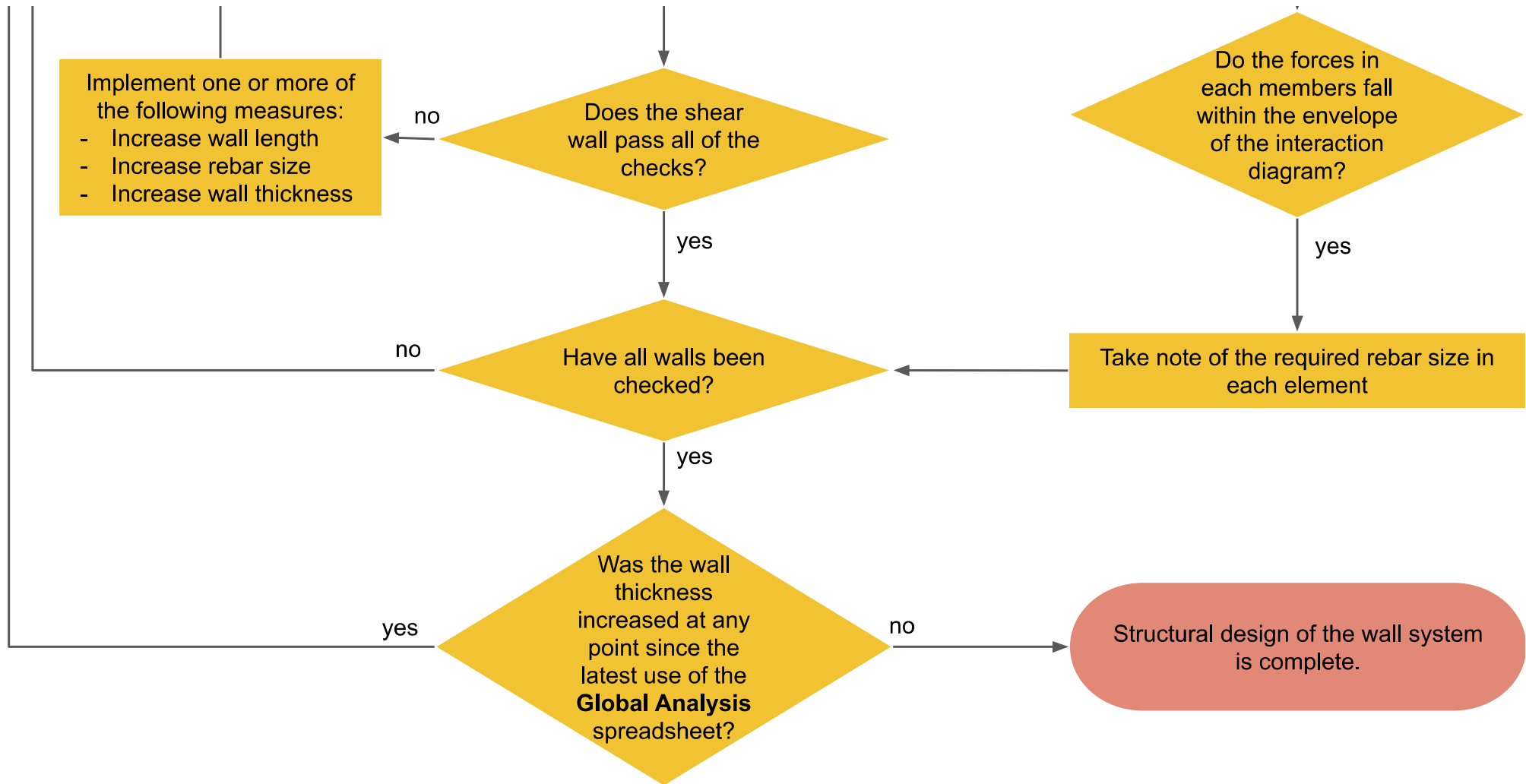
THE ROW LOCK BOND DESIGN FLOW CHART

Sequential RLB structure design steps



THE ROW LOCK BOND DESIGN FLOW CHART

Sequential RLB structure design steps



THE **RLB STRUCTURAL DESIGN GUIDANCE**

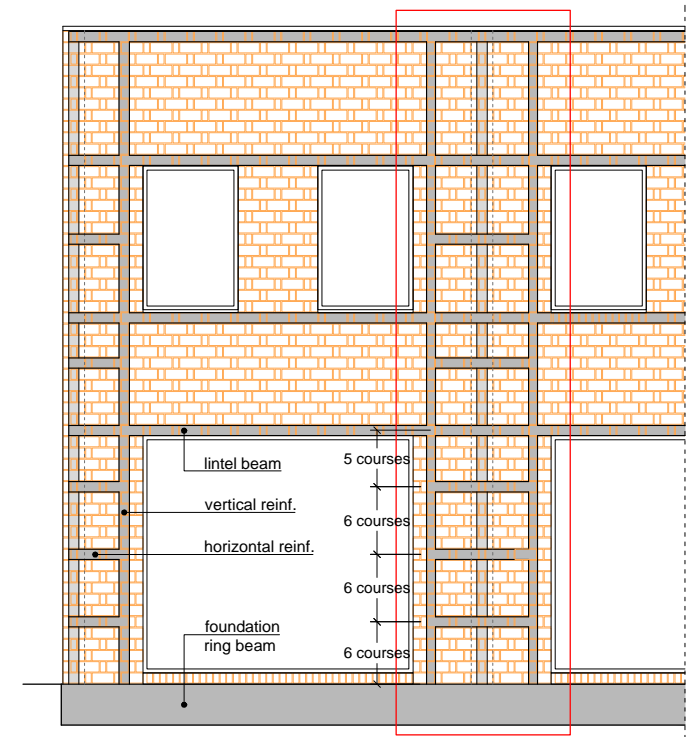
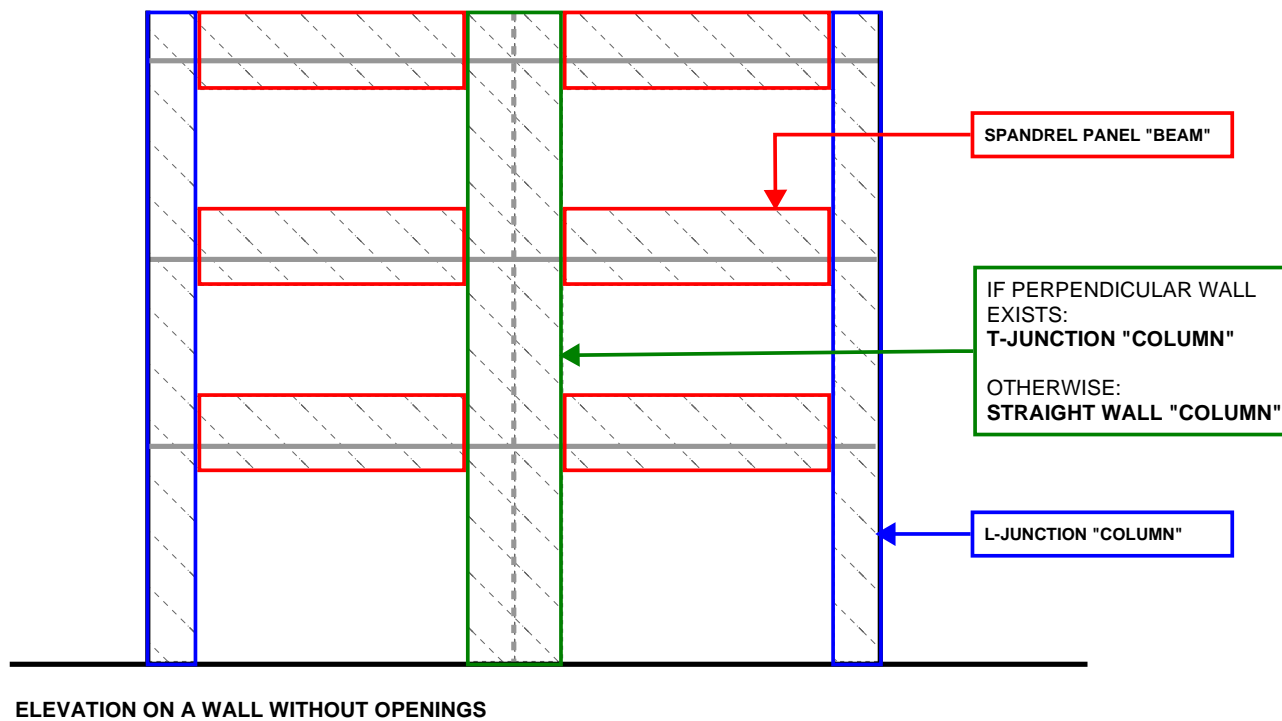
Assumptions

List of relevant EUROCODES

BS EN 1990 Basis of Structural Design
BS EN 1996 Design of Masonry Structures
BS EN 1998 Design of Structures for Earthquake Resistance

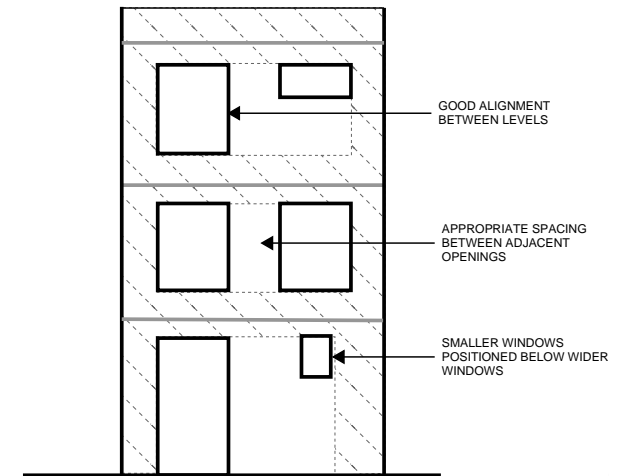
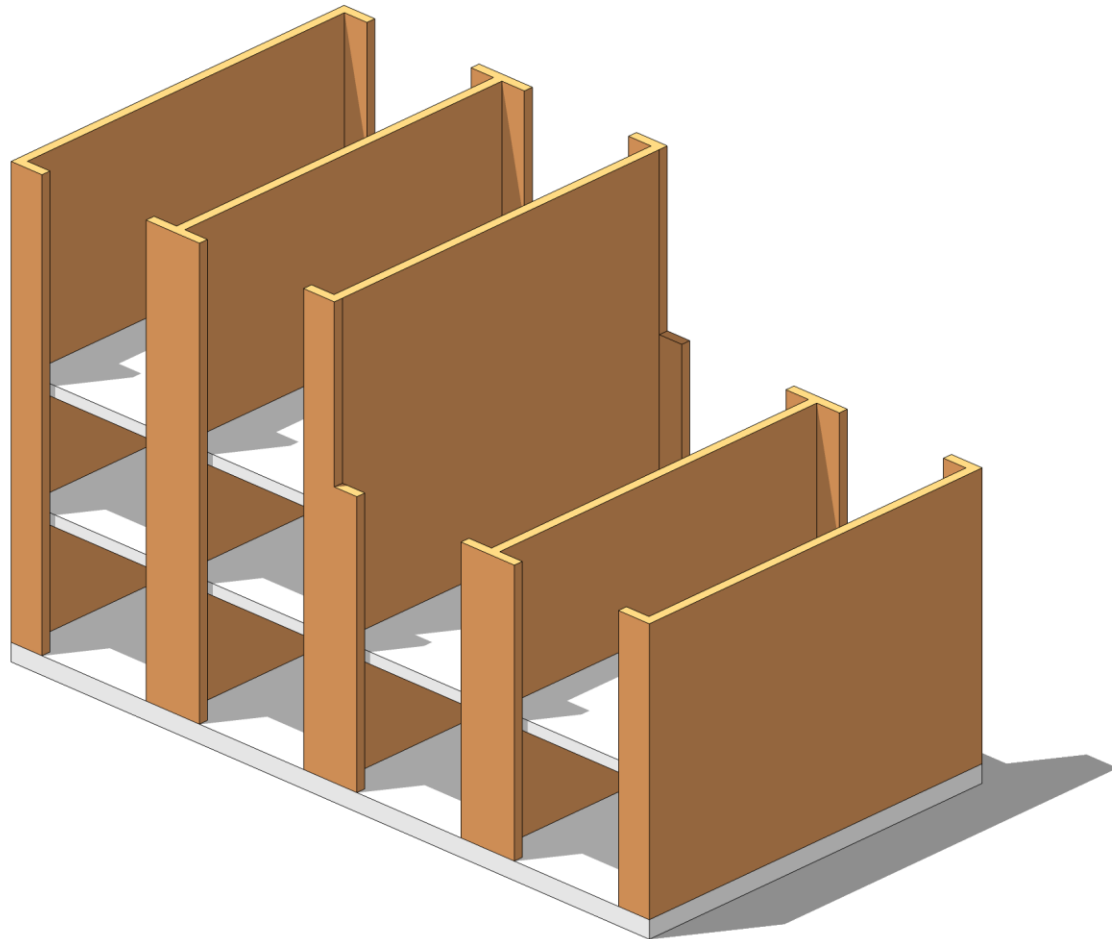
THE RLB STRUCTURAL DESIGN GUIDANCE

General design rules

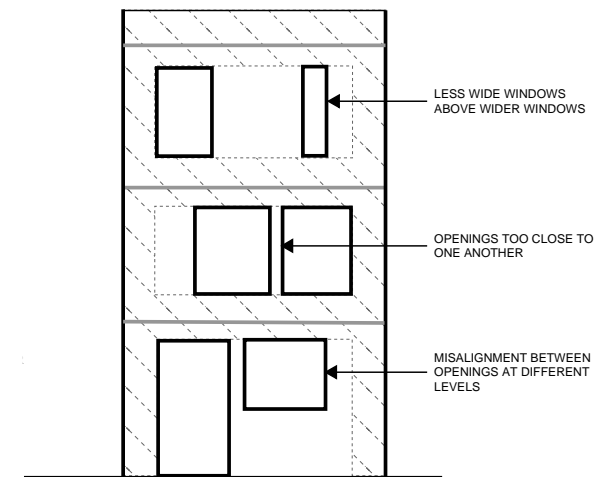


THE RLB STRUCTURAL DESIGN GUIDANCE

General design rules



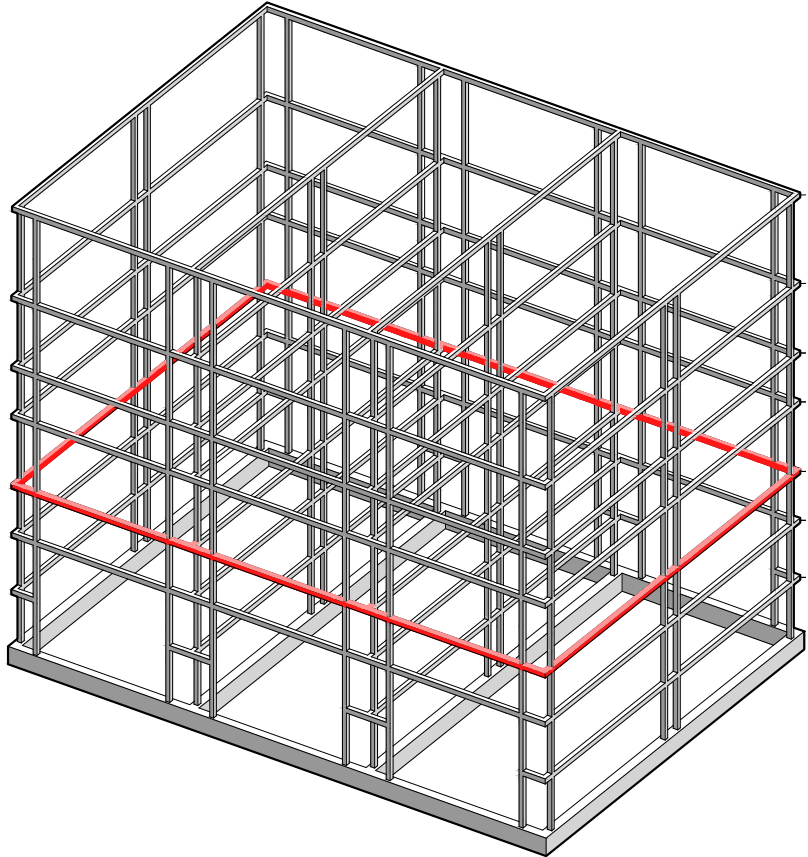
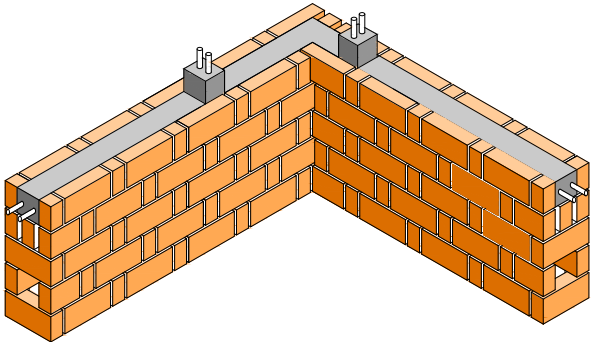
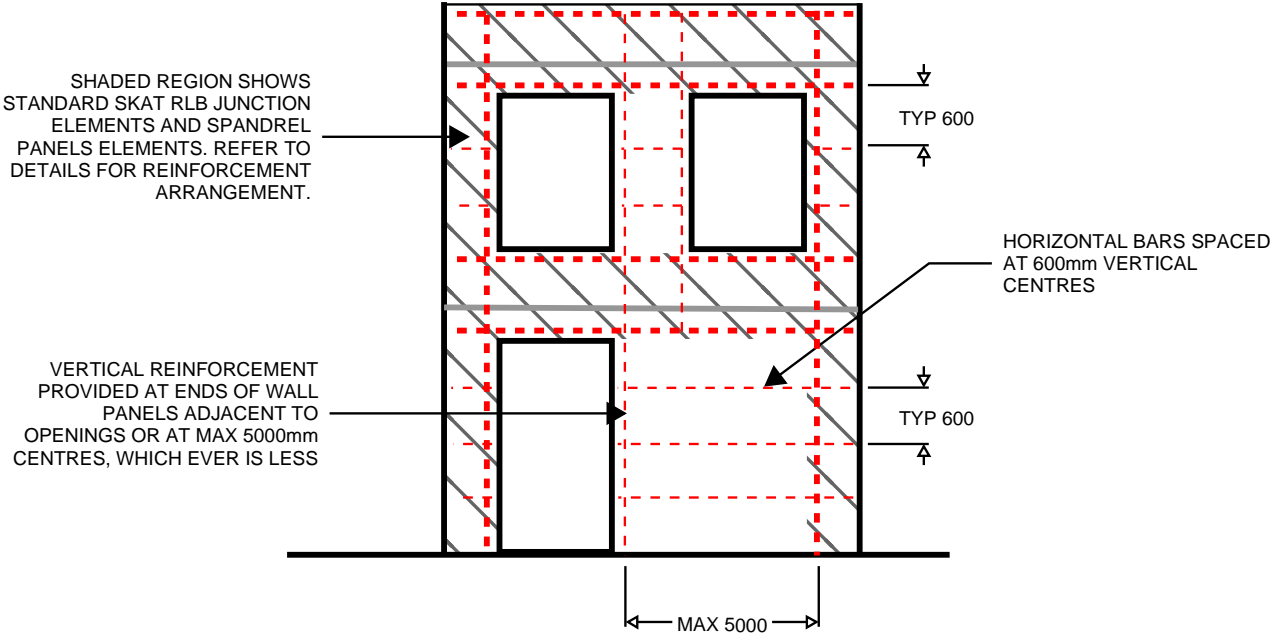
RECOMMENDED



NOT RECOMMENDED

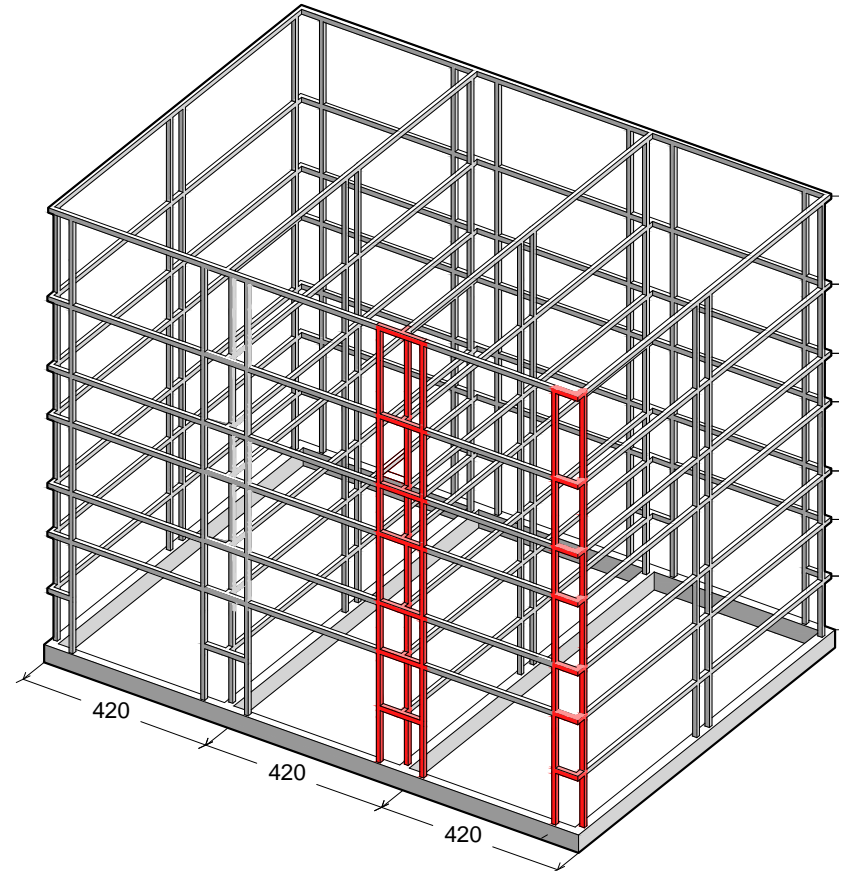
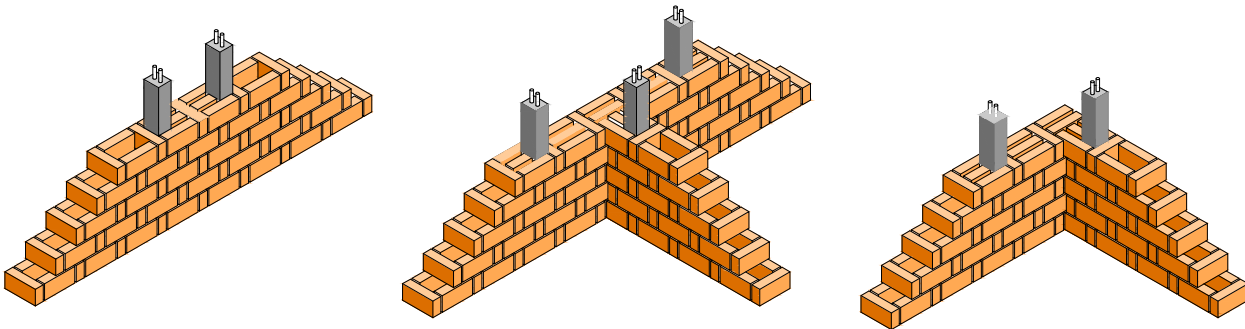
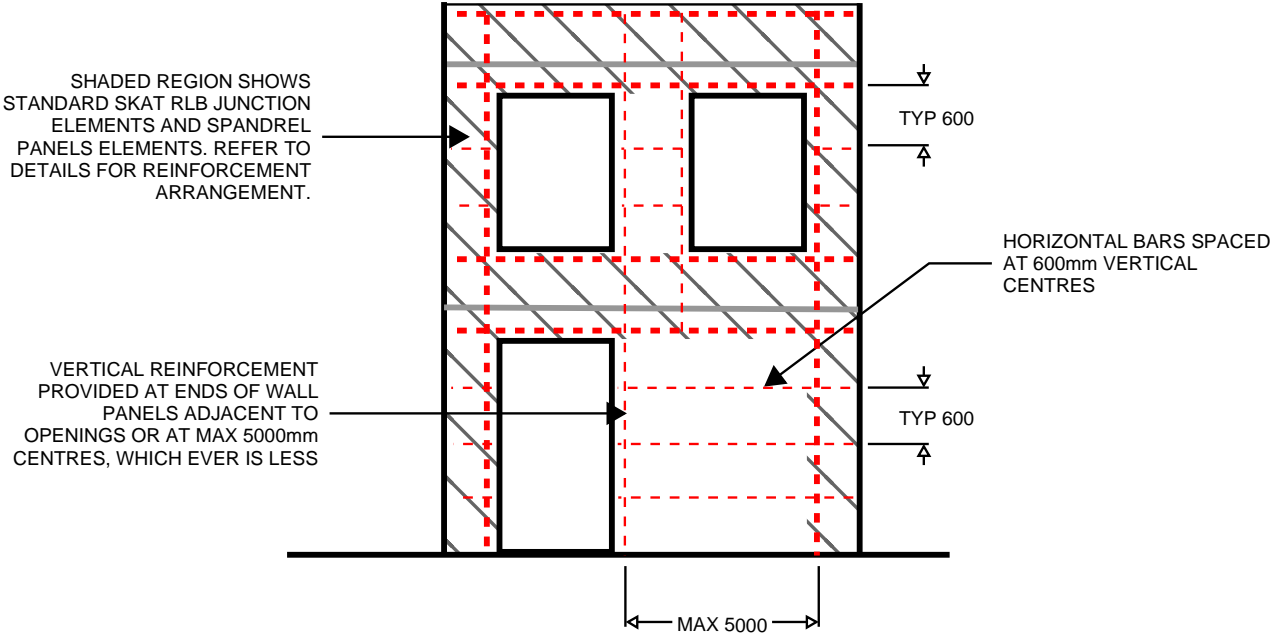
THE RLB STRUCTURAL DESIGN GUIDANCE

Minimum reinforcement



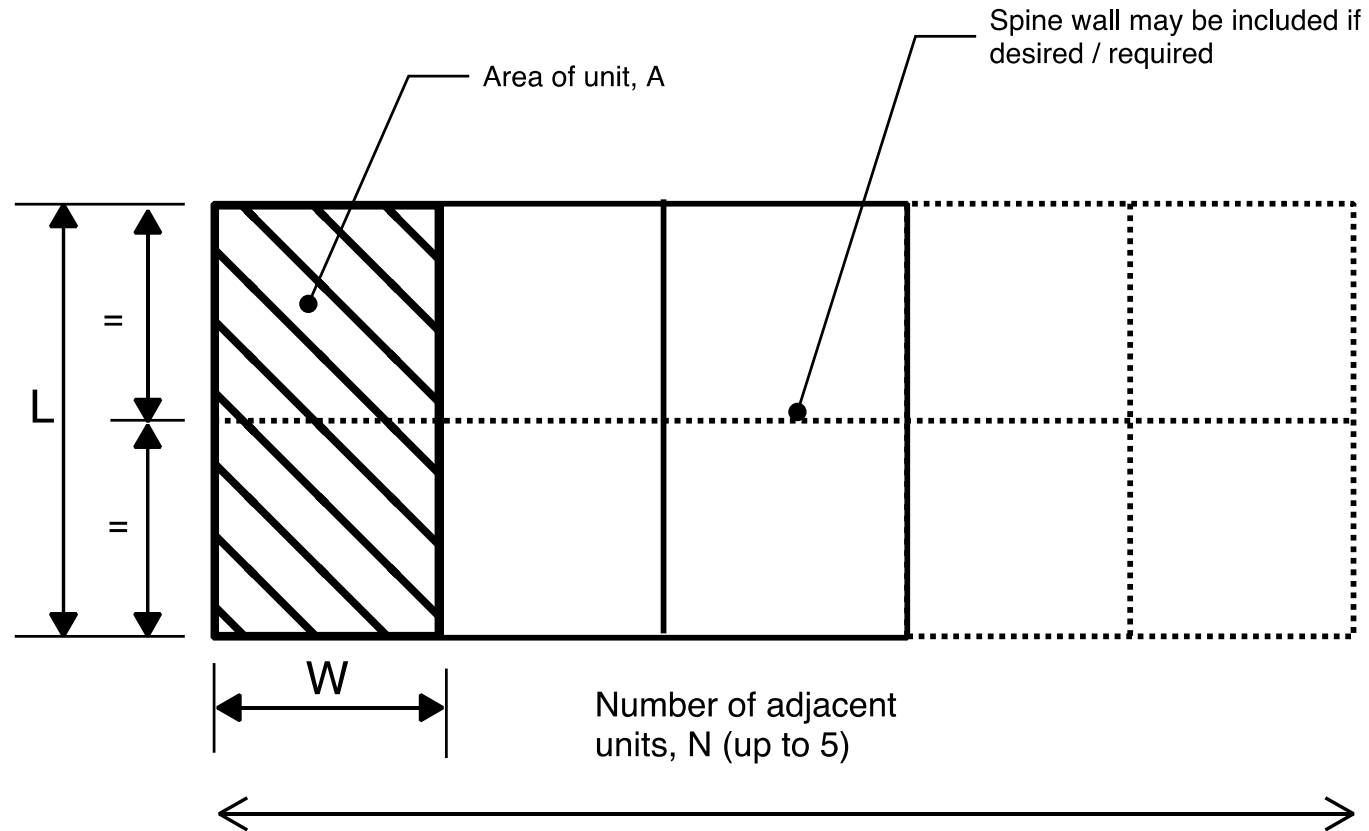
THE RLB STRUCTURAL DESIGN GUIDANCE

Minimum reinforcement



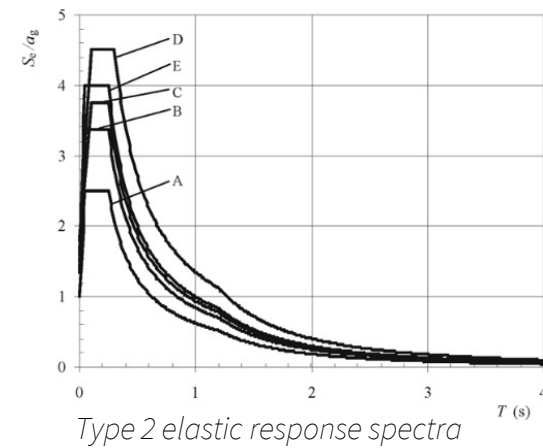
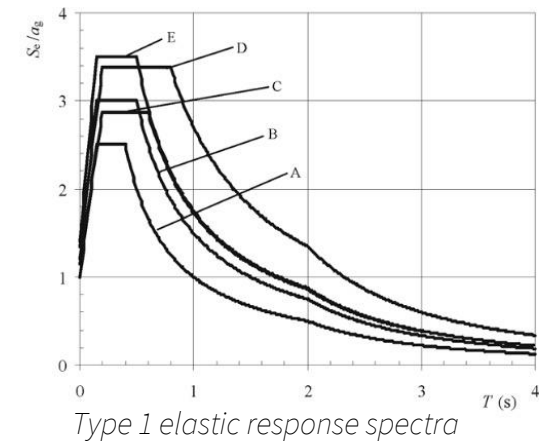
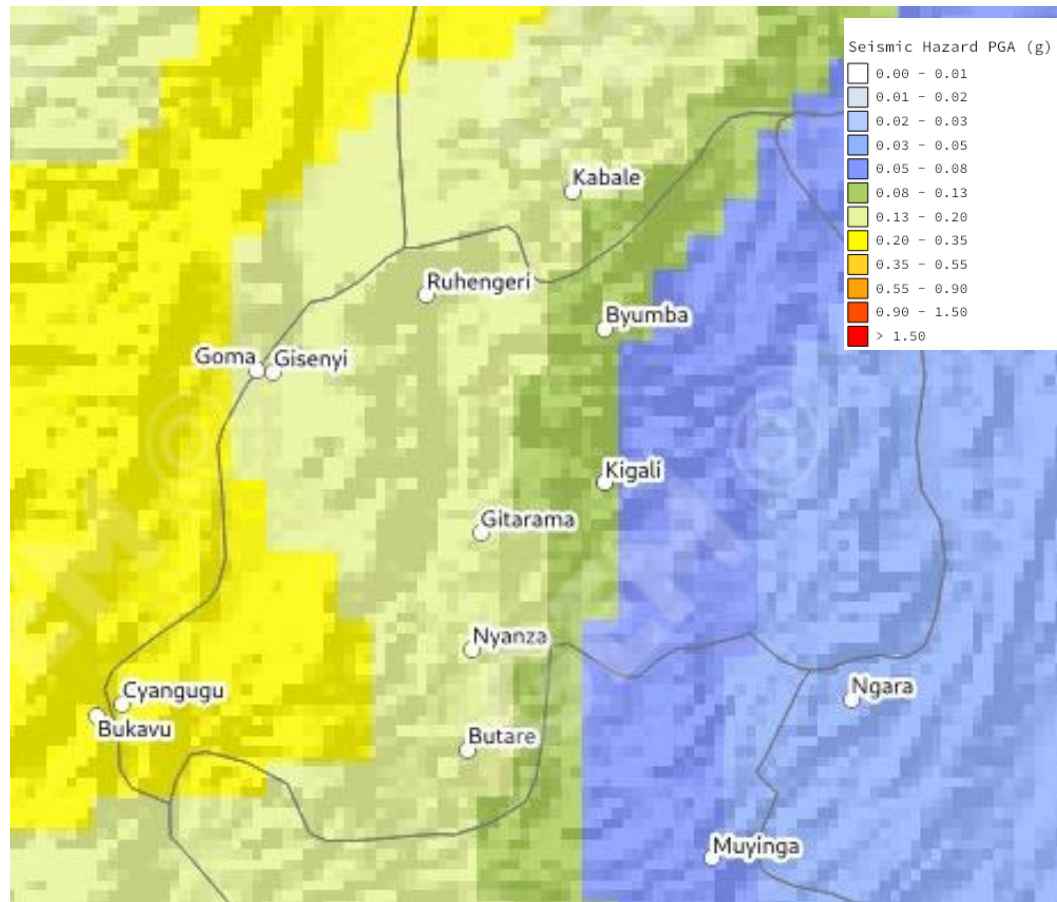
THE RLB STRUCTURAL DESIGN GUIDANCE

Other limitations



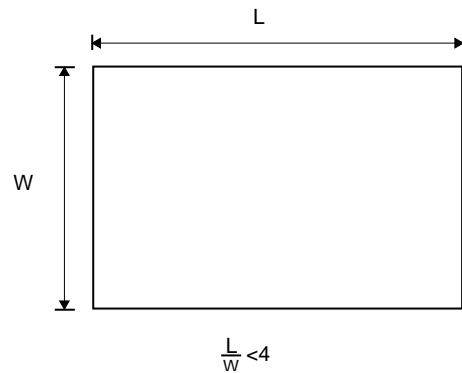
THE RLB STRUCTURAL DESIGN GUIDANCE

Seismicity and design ground acceleration

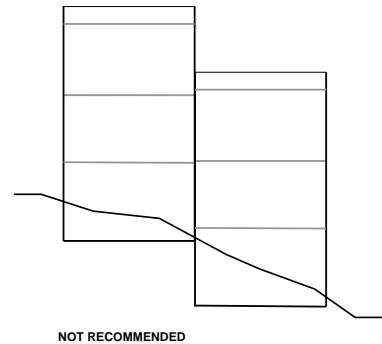


THE RLB STRUCTURAL DESIGN GUIDANCE

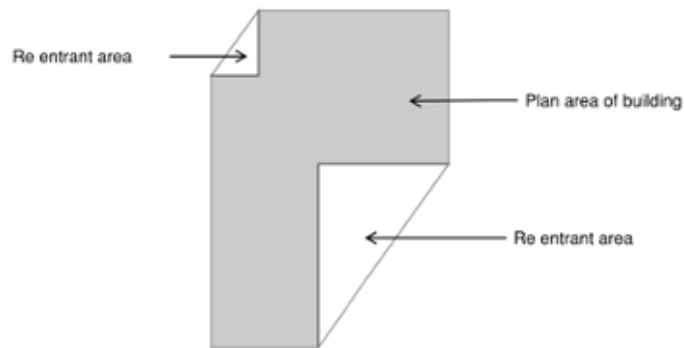
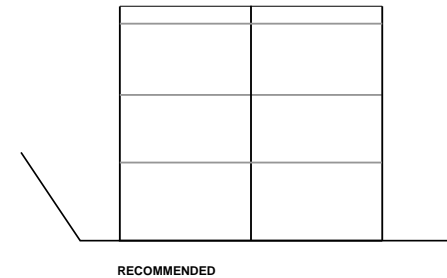
Equivalent static force method



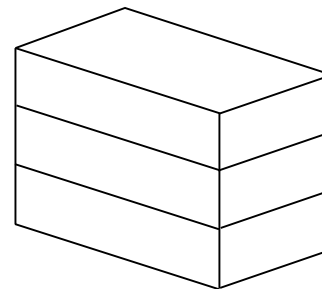
Rectangular building footprint



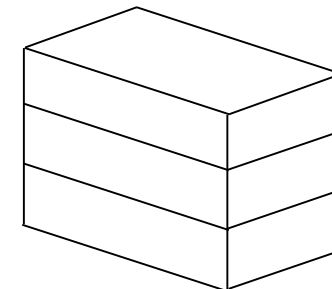
Uniform foundation level



Avoid re-entrant corners



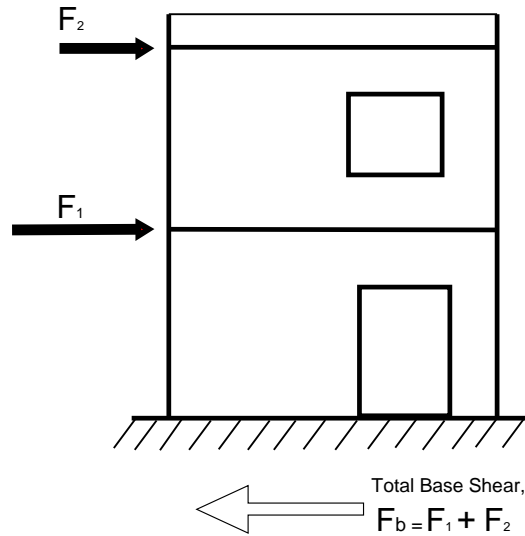
Continuous lateral stability elements



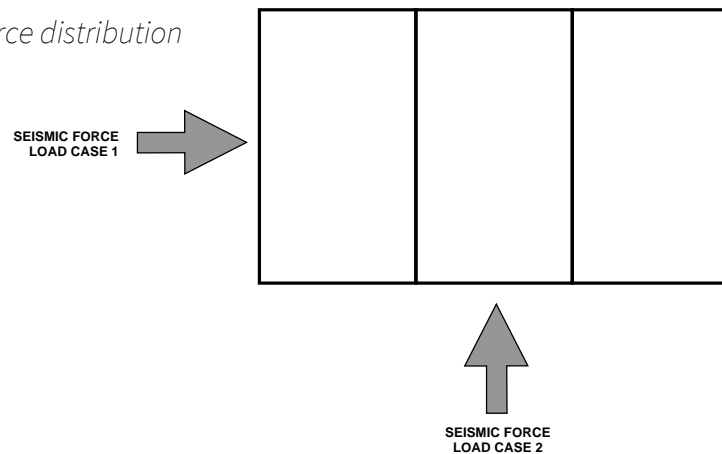
THE RLB STRUCTURAL DESIGN GUIDANCE

Total base shear and force distribution

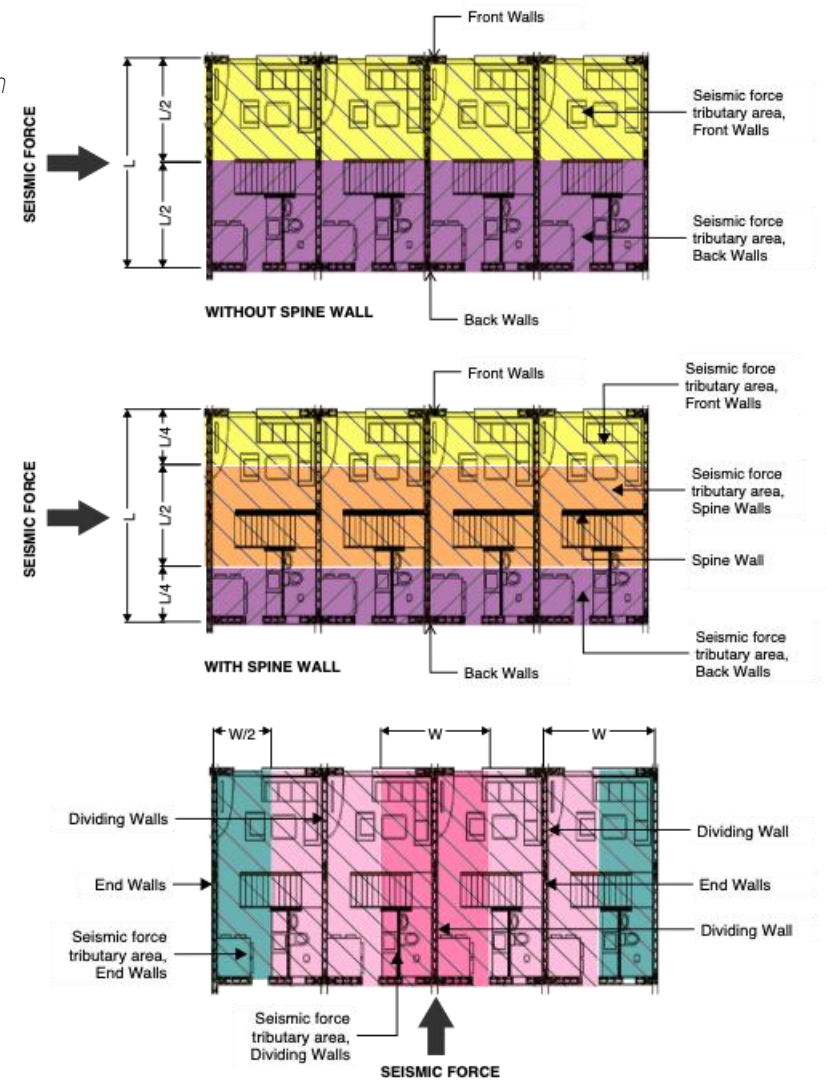
Vertical force distribution



Horizontal force distribution



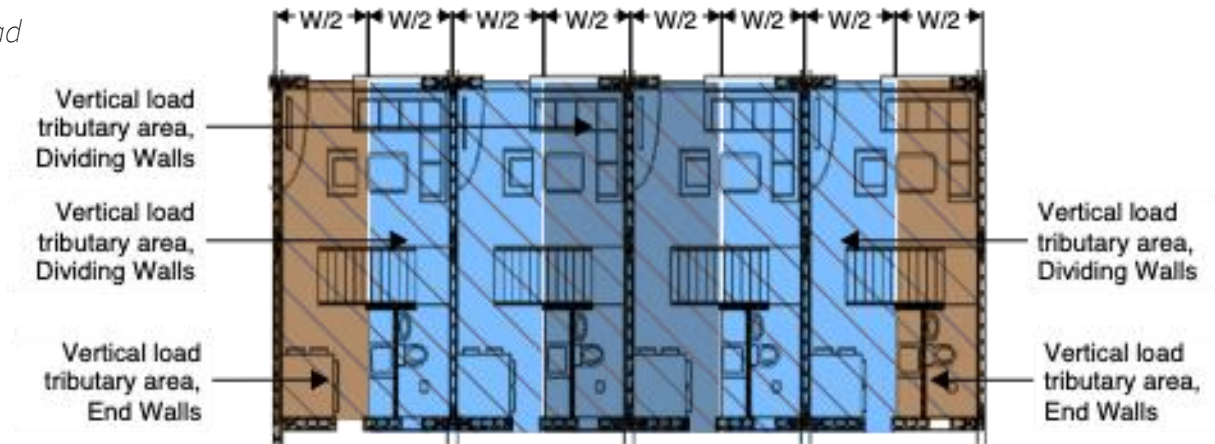
Floors load distribution



THE RLB STRUCTURAL DESIGN GUIDANCE

Vertical loads

Longitudinal vertical load

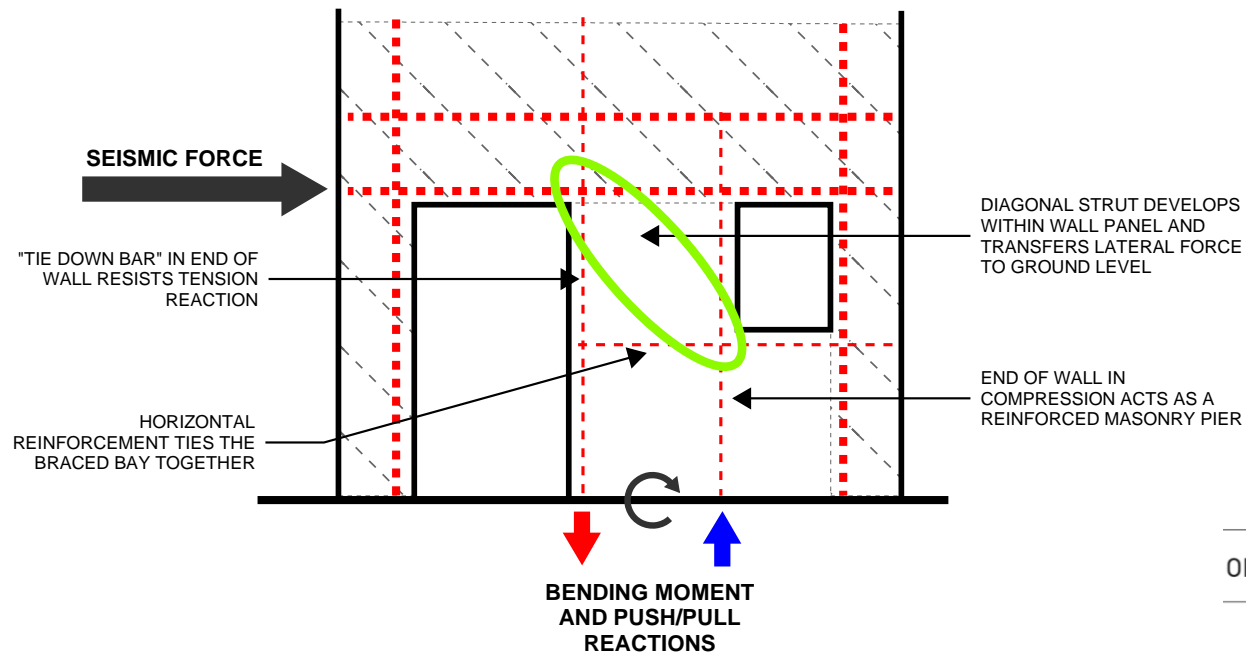


Transverse vertical load

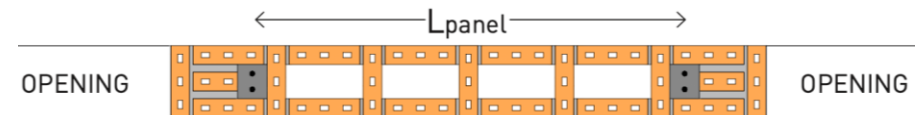


THE RLB STRUCTURAL DESIGN GUIDANCE

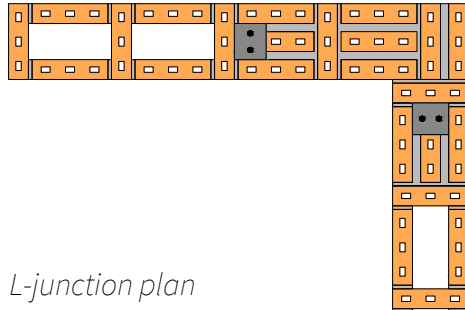
Assumed structural systems: SHEAR WALLS



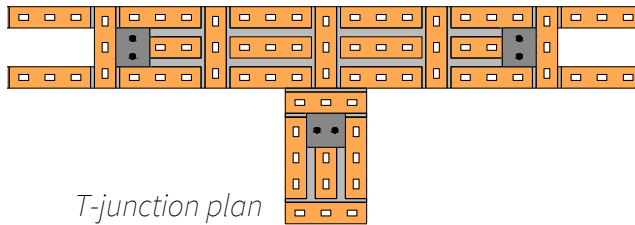
N. of Storeys	$L_{\text{panel,min}}$ (mm)
1(G+0)	1000
2(G+1)	1600
3(G+2)	2200



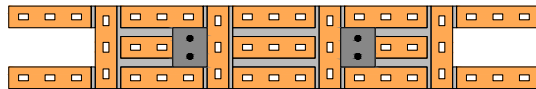
Assumed structural systems: MOMENT FRAME



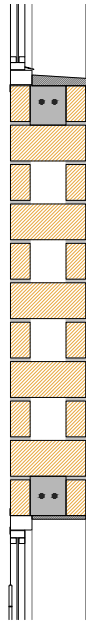
L-junction plan



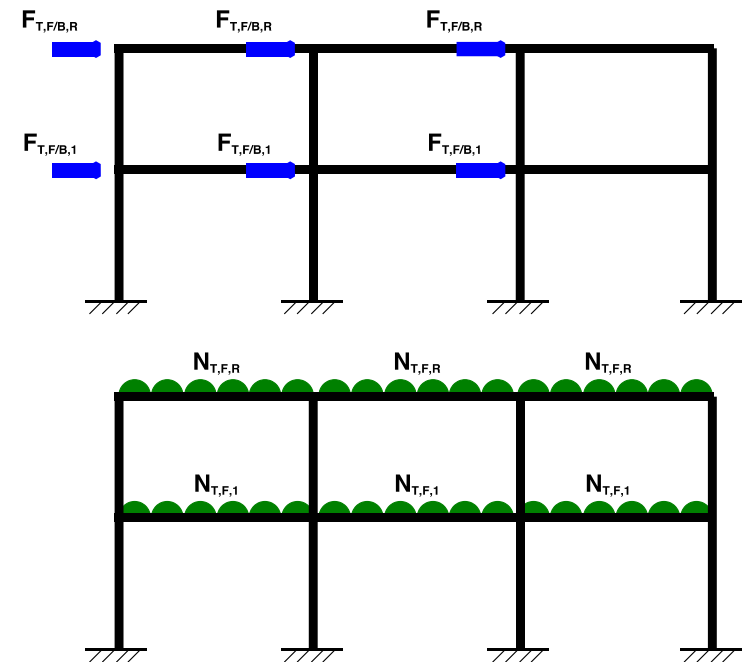
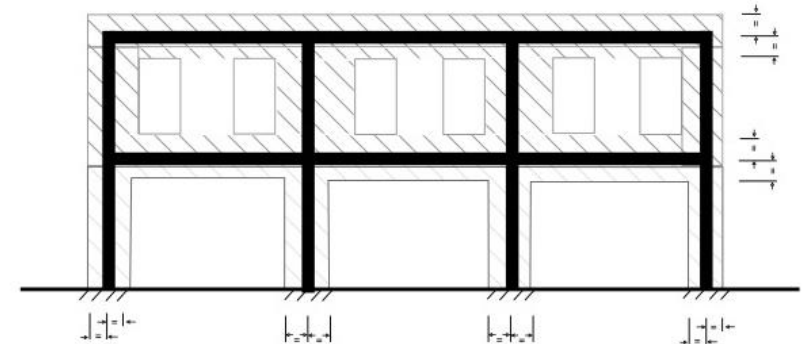
T-junction plan



Rectangular column plan



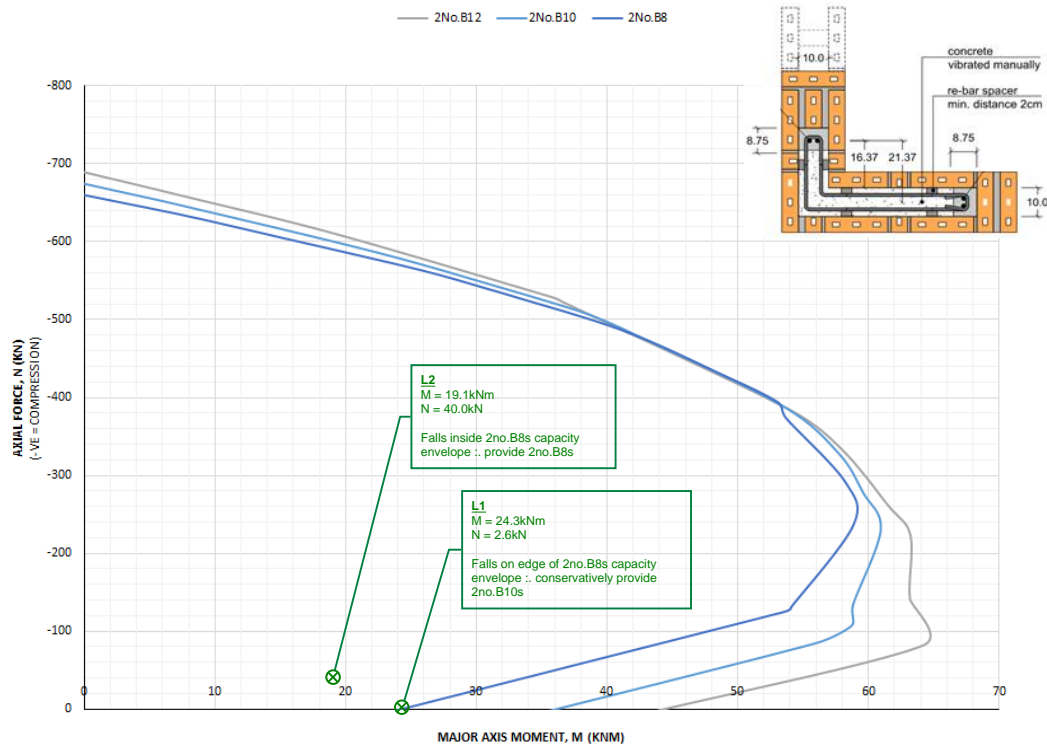
Spandrel panel section



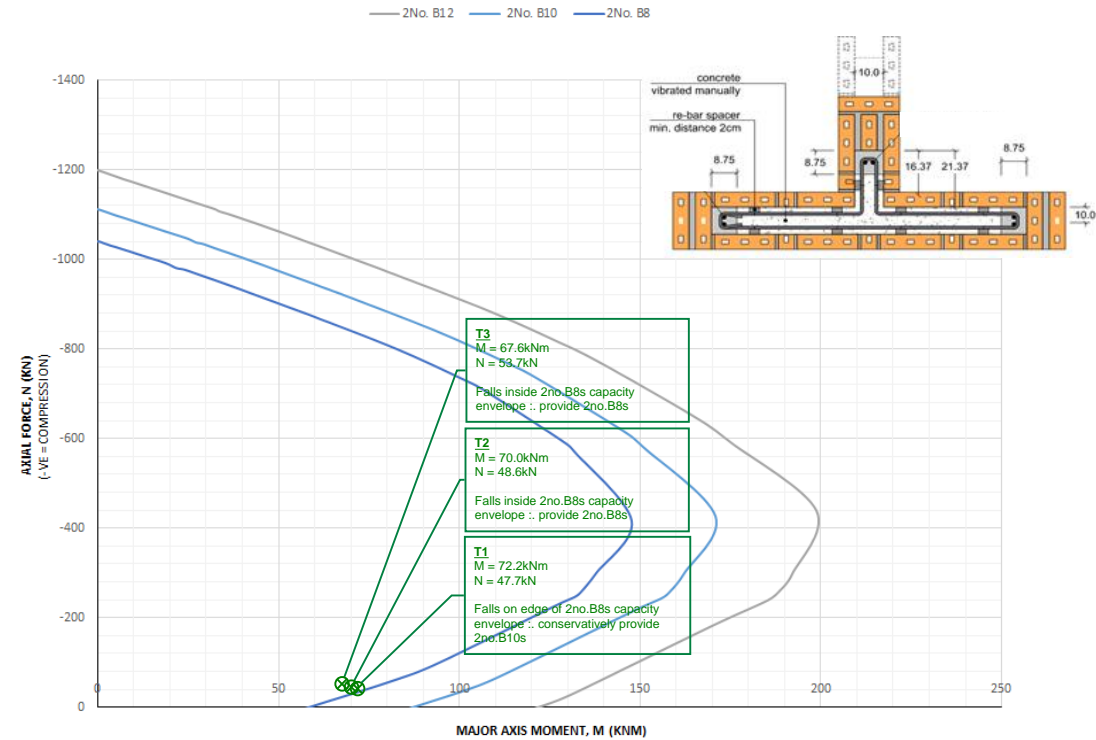
THE RLB STRUCTURAL DESIGN GUIDANCE

Assumed structural systems: INTERACTION DIAGRAM

210 THICK WALL : 'L'-JUNCTION COLUMN



210 THICK WALL : 'T'-JUNCTION COLUMN



THE **RLB STRUCTURAL DESIGN GUIDANCE**

More complex structures and further work



THE RLB STRUCTURAL GLOBAL ANALYSIS

Worked example

GLOBAL ANALYSIS - WORKED EXAMPLE

This worked example is based on the design of the existing SKAT Rowlock Bond housing located at Mpazi, Nyabagogo, Kigali, Rwanda.

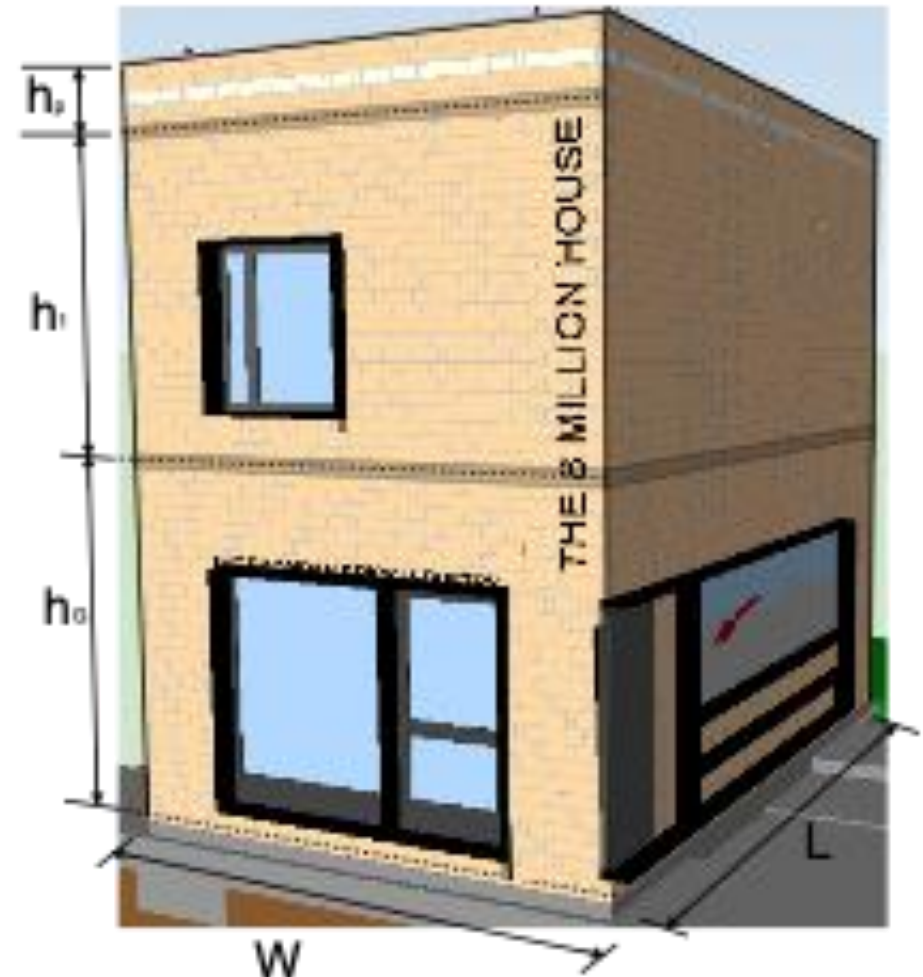
Seismic Design Parameters

Rwanda is considered a region of moderate seismicity given its location adjacent to the East African Rift System. The following seismic parameters are considered appropriate for the site based on the Rwanda Building Code, Global Earthquake Model (GEM) and the requirements and values set out in Eurocode 8 (where Response Spectra Type 1 is assumed for the purposes of this design).

RBC / GEM	Peak Ground Acceleration (PGA)	$a_g = 1.6 \text{ m/s}^2$
$g = 9.81 \text{ m/s}^2$	Ratio of PGA to Gravity	$\alpha = a_g / g = 0.16g$
EC8, Table 3.1	Soil Factor - Assume Spectrum Type 1, Soil Type C	$S = 1.15$
EC8, Table 4.3	Importance Factor - Assume Importance Class II	$\gamma_i = 1.0$
EC8, Table 4.4	Ductility Factor - Reinforced Masonry	$q = 2.0$
EC8, Eqn 3.14	Design Seismic Acceleration	$S_d = 2.5 \alpha S \gamma_i / q = 0.234g$

Building Geometry

The units are rectangular in plan and the footprint of an individual unit is 4.5m x 6.5m and there are four units constructed in a single terrace. 210mm thick RLB structural walls exist on the 4 sides of each unit, and there is no spine wall. The units are 2storeys tall and each storey has a different height. The masonry walls extend above roof level to form a parapet around each individual roof.



THE RLB STRUCTURAL GLOBAL ANALYSIS

The RLB calculation tool

COMPANY NAME	client :-		sheet		
	project :-		by		
	contact information:	file :-		date	
				chkd	

Ref.	Calculations	Output																																	
	<p>Disclaimer</p> <p>THIS SPREADSHEET IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE</p> <p>Spreadsheet key</p> <p> Input cells to be completed by user</p> <p> Instruction, must be followed</p> <p> Output Cell</p> <p>Introduction</p> <p>This calculation spreadsheet calculates the seismic force acting along each structural wall line in a single or group of simple housing units built with Skat Rowlock Bond Masonry Technology.</p> <p>Limitations of the spreadsheet include - Refer to Construction Manual for more information:</p> <ul style="list-style-type: none">- The housing unit must be rectangular in plan, with no re-entrant corners.- SKAT RLB junction elements to be continuous over height of the building.- The unit may have a single additional transverse wall (Spine Wall) centred on the plan- The housing unit can be single storey, two storey or three storey.- Each storey of the unit must have the same building footprint i.e. no step backs.- A structural diaphragm is achieved at each floor level and the roof level.- All diaphragms are considered to be flexible.- Up to 5no. identical units can be considered to act as a single building.- The overall building footprint should not exceed a Length to Width ratio of 4.0 <p>Inputs</p> <p>Seismic Design Parameters</p> <table><tr><td>ag</td><td>Peak ground acceleration</td><td>1.6 m/s²</td></tr><tr><td>α</td><td>Ratio of pga, gravity</td><td>0.16 g</td></tr><tr><td></td><td>Response Spectrum Type</td><td>1</td></tr><tr><td></td><td>Soil Type</td><td>D</td></tr><tr><td>S</td><td>Soil factor</td><td>1.35</td></tr><tr><td>ya</td><td>Importance Factor</td><td>1</td></tr><tr><td>q</td><td>Ductility Factor</td><td>2</td></tr><tr><td>Sd</td><td>Design seismic acceleration on plateau</td><td>0.275 g</td></tr></table> <p>Geometry</p> <table><tr><td>L</td><td>Unit Length</td><td>9 m</td></tr><tr><td>W</td><td>Unit Width</td><td>4 m</td></tr><tr><td>A</td><td>Area of Unit Footprint</td><td>36.0 m²</td></tr></table>	ag	Peak ground acceleration	1.6 m/s ²	α	Ratio of pga, gravity	0.16 g		Response Spectrum Type	1		Soil Type	D	S	Soil factor	1.35	ya	Importance Factor	1	q	Ductility Factor	2	Sd	Design seismic acceleration on plateau	0.275 g	L	Unit Length	9 m	W	Unit Width	4 m	A	Area of Unit Footprint	36.0 m ²	
ag	Peak ground acceleration	1.6 m/s ²																																	
α	Ratio of pga, gravity	0.16 g																																	
	Response Spectrum Type	1																																	
	Soil Type	D																																	
S	Soil factor	1.35																																	
ya	Importance Factor	1																																	
q	Ductility Factor	2																																	
Sd	Design seismic acceleration on plateau	0.275 g																																	
L	Unit Length	9 m																																	
W	Unit Width	4 m																																	
A	Area of Unit Footprint	36.0 m ²																																	

Ref.	Calculations	Output									
	<p>Y/N Spine Wall Included? Yes</p> <p>N Number of Adjacent Units 2</p> <p>Construction</p> <table><tr><td>1F</td><td>Select Floor Construction</td><td>MaxSpan Slab</td></tr><tr><td>2F</td><td>Set as N/A</td><td>N/A</td></tr><tr><td>RF</td><td>Select Roof Construction</td><td>Timber Trusses/Joists</td></tr></table> <p>DL Timber Trusses/Joists 0.40 kN/m²</p> <p>DL Maxspan Floor 2.60 kN/m²</p> <p>SDL Floor Superimposed Dead Load (incl. Partitions) 0.40 kN/m²</p> <p>SDL Roof Superimposed Dead Load 0.20 kN/m²</p> <p>EC1, Table 6.2</p> <p>LL Live loads 1.50 kN/m²</p> <p>SW Masonry Walls Selfweight 2.63 kN/m²</p> <p>SDL Glazing 0.15 kN/m²</p> <p>Global Seismic Forces</p> <p>Yw DL Seismic Contribution Factor 1.0</p> <p>Yp LL Seismic Contribution Factor 0.3</p> <p>EC0 6.4.3.4, Table A1.1</p> <p>Wu Vertical load of Masonry per Metre Height of Wall (all Units) 134 kN/m</p> <p>W1 Vertical load of First Floor per Unit 124 kN/unit</p> <p>W2 N/A N/A kN/unit</p> <p>We Vertical Load of Roof per Unit 22 kN/unit</p> <p>EC8, Eqn 4.5</p> <p>Fb Total Base Shear 233 kN</p>	1F	Select Floor Construction	MaxSpan Slab	2F	Set as N/A	N/A	RF	Select Roof Construction	Timber Trusses/Joists	
1F	Select Floor Construction	MaxSpan Slab									
2F	Set as N/A	N/A									
RF	Select Roof Construction	Timber Trusses/Joists									
	<p>z1 Height Above Ground (1F) 2.50 m</p> <p>z2 Height Above Ground (2F) N/A m</p> <p>z3 Height Above Ground (RF) 5.00 m</p> <p>h1,1 Tributary Height of Wall (1F) 2.50 m</p> <p>h1,2 Tributary Height of Wall (2F) N/A m</p> <p>h1,3 Tributary Height of Wall (RF) 2.25 m</p> <p>m1 Seismic Weight (1F) 584 kN</p> <p>m2 Seismic Weight (2F) N/A kN</p> <p>m3 Seismic Weight (RF) 345 kN</p> <p>z1.m1 Height x Seismic Weight (1F) 1459 kNm</p> <p>z2.m2 Height x Seismic Weight (2F) N/A kNm</p> <p>z3.m3 Height x Seismic Weight (RF) 776 kNm</p> <p>EC8, Eqn 4.11</p> <p>F1 First Floor Seismic Force 152 kN</p> <p>F2 Second Floor Seismic Force N/A kN</p> <p>F3 Roof Seismic Force 81 kN</p>										

THE **RLB STRUCTURAL DESIGN GUIDANCE**

Resources website

www.madeingreatlakes.com



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development
and Cooperation SDC

skat

Swiss Resource Centre and
Consultancies for Development

PROECCO **PRO**moting **E**mployment through
Climate Responsive **CO**nstruction