Guide 1 -

# Léém Earth Blocks



# Introduction

This Léém Earth Block Guide aims to provide trustable information to the building professional (architect, engineer, contractor) on the topic of earth block masonry with Léém earth building materials. As such, we – the authors of the cooperative BC materials – have chosen to heavily « stand on the shoulders of giants »: the knowledge and guidelines which are asserted in sections 1,3,4 and 5 come from reference works from two of the most experienced earth building communities: the French and the German community. The French network is built around the university research institution CRAterre, and spreading out towards organisations such as Cycle-terre, Amaco, ENTPE, CSTB. The German network is built around the Dachverband Lehmbau, with experts such as Dr.-Ing Horst Schröder, Dr.-Ing Christof Ziegert, and nation-wide regulation such as DIN norms and the EPD framework.

This Léém Earth Block Guide is hence a compilation of the most recent research publications, technical approvals and norms in Germany and France, updated with specific extra research and experience by BC materials and Buildwise related to a Benelux context. We have tried to show as much as possible from which reference we have compiled certain specific information, by mentioning the reference in the side column in the text, and by adding the full bibliography in section 6. We are more specific in who to thank for what kind of contribution in our acknowledgement section at the end of this guide.

We hope to have made clear how this guide exists from a European spirit of sharing earth building expertise. We hope this Léém Earth Block Guide will facilitate you, and hence continue to grow the earth building sector in Benelux.

# Contents


Introduction 3

1. Earth blocks for interior walls 9

1.1 What is an earth block ? 10

1.2 The production process of a Léém block 11

1.2.1 Secondary and primary resources 11

1.2.2 Preparation of raw materials 11

1.2.3 Moulding or pressing of the blocks 12

1.2.4 Drying 12

1.2.5 Packaging and transport 13

1.3 Unfired, is it solid enough? 14

1.4 Is it water-resistant? 14

1.5 Why 2 blocks and 3 mortars? 15

1.5.1 Wall typologies 15

1.5.2 The right block in the right place : what about market alternatives? 18

1.5.3 The right Léém block in the right place : how to choose? 19

1.6 What about environmental impact ? 20

1.7 Building standards and quality control 21

2. Physical properties & designations 23

2.1 Designations of Léém Blocks 24

2.2 Designation or physical properties of Léém Mortar types 28

2.3 Physical properties of Léém masonry systems 29

2.3.1 Masonry with Moulded Earth Blocks 29

2.3.2 Masonry with Compressed Earth Blocks 29

2.3.3 Extra: Coefficient of linear thermal expansion 30

# 3. Design Guidelines 33


3.1 General principles 34

3.2 Field of application 34

3.2.1 Application classes 34

3.2.2 Application norm for dimensioning loadbearing walls 36

3.3 Moisture conditions 36

3.3.1 Moisture protection of the wall surface 36

3.3.2 Moisture protection of wall footings 38

3.3.3 Protection in wet rooms 39

3.3.4 Hygrothermal design for exterior walls 40

3.4 Conditions on deformations 42

3.4.1 Vertical settlements, horizontal shrinkage and differential settlements 42

3.4.2 Structural joints 43

3.4.3 Conditions on structural deformations 45

3.4.4 Conditions on deformation of floors and lintels 45

3.5 Slenderness ratios 46

3.6 Bracing 47

3.7 Support loads 49

3.8 Lintels 49

3.9 Ring beams for loadbearing masonry 50

3.10 Junctions 51

3.10.1 Junctions between loadbearing walls 51

3.10.2 Junction between non loadbearing walls and loadbearing structure : U-shape 52

3.10.3 Junctions between non loadbearing walls and loadbearing structure : central rib 53

3.10.4. Junctions between non loadbearing walls and loadbearing structure : anchoring system 53

3.10.5 Connection with joinery 60

3.11 Angles 61
3.12 Acoustic walls 62
3.12.1 General Principles 62
13.12.2 (Calculated) values of acoustic wall insulation 64
13.12.3 Acoustic isolation between dwellings 65
3.13 Airtightness 65
3.14 Inner leaf of exterior (cavity) walls 66
3.14.1 Case A: Léém masonry infill wall to the surrounding structural frame. 66
3.14.2 Case B : Interior infill lining of an exterior loadbearing façade wall 67
3.14.3 Case C : Loadbearing insulated exterior wall 68
3.14.4 Hygrometric validation of cases 68
3.14.5 Dimensions of the air cavity 68
3.15 Fixing of heavy loads 69
3.16 Protection against abrasion 69
3.17 Grooves and holes in the walls 69

4. Implementation guidelines 71

4.1 Preparation and site conditions 72
4.2 Laying rules 76
4.2.1 10mm joints with Léém mortar 76
4.2.2 10mm joints with bastard mortar and Léém Additive 77
4.2.3 1-3mm fine joints with Léém Adhesive mortar 77
4.2.4 Assembling rate and drying time 77
4.3 Tolerance of execution 80
4.4 Cladding finishes and appearance 80

## 5. Construction details 83

5.1 General details for all types of walls 84

5.2 Details for loadbearing walls 86

5.3 Details for non-loadbearing walls 87

## 6. Bibliography 117

## 7. Acknowledgements and credits 119

# 1. Earth blocks for interior walls



For thousands of years, mankind has built with what was close at hand and abundant: earth. By shaping this earth into blocks and turning them into walls, people were able to create a shelter, a warm home for their families and loved ones. Over time, and at the end of the 18th century, we discovered the advantages of fossil energy and quickly transformed unfired clay into fired bricks. But today, the intensive use of fossil fuels is creating many dangers, as it is warming our climate, causing massive heat waves, droughts, severe flooding and rising sea levels. We believe that by going back to raw earth and improving it with state-of-the-art production infrastructures, we can reduce the huge carbon footprint of the building materials sector, recover locally abundant materials (considered waste) and improve the quality of life (in terms of air quality, acoustics, etc.) for many people.

# 1.1 What is an earth block ?

The Léém Blocks are rectangular-shaped earth building materials which are made from excavated earths, comprising clays, silts, sands and gravels. Clay is the main binder. The shaping process is decisive for the type of earth block:

— **Compressed Earth Block**: humid earth is compressed through mechanical force, hydraulic force or vibrocompacting force exerted by specific machinery. The blocks are subsequently cured and air dried at ambient temperatures.
— **Moulded Earth Block**: plastic earth is moulded in a formwork and then demoulded, either by hand or by machinery. The blocks are subsequently most often dried in drying chambers using recuperation heat until 80°C.

Earth blocks are mortared with earth mortar or earth adhesive mortar in order to become earth block masonry to be used as a building element.

Sometimes, extra ingredients are added to raw earth blocks to gain certain characteristics and performances. When these extra ingredients do not contribute significantly to the water-resistance of earth blocks, they are called additives. When they do contribute significantly to water-resistance of earth blocks, they are called stabilisers.

Currently BC Materials offers the Léém Moulded Block, which is a raw earth block without additives nor stabilisers, and the Léém Compressed Block, which is an earth block stabilised with 3,85% (wt.) of cement. Henceforth, this document will focus on these two typologies.



Compressed Léém Block



Moulded Léém Block

# 1.2 The production process of a Léém block

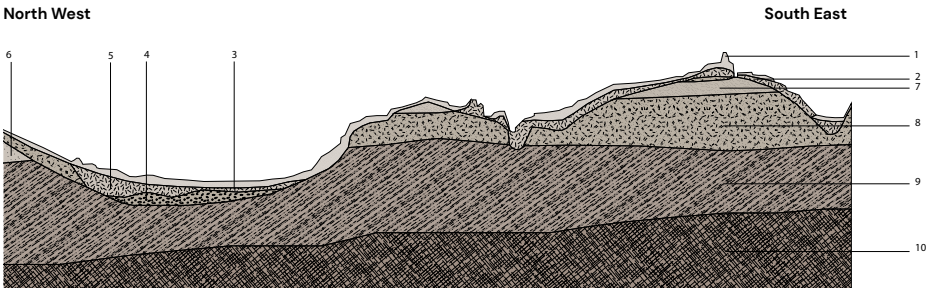
## 1.2.1 Secondary and primary resources

Secondary resources such as excavated earth and/or mineral waste streams are sourced from construction sites and temporary storage centres. These resources are free of pollution according to the legally required thresholds of OVAM Flanders and Brussel Leefmilieu, and even extra pollution markers by BC Materials. In total, 40+ parameters are checked. This secures the resources of Léém to be free of PCB, PFC, asbestos, lead, heavy metals, flame retardants, phthalates et isocyanates.

For some construction techniques, quarried primary resources such as specific clays and sands are added in the minimum necessary quantities.

**Quaternary**
1. Superficial formations
2. Slope silts
3. Alluvial clays
4. Alluvial sand and gravels
5. Alluvial silts

**Tertiary**
6. Asschian (clays and sands)
7. Ledian (sands and sandstones)
8. Bruxellien (decalcified sands, limestones and sandstones)
9. Ypresian (clayey sands and clays)
10. Landenian (sands, silts and clays)



Geological section of Brussels

## 1.2.2 Preparation of raw materials

BC Materials dries, sieves and premixes according to controlled recipes, and exerts quality control. These mixed quantities are then delivered as Léém earth premixes to partners.


Premixing


Loading of the Léém premix


Léém premix at production partner



Installation of block moulds



Block calibration



Blocks after vibrocompaction

## 1.2.3 Moulding or pressing of the blocks

The Léém premixes arrive at production partners in a process of “industrial coworking”: they are moulded or compressed by electrical machinery into its rectangular shape as Léém Moulded Blocks and Léém Compressed Blocks.




Transfer of the blocks to the drying area




Drying area for the blocks

## 1.2.4 Drying

Léém Moulded Blocks are air-dried for 3 days using recuperated heat from brick-making ovens. Léém Compressed Blocks are cured in a non-heated non-ventilated chamber for 10 days.



Palletisation



Pallet packing



Transfer to storage

## 1.2.5 Packaging and transport

Léém blocks are palletised, wrapped and labelled in a recyclable plastic, and ready to leave for the construction site.



Storage



Loading for transport



Securing the pallets for transport

# 1.3 Unfired, is it solid enough?

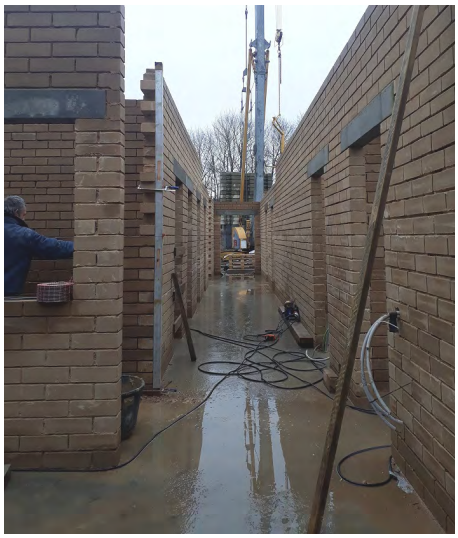
[8] DIN 18940 Maçonnerie porteuse en terre crue

The Léém Moulded Block exclusively uses clay to bind silts, sands and gravels. The dry compressive strength is minimum 5MPa. Since clay is the only binder, these blocks are very sensitive to strength loss when the water content of the blocks increases. Moreover, the clay binding forces are reversible, which means they can be unbound by water; the earth block becomes earth again. With proper design taking these characteristics into account, raw earth blocks can be used for load bearing interior masonry of 13 metre high [8] (p.5) . **So yes, Léém blocks are solid.**

The Léém Compressed Block has a different production technique and an extra ingredient – 3,85% (wt.) of cement – to make the blocks more water-resistant and even stronger: minimum 9 MPa. Since stabilised blocks are stronger than raw earth blocks, they can be assumed to be used for loadbearing masonry of at least 13 m high, or higher after structural calculations by a qualified engineer. **Léém Compressed Blocks are water-resistant.**



Loadbearing masonry in Compressed Blocks



Water resistance of the Compressed Blocks

# 1.4 Is it water-resistant?

Léém Moulded Block and Compressed Block masonry can be used for all existing interior walls (including the interior side of outside walls), in dry spaces as well as in wet spaces (such as bathrooms, kitchens, ...). As a principle, proper design and construction site management protects the Léém masonry walls from direct water contact such as recurrent condensation, rain, capillary rise, splash water, leakages, etc.

Léém Compressed Block masonry also supports some extra usage because of its overall improved water resistance:

— exterior use protected from rain
— interior use receiving occasional splash water (such as plinths receiving cleaning water)

# 1.5 Why 2 blocks and 3 mortars?

The combination of 2 blocks and 3 mortars in the Léém product range makes it possible to design and execute all typologies of internal masonry (see section 1.4.1) and replace all kinds of fossil fuel intensive alternatives currently on the market (see section 1.4.2).

The Léém Moulded Block range contains no additives nor stabilisers; it exists mainly from excavated earths of construction sites. It is our most ecological and circular range of blocks, while also offering the aesthetics of craft through its texture and colour.

The Léém Compressed Block range uses 3,85% (wt.) of cement as a stabiliser, and is more water-resistant, acoustic, fire-resistant and stronger. The aesthetics is more industrial through its aspect and colour.

Léém Mortar is used to mason both Léém Moulded Block and Compressed Block ranges with 10mm joints.

Léém Adhesive mortar is used to mason both Léém Moulded Block and Compressed Block ranges with 1-3mm joints.

A bastard mortar (based on lime and cement) with Léém Additive for Bastard Mortar can be used to mason the Léém Compressed Block ranges with 10mm joints in exceptionally demanding circumstances.



Compressed Blocks masonry



Moulded Blocks masonry

## 1.5.1 Wall typologies

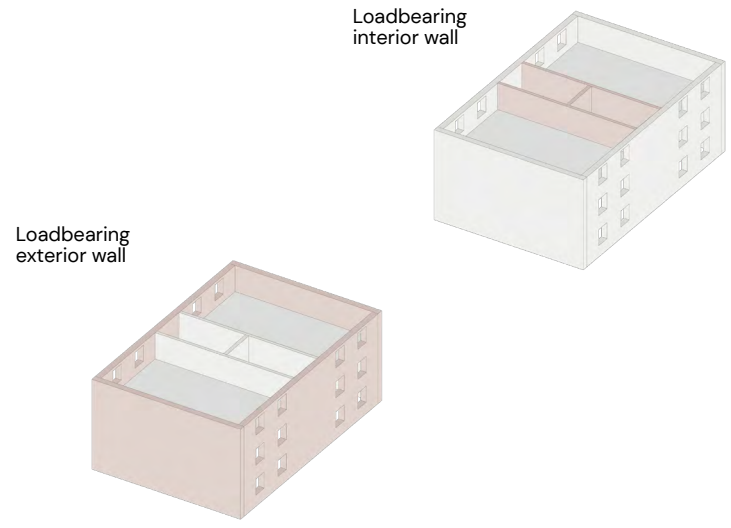
In the table here under we categorize characteristics of walls as well application typologies of walls in order to clearly define where Léém Moulded and Léém Compressed Block masonry with different Léém mortar types can be used. Here are some general principles:

— Both Léém Moulded and Compressed Blocks are for masonry protected from weather and capillary rising water; hence no exterior façade walls nor underground walls are possible.
— Both Léém Moulded and Compressed Blocks can be used for loadbearing applications as well as non-loadbearing applications, in the building envelope as well as in the interior plan.
— Léém Compressed Blocks in loadbearing masonry needs a bastard mortar with Léém Additive or a Léém adhesive mortar.
— Léém Moulded Blocks can only be mortared by Léém Mortar or Léém Adhesive Mortar (and thus not with bastard mortar).

# Wall typologies with Léém Blocks

| | LOADBEARING WALLS | |
|---|---|---|
| | Loadbearing masonry | |
| | Exterior wall | Interior wall |
| **Characteristics** | | |
| Visible | ✓ | ✓ |
| Not visible | ✓ | ✓ |
| Protected from weather | ✓ (Insulated exterior wall and internal partition of a cavity | ✓ |
| Weather-exposed | | |
| Underground | | |
| Above-ground | ✓ | ✓ |
| Filling | | |
| Independant | ✓ | ✓ |
| Double wall | | |
| Lined wall | ✓ | ✓ |
| Fire resistant | ✓ | ✓ |
| Acoustic performance | ✓ | ✓ |
| **Which masonry system?** | | |
| Léém Mortar (10mm) | Léém Moulded Block | |
| Léém Adhesive Mortar (1-3mm) | | |
| Bastard mortar with Léém Additive (10mm) | | |

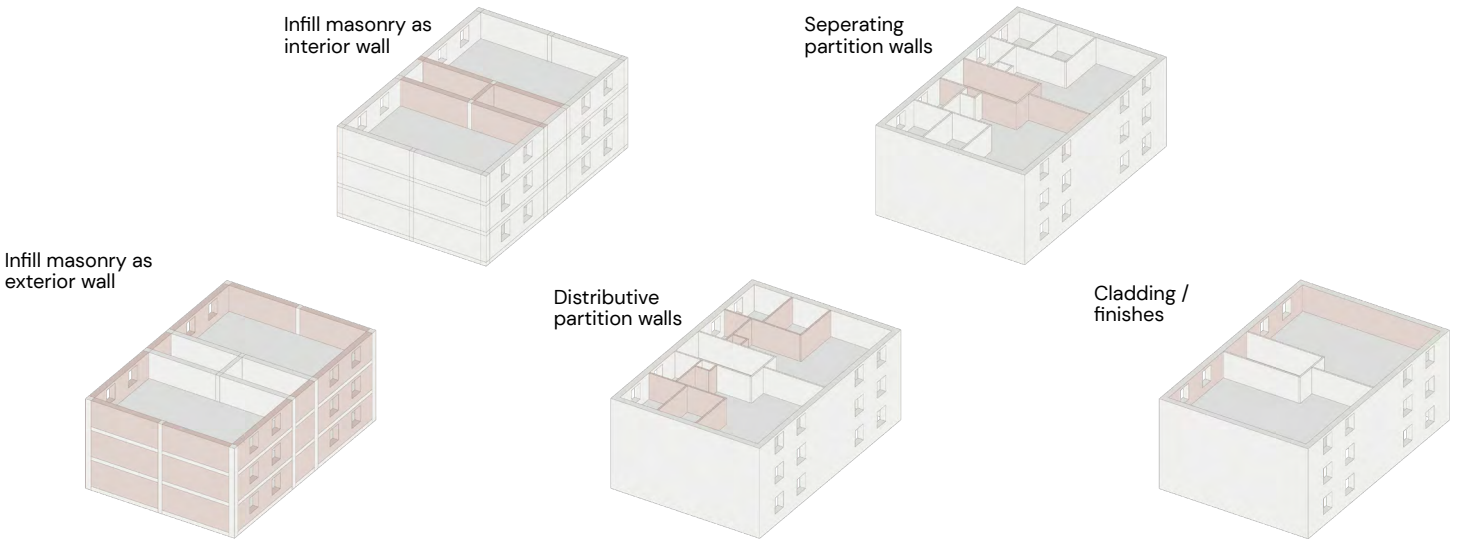
* : only for Léém Compressed Blocks with bastard mortar with Léém Additive, a



| NON-LOADBEARING WALLS | | | | |
|---|---|---|---|---|
| Infill of (non-)loadbearing frame | | Partition walls | | Cladding / Finishes |
| Exterior wall | Interior wall | Distributive | Seperating | |
| | | | | |
| ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓<br>(internal partition of a cavity wall) | ✓<br>(Filling wall) | ✓ | ✓ | ✓ |
| | | | | * |
| | | | | |
| ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | |
| | | ✓ | ✓ | |
| | | | ✓ | |
| ✓ | ✓ | | ✓ | |
| ✓ | ✓ | | ✓<br>Fire wall | |
| ✓ | ✓ | ✓ | ✓<br>Party wall | |

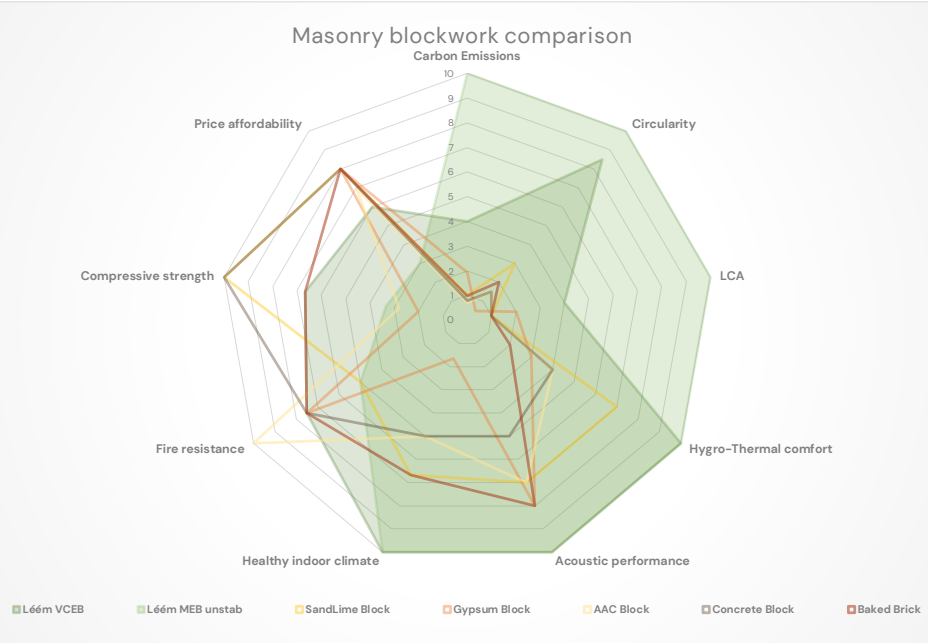
| |
|---|
| Léém Moulded and Compressed Block |
| Léém Moulded and Compressed Block |
| Léém Compressed Block |

nd to be assessed per project



## 1.5.2 The right block in the right place : what about market alternatives?

In building design and construction, BC Materials follows the motto “the right material in the right place”. Our proposal of the Léém product range comes from the conviction that a lot of carbon intensive building materials can be replaced by non-fired earth building materials with adequate technical performance and economical benefits, while bringing unparalleled benefits for healthy interior climates and environmental impact. Let’s compare the Léém Moulded and Compressed Block ranges to current carbon intensive standard market alternatives.




Comparison of Leém blocks with current market alternatives (per m2 of wall)

All data is based on quantitative third party data and proportionally transposed to a scale between 0 and 1 - except for circularity which is a quantitative and qualitative assessment based on End-Of-Life scenario’s taking into account the use of secondary resources for production, waste management, reuseability and reversibility.

The radar chart shows exceptional performance of Léém Moulded and Compressed Blocks on topics of circularity, environmental impact, carbon emissions, hygrothermal comfort, acoustics and fire resistance, while showing medium performance on compressive strength and affordability. It is to be mentioned that affordability will change in the future once costs related to carbon emissions, waste management and environmental impact will be integrated into economic pricing.

## 1.5.3 The right Léém block in the right place : how to choose?

With 2 ranges of blocks and 3 types of mortar, Léém offers 5 masonry systems. In order to choose one, considerations such as economical cost, speed of buildup, construction site management, ... are needed. Here under is a summary which might help to choose which masonry system to use where. Here are some general principles:

— Léém Moulded Blocks are more ecological, more expensive and need more construction site management (with regards to rainwater on construction site and transport breakage)
— Léém Compressed Blocks are more performant, cheap and need less construction site management.

**Comparison between Léém Masonry**

| | **Léém Moulded Blocks** | | **Léém Compressed Blocks** | | |
|---|---|---|---|---|---|
| | **Léém Mortar 10mm** | **Léém Adhesive Mortar 1-3mm** | **Léém Mortar 10mm** | **Léém Adhesive Mortar 1-3mm** | **Bastard mortar with Léém Additive 10mm** |
| **Characteristics** | | | | | |
| Stabilisation (wt.) | - | - | 3,85% of blocks | 3,85% of blocks | 3,85% + bastard mortar |
| Made from local resources | +++ | +++ | ++ | ++ | + |
| Made from secondary resources | +++ | +++ | ++ | ++ | + |
| Humidity regulation | +++ | +++ | ++ | ++ | ++ |
| Thermal inertia | ++ | ++ | +++ | +++ | +++ |
| Acoustics | ++ | ++ | +++ | +++ | +++ |
| Fire Resistance | ++ | ++ | +++ | +++ | +++ |
| Aesthetic possibilities | +++ | +++ | +++ | +++ | ++ |
| Environmental impact | +++ | +++ | ++ | ++ | ++ |
| Carbon Emissions | +++ | +++ | ++ | ++ | ++ |
| **Conception** | | | | | |
| Blocks/m2 | 59 - 79 | 67 - 94 | 24 | 26 | 24 |
| Mortar % of masonry (volume) | 16,7 - 22,5% | 5,7% - 8% | 16,7 - 22,5% | 3,0% | 9,12% |
| Price/m2 of material | 65-113 € | 74 - 142 € | 58 - 60 € | 49 - 63 € | 51-54 € * |
| Price/m2 of transport | 4-7 € | 4-6 € | 6 - 10 € | 6 - 8 € | 5 - 8 € * |
| Price/m2 of fixing | 60 - 80 € | 50 - 70 € | 40 - 60 € | 30 - 45 € | 40 - 60 € |
| Price/m2 total | 129 - 200 € | 128 - 218 € | 104 - 130 € | 85 - 116 € | 96 - 122 € |
| Loadbearing | (yes) | (yes) | (yes) | yes | yes |
| | | | | | * excl. bastard mortar |
| **Execution** | | | | | |
| Expected Transport Damage for Blocks | < 5% | < 5% | < 2% | < 2% | < 2% |
| Expected block/mortar Loss | 4% / 10% | 4% / 10% | 4% / 10% | 4% / 4% | 4% / 10% |
| Speed of buildup in m2/h/person | | -20% | | -40% | |
| Maximum courses per day | 12 | 12 | 12-15 | 12-15 | 12-15 |
| Drying time before continuing work | 7 days | 3 days | 7 days | 3 days | 1 day |
| Ease of Demounting | +++ | ++ | +++ | ++ | + |
| Ease of waste management | +++ | ++ | ++ | ++ | + |
| Construction site management | Head, bottom and lateral protection from water | Head, bottom and lateral protection from water | Head and lateral protection from water | Head protection from water | Head protection from water |

# 1.6 What about environmental impact ?

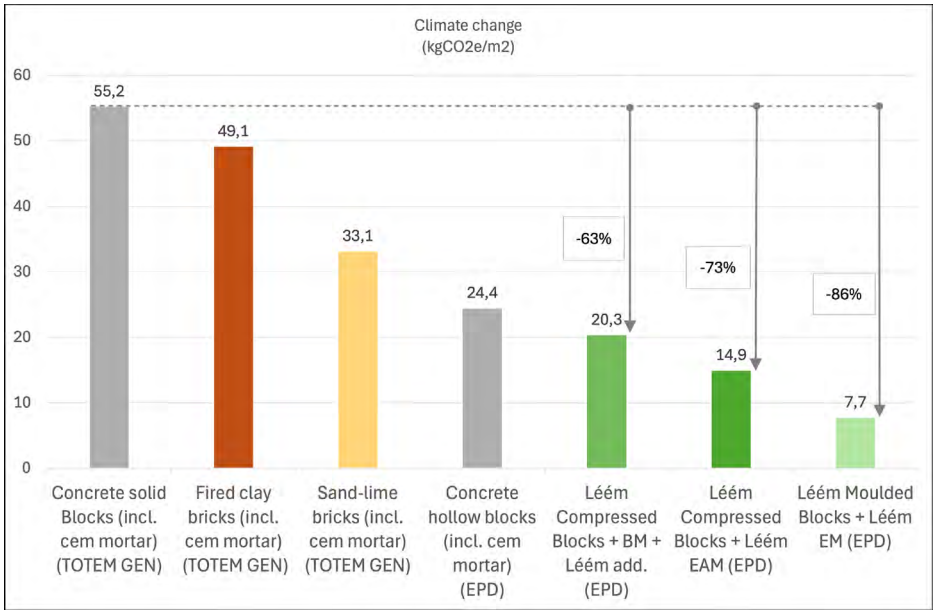
[27] TOTEM v2025.2.4

Léém aims to offer materials that are recyclable, minimally processed and originating from geosourced and secondary resources (see section 1.2). This, among others, to minimize their environmental impact. Léém masonry is no exception to this.

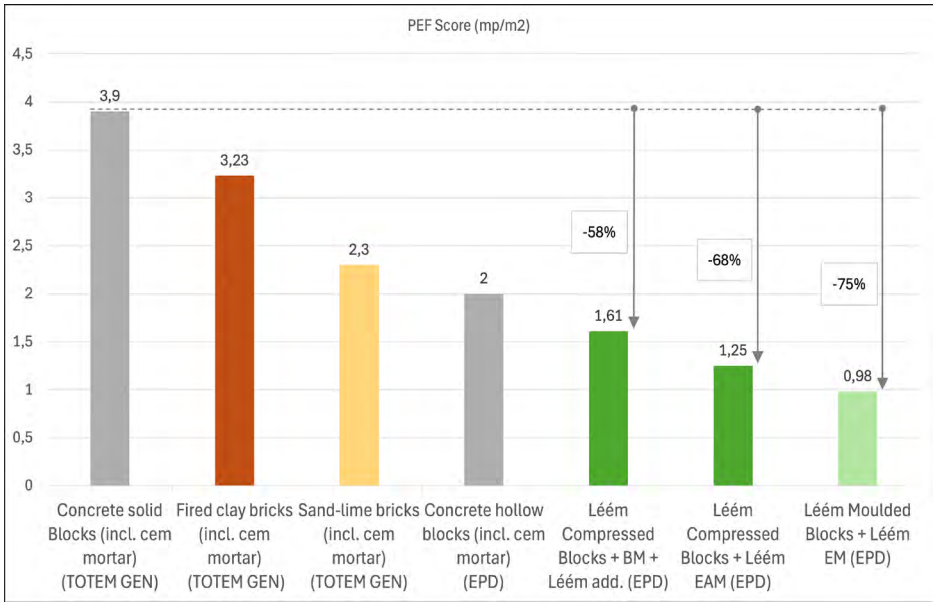
For maximum transparency and as described in the Léém General Guide (paragraph 2), we have carried out a Life Cycle Assessment (in accordance with EN 15804) of some of our the masonry systems. This standardized scientific approach avoids greenwashing and provides the most objective information possible.

In the construction sector, the main environmental impact indicator monitored is Global Warming Potential. Léém block masonry emits **between 5,3 and 27,6 kg $CO_2$eq per m²**. This is a wide range, but the value depends on a lot of different factors such as block density, wall thickness, whether they are moulded or compressed, and most importantly: mortar type. The above minimum value corresponds to one m² of Léém Moulded Blocks of 7,7 cm thickness, masoned with Léém earth mortar. The maximum value on the other hand corresponds to one m² masonry of Léém Compressed Blocks, 19 cm thickness, with bastard mortar and Léém Additive.

Now let's compare those values to other common masonry types on the market. These values are obtained from the TOTEM database [27]. The results show that Léém masonry emits between **20% and 86% less greenhouse gases** than the alternatives currently available on the market. We have to note that this comparison should be explored further to compare **function-like masonry systems**: Léém masonry possesses acoustics and thermo-hygroregulation characteristics which alternatives may not have.



This **reduced environmental impact** is also verified by the European PEF (Product Environmental Footprint) single score in millipoints, shown in the figure below. This score doesn't only look at global warming potential (kg $CO_2$eq), but also to 12 other environmental impacts like acidification, ozone layer depletion, water use etc... The figure below shows an environmental impact of Léém masonry, between 20% and 75% lower than the traditional alternatives.




# 1.7 Building standards and quality control

[26] Agrément technique

There are currently no European Harmonized Standards (EN) for earth blocks, earth block masonry, nor earth masonry mortar. However, standards for earth blocks are issued in Germany and France (DIN18945 and AFNOR XP P13-901) and a standard is issued for earth masonry mortar in Germany (DIN18946). BC Materials declares the performance of Léém Moulded Block, Léém Compressed Block and Léém (adhesive) mortar on its technical sheets according to these DIN and AFNOR standards.

For the calculation of loadbearing earth block masonry, a draft standard has been issued in Germany (DIN18940) which essentially calculates earth block masonry according to the Eurocode 6 standard (EN1996-1-1 Design of masonry structures) with some material specific exceptionalities.

Besides these existing German and French standards, BC Materials will apply for a third party certified ATG[1] for interior (non-)loadbearing Léém Block masonry.

Quality control of Léém Block and Léém Mortar production happens according to DIN18945, DIN18946 and the possible extra specifications mentioned in an ATG.

These standards, third party certification and standardized quality control protocol provides the security and insurability of building with Léém Compressed Block and Moulded Block masonry systems for all of your projects.

# 2. Physical properties & designations

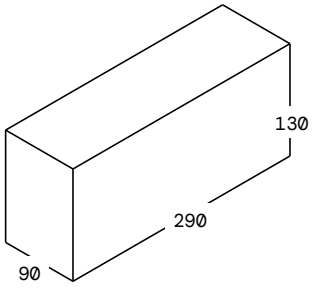


# 2.1 Designations of Léém Blocks

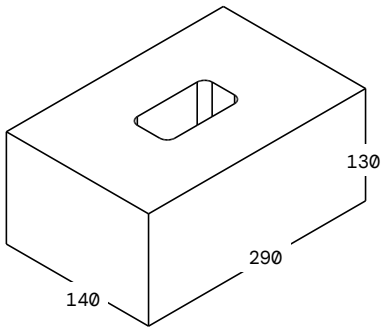
For complete physical properties of Léém Blocks, we kindly refer to the Technical Sheets downloadable on the website www.leem.works. In this section, we will present the general classification system for earth blocks as proposed by the French norm XP P13-901 and the German norm DIN18945. This general classification based on physical properties results in a line of text: the *designation*.

Here under are the designations per type of Léém block :

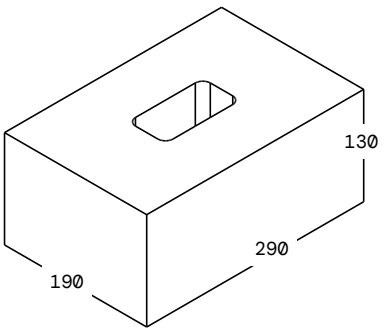
**Compressed Block CEB_90** :
BTC– CL1 – RC 7 – Mv 2,0 – 90 × 290 × 130 – S 3,85% CEM III 42,5 – XP P 13-901



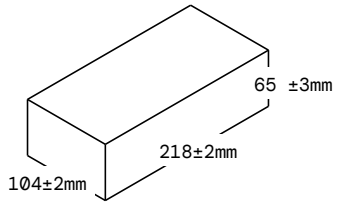

**Compressed Block CEB_140** :
BTC– CL1 – RC 7 – Mv 1,8 – 140 × 290 × 130 – S 3,85% CEM III 42,5 – XP P 13-901



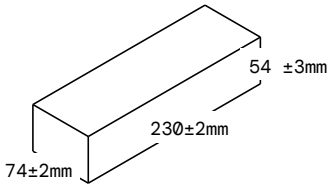

**Compressed Block CEB_190** :
BTC– CL1 – RC 7 – Mv 1,8 – 190 × 290 × 130 – S 3,85% CEM III 42,5 – XP P 13-901



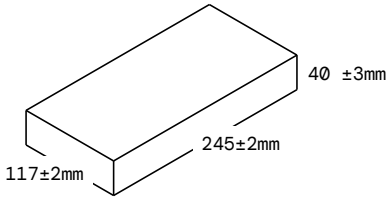
**Moulded Block Brown MEB_b** :
BTM – CL3 – RC 2 – Mv 1,8 – 6,5x10,5x21,8 – XP P 13-901
Lehmstein (LS) — tragend — DIN 18945 — f 2 — II — 1,8 — 6,5x10,5x21,8




**Moulded Block Ochre MEB_o** :
BTM – CL3 – RC 1 – Mv 1,8 – 5,7x7,8x23,8 – XP P 13-901
Lehmstein (LS) — nichttragend — DIN 18945 — f 1 — II — 1,8 — 5,7x7,8x23,80




**Moulded Block Cream MEB_c** :
BTM – CL3 – RC 1 – Mv 1,8 – 3,8×12,0×25,0 – XP P 13-901
Lehmstein (LS) — nichttragend — DIN 18945 — f 1 — II — 1,8 — 3,8×12,0×25,0



The designation of an earth block according to French and German norms comprises following information:

**Method of production**: this informs how the earth block was shaped
— Moulded (BTM - Bloc de Terre Moulée = f - Formgeschlagen Lehmstein)
— Compressed (BTC - Bloc de Terre Compressée = p - Formgepresste Lehmstein)
— Extruded (BTE - Bloc de Terre Extrudée = s - Stranggepresste Lehmstein)

**Application Class**: this informs in what conditions the block can be used based on several humidity and frost tests on the earth blocks. While the French norm allows for exposed outside masonry (CL1) as a maximum, the German norm only allows for *rendered* outside masonry (AK Ia) as a maximum. This is consistent with the French norm allowing for stabilisation, while the German norm does not allow for stabilisation. Here is the summary of the designated Application Class codes:
— CL1 : Exposed outside masonry. This Class does not exist in German norms.
— CL2 = AK Ia + AK Ib : Rendered outside masonry. (The German Application Class AK Ia is more detailed: Rendered outside masonry *infill of a facing timber-frame external wall construction)*
— CL3 = AK II : Insulated outside masonry protected from weather, and internal masonry.
— CL4 = AK III : Dry, mortar-less internal applications (such as floor filling, or dry-stacked infill walls, ...)

**Strength Class**: this gives an indication of the compressive strength of the blocks. The French norm is more simple since its strength classes communicate directly the mean compressive strength value (MPa) of the blocks. The German norm is less straightforward in setting higher thresholds for mean compressive strength (e.g. 3,8 MPa for «Drukfestigkeitsklasse 3»), which leads to a non-intuitive correspondence of strength classes between French and German norms.
— RC0/1/2/3/4/5/6: blocks with mean compressive strength 0/1/2/3/4/5/6 MPa.
— Druckfestigkeitsklasse 2/3/4/5/6: blocks with minimum compressive strength of 2/3/4/5/6 MPa and mean compressive strength of 2,5/3,8/5,0/6,3/7,5 MPa.

**Density Class**: this gives an indication of the bruto density of the block. The French norm rounds down, while the German norm rounds up, which leads to a non-intuitive correspondence of density classes between French and German norms.
— Mv1,4 - Mv2,1: Earth blocks covered in this norm have a density between 1400 kg/m3 and 2199kg/m3, rounded down to the next 100kg/m3.
— Rohdichteklasse 0,5 - 2,2: Earth blocks covered in this norm have a density between 501 kg/m3 and 2200 kg/m3, rounded up to the next 100 or 200 kg/m3.

**Dimensions**: this gives the dimensions of the earth block in cm.

**Stabilisation method**: the French norm allows for a declared stabilisation, while the German norm does not allow for stabilisation. In the French norm the % by weight of stabilisation within a total 100% of mix is given, as well as the type of stabiliser.

**Loadbearing or not:** Only the German norm designates if a block can be used in (non-)loadbearing applications. The necessary classes are AK Ib or II, minimum Rohdichteklasse 1,4, minimum Druckfestigkeitsklasse 2.

**The referenced norm**: XP P13-901 in France and DIN 18945 in Germany.

The table on the right summarizes the designation method for the French and German norm.

## Comparison between French and German Designation systems for Earth Blocks: XP P13-901 and DIN18945

| Method of Production | | Application Class | | Strength Class | | Density Class | | Dimensions (cm) | | Stabilisation method | | Loadbearing or not | Normative Reference | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mode de Fabrication | Herstellungs-verfahren | Classe d'application | Anwendungs-klassen | Catégorie de résistance à la compression | Druckfestig-keitsklasse | Catégorie de masse volumique | Rohdichte-klasse | Dimensions (cm) | Abmessungen (cm) | Stabilisation (% de la masse séche) | Stabilisierung | | Référence normative | Normreferenz |
| BTC | p | CL1 | / | RC 0 | | / | 0,5 | h × l × L | h × l × L | % de stab- | Norm nicht | Pas de | XP P13-901 | DIN18945 |
| BTE | s | CL2 | Ia | RC 1 | | | 0,6 | | | ilisateur | gültig | designation | | |
| BTM | f | | Ib | RC 2 | 2 | | 0,7 | | | | | tragend | | |
| | | CL3 | II | RC 3 | 3 | | 0,8 | | | | | nichttragend | | |
| | | CL4 | III | RC 4 | | | 0,9 | | | | | | | |
| | | | | RC 5 | 4 | | 1 | | | | | | | |
| | | | | RC 6 | 5 | | 1,2 | | | | | | | |
| | | | | | | | 1,4 | | | | | | | |
| | | | | | | Mv 1,4 | | | | | | | | |
| | | | | | | Mv 1,5 | 1,6 | | | | | | | |
| | | | | | | Mv 1,6 | | | | | | | | |
| | | | | | | Mv 1,7 | 1,8 | | | | | | | |
| | | | | | | Mv 1,8 | | | | | | | | |
| | | | | | | Mv 1,9 | 2 | | | | | | | |
| | | | | | | Mv 2,0 | | | | | | | | |
| | | | | | | Mv 2,1 | 2,2 | | | | | | | |

# 2.2 Designation or physical properties of Léém Mortar types

Léém offers 3 types of masonry mortars:

— Léém Earth Mortar (product code EB-EM): standard earth mortar for 10mm joints

— Léém Earth Adhesive Mortar (product code EB-EAM): earth mortar for 2-3mm joints with higher adhesive strength.

— Léém Additive for bastard mortar (product code EB-EA): earth additive to add to a M10 bastard mortar for 10mm joints in water-resistant earth masonry.

For complete physical properties of Léém Earth Mortar, Léém Earth Adhesive Mortar, and Léém Additive for bastard mortar, we kindly refer to the Technical Sheets downloadable on the website www.leem.works. In this section, we will present the general classification system for earth mortar as proposed by the German norm DIN18946. This general classification based on physical properties results in a line of text: the *designation*.

Only Léém Earth Mortar has a designation based on DIN18946. Léém Adhesive Earth Mortar as well as Léém Additive for bastard mortar do not have a designation, since they fall out of the scope of DIN18946 marking.

Here under is the designation for Léém Earth Mortar (product code EB-EM) according to DIN 18946 :

**Lehmmauermörtel (LMM) — DIN 18946 —0/2 (f) — M2,5 — 2,0**

The designation of an earth masonry mortar according to German norm comprises following information:

**Product type:**
— LMM = Lehmmauermörtel = Earth Masonry Mortar

**The referenced norm**: DIN 18946.

**Particle size group:** For particle size group 0/2mm between 85 and 99% of particles in the mortar are size 2mm or under, while between 95% and 100% are size 4mm or under. The possible addition of letter «f» points to the presence of fibers in the earth masonry mortar recipe.

**Strength Class**: this gives an indication of the compressive strength of the mortar, as tested following DIN18946. The letter M points to the fact that it is (Earth Masonry) Mortar.

**Density Class**: this gives an indication of the density of the earth masonry mortar.
— Rohdichteklasse 0,9 - 2,2: Earth masonry mortar covered in this norm have a density between 901 kg/m3 and 2200 kg/m3, rounded up to the next 100 or 200 kg/m3.

Léém Adhesive Mortar (product code EB-EAM) and bastard mortar with Léém Additive (product code EB-EA) is characterised according to EN1015. These do not have designations, and their physical properties can directly be read from their respective Technical Sheets, downloadable on leem.works.

# 2.3 Physical properties of Léém masonry systems

Different Léém earth block masonry systems are proposed in section 1.4 . They reappear in the table here under, in different combinations of Léém Blocks and Léém Mortars, showing some specific physical properties.

## 2.3.1 Masonry with Moulded Earth Blocks

| | |
|---|---|
| **Shelf life** | Can be kept indefinitely when dry. |
| **Field of application** | For masonry protected and insulated from the elements. Suitable for damp rooms, do not apply in areas of direct contact with water. See our Earth Block Guide for conception and execution guidelines.<br>Suitable for load-bearing walls if DIN18940 is followed: contact BC materials. |

## 2.3.2 Masonry with Compressed Earth Blocks

| | (10mm) | Mortar (2-3mm) | Léém Additive (10mm) | |
|---|---|---|---|---|
| Compressive Strength ($f_{k,95\%}$) | 4,6 N/mm² | 5,9 N/mm² | 6,2 N/mm² | EN1052-1 |
| Static E-modulus (mean) | 3600 N/mm² | 4500 N/mm² | 7900 N/mm² | EN1052-1 |
| Flexural Strength ($f_{xk1,2}$) | ⊥ 0,20 N/mm²<br>∥ 0,03 N/mm² | ⊥ 0,30 N/mm²<br>∥ 0,15 N/mm² | ⊥ 0,31 N/mm²<br>∥ 0,14 N/mm² | EN1052-2 |
| Initial Shear Strength ($F_{vOk}$) | 0,02 N/mm² | 0,12 N/mm² | 0,22 N/mm² | EN1052-3 |
| Bond Wrench Strength ($F_{wk}$) | 0,02 N/mm² | 0,10 N/mm² | 0,08 N/mm² | EN1052-5 |
| Airborne Sound Insulation (14cm th. without plaster) | | 54,3(-1,6;-4,9)dB | | EN ISO 717-1 |
| Fire Resistance (14cm th. without plaster) | | (R)EI 180 | | NBN EN 1363-1 |
| Specific Heat Capacity | 1000 J/kgK | 1000 J/kgK | 1000 J/kgK | |
| Thermal Effusivity | 15,79 m²/s | 15,79 m²/s | 15,79 m²/s | |
| Thermal Diffusivity | 0,25 $Wh^{0,5}/(m^2K)$ | 0,25 $Wh^{0,5}/(m^2K)$ | 0,25 $Wh^{0,5}/(m^2K)$ | |
| °T Amplitude Attenuation | | TBC Q4 2025 | | |
| Phase Shifting | | TBC Q4 2025 | | |
| Global Warming Pot. (GWP)(C2C) | | 14,9 $kgCO_2eq/m^2$ | 20,3 $kgCO_2eq/m^2$ | EN15804:A2 |

[9] Earth Masonry : Design and Construction Guidelines

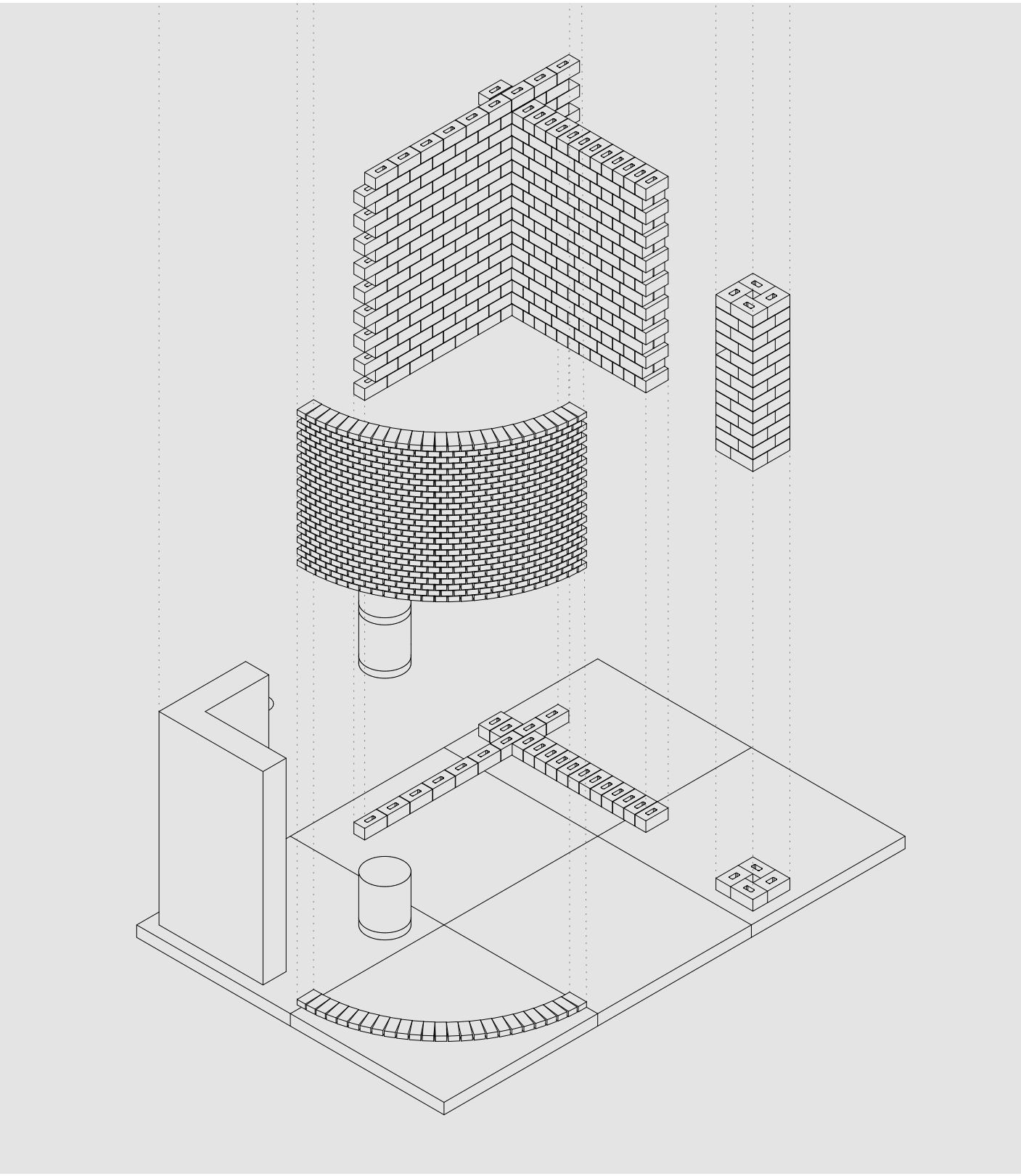
### 2.3.3 Extra: Coefficient of linear thermal expansion

The coefficient of linear thermal expansion is a material property that is indicative of the extent to which a material expands upon heating. This can be used to calculate thermal strain.

The coefficient of linear thermal expansion of a raw earth masonry is about 0.006 mm/mK (as a comparison: for concrete it is 0.01 mm/mK) [9] (p.72)



# 3. Design Guidelines

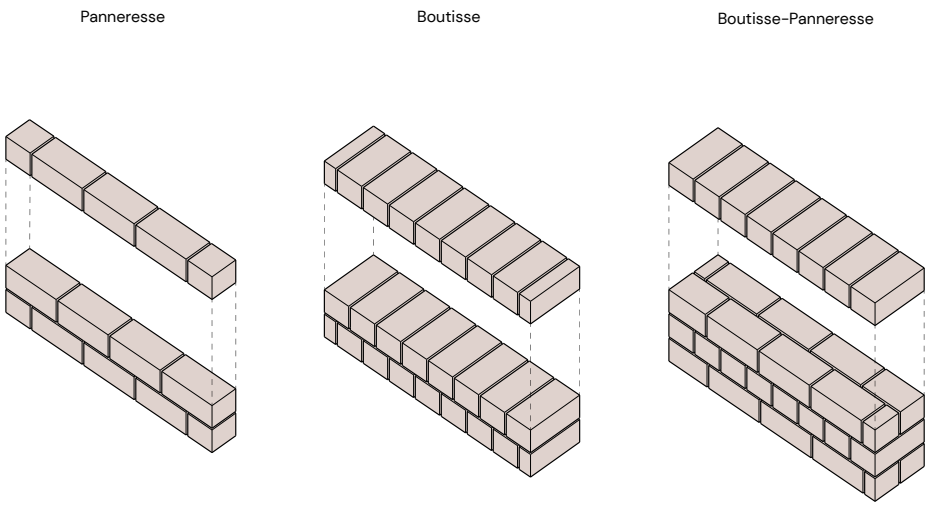


# 3.1 General principles

[2] ATEx A 2957 Murs porteurs
[7] Cycle Terre, Guide

Prior to site work, Léém masonry requires an awareness of its unique earthen properties during the detailed design stage. Here under we give the most notable principles:

— Protection from excess moisture and prolonged wetness must be considered.
— Léém blocks have a good compressive strength but a poor tensile strength à it is necessary to avoid tensile stresses in the structure.
— It is essential to seek a good load distribution within the wall and avoid concentrated loads or off-centre loads.
— Constructive complexities can easily be sources of pathologies. The sobriety of the plan, the volumetry, the facades, the compositions of walls, the openings and the technical details makes it possible to reduce the costs (economic and environmental) while reducing the risks of degradations. [7] (p.78)




Three non-exhaustive types of laying patterns for blocks

# 3.2 Field of application

[2] ATEx A 2957 Murs porteurs
[3] ATEx A 2991 Parement intérieur
[4] ATEx A 2990 Maçonnerie de remplissage
[6] NIT 271 - Exécution des maçonneries
[8] DIN 18940 Maçonnerie porteuse en terre crue
[18] DIN 18945 Earth Blocks
[24] AFNOR XP P13-901 Blocs de Terre crue

## 3.2.1 Application classes

The building element typologies in which Léém block masonry can be used, are given in Section 1.5. Here under, the application domains are given. These application domains differ for Léém Moulded Blocks and Léém Compressed Blocks, due to the fact that Léém Moulded Blocks are non-stabilised and Léém Compressed Blocks are stabilised with 3,85% (wt.) of cement.

If the use of Moulded Block and Compressed Block ranges falls within below application domains, all guidelines mentioned in this publication can be directly applied. If a project team would envision a use of Moulded Block and Compressed Block ranges outside of these application domains, BC materials can help with regards to bespoke detailing and calculations in order to validate the application.

| | Moulded Block Masonry (EB-MEB + EB-EM) | Compressed Block Masonry (EB-CEB + EB-EA(M)) | Reference |
|---|---|---|---|
| **Summary of most challenging application** | Unexposed in spaces with limited humidity and proper ventilation | Exposed, humid environment with light freeze/thaw cycles | |
| **Exposure class** | MX1 | MX2.1 (MX3.1*) | [18] [24] |
| **Interior Climate Class** | I or II | I or II or III | [6] (p.44), [2] (p.16/90), [3] (p.31) |
| **Seismic Zone (for non/loadbearing applications)** | all / 0 or 1 | all / 0, 1, (2**) | [8] (p.14), [2] (p.16/90), and [6] (p.44) |
| **Max. elevation of highest floor level** | R+3 or 13m with conditions | calculation | [8] (p.5). |
| **Loadbearing dimensioning norm** | DIN18940 | Eurocode 6 | |
| **Excluded from application** | Buried and semiburied structures, facades located on the sea dfront or in mountain climate (altitude >900m) | | |

* MX3.1 when interpreting application class CL1 of XP P13-901 (exposed to freeze-thaw)
** zone 2 only if the building has a low or very low risk of seismic loading

For info: Common buildings (*) and associated indoor climate classes [6] p.44

| | Indoor climate classes and types of buildings concerned | Exemples de bâtiment |
|---|---|---|
| **Class I** | Buildings where humidity production is permanently low or non-existent | Dry goods warehouses, churches, showrooms, garages, workshops |
| **Class II** | Well-ventilated buildings with limited limited moisture production per m³. | Ventilated housing, schools, shops, non-air-conditioned offices, sports halls and multi-purpose halls |
| **Class III** | Moderately ventilated buildings, with higher moisture production per m³ | Unventilated dwellings, hospitals, homes, consumer lounges, restaurants, village halls, theatres, low air-conditioned buildings air-conditioned buildings (RH ≤ 60 %) |
| **Class IV** | Buildings with high humidity production | Highly air-conditioned buildings (RH > 60%), hydrotherapy areas, indoor swimming pools, damp industrial areas such as laundries, printing works, breweries, paper mills, etc. |

(*) Buildings with excess pressure or highly variable humidity levels (discotheques, for example) require a special hygrothermal study.

For info: Relevant masonry exposure classes accordign to Eurocode 6 EN 1996-2 [6] p.51

| Class | Microconditions of masonry | Examples |
|---|---|---|
| **MX1** | **Dry environment** | Interiors of buildings used for normal residential and office purposes, including the inside walls of cavity walls that are not at risk of becoming damp. External rendered masonry, not exposed to moderate or intense heavy rain and isolated from the moisture of adjacent materials or masonry. |
| **MX2** | **Exposure to moisture or wetting** | Internal masonry exposed to high levels of water vapour, such as in a laundry. Exterior masonry covered by overhanging eaves or a coping to protect it from the rain. Masonry in a frost-free zone in non-aggressive, well-drained soil. Masonry not exposed to frost or aggressive chemicals aggressive chemicals (e.g. masonry buried at a depth of more than 80 cm). |
| **MAX2.1** | Exposure to moisture, but not to freeze/thaw cycles or external sources of sulphates or aggressive chemicals. | |
| **MX2.2** | Exposure to severe humidity, but not to freeze/thaw cycles or external sources of sulphates or aggressive chemicals. | |
| **MX3** | **Exposed to wetting plus freeze/thaw cycling** | |
| **MX3.1** | Exposed to moisture or wetting and freeze/thaw cycling but not exposed to extenlal sources of significant levels of sulfates or aggressive chemicals | Masonry as class MX2.I exposed to freeze/thaw cycling. |

### 3.2.2 Application norm for dimensioning loadbearing walls

For loadbearing Léém Moulded Block masonry, we propose DIN18940 as a calculation standard, which could be considered as an Annex to Eurocode 6 for low-compressive strength earth blocks with some extra considerations given the specific nature of earth block masonry. [8] (p.14)

For loadbearing Léém Compressed Block Masonry, Eurocode 6 can be used, taking into account the folllowing:
- The technical sheets mention all necessary masonry tests (EN1052-1/2/3/5)
- Léém Compressed Blocks are part of Group 1, Category 2 Blocks and parameters of Limesand blocks or concrete blocks can be used.
- To define $\gamma_m$ , factors are Code B, Class S.
- Curing factor $\delta_c$ is 1.

BC Materials is capable to help structural engineers in applying this standard.

# 3.3 Moisture conditions

[1] Guide des bonnes pratiques: Briques de terre
[7] Cycle Terre, Guide

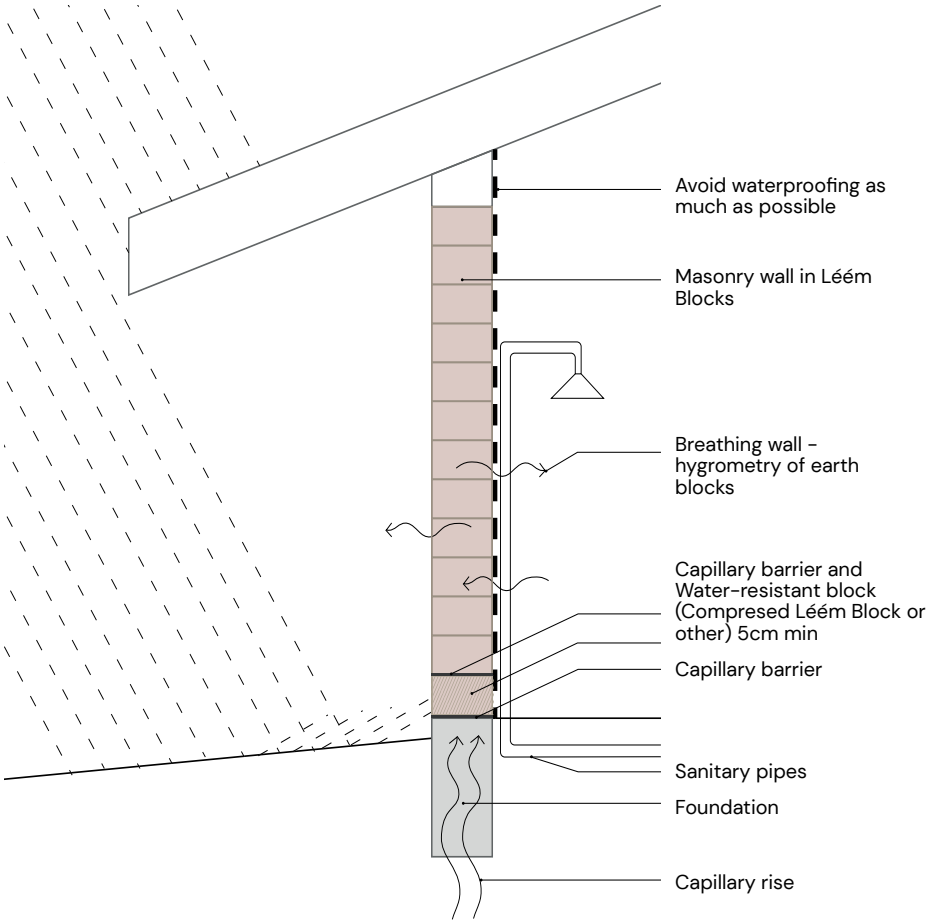
Section 3.1gave the general principles of earth block masonry design, among which a high attention to moisture control. Section 3.2 stated that earth block masonry is for walls with MX1 or MX2.1 or MX3.1 exposure class, therefore above-ground internal walls in a dry or humid environment. In this section, these principles of moisture control are specified further.

### 3.3.1 Moisture protection of the wall surface

It is essential to «minimize water input and maximize evaporation», to avoid surface erosion and water accumulation inside the wall which can deteriorate its mechanical properties. In this context, special attention must be paid to following aspects:

— The connection of a horizontal (or sloping) surface to an earth block wall (wall/floor junctions, wall/work surface, balcony, roofing planes) is likely to generate a water flow and/or stagnation. [1] (p.34) The water present on this surface (rainwater, washing water) can come into contact with the wall, which might erode the wall surface and weaken the wall. To prevent this risk, it is recommended to protect walls in contact with a horizontal or sloping surface likely to receive water. The height of the protections should be adapted to the specific context, but should not be less than 5 cm. [1] (p.34)
— Earth block masonry may only be used above anticipated flood levels.
— Earth block walls need to be protected from weathering, at least by detailing correct overhangs which protect an exposed façade from (driving) rain.
— Dampproof layers (rain screens, waterproofings, ...) should be avoided: these block the surface evapouration (drying potential) of the wall and hence heighten internal condensation risks [1] (p.18) The «drying potential» of the wall must be preserved to avoid «the risk of internal condensation». For more details on bathroom wall surface waterproofing, see section 3.3.3 .
— Drainage and other sanitary pipes: due to the effects of potential water leaks, conduits/pipes can only be incorporated into non-loadbearing Léém Block masonry. Take the necessary precautions to make any leaks apparent, easy to repair and limit damage to the wall [9] (p.87)
— Avoid regular and abundant water spraying such as shower splash water. Take into account erosion effect of sprinkler systems on loadbearing or fire-resistant

earth block masonry.
— Provide a waterproof barrier at the wall top [7] (p.77) and also at the wall base see section 3.3.2




Water protection for a masonry wall made of Léém Blocks

## 3.3.2 Moisture protection of wall footings

[3] ATEx A 2991 Parement intérieur
[4] ATEx A 2990 Maçonnerie de remplissage

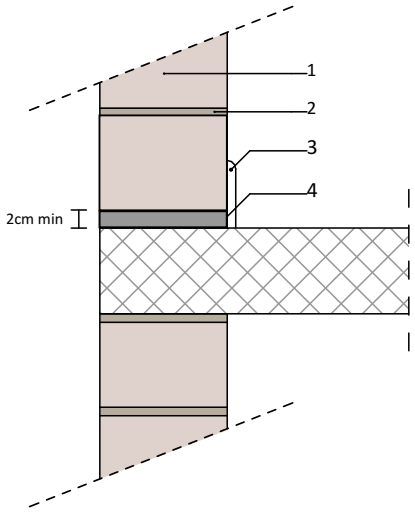
This section will mainly explain the control of capillary rise at the connection with an intermediate floor or with the ground, for which we find the same principles. We will therefore see the different elements necessary for these two situations in order to obtain «good boots».

A Léém Moulded Block wall footing in contact with the ground must be made of a water-resistant material at least 5 cm above the finished level of the adjacent floor and at least 20cm above the finished level of the outside soil. A Moulded Block wall footing on an above ground level must be made of a water-resistant material at least 2 cm above the finished level of the adjacent floor. This first layer of water-resistant material can be a cement mortar bedding and a course of the Léém Compressed Block range. In both cases, an anti-capillary membrane or waterproof mortar should be placed on top of this footing. (see Section 5)

A Léém Compressed Block wall footing in contact with the ground or on an above ground level can be executed in Compressed Blocks on a cement mortar bedding. [4] (p.27)

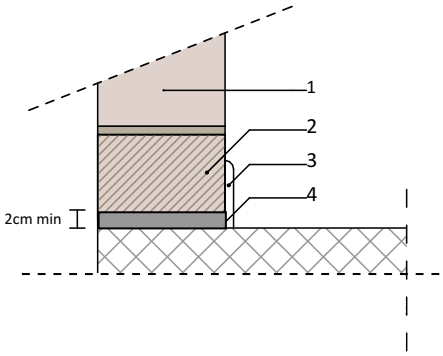
Both Moulded and Compressed Block masonry walls needs to be situated above flooding levels.

Both Moulded and Compressed Block masonry wall footings need to be protected from humidity, in particular with poured or projected screeds, during construction by installing a waterproofing layer of at least 2 cm above the finished level of the screed. [4] (p.28) et [3] (p.16)




**Wall footing on intermediate floor**

1. Léém Moulded or Compressed Block masonry wall
2. Mortar
3. Baseboard
4. Capillary protection - waterresistant mortar




**Wall footing on ground floor**

1. Léém Moulded or Compressed Block masonry wall
2. Water-resistant block (Compressed Léém Block or other)
3. Baseboard
4. Capillary protection with waterresistant mortar




Laying of the waterproof membrane

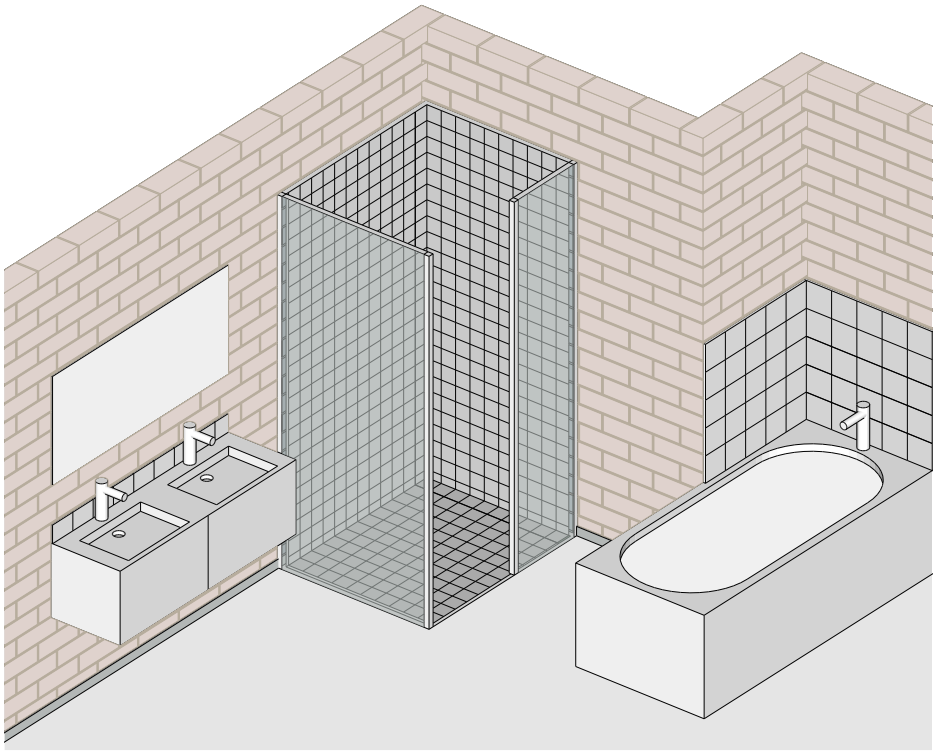


Waterproof membrane between concrete masonry and Compressed Léém Blocks

### 3.3.3 Protection in wet rooms

Léém Moulded Block and Compressed Block walls cannot be exposed to regular splash water in wet rooms, such as shower zones and splashback areas. However, they can be locally covered by damp- and waterproof layers for areas in direct contact with water. This situation constitutes a “lining area” for the Léém block masonry. (see Section 5.1) Two moisture control strategies are possible: the lining area in question is subject to a 2D dynamic hygrothermal study as for thermal bridges, or the following 4 provisions are complied with simultaneously:

— As represented below, Léém Blocks are protected from direct exposure to water, particularly at the level of water points (such as shower wall, bathtub, sink, ...) by the implementation of a traditional lining such as Kerdi and others (see e.g. NIT 277).



Protection of Léém Blocks from direct water exposure

— To benefit from the hygrometric regulation qualities of the earth, a minimum of 20% of the surface of the Léém masonry must remain non-waterproofed.
— If a Léém masonry wall is located at the separation between two shower rooms, it is also necessary to leave at least 20% of the surface of the Léém Compressed Block unwaterproofed, on each side.
— In all cases, n Léém masonry wall must not be waterproofed on the side where the water vapour exits (the side of the wall that is exposed to the least humid environment), in order to allow the migration of water vapour. [2] (p.29/90)

To waterproof earth block masonry walls for shower and bath use, a lime tile adhesive with a net can be used to flatten out the surface in order to receive traditional liquid or membrane damp- and waterproofing system (such as Kerdi, Webersys, ...) on top of which standard bathroom tiles can be applied. It is advised to use the Léém Compressed Block range for bathroom walls, since their stabilisation increases their water resistance in comparison to non-stabilized Léém Moulded Block range.

## 3.3.4 Hygrothermal design for exterior walls

[2] ATEx A 2957 Murs porteurs
[10] Sustainable Building with Earth

Léém earth block masonry as used in exterior (insulated) walls needs to take into account possible condensation.

Practical experiences with residential buildings under normal conditions of use have shown that dry earth building materials possess a sufficient level of capillarity which properly distributes condensate forming on the building element surfaces through capillary action. Moisture penetration can therefore be prevented as long as the minimum thermal insulation requirements are met. This eliminates the conditions required for mold formation. Under unfavorable conditions (mostly in winter), the water vapour saturation pressure might also be reached in the interior of the earth building element causing the vapour to change over to the liquid phase. Here, practical earth building experiences have also shown that the calculated condensate (e.g., determined using the Glaser method) can be distributed via capillary action without any harm to the earth building element. [10] (p. 407)

In order to prevent the development of condensate inside the building element, the building element layers should generally be as follows:

— The heat transfer resistance R should increase from the inside to the outside
— The water vapour diffusion resistance factors μ should decrease from the inside to the outside [10] (p. 407)

More specifically, Buildwise has validated détails of case C in Section 3.14 and Section 5.2.1 for earth block masonry in inner cavity leaf wall applications and in insulated exterior wall applications, which also follows the general rule of increasing thermal resistance and decreasing water vapour diffusion.

Vapour permeable insulation is recommended to take advantage of the hygrothermal benefits of raw earth walls. These include fillings made of reeds, straw, hemp, flax, lime hemp, wood wool, grass, rock wool,...

Condensation of water vapour on or inside interior building element surfaces occurs when the temperature of the indoor air or building material falls below the dew point. The dew point is the air temperature at 100 % water vapour saturation. In conventional construction methods, dew points can be reached when using vapour screens because these are difficult to install in a completely waterproof way. Therefore, there is an important risk of high condensation in areas where the vapour screen was not installed correctly. In specification of the general rule, it is dangerous to block water vapour by a vapour screen when using Léém Block masonry, because it limits the possible evacuation of condensation in the walls.




Prototype of hygrothermal design for an exterior wall

# 3.4 Conditions on deformations

## 3.4.1 Vertical settlements, horizontal shrinkage and differential settlements

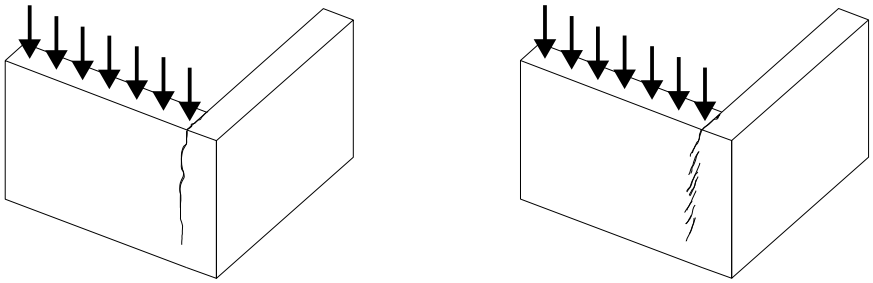
[2] ATEx A 2957 Murs porteurs
[3] ATEx A 2991 Parement intérieur
[7] Cycle Terre, Guide
[9] Earth Masonry : Design and Construction Guidelines
[10] Sustainable Building with Earth

The vertical settlement of Léém masonry during drying is about 3mm/m (values after 2-3 weeks of drying) when using 10 mm mortar joints. If 2 to 3 mm mortar joints are used, the vertical settlement will be at least 3 times less important. Settlement joints should be provided for non-uniform loads on the masonry. In both cases, vertical settlement is reduced if the mortar dries during the construction of the wall. [9] (p.72), [7] (p.126)

The horizontal shrinkage of Léém masonry is about 0.6mm/m when using 10mm vertical mortar joints. Again, if 2-3 mm vertical mortar joints are used, the vertical settlement will be at least 3 times less. [3] (p.16)

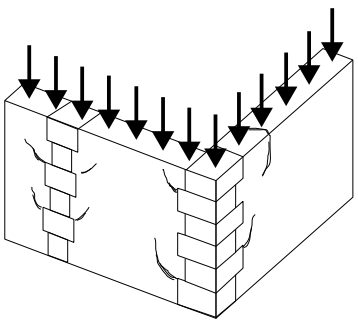
Differential settlements, resulting from differential loads on the wall or in the wall or under the wall, must be avoided. [10] (p.313)

Below is an example of differential settlement due to differential loads or moments at the top of the wall [2] (p.33)



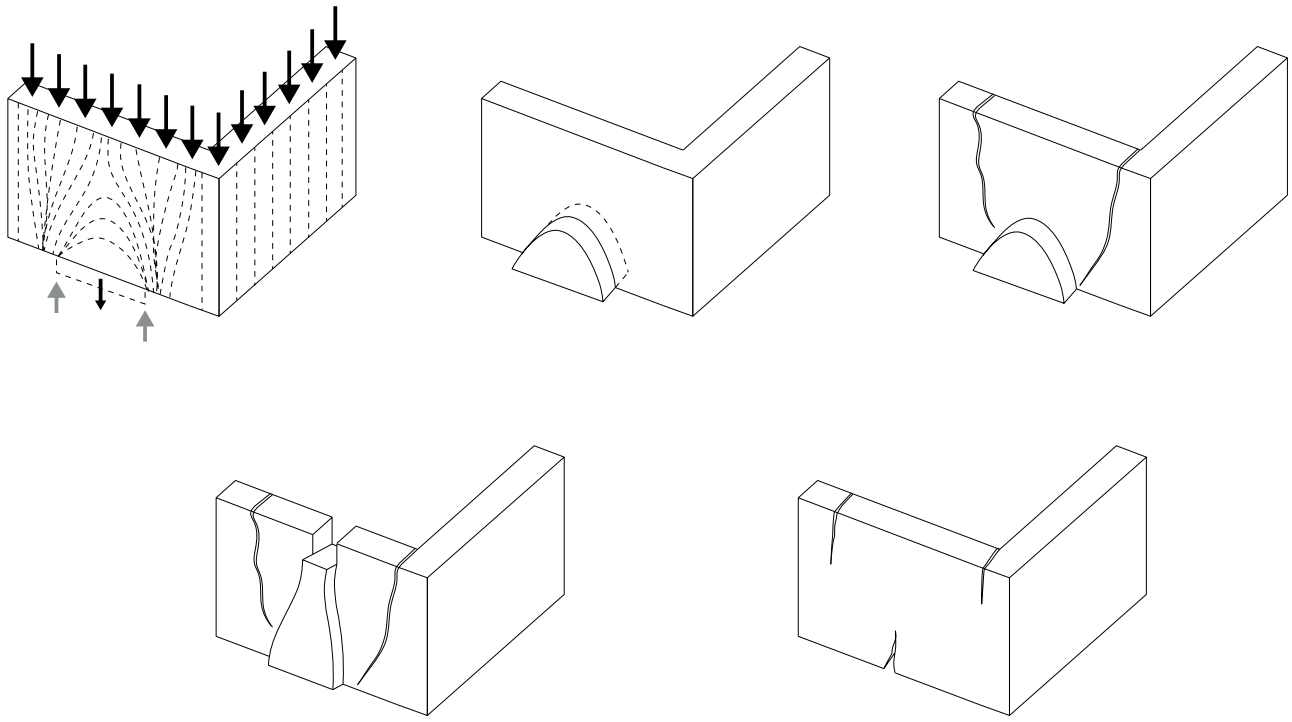
Differential settlement due to differential loadings [2] p.33

Below is an example of differential settlement due to the difference in strength in the wall: earth blocks and masonry elements made of clay, natural stone or other materials. This phenomenon can be avoided by continuously using one material per horizontal layer. Vertical loadbearing columns next to loadbearing Léém walls should therefore be avoided as it is much more rigid than Léém block masonry walls. [2] (p.32)



Differential settlement due to differences in resistance [2] p.32

Below is an example of differential loading due to non-homogenous foundations. [2] (p.34)



Differential settlement due to non-homogenous foundations [2] p.34

## 3.4.2 Structural joints

[2] ATEx A 2957 Murs porteurs
[3] ATEx A 2991 Parement intérieur
[4] ATEx A 2990 Maçonnerie de remplissage
[6] NIT 271 - Exécution des maçonneries
[7] Cycle Terre, Guide

**a. Shrinkage and expansion joints**

Contraction and expansion joints are used in Léém masonry walls when the maximum wall length is reached. [4] (p.27) The distance between the expansion joints depends on:

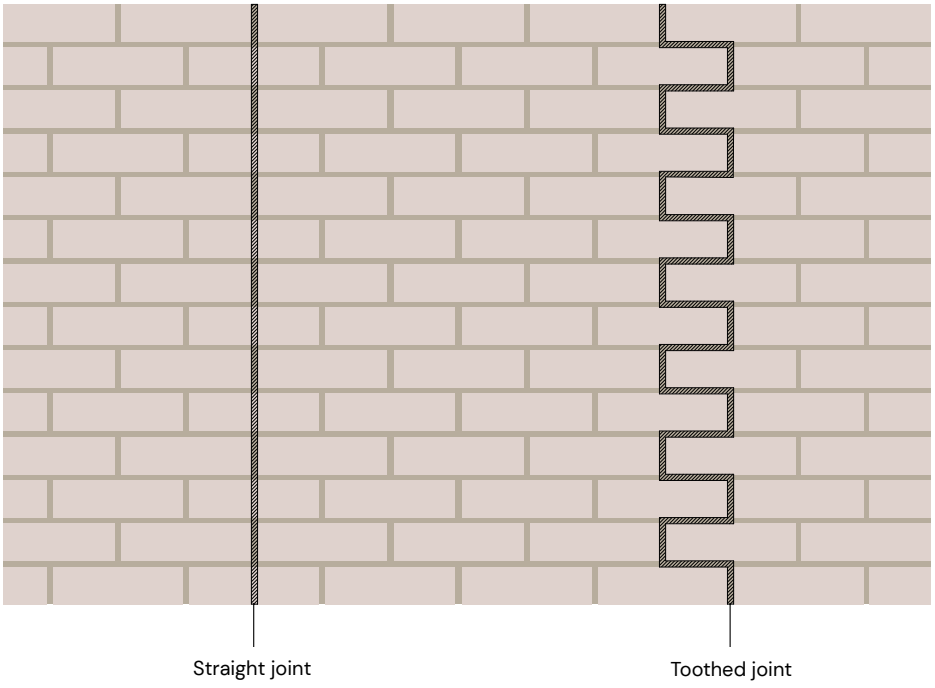
— The horizontal shrinkage during the drying period of the masonry (see Section 3.4.1)
— The thermal linear expansion (see Section 2.3.1)
— The hygrometric linear expansion (see Section 2.3.1)

Because of the values of these parameters as mentioned in Section 2.3, the maximum distance in between dilatation joints can be the same as for non-loadbearing fired clay masonry, namely 12m. [6] (p.106) (However, slenderness considerations according to Section 3.5 will also influence the possible length of a wall.)

The width of the dilatation joint should be at least equal to that provided in the masonry, but not less than 2 cm. The joint may be left empty or filled with a non-hydrophilic mineral wool with a density of less than 30 kg/m3 or an elastomeric Elastic kit. [7] (p.137)

This joint may be straight or notched to follow the offset of the blocks from one course to the next. The shrinkage joint can be caulked with a suitable sealant. It is

possible to use caulking and sealing compounds adapted to conventional masonry mortar type supports. [3] (p.24-25) (see Section 5.1)




Straight or toothed masonry joints [3] p.24

Special anchors can be placed in the mortar beds on both sides of the dilatation joints, which allow for lateral horizontal movement but prevent transversal horizontal movement.(see Section 3.10.4)

**b. Settlement joints**

Settlement joints are gaps or spaces intentionally left between two adjacent parts of a structure or building element to allow for movement caused by settlement. We discuss following locations for settlement joints:

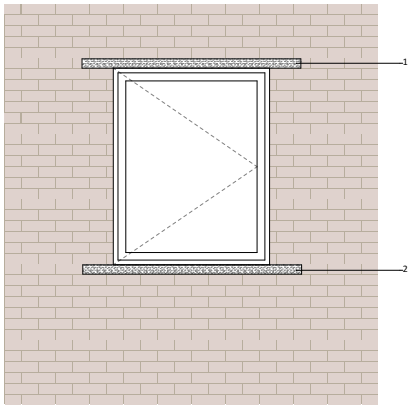
Below the window around the windowsill there are 2 possibilities:

— Either the bay sill extends on both sides of the bay by at least 20 cm. In this case, the junction can be made by harping.
— Or the bay sill does not extend. In order to avoid the shearing of the sill, the solution of settling joints between the sill and the wall should be chosen. The settlement joint will be treated in the same way as the expansion joint

For the lintel:

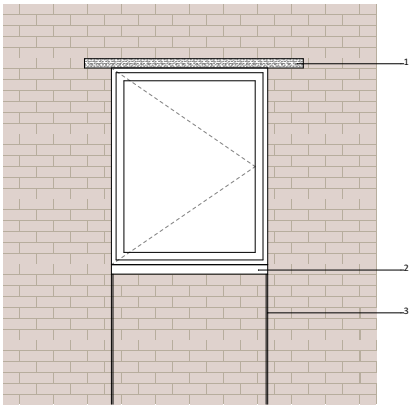
— Either the lintel extends at least 20 cm on either side of the opening. In this case, the junction can be made by harping.
— Or the lintel is made by metal support bracket. In this case, measures must be taken to avoid the appearance of cracks in the upper corners of the frame. For example: dilatation joints, insertion of metal reinforcement such as Murfor from Plaka or equivalent in the masonry located above the bracket. [3] (p.27)

Insertion of openings with extension of sills and lintels [3] p.27



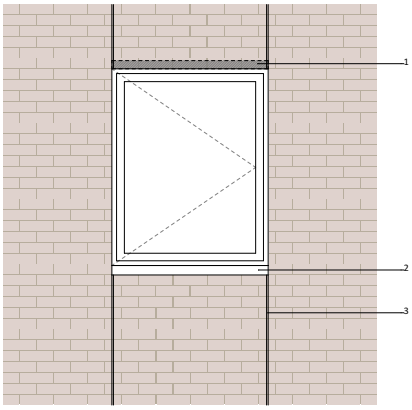
1. Lintel with a minimum bearing length of 20cm on both sides of the opening
2. Sill with an extension of the bearing length of a minimum 20cm on both sides of the opening

Insertion of openings with lintel extension and dividing joints [3] p.27



1. Lintel with a minimum bearing lentgh of 20cm on both sides of the opening
2. Sill without an extension of the bearing length
3. Expansion joints

Insertion of openings with full-height expansion joints [3] p.27



1. Console lintel
2. Sill without an extension of the bearing length
3. Expansion joints

## 3.4.3 Conditions on structural deformations

[4] ATEx A 2990 Maçonnerie de remplissage

When using Léém masonry walls as infill walls in a loadbearing concrete or wood structure, the horizontal and vertical deformations of that framing structure need to be taken into account. Deviations from these guidelines are possible upon special design provisions defined by the structural engineer of the project. The indications that aim to isolate the Léém masonry wall from the deformations of the primary structure are valid for all non-bearing walls (infill walls, partition walls, ...).

**Horizontal beam deflection**: The compatibility of the vertical deformations of the framing with the use of Léém Moulded Block or Compressed Block infill panels is ensured by limiting the deflections of the structural beams to 1/500th of their spans, within the limit of 10 mm. One or more resilient strips are integrated at the interface between the main frame and the masonry, at the head and/or wall base, for a total thickness of 10 mm.

**In-plane deformation of column**: The limitations of the deformations in their planes of the vertical framing columns in direct connection with the Léém masonry are limited to H/300 at the Ultimate Limit State (ULS), with H the storey height, within the limit of 5mm. Anchors between Léém infill wall and loadbearing post shall allow for vertical movement. [4] (p.65)

**Out-of-plane deformation of column**: Limitations on out-of-plane deflections of vertical framing columns in direct connection with the Léém masonry are limited to H/500 at ULS, with H the storey height. [4] (p.65)

## 3.4.4 Conditions on deformation of floors and lintels

[8] DIN 18940 Maçonnerie porteuse en terre crue

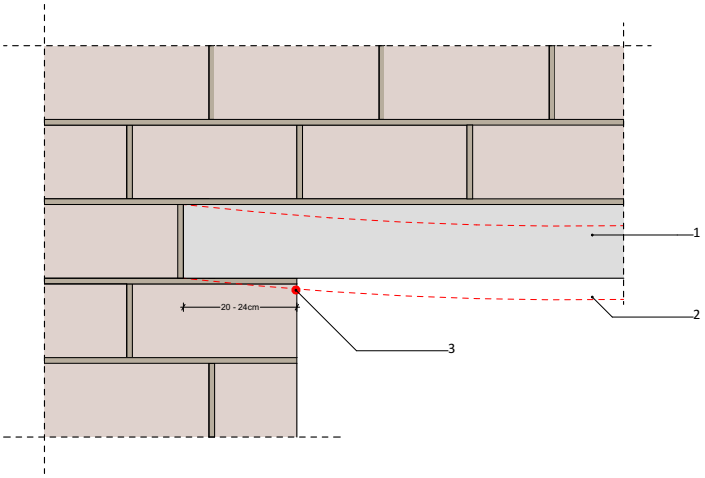
The deformation at floor and lintel supports can lead to local differential settlement cracking in Léém masonry walls, visible in the mortar joints, at the edge of the Léém block or in the eventual plaster. Following solutions aim to:

Either reduce the causes of the heave tendency, for example: increase the mass of the upper wall (weight wall), reduce the span of the floor...

Either reduce the consequences of the effects of the heave tendency, for example:

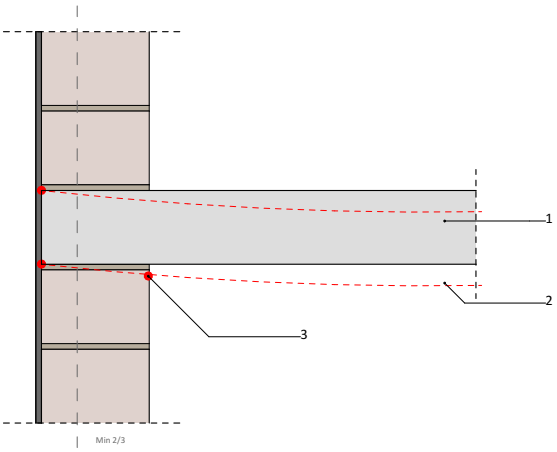
— A 15 to 20 mm thick layer of lime-based mortar supporting the slab (see Section 5.4)
— When the span of the floor slab l ≥ 6.0 m, limit the bending moments from the slab angle of rotation by structural measures, e.g. centring strips. In the case of two-axis spanned slabs, the shorter of the two support spans is to be used for l. [8] (p.14)
— For a floor: Minimum bearing surface of 14cm into the wall and minimum 2/3 of the wall thickness.
— For deformation of lintels (see Section 3.8), deformation of less than 1/500 of the span

Lintel deformation




1. Wood, concrete or Léém Block masonry with metal consoles
2. Deflection L < l/500
3. Rotation of the support following the deflection

Slab deformation



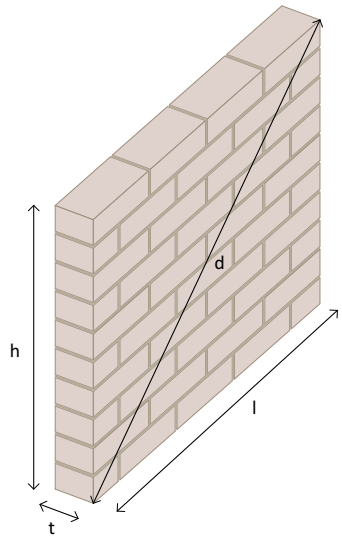

1. Wood or concrete slab
2. Deflection L < l/500
3. Rotation of the support following the deflection and possible cracks in the finishing plaster

# 3.5 Slenderness ratios

[8] DIN 18940 Maçonnerie porteuse en terre crue
[4] ATEx A 2990 Maçonnerie de remplissage

The slenderness ratio is the proportion between height and thickness (vertical slenderness), length and thickness (horizontal slenderness) or diagonal and thickness (diagonal slenderness) of specific masonry wall panels.

For **loadbearing** Léém Moulded Block masonry, maximum slenderness ratios can be calculated according to DIN18940. [8] (p.14+19). For **loadbearing** Léém Compressed Block masonry, Eurocode 6 can be used together with the results of masonry tests as mentioned on the Technical Sheets downloadable at www.leem.works.




For **non-loadbearing** Léém masonry, we consider that these walls are held at the head and the sides, through wall corner design, anchors, or buttresses. In this case, the maximum slenderness ratio allowed follows this fist rules: [4] (p.25)

| | MEB 105mm | MEB 230mm | CEB |
|---|---|---|---|
| vertical | h/t < 27 | h/t < 20 | h/t < 30 |
| horizontal | l< 26(t+1,5)+1,5<br>l < 8m | l< 26(t+1,5)+1,5<br>l , 8m | l/t < 60 |
| diagonal | d/t < 40 | d/t < 40 | d/t < 70 |

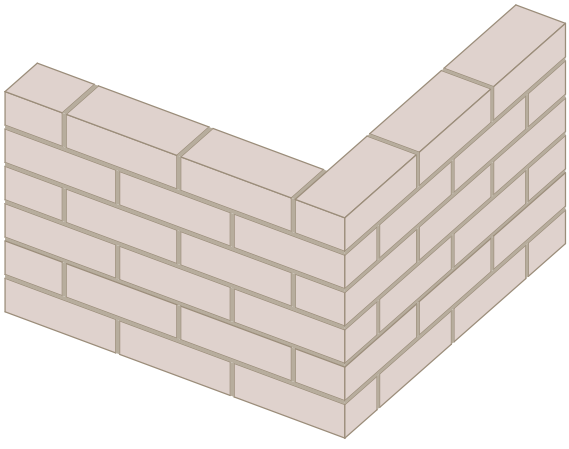
These are conservative slenderness ratios, and much more is possible. Contact us for your specific project.

# 3.6 Bracing

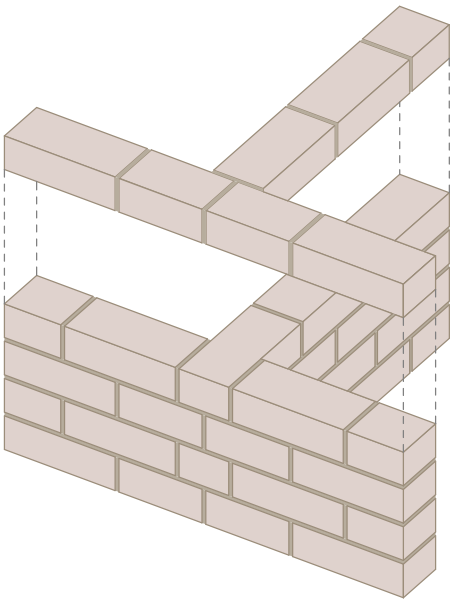
[5] ATEx A 2911 Cloisons
[9] Earth Masonry : Design and Construction Guidelines

As with construction using other building materials, loadbearing earth walls require stiffening building elements (rigid diaphragms: transverse walls and ceilings/floors) to be able to absorb and transfer horizontal loads (wind, earthquakes). […] Stiffening transverse walls need to be constructed at the same time as the loadbearing exterior walls. […] If stiffening transverse walls are to be constructed using a different technique or at a later point in time, a suitable structural connection between the transverse walls and the loadbearing exterior walls must be guaranteed. In Léém masonry, a toothing technique can be used to connect transverse walls as long as the same Léém masonry materials are used. [9] (p.310)

In a concrete or wooden structural frame, the stiffening of Léém masonry infill walls is guaranteed by the proper anchoring into structural elements. (see Section 3.10.4)



L-shaped corner fitting principle [5] p.19



T-shaped corner fitting principle [5] p.19


BAUHAUS

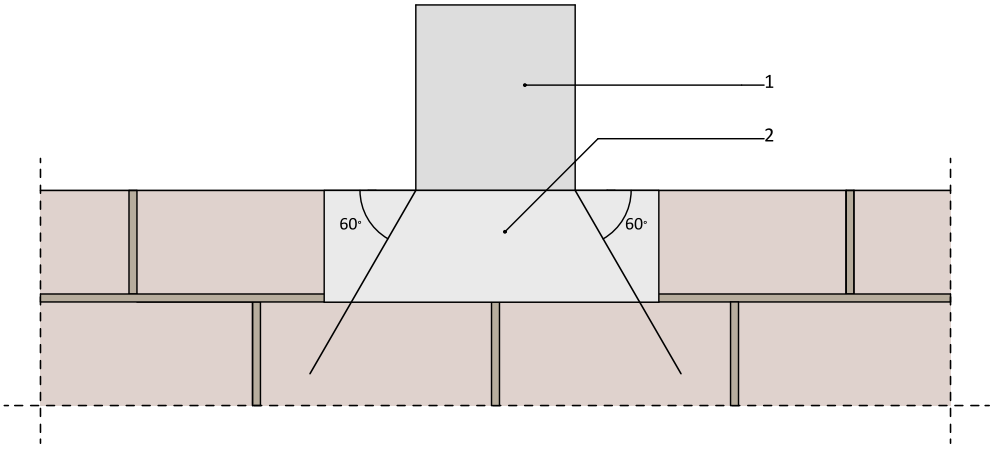
# 3.7 Support loads

[1] Guide des bonnes pratiques: Briques de terre
[8] DIN 18940 Maçonnerie porteuse en terre crue

In the case of isolated loads supported by a Léém masonry wall, the bearing surface must have a minimum length of 9cm [8] (p.10). The strategy in order to avoid masonry cracking at and around the point of concentrated loads is to:

— Limit the stress at the bearing points to 0.6 MPa. A structural engineer can deviate from this limitation through calculation.
— Keep the resultant of the applied load within the central third of the wall (to avoid generating tensile forces in the wall)
— Use distribution pieces if necessary to reduce the stress at the bearing points [1] (p.37)

For this last point, it is possible to use a bearing element in concrete or wood to better distribute the point load of a beam supported on the wall. The width of this bearing plate corresponds to the minimum bearing width, plus an additional length on each side calculated based on a 60° spacing to the underside of the distribution element or beam.




1. Beam
2. Asselet (distribution beam)

Minimum dimension of masonry elements or of a distribution beam under centred load [6] p.87

# 3.8 Lintels

[1] Guide des bonnes pratiques: Briques de terre
[7] Cycle Terre, Guide
[8] DIN 18940 Maçonnerie porteuse en terre crue
[9] Earth Masonry : Design and Construction Guidelines
[10] Sustainable Building with Earth

Lintels above doors and windows need to be supported by bearing surfaces of a minimum length of 24 cm [8] (p.10), [10] (p.310) for non-loadbearing masonry and 20 cm for loadbearing masonry. In order to determine the size of the bearing surfaces, including lintels, a good approximation is to take into account all the loads contained within the triangle at a 60° angle above the opening. The pressure they exert must not exceed the strength of the blocks. [1] (p.40)

Where calculations require longer bearing surfaces, lintel deflection should be limited to 1/500 (length of the span divided by 500). [10] (p.310) see also Section 3.4.4

Elements that take bending forces well will make good lintels, such as wood, metal or reinforced concrete beams. [7] (p.78) However, given thermal and hygrometric

linear expansion, materials for lintels are preferably wood, prefab and in situ concrete. When using timber lintels it is important they have the correct moisture content." [9] (p.90)

Galvanized or inox metal consoles such as Korbo can be used for lintels if used with proper mortar anchors and mortar reinforcement.

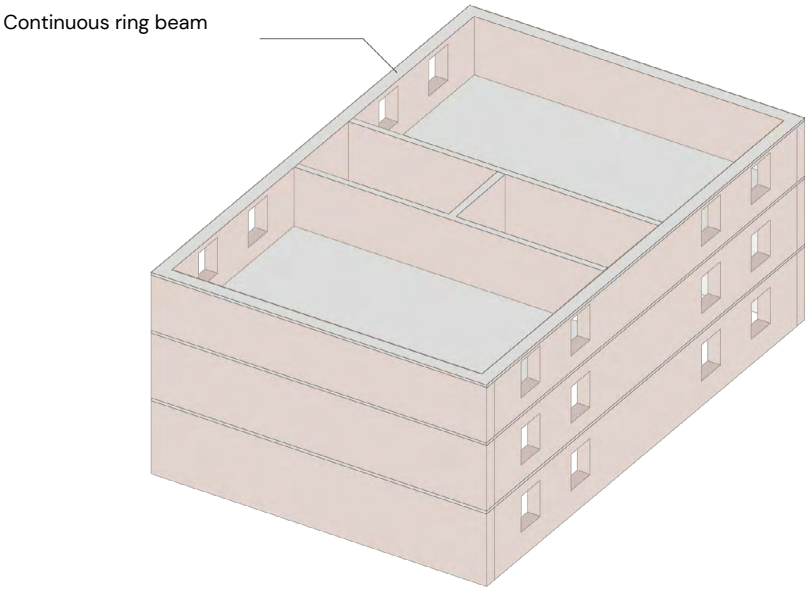
Beware of structural settlement joints around some lintel designs as shown in Section 3.4.2. and Section 3.4.4.

# 3.9 Ring beams for loadbearing masonry

[2] ATEx A 2957 Murs porteurs
[8] DIN 18940 Maçonnerie porteuse en terre crue

Loadbearing Léém masonry walls are always chained or ringed together horizontally in a continuous and closed way [2] (p.52) at each floor. These ring beams can be made of wood, of U-shaped elements prefabricated and then filled with concrete on site. A floor plate in CLT wood or in concrete can also act as a ring beam, as long as it is put onto the wall for at least 2/3 of the wall thickness. Cast-in-place concrete can be used as ring beam on top of Léém Compressed Blocks only. A waterproof membrane must be installed between the poured concrete and the Léém Compressed Blocks in order to prevent moisture damage in the blocks.

Reinforced concrete anchors must contain at least two reinforcing bars with a total cross-section of at least 140 mm2. The connections must be made according to EN 1992-1-1 and if possible, in staggered rows. In addition to all the functions of an anchor, the ring beams must be able to withstand bending perpendicular to the wall axis as far as necessary. For reinforced concrete ring beams, a minimum of four reinforcing bars and corresponding transverse reinforcement should be provided.» [8] (p.10) Further design guidelines for ring beams on loadbearing Léém masonry can be consulted in DIN18940.




Continuous ring beam in loadbearing masonry made of Léém Blocks

Reminder: loadbearing columns juxtaposed to loadbearing Léém masonry are not allowed, because of resulting differential settlements! [8] (p.10)

Technical details see Section 5.4

# 3.10 Junctions

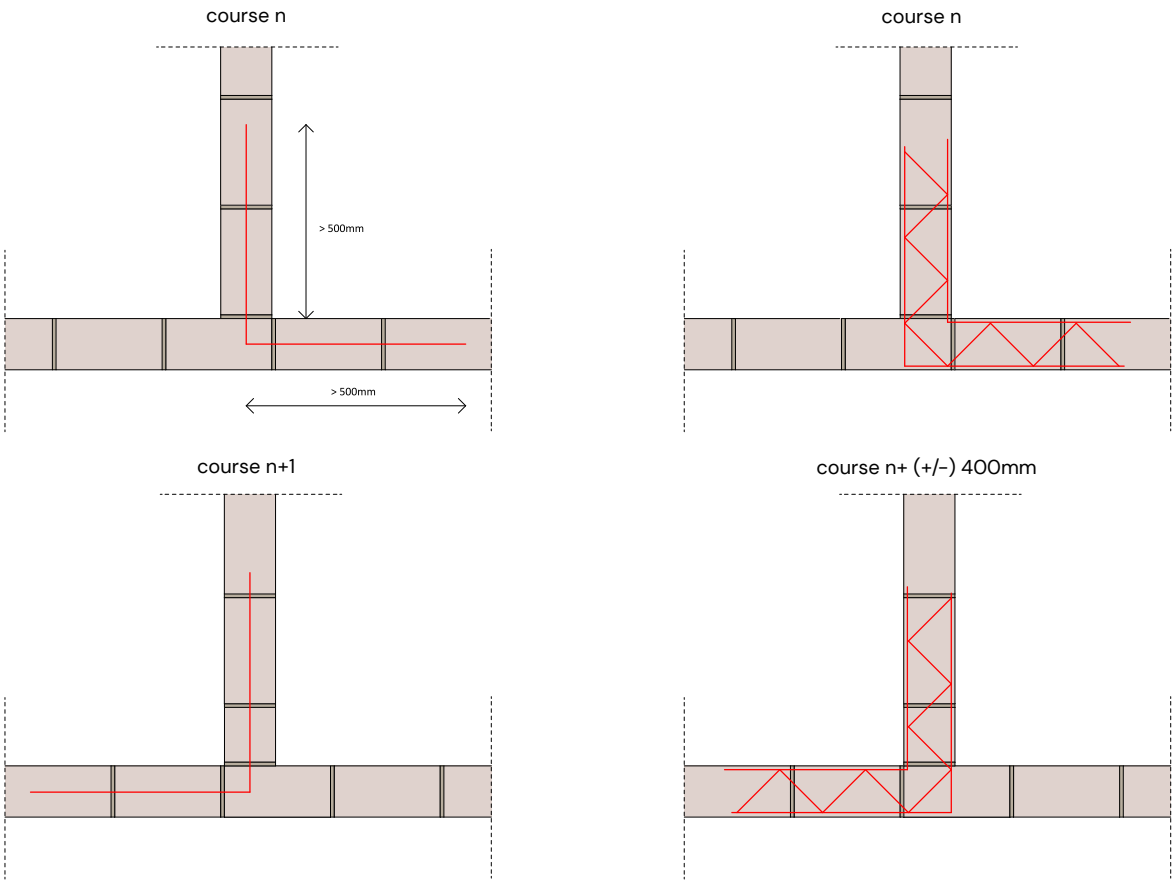
## 3.10.1 Junctions between loadbearing walls

[6] NIT 271 - Exécution des maçonneries
[10] Sustainable Building with Earth
[23] Traité de construction en terre

Ceilings and bracing walls need to be sufficiently anchored to loadbearing, enclosing walls to be able to resist tensile stresses. There are different options:

— In earth walls which are only stiffened on one side, tie rods need to be installed at ceiling height and at each third of the wall height. These rods must tie into the transverse walls at a minimum depth of 1.5 m.
— Mesh-like webbing of reinforced plastic can be used as tensile-resistant tie material. Such meshes are commonly used in foundation engineering, for example, to stabilize embankments (so-called geogrids).” [10] (p.311)
— Horizontal reinforcement bars in mortar joints (such as Murfor) can be used as tensile resistant tie material. These must be galvanized or in inox. [23] (p.260)
— Interlocking between loadbearing Léém masonry walls [6] (p.89)

Technical details see Section 5.1.3

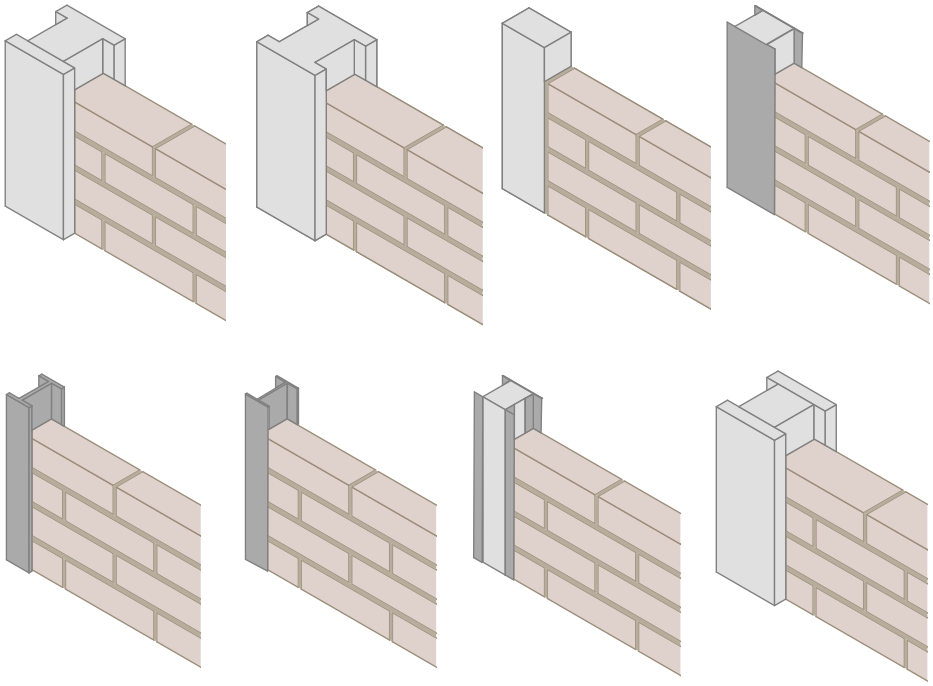



Examples of T-junctions using reinforcement bars [6] p.90

## 3.10.2 Junction between non loadbearing walls and loadbearing structure : U-shape

[4] ATEx A 2990 Maçonnerie de remplissage
[7] Cycle Terre, Guide

The junction between non-loadbearing walls and the loadbearing structure can be achieved by the use of U-shaped stiffeners. They must be placed at each end of the wall. Maximal wall length is defined mainly by slenderness ratio's (see Section 3.5).



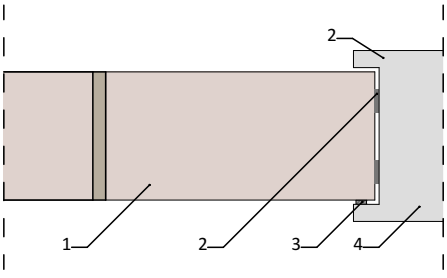
Examples of linear connections with groove, rebate or joint profiles [4] p.133

A U-shaped stiffener of the column is recommended when high acoustic performance of the façade is expected [4] (p.33-35). This U-profile can be achieved by a grooved column section and/or by rebate profiles and their subsequent assembly.

«The rebate must be 15 mm deep so that the masonry is covered by a minimum distance of 8 mm. [7] (p.132-134)

Technical details see Section 5.1

1. Léém Moulded or Compressed Block
2. Pre-compressed Elastic kit Expanding foam tape strip if acoustic requirements are required
3. Sealant joint if acoustic requirements are required
4. Stiffener



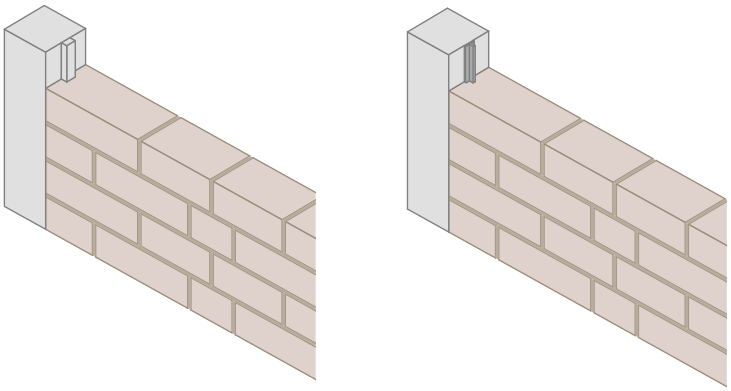

Rebate detail [7] p.133

## 3.10.3 Junctions between non loadbearing walls and load-bearing structure : central rib

[4] ATEx A 2990 Maçonnerie de remplissage
[7] Cycle Terre, Guide

In the case of masonry walls with a thickness greater than or equal to 15cm, a connection by interlocking by central rib is possible. A cleat (width and depth 25 mm) or a metal profile (depth 25 mm) is attached to the stiffener, and a groove is cut in the CEB on site. [7] (p.133-134)

Technical details see Section 5.1



Examples of linear connections with a central rib [4] p.135

## 3.10.4. Junctions between non loadbearing walls and load-bearing structure : anchoring system

[2] ATEx A 2957 Murs porteurs
[3] ATEx A 2991 Parement intérieur
[4] ATEx A 2990 Maçonnerie de remplissage
[6] NIT 271 - Exécution des maçonneries
[7] Cycle Terre, Guide

Anchors in Léém masonry walls are used in order to prevent movement in a certain direction, and possible allow for movement simultaneously in another dimension. As such, they help the structural integrity of a building by controlling which movement is allowed (e.g. differential hygrothermal linear expansions, ...) and which movement is prevented (e.g. buckling of walls, ...). Anchors are needed in several situations:

— They are sometimes used to join two parts of a wall together in the case of an expansion joint (see Section 3.4.2)
— They are used to laterally join a partition or an infill wall to a stiffening element, whether it is a post, a wall, a frame.
— They are used to attach a cladding wall to a supporting backing wall

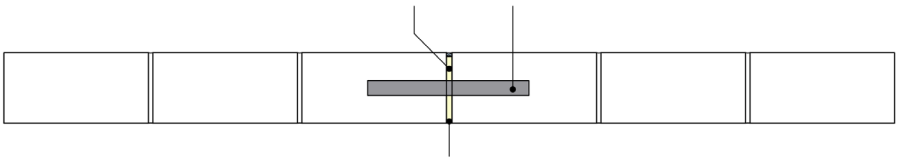
There are different types of anchors for different purposes. The type of anchor is determined by the movements allowed or prevented, the loads to be taken and the characteristics of the adjacent building elements. As a general rule, anchors should be made of anti-corrosive materials and should always set in the mortar joints, never directly in Léém blocks. [2] (p.33)

## a. Slide anchor between masonry walls

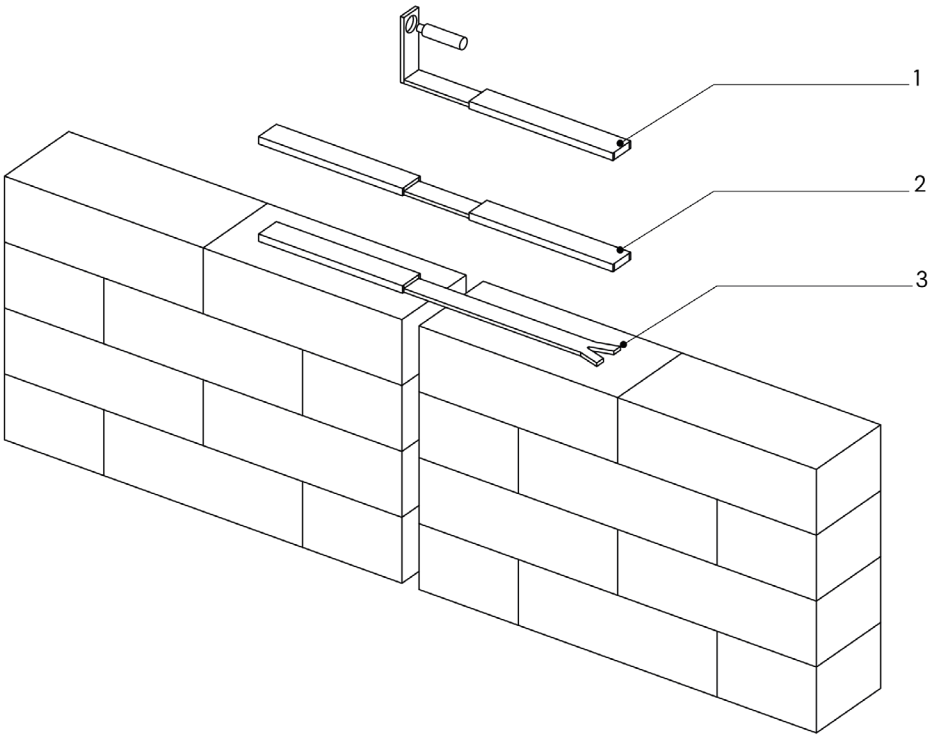
For an explanation of expansion joints, see Section 3.4.2. Slip anchors are used to prevent lateral movement and allow for longitudinal movement in expansion joints between 2 non-loadbearing Léém masonry walls. T-versions of slip anchors can be used on T-junctions between non-loadbearing Léém masonry walls.

In loadbearing Léém masonry walls, slip anchors can be used also, however, these slip anchors should prevent both lateral and longitudinal movement.

(Technical details see Section 5.1)



Creation of a movement joint that does not allow transverse movement [6] p.105




1. Assymetrical slide anchor : fixed - slide
2. Symmetrical slide anchor: slide - slide
3. Assymetrical slide anchor fixed - slide

Examples of transversally retaining anchors [6] p.26



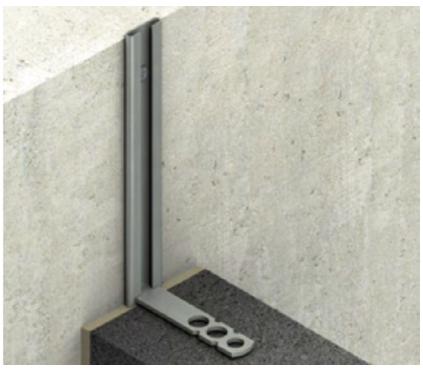
Example of an expansion anchor in cellular concrete masonry [6] p.105

## b. Sliding anchor between masonry wall and structure

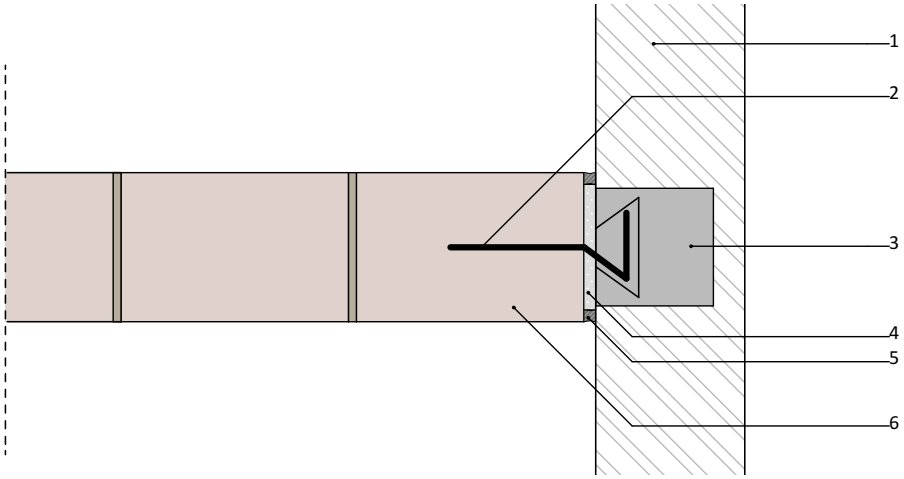
In the case of a lateral attachment of a Léém masonry wall to a stiffener or structure:

— Anchors are identical to those used in conventional masonry (see also NIT 271, and compliant to EN 845-1 Specification for Masonry Accessory Components)
— Anchor are mechanically attached to the stiffeners with screws and/or plugs appropriate to the nature of the material and the strength sought. They are sealed as they are installed in the horizontal mortared joints of the Léém masonry. Their capacity is greater than the calculated shear force. [4] (p.13)
— They are placed as close to the centerline of the wall plane as possible, in the middle third of the wall thickness, and must have a thickness (or diameter) less than or equal to one-half the thickness of the assembly joint.
— They must also be able to absorb differential movement between stiffener and Léém masonry wall, for which they must have provisions allowing vertical clearance: oblong hole, slide, etc. [7] (p.136)
— There are different types of anchors [4] (p.13) :
    - Non-corrodible steel anchors type SPB 125 or SPV 125 or SP21 or SP28 from Ancon or equivalent arranged in the thickness of the horizontal joints of the infill
    - Ancon PPV or PPB or PP21 type anchors with release sleeve





Ancon's SPB and SP28 fastener [4] p.13



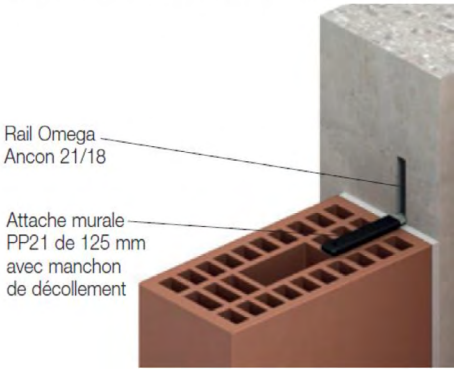

1. Baked brick masonry
2. Point-to-point fastener distributed along the height
3. Stiffener
4. Rock wool insulation
5. Caulking joint
6. Masonry with Compressed or Moulded Léém Blocks

Connection between a Léém Block wall and a clay brick wall [2] p.34

*Ankrobrick (Plaka) :*

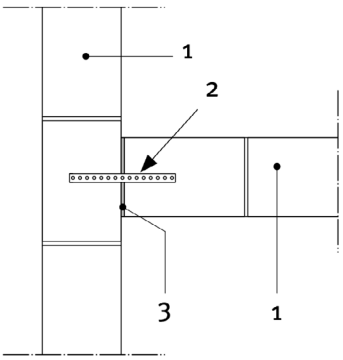


*Attache PP21 avec Rail Omega (Ancon) :*




Examples of sliding anchors [2] p.34

## c. Shear anchor

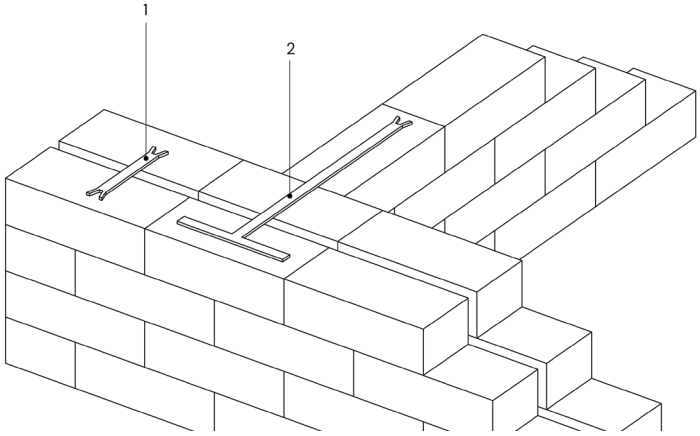






1. Loadbearing masonry
2. Shear fastener
3. Fire-resistant seal for fire requirements (e.g. mortar, mineral wool, non-combustible material class A2-S3-do or better, melting point ≥ 1000°C)

Examples of junctions using connecting brackets (shear fastener) [6] p.26



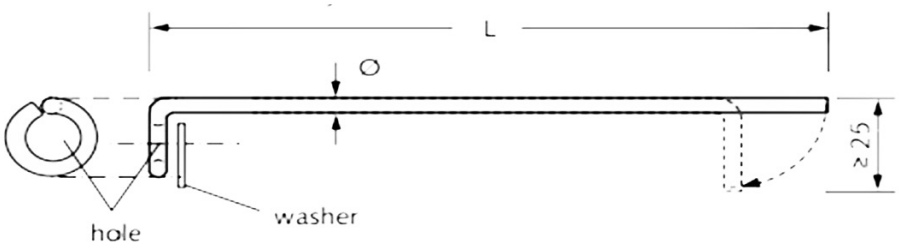

1. Symmetrical type with split ends
2. Asymmetrical T-type

Examples of shear fasteners [6] p.26

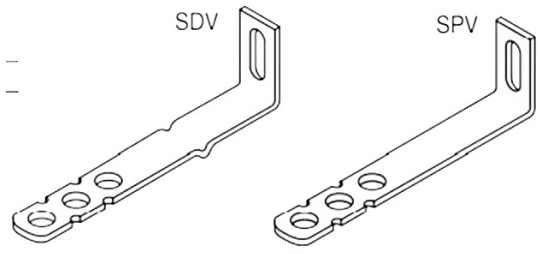
## d. Anchor in interior cladding wall to a loadbearing wall

Anchors are selected according to the expected differential deformations and the width of the cavity (see table [3] (p.18)). Following anchors are conform EN845-1 and have been tested on pullout strength according to EN 846-5, however equivalent anchors can be chosen if they are declared and tested equivalently.

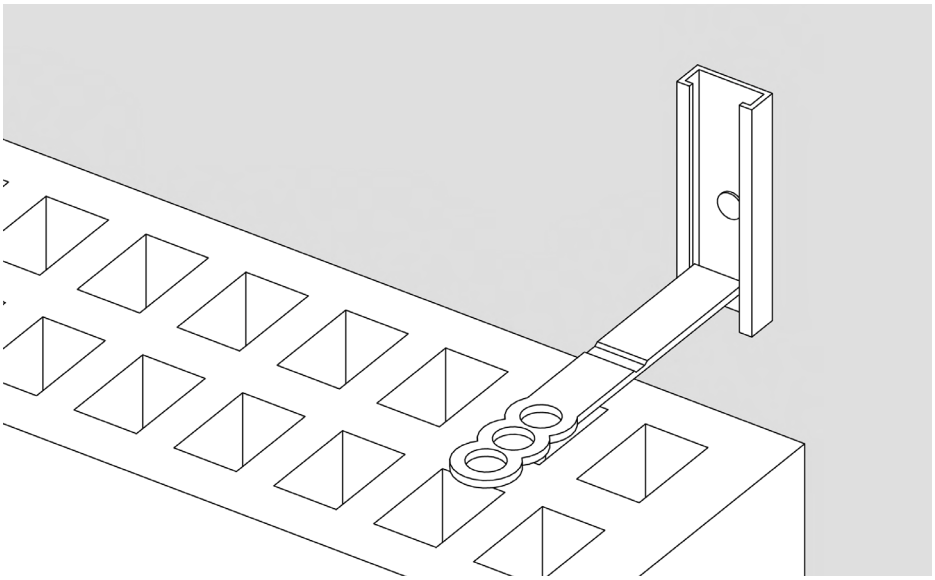
— LSA-L from Halfen
— SPV (or SDV), SP21/28 (or SD21/28), TFMT or AMR from Ancon [3] (p.9)



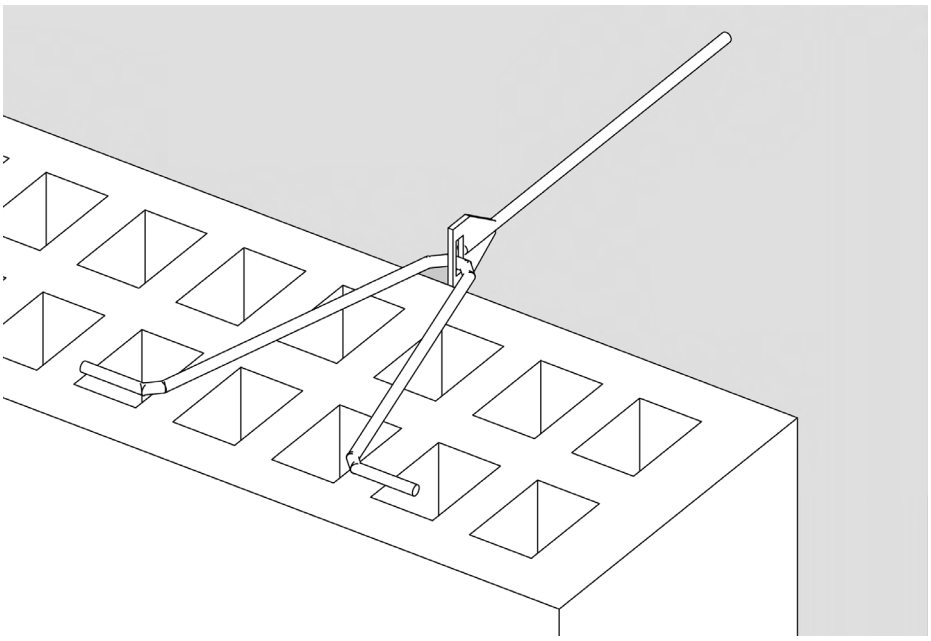

Masonry bonding clip LSA-L-HALFEN [3] p.10




Masonry bonding clip Ancon's SDV and SPV [3] p.10



Masonry bonding clip Ancon's TFMT [3] p.10



Masonry bonding clip Ancon's AMR [3] p.10

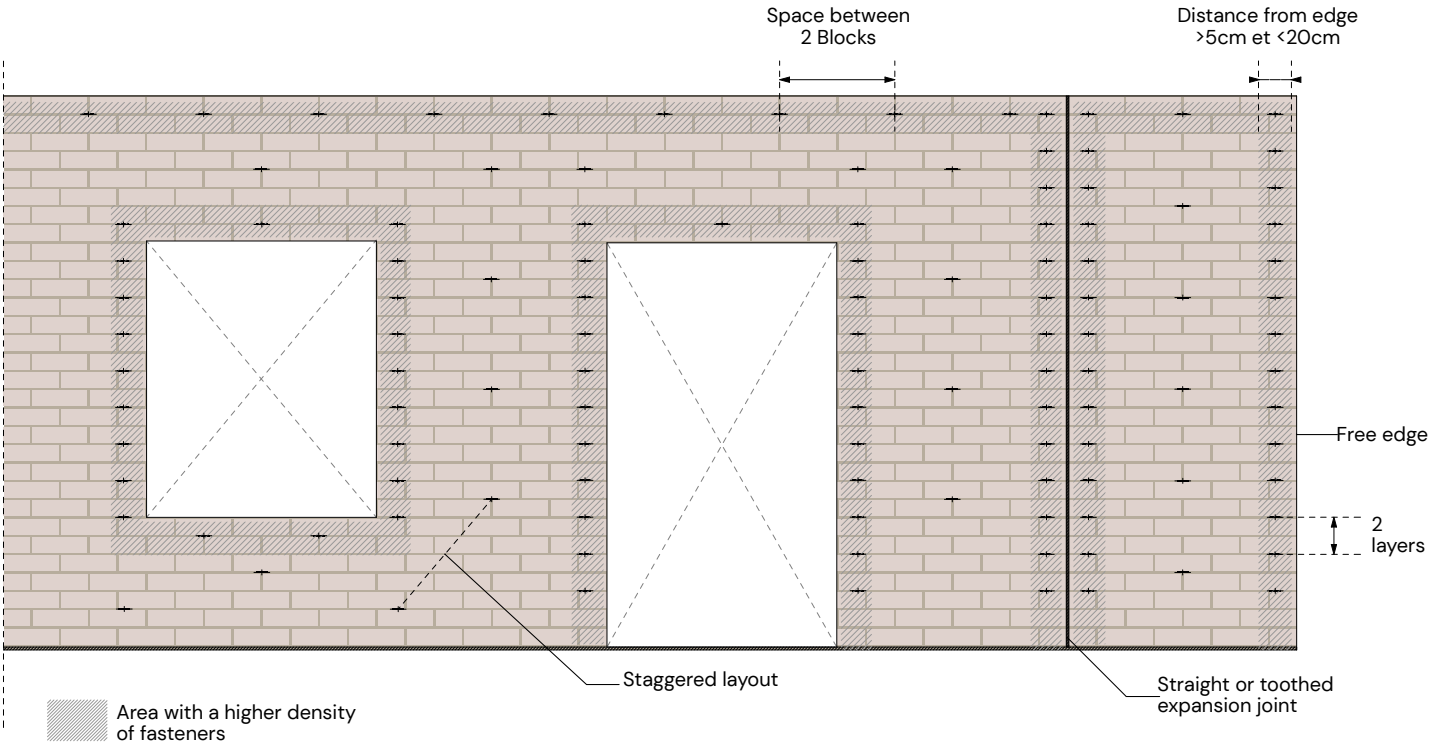
Following aspects are to be taken into account:

— The number of fasteners required depends on the humidity (2-4 fasteners/m², more details in [3] (p.18) )

| Climate class and type of building | Halfen's LSA-L | Ancon's SDV ou SD28 |
|---|---|---|
| Class I | 3 | 2 |
| Class II | 4 | 3 |

Number of fasterners/m2 depending on the model and humidity of the room [3] p.18

— The number of fasteners is more important at singular points (wall head, free edges): one fastener every two Léém Compressed Block beds (vertically) and one fastener every other Compressed Block (horizontally). These ties must be at a distance 5 to 20 cm from the edge of the masonry. These ties should be evenly distributed over the surface, while taking into account the dimensions of the insulation boards where applicable. [3] (p.21)




Number of anchors close to sensitive areas [3] p.21

— Distance from the end of the fastener to the visible face of the facing wall :

| Anchor models | Moulded Léém Block | | | Compressed Léém Block | | |
|---|---|---|---|---|---|---|
| | mm | 104mm | mm | 90mm | 140mm | 190mm |
| Halfen's LSA-L | 30mm | 45mm | 50mm | 37mm | 65mm | 105mm |
| Ancon's SD / P | 20mm | 40mm | 50mm | 30mm | 60mm | 120mm |

Distance between the end of the fastener and the visible face of the facing wall [3] p.35

— The type of fastener should also be determined according to the expected deformations of the supporting wall at ELS (Table 6 [3] p. 18 )

Technical detail see Section 5.2.2

## 3.10.5 Connection with joinery

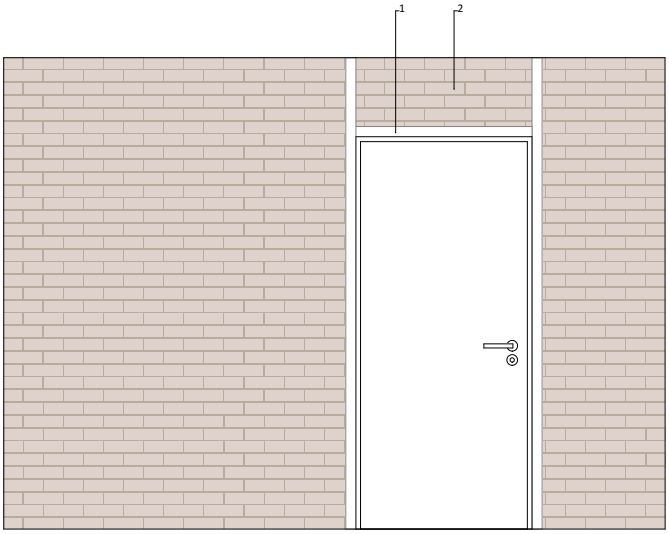
[1] Guide des bonnes pratiques: Briques de terre
[2] ATEx A 2957 Murs porteurs
[3] ATEx A 2991 Parement intérieur
[7] Cycle Terre, Guide

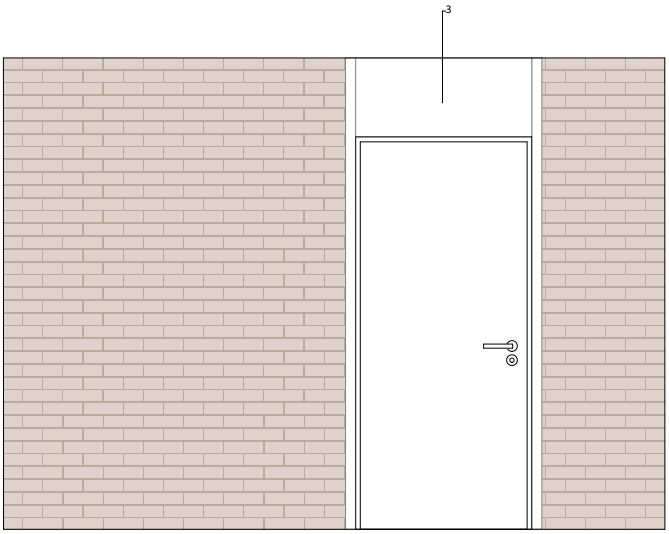
Window or door frames receive dynamic stresses through actions of opening and closing, as well as through wind and other horizontal loads. In order to avoid cracking or tearing due to these stresses, following options have to be applied:

— A window or door pre-frame is made integral with the wall by embedding (fixing) or by sealing (fixing and mortaring). In both cases, the fixing lugs are inserted in the mortar used to lay the blocks. This pre-frame option is to be preferred in the case of loadbearing walls. The material of the pre-frame can be steel, wood, aluminium.When choosing sealing of the pre-frame, the sealing must be compatible with maintenance, repairs and eventual replacement of the carpentry, without damaging the structure of the Léém masonry wall. [2] (p.55)
— A continuous solid window or door lining made of materials resistant to these constraints (nature stone, fired bricks,...)
— Punctual insertion of materials resistant to these constraints (nature stones, fired bricks, small pieces of wood) embedded in the Léém masonry wall.» [1] (p.42)

When choosing a preframe system, the window or door frame can be used as a stiffener:

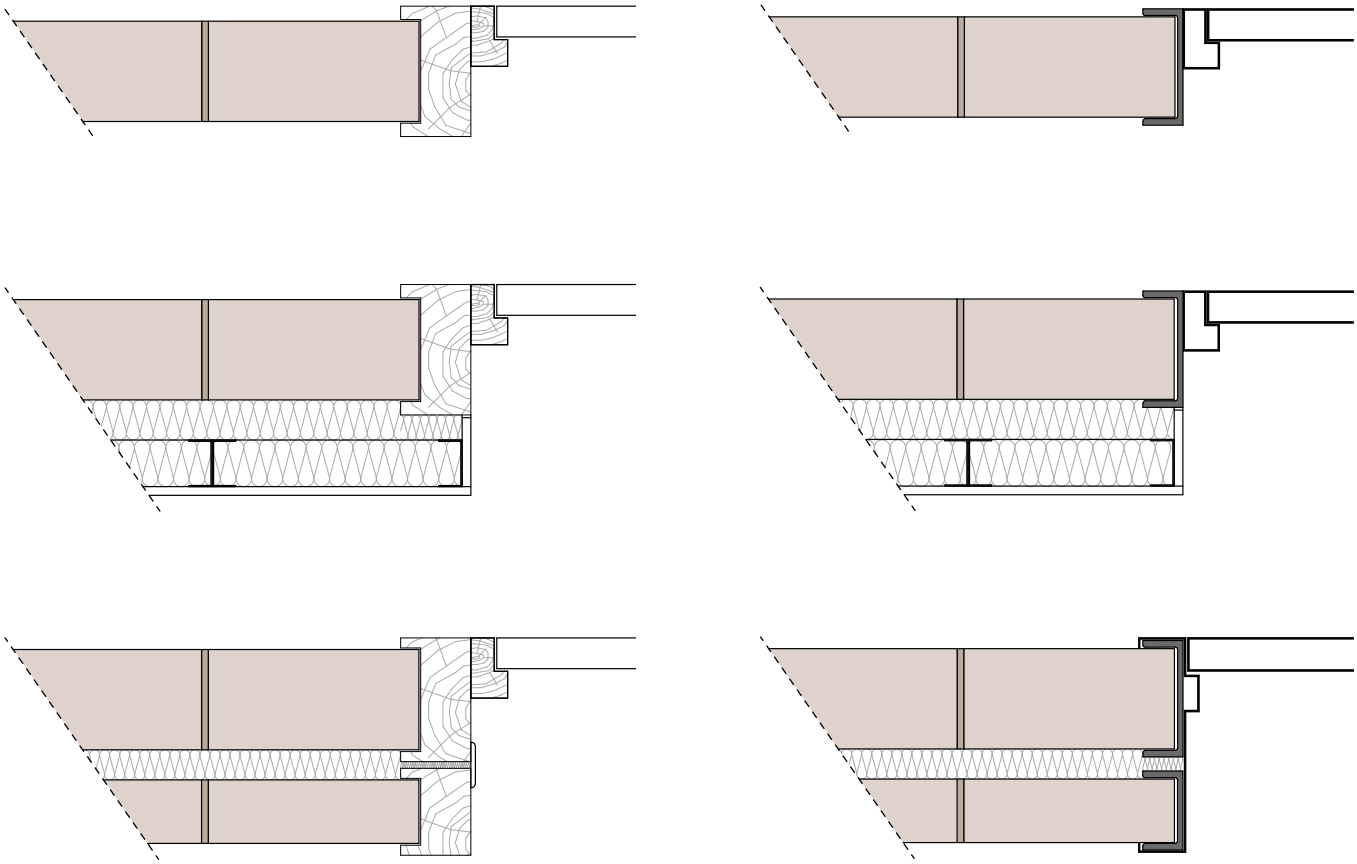
— The frame goes to the top of the wall and is attached at the bottom and at the top
— The frame and the junction between the wall and the frame must meet the criteria of a stiffener (see Section 3.10 and Section 5)
— As stiffeners, the door frame jambs must be sized the same as the stiffeners and have a U-shaped profile in section to accommodate the masonry blocks. [7] (p.146) (see Section 3.10.2)
— In the specific case of a masonry infill, the openings must be framed with framing elements (posts, lintel, headers) and the joinery must be anchored in these elements (technical details see Section 5.2.2)




1. Lintels fixed to the stiffeners
2. Transom in Léém Moulded or Compressed Blocks
3. Transom included in the carpentry package with the door block

Examples where the door frame acts as a stiffener [7] p.146



Exemples de jonctions avec un cadre de porte jouant le role de raidisseur [5] p.30

# 3.11 Angles

[4] ATEx A 2990 Maçonnerie de remplissage
[5] ATEx A 2911 Cloisons

For Léém masonry walls in general, the corners must be made by interlocking the successive courses, in order to ensure the continuity of the masonry bond. It must be ensured that the foreseeable deformations of the masonry on both sides of the corner are similar (in particular the settlement of the masonry, linked to its height and the rhythm of installation) [4] (p.35)

In the case of double walls, the corners must be made so that the insulation is continuous. (section 3.12).

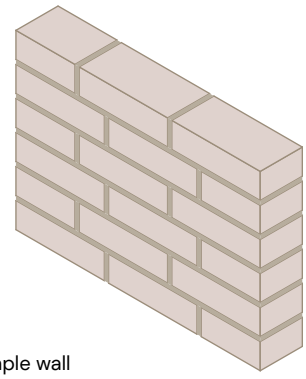
In the case of infill masonry, the corners can be treated also by incorporating and anchoring properly to a stiffener (see Section 3.10.4)

# 3.12 Acoustic walls

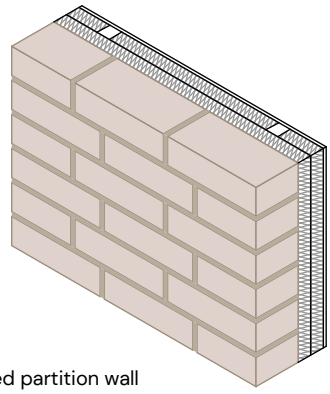
[4] ATEx A 2990 Maçonnerie de remplissage
[5] ATEx A 2911 Cloisons
[6] NIT 271 - Exécution des maçonneries
[7] Cycle Terre, Guide

## 3.12.1 General Principles

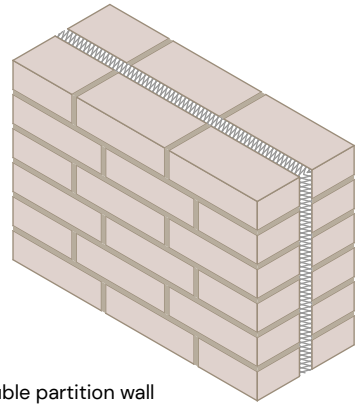
Acoustic walls aim to attenuate sound transmission of airborne and impact sounds, through material choices and detailing. Following general provisions should be integrated to achieve sound attenuation through acoustic walls:



simple wall

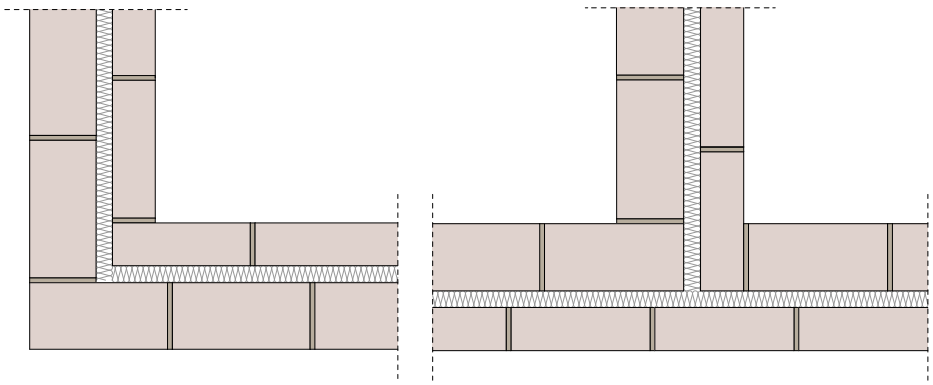


Lined partition wall



Double partition wall

— Continue the acoustic insulation at corners [7] (p.84-85)
— The application of a Léém plaster allows an improvement of this attenuation, since this prevents acoustic leaks through the mortar joints by covering them up with plaster [4] (p.27)
— Continue the acoustic interruption on the uncoupled sides of Léém masonry walls (at the level of the slabs and foundations, ceilings, stiffeners, primary structural columns and beams, ...) through the use of resilient strips, Expanding foam tapes, sealants, cleats, angles and other overlapping systems, etc. [4] (p.27), [6] (p.47-48)



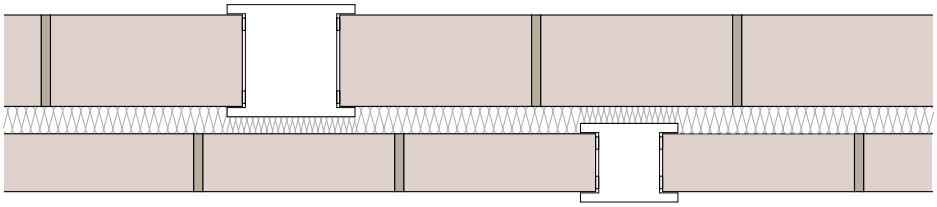
Examples in plan of L and T angles for the continuity of insulation in a double partition wall [5] p.25

Specific provisions should be integrated in the case of lined or double partitions (technical details see Section 5.3.3).

— Lined partition wall: Léém masonry wall + insulation + plasterboard. It is important to pay attention to the uncoupling of the lining frame from the Léém masonry wall to avoid acoustic bridges (For more information on metal framing and plasterboard attachment see [5] (p.9))
— Double partition wall: Léém masonry wall (≥ 9cm) + void (≥ 2cm) + Léém masonry wall (≥ 9cm). Care must be taken to ensure continuity of insulation at the corners! [7] (p.84-85).

In double partition walls it is necessary to:

— Preferably use two walls of different thickness with a void of 4cm between these walls. This gap is either filled completely with a flexible insulation or partially with a rigid insulation (leave a gap of min. 2cm) [6] (p.47-48)
— Use a vapour permeable insulation (insulation with a lower Sd than the Sd of the Léém blocks: for a 9cm thick wall à Sd = 0.9m; for a 13cm thick wall à Sd = 1.3m); mineral wool is often used [5] (p.9)
— Decouple the stiffeners in a double wall to ensure acoustic performance [7] (p.84-85) and [5] (p.19)



Example of offset stiffeners for a double partition where acoustic performance is required [5] p. 20

## 13.12.2 (Calculated) values of acoustic wall insulation

Based on lab testing at Buildwise , and calculation by Buildwise using Insul Software (See section 2.3.2), following values are to be expected when using Léém blocks:

| Type of partition wall | Rw (C; Ctr) in dB | | |
|---|---|---|---|
| Simple 9 cm thick partition wall | 50 dB | | Calculated value |
| Simple 10,5 cm thick partition wall | 52 dB | | Calculated value |
| Simple 14 cm thick partition wall | 54.3 (-1.6;-4.9) dB | | tested to ISO 10140-2 |
| Simple 14 cm thick partition wall plastered | 54.4(-1.8;-4.9) dB | | tested to ISO 10140-2 |
| Simple 19 cm thick partition wall | 57.7 dB | | Calculated value |
| Simple 23 cm thick partition wall | 60.2 dB | | Calculated value |
| Simple 29 cm thick partition wall | 63.2 dB | | Calculated value |
| Double partition wall 9 - 2cm of wool - 9 structurally decoupled, with and without anchors (non-acoustical) | 61 dB | 73dB | Calculated value |
| Double partition wall 14 - 2cm of wool - 9 structurally decoupled, with and without anchors (non-acoustical) | 64 dB | 76 dB | Calculated value |

For other wall buildups, the designer can use Insul software to estimate airborne sound insulation according to EN ISO 12354-1, making use of the given density and E-modulus (see technical data sheets).

For rough estimates of calculation values without software, it should be remembered that the condition of a coating on at least one side of the masonry wall must be met. This condition makes it possible to apply article 8.8.1 « law of mass» by obstructing the possible « acoustic leaks ». [2] (p.43) The «Law of mass" is a calculation law to which the sound insulation value of a wall obeys as a function of its surface mass: the energy transmitted is inversely proportional to the square of the mass. It follows from this law, also known as Berger's law, that the gross acoustic attenuation index of a wall increases by 6 dB by doubling the mass or, for a homogeneous material, by doubling the thickness [1] (p.52)

Summary table of aimed variants [7] p.162

### 13.12.3 Acoustic isolation between dwellings

Using TVN 281 'Acoustic insulation of dwellings', we can compare the impact sound insulation (based on surface mass) and airborne sound insulation (based on acoustic tests) of Léém blocks against those of sand-lime blocks, baked bricks, poured concrete and concrete blocks. This shows that in each building concept of acoustic separation (single wall with insulation, double wall, single wall with lining), Léém blocks isolate better than sand-lime bricks, baked bricks, poured concrete and concrete blocks.

If you want to use Léém blocks acoustically as a separating wall in row housing, appartment blocks or column houses, and want to know whether this complies with the validated building concepts in TVN 281, contact us to obtain our memo with validated building concepts with Léém blocks.

# 3.13 Airtightness

[2] ATEx A 2957 Murs porteurs
[7] Cycle Terre, Guide
[10] Sustainable Building with Earth
[22] NIT 284 Les enduits intérieurs
[25] NIT 255 Etanchéité à l'air

Airtightness with Léém masonry walls can be assured by following provisions:

— An earth plaster of minimum 10mm, as advised by Buildwise in NIT 284, guarantees the airtightness of Léém masonry wall surfaces and corners [22] (p.53), [10] (p.415-416), [7] (p.79). Air leaks through mortar joints are covered up by the plaster. This plaster can be applied at both the exposed side of a Léém

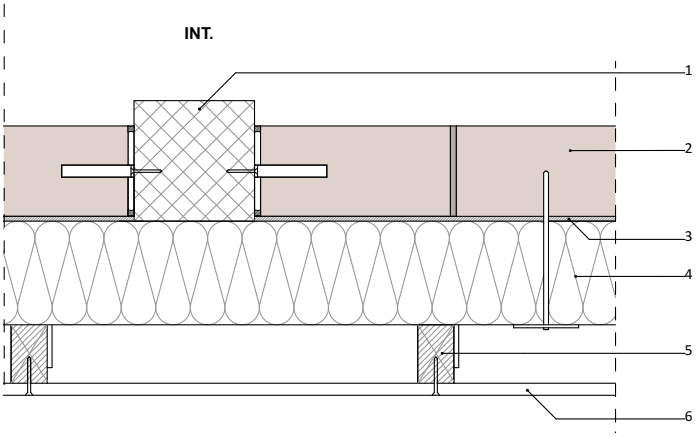
# 3.14 Inner leaf of exterior (cavity) walls

[3] ATEx A 2991 Parement intérieur
[4] ATEx A 2990 Maçonnerie de remplissage

Different types of wall buildups are possible. We list them here under in different cases and only show basic principles. Full construction details can be found in section 5.3.1

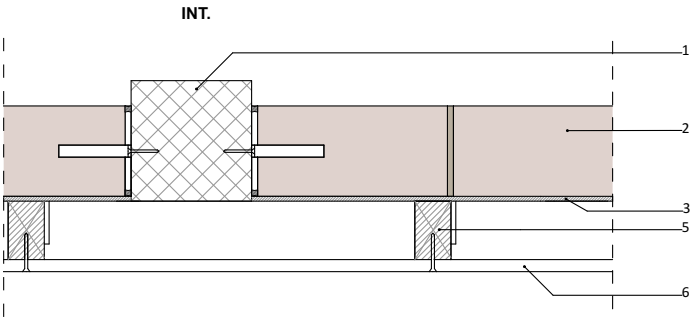
## 3.14.1 Case A: Léém masonry infill wall to the surrounding structural frame.

Case A comprises Léém masonry as infill to the surrounding structural frame. The subsequent external façade buildup will consist of facade cladding fixed to a secondary framework and a ventilated air cavity underneath the cladding, and potentially an insulative layer. The secondary framework consists of wooden rafters or metal studs fixed to the structural frame. (Minimum thickness of the Léém masonry wall: 15cm) [4] (p.5+14) (Léém Moulded Blocks can only be used in this configuration if these are insulated.)




Plan view - Case with external thermal insulation [4] p.6

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Léém Clay Plaster on Léém Moulded or Compressed Blocks
4. Insulation
5. Secondary structure of external facing + ventilated air gap
6. Exterior cladding

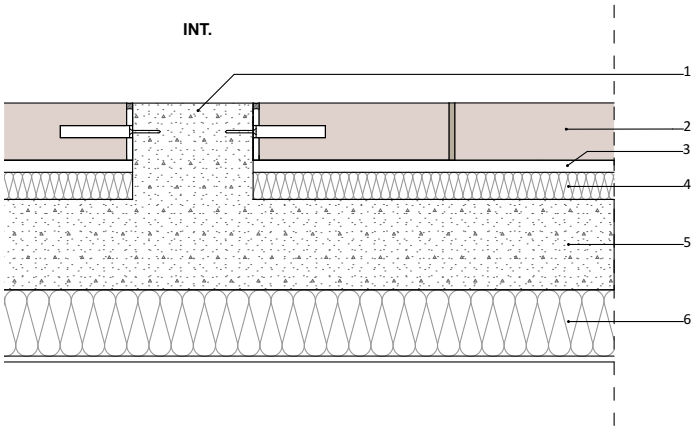



Plan view - Case without external thermal insulation [4] p.6

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Léém Clay Plaster on Léém Moulded or Compressed Blocks
4. Secondary structure of external facing + ventilated air gap
5. Exterior cladding

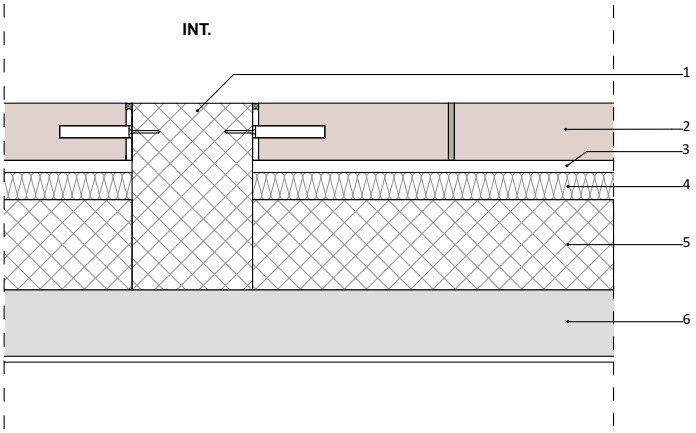
## 3.14.2 Case B : Interior infill lining of an exterior loadbearing façade wall

Case B : The Léém masonry wall only acts as an interior lining infill of an exterior loadbearing façade wall. This façade wall can be a full concrete, timber frame or masonry wall, or a hybrid concrete/wood frame wall. There must be an air gap of at least 1cm between the Léém masonry lining wall and the exterior facade wall (the latter may be ventilated: see p.23+5) The minimum thickness of the Léém masonry wall is 9 cm [4] (p.5+14) , [3] (p.5)



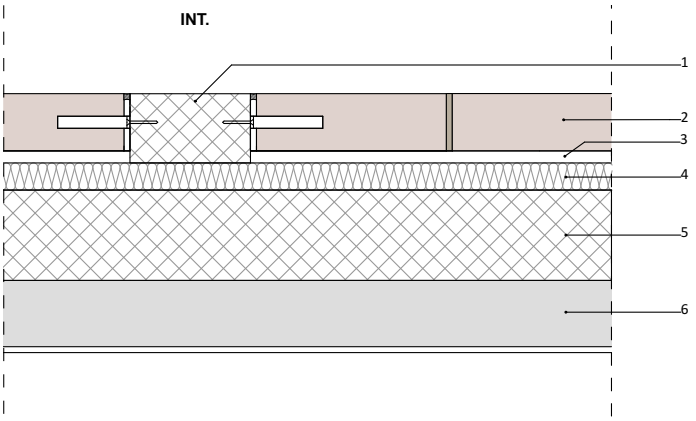

Plan view - Example with concrete framework and rendered pannels for external insulation [4] p.7

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Air-gap
4. Insulation
5. Reinforced concrete wall
6. Insulation + plaster adapted to the substrate



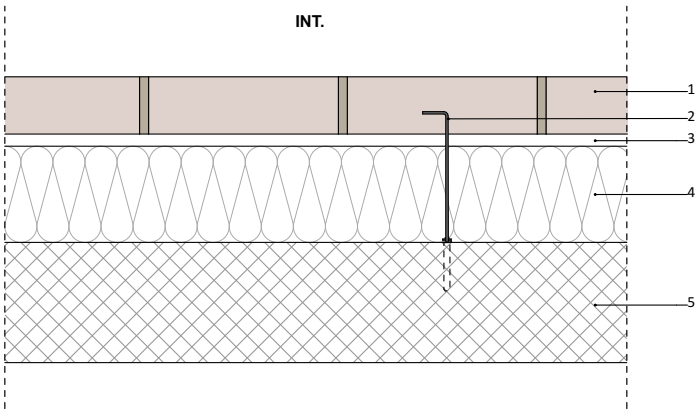

Plan view - Schematic diagram with main framework post supporting the cladding [4] p.7

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Ventilated or non ventilated air-gap
4. Insulation if necessary
5. Masonry of timber envelope wall - support for external cladding
6. Exterior cladding




Plan view - Schematic diagram with secondary framing column supporting the cladding [4] p.7

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Ventilated or non ventilated air-gap
4. Insulation if necessary
5. Masonry of timber envelope wall - support for external cladding
6. Exterior cladding

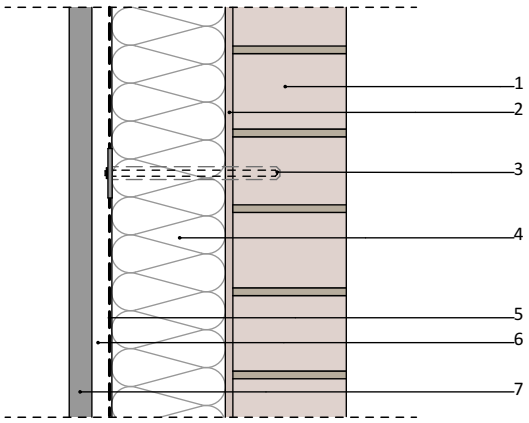



Plan view - Schematic diagram of masonry cladding in Léém Blocks

1. Cladding with Léém Moulded or Compressed Blocks
2. Metal connecting bracket
3. Air gap
4. Interior thermal insulation
5. Supporting wall, optionally with exterior thermal insulation

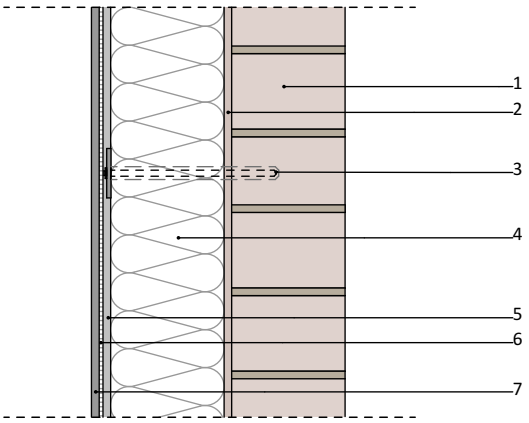
## 3.14.3 Case C : Loadbearing insulated exterior wall

Case C : The Léém masonry wall acts as the loadbearing insulated interior side of an exterior wall, with option of a cavity. The minimum thickness of the Léém masonry wall is 14 cm.




Cross-section - Léém masonry wall checked by Buildwise for humidity performance

1. Léém Moulded or Compressed Block masonry wall (14 to 29cm)
2. Léém Earth Plaster or Adhesive Mortar for windtightness
3. Insulated insulation plug
4. Insulation compatible with exterior rendering (15cm)
5. Waterproof vapor-open rainscreen
6. Air gap
7. External cladding




Cross-section - Léém masonry wall checked by Buildwise for its hygromectric performance in an ETICS construction system

1. Léém Moulded or Compressed Block masonry wall (14 to 29cm)
2. Léém Earth Plaster or Adhesive Mortar for windtightness
3. Insulated insulation plug
4. Insulation compatible with exterior rendering (15cm)
5. Reinforced mortar
6. Reinforcement
7. Primer, finishing plaster and finishing paint

## 3.14.4 Hygrometric validation of cases

Generally, Section 4.3.4 provides information on the hygrometric design of these wall buildups. It suffices here to repeat that currently BC Materials and Buildwise have validated Case A insulated version and Case C through hygrometric calculations. Theses calculations confirmed the more general rule that from inside to outside, Heat Transfer Resistance values R of building layers should go up and Water Vapour Diffusion resistance factors μ should decrease.

## 3.14.5 Dimensions of the air cavity

The dimensions of the air cavity (for two types of conditions) should be considered as follows:

— Normal conditions: minimum thickness of the air cavity = 1cm. This air gap can be ventilated to increase the exchange surface between the ambient air and the Léém Compressed Block masonry. This improves the inertia and humidity regulation of the room. However, ventilation of the air space is unfavourable from an acoustic point of view
— Room with higher humidity (MX2.1) and support/vapour barrier wall with Sd > 20 m: minimum air gap thickness = 2cm + recommended air gap ventilation [3] (p.19)

(Technical details see Section 5.3.1)

# 3.15 Fixing of heavy loads

[3] ATEx A 2991 Parement intérieur
[4] ATEx A 2990 Maçonnerie de remplissage

Here are some guidelines for fixing loads in an Léém masonry wall :

— The fixing of objects with a mass of less than 30 kg is permitted with plastic expansion plugs or rubber expansion plugs.
— The fixing of objects weighing between 30 and 100 kg is permitted either with HUS3 screws from Hilti or equivalent, or with HIT-V threaded rods with chemical sealing with HY 170 resin from Hilti or equivalent, with a minimum of 4 screws or rods.
— The fixing of structural elements in the masonry is not allowed! [4] (p.47) and [3] (p.31)

For specific applications, e.g. suspension of façade systems to Léém Masonry, please contact BC materials. We have test reports available which allow much higher loads than the rules of thumb above.

# 3.16 Protection against abrasion

[4] ATEx A 2990 Maçonnerie de remplissage

In most cases, no special protection is required for the masonry, as it is generally not subject to much abrasion and is not very sensitive to impact. In areas where the risk of abrasion is particularly high, mechanical protection or the application of a surface finish to all or part of the masonry can reinforce the resistance of the wall. [4] (p.23) For the different types of surface finishes please refer to Section 4.3.

# 3.17 Grooves and holes in the walls

[7] Cycle Terre, Guide

Reservations and penetrations in walls are permitted if there are no fire resistance requirements and as long as their area is limited to 200cm² and their width to 10cm. The total width of the openings and penetrations must be less than one tenth of the width of the wall. [7] (p.150-151)

# 4. Implementation guidelines



# 4.1 Preparation and site conditions

**Weather conditions**: Care must be taken when laying masonry, particularly in cold, or hot and windy weather. If there is a risk of frost, masonry work should not be carried out. As soon as the temperature is permanently above 30°C, when using bastard mortar with Léém Additive, it is preferable to prepare small quantities of mortar that can be used in less than 30 minutes. When using Léém (Adhesive) Mortar, do not hesitate to re-wet the mixture regularly to maintain the initial mortar texture.

If the masonry dries out too quickly, cracks may appear due to severe shrinkage. A few simple precautions can be taken: build during the least hot hours, protect the mortar and masonry from drying out (light wetting, tarpaulin, etc.).

**Storage of blocks and mortar**: Léém materials should be protected from rain and damp during all handling and storage phases prior to laying. It is preferable to store Léém blocks away from water and to remove the packaging films from the pallets a few days before laying, to allow any condensation that may appear underneath to dry.

**Protecting the work during construction**: The masonry must be installed in such a way as to guarantee its stability during construction. During the building work and until it is completed, the wall surfaces, and especially the protruding corners, must be protected from impacts that could damage them. This damage is most often caused by the handling of heavy elements during construction (formwork, scaffolding, various tools) or by the manoeuvring of machinery and vehicles on the site.

**Appearance validation and prototype wall:** In the case of exposed Léém masonry, the quality of the finish of the facings (texture, colour, pointing and finish) can be validated by creating one or more prototype walls at the start of the worksite to define the desired result and its acceptance criteria. The prototypes are made using the materials and application specific to the planned contract and with a geometry defined by the project manager. The prototypes are produced on site and kept for the duration of the project. The appearance will be checked on site and accepted on delivery by comparison with the prototype walls, in accordance with the tolerances defined beforehand.

**Mortar preparation**: See the following table

## Preparation of different Léém Mortars

| | Léém Mortar 10mm | Léém Adhesive Mortar 1-3mm | Bastard Mortar with Léém Additive 10mm |
|---|---|---|---|
| **Dosage** | Mix the mortar with water in the proportions indicated on the product sheets or until you obtain a smooth, homogeneous paste that is pleasant to work with. | Mix the mortar with water in the proportions indicated in the product sheets. | Mix the dry additive with Bastard Mortar M10. Then mix with water in the proportions indicated in the product data sheets. |
| **Mixing** | Mixing can be carried out using various types of concrete mixers, vertical or horizontal helical or planetary mixers. For small quantities, painter's mixers or a mixing attachment on a drill can be used. Hand mixing (using a trowel or shovel) is also possible. Mix until a homogeneous paste is obtained. It is advisable to let the mixture rest for 30 minutes and remix. | Mixing can be carried out using mixers specifically designed for adhesive mortar. For small quantities, painter's mixers or a mixing attachment on a drill can be used. Hand mixing (using a trowel or shovel) is also possible. Mix until a homogeneous paste is obtained. It is advisable to let the mixture rest for 30 minutes and remix. | Mixing can be carried out using various types of concrete mixers, vertical or horizontal helical or planetary mixers. For small quantities, painter's mixers or a mixing attachment on a drill can be used. Hand mixing (using a trowel or shovel) is also possible. Mix until a homogeneous paste is obtained. The mixture must be used immediately after mixing |
| **Duration of use** | Once mixed, the mortar remains usable indefinitely if kept damp, as there is no hydraulic setting of the mortar or any organic material that can degrade with water. Howevern the corrosive effect on machines and equipment should still be considered. When fibers are added to the mortar, it remaines usable for 2 days. | Once mixed and rested, the mortar must be applied. | Once mixed, the mortar should be used quickly. In particular, in hot weather, it is advisable to it less than 30 minutes after it had been made. |




Dosage du Mortier et de l'eau pour le mélange




Mélange du Mortier



Application du Mortier Colle de Léém



Application du Mortier de Léém




Protection of Compressed Léém Blocks on construction site

# 4.2 Laying rules

[3] ATEx A 2991 Parement intérieur

As explained in section 1.4, the Léém range has 2 types of blocks (Léém Moulded and Léém Compressed Blocks) and 3 types of mortar (Léém Mortar, Léém Adhesive Mortar, and a bastard mortar with Léém Additive). The masonry of these types of Earth Blocks and Mortars is very similar to conventional masonry. An experienced mason will therefore be able to do it. However, there are some points of attention which are specific to the Léém range that the mason must take into account, mainly related to the management of moisture in the masonry, and the placing of the block in the mortar. These are listed below:

— Before laying, an earth block needs to be wetted to guarantee a correct adhesion with the mortar. The Léém Compressed Block will be immersed in water and immediately removed. However, the Léém Moulded Block will be slightly moistened on the faces receiving mortar, using a sponge or a wide brush, such as a whitewash brush. The laying surface should be slightly wetted using the same technique.
— The mason can strike or hammering the earth block lightly using a rubber hammer. (A sledgehammer, a hammer or even the handle of a trowel should also be avoided, as this may cause splintering of the facing and edges, or even cracking of the blocks, or destabilising of the previously laid masonry.)
— Cutting of blocks happens dry, with suction on the cutting device. Léém Compressed Blocks could be cut with a wet cutting device, where the water addition can be controlled.
— Once the block has been placed, it cannot be lifted anymore to push under additional mortar. It is better to lift the block, take away old mortar, apply new mortar and place the block again.
— Vertical joint mortar shall be put on the block before laying.
— It is forbidden to use blocks of less than ¼ block size.
— The superposition of vertical joints is forbidden, except in exceptional cases and on maximum 3 successive layers
— Establishing a masonry bond plan is recommended.
— Laying the blocks in case of frost is not recommended.
— Always cover the walls during the building process. For Léém Compressed Block Masonry, protect the head of wall. For Léém Moulded Block Masonry, protect the head of wall and the wall surfaces.
— To improve plaster adhesion, cutting a 1-cm-deep channel into the wet joints is also recommended. [10] (p. 326)
— It is absolutely not allowed to add mortar oil, soap, or any additives to Léém mortar.

## 4.2.1 10mm joints with Léém mortar

[1] Guide des bonnes pratiques: Briques de terre
[2] ATEx A 2957 Murs porteurs
[7] Cycle Terre, Guide
[10] Sustainable Building with Earth

Léém mortar is an earth mortar without additives nor stabilization, for joints of 10mm. The less moisture in the mortar, the lower the shrinkage in the mortar joint, but the greater the risk of weakening the bond by drying too quickly. It is important to follow the instruction given on the Mortar technical sheet.

Joints can be applied in several ways: [1] (p.15-17)

— Without repointing: the blocks are laid in a overflowing mortar technique, with full joints
— With direct repointing: overflowing mortar is scraped off; directly, smoothing and tightening are carried out with a jointing iron. This technique is only possible for Léém compressed blocks.
— With repointing after drying: the joints are left recessed as the masonry is installed, this can happen by scraping the joints; then, after the laying mortar

has sufficiently hardened or is completely dry, the joints are filled with mortar; smoothing and tightening are carried out with a jointing iron

Repointing can be carried out using half-round joints, triangle joints, smooth joints and, for interior masonry, hollow joints.

### 4.2.2 10mm joints with bastard mortar and Léém Additive

A bastard mortar M10 (such as Diamur 265B M10) is mixed on-site 3:1 by weight with Léém Additive. This modified bastard mortar is used on construction sites with high demands on water resistance or with exceptional loadbearing characteristics or specific drying needs. Joints made with this bastard earth mortar will harden more quickly than joints made of Léém mortar.

Section 4.2.1 applies integrally.

### 4.2.3 1-3mm fine joints with Léém Adhesive mortar

Léém Adhesive Mortar is used to "glue" Léém Compressed Blocks in joints of 1-3 mm. Use the proper tools such as Adhesive Mortar Spreader Box available in the Léém Masonry accessory range, or generic adhesive mortar spreading trowels.

This mortar is used only with Léém compressed blocks and on construction sites with high demands on speed of execution and loadbearing characteristics.

### 4.2.4 Assembling rate and drying time

[2] ATEx A 2957 Murs porteurs
[3] ATEx A 2991 Parement intérieur

When using Léém (Adhesive) Earth Mortar, it is important to note that it needs more time to harden than lime or cement mortar.

Here are some indications on the assembly rate and drying time in function of its loading [2] (p.37/90):

— Drying time depends on climatic conditions, the type of block and the chosen mortar.
— Fresh Léém masonry must not be loaded by a floor or by an upper wall until it has reached sufficient strength to support the load without damage (We consider that the "conventional" resistance, corresponding to 80% of the maximal resistance, is reached in normal circumstances of 18-25°C and 40%-60% RH after 28 days for Léém Moulded Block masonry and after 14 days for Léém Compressed Block masonry.)
— Fresh Léém masonry must not be plastered before its drying shrinkage has occurred. As a general principle, 3 weeks in normal hygrothermal conditions should be counted for settlement to occur to prevent cracking in plaster.
— An earth block wall must be built by laying a maximum number of stacked courses per day, so as to avoid any risk of uncoupling from the lower courses: 12 courses/day for small blocks; maximum 10 x thickness of the wall (generally between 95 and 150cm/day)
— Where the height of the wall exceeds 4.5 m, it is recommended that the masonry elevations are completed in two stages separated by a period of two weeks. In hot, dry weather, this period can be reduced to one week. This precautionary measure is intended to limit the phenomenon of settling at the top during the drying process. [3] (p.34)



The Compressed Block is wetted for better adhesion to mortar



Application of Léém Adhesive Mortar



Application of Léém Adhesive Mortar



Installing the Compressed Block

## Comparison between Léém Masonry

| | Léém Moulded Blocks | | Léém Compressed Blocks | | |
|---|---|---|---|---|---|
| | **Léém Mortar 10mm** | **Léém Adhesive Mortar 1-3mm** | **Léém Mortar 10mm** | **Léém Adhesive Mortar 1-3mm** | **Bastard mortar with Léém Additive 10mm** |
| **Execution** | | | | | |
| Expected Transport Damage for Blocks | 5% | 5% | 2% | 2% | 2% |
| Expected block/mortar Loss | 6% / 10% | 4% / 10% | 4% / 10% | 4% / 4% | 4% / 10% |
| Speed of buildup in m2/h/p | | -20% | | -40% | |
| Maximum courses per day | 12 | 12 | 12-15 | 12-15 | 12-15 |
| Drying time before continuing work | 7 days | 3 days | 7 days | 3 days | 1 day |
| Ease of Demounting | +++ | ++ | +++ | ++ | + |
| Ease of waste management | +++ | ++ | ++ | ++ | + |
| Construction site management | Head, bottom and lateral protection from water | Head, bottom and lateral protection from water | Head and lateral protection from water | Head protection from water | Head protection from water |

# 4.3 Tolerance of execution

[5] ATEx A 2911 Cloisons
[6] NIT 271 - Exécution des maçonneries

The dimensional tolerances of the earth block constructions (Compressed Block / Moulded Block), deviations of implantation (vertical alignment), plumbness (perpendicular alignment), flatness (straightness) and thickness will be those applied to small masonry wall panels. [5] (p.36) They are summarized in the table from the NIT 271 found in [6] p.116.

# 4.4 Cladding finishes and appearance

[1] Guide des bonnes pratiques: Briques de terre
[9] Earth Masonry : Design and Construction Guidelines

There are different types of cladding walls:

— Ordinary cladding: the wall is intended to be plastered or lined
— Clean cladding: the wall is intended to remain visible. For clean cladding, "The appearance of earth masonry can be considered in four main aspects: colour, texture, mortar joints and applied finishes." [9] (p.61)

In order to control the esthetic aspect, attention must be paid to the following points:

— The masonry pattern, with particular attention paid to the regular distribution of joints and blocks, 1/2 block (half block) or 3/4 block
— The finishing of joints [1] (p.16-17)
— The to be executed earth blocks need to be mixed from at least 10 different palettes, in order to avoid colour and aspect differences between different parts of the wall.

Léém Moulded Block masonry can be sponged, this will unify color and texture between blocks and mortar. Léém Compressed Block masonry can be sponged also, however this will only clean the masonry.

Oils or waxes can be applied on the wall as a finish. Their impacts on the earth masonry can be described as follows:

— Increase of the hardness and therefore durability of the wall surface
— Increase of the water resistance
— Accentuation of the natural colour of minerals
— Reduction in surface permeability and thus water regulation capacity. [9] (p.65) Best is to apply this locally

The application of a fixative or a painting on earth masonry can prevent dust or fine grains from coming off the wall. Non-film-forming and vapour-permeable solutions should be used [3] (p.36), such as Léém clay paint, Léém Fixative, or other solutions based on sodium silicate, ...

For ordinary cladding, it is also possible to apply a vapour permeable plaster (perspiring plaster), preferably Léém clay plasters, but vapour permeable lime plasters are also possible.




Application of mortar joints

# 5. Construction details

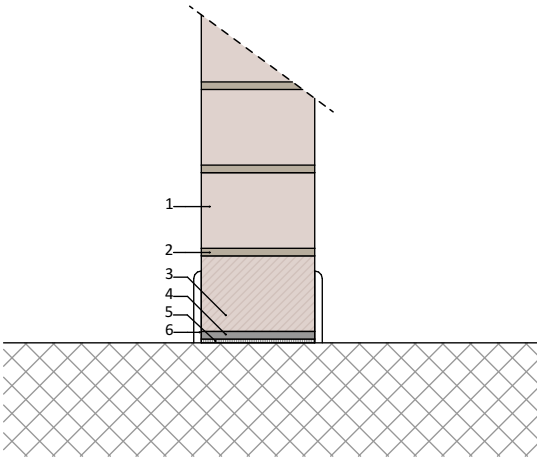


All construction details in this section are grouped according to the wall typologies as introduced in section 1.5.1 :

- Load-bearing: external wall or internal wall
- Non-load-bearing: infill masonry as exterior wall, infill masonry as interior wall, distributive partition wall, separative partition wall, cladding.

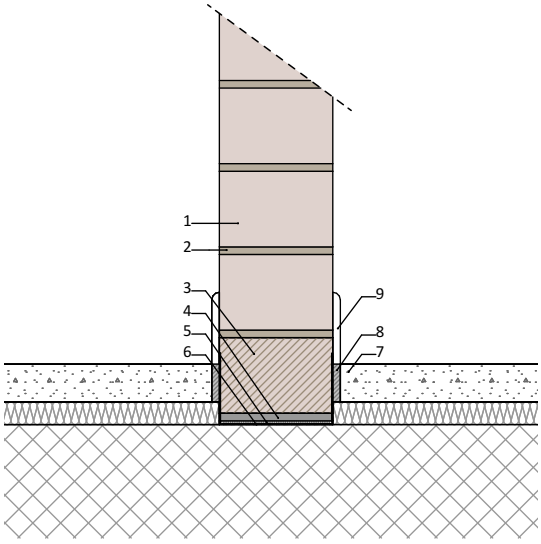
# 5.1 General details for all types of walls

## 5.1.1 Protection of the wall base




**Cross-section of junction with finished floor - 1/10e [5] p. 27**

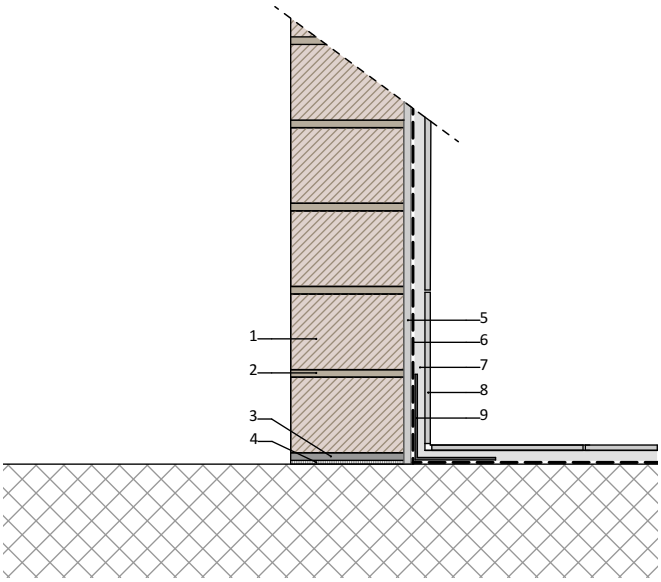
1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar
3. Water-resistant block (Léém Compressed Block, limesand block)
4. Sand-cement mortar (minimum thickness 2cm)
5. Optional decoupling strip (thickness 5-10mm)
6. Baseboard




**Cross-section of junction with floating screed - 1/10e [5] p.28**

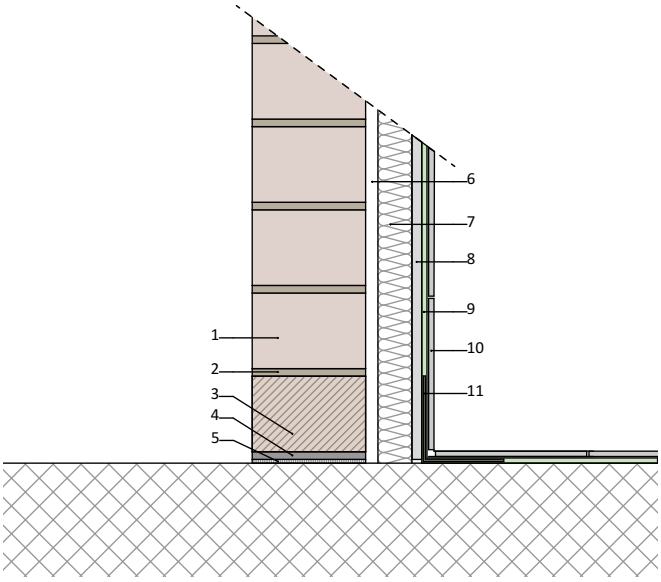
1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar
3. Water-resistant block (Léém Compressed Block, limesand block)
4. Sand-cement mortar (minimum thickness 2cm)
5. Optional decoupling strip (thickness 5-10mm)
6. Waterproof barrier extending at least 2cm above the finished floor level
7. (Floating) screed
8. Perimeter caulking
9. Baseboard

## 5.1.2 Protection of walls in wet rooms




**Cross-section detail of the base of a wall in wet rooms - 1/10e [5] p.31**

1. Léém Compressed Block (water resistant)
2. Bastard mortar with Léém Additive
3. Sand-cement mortar (minimum thickness 2cm)
4. Optional decoupling strip (thickness 5-10mm)
5. Lime trass plaster
6. Kerdi or similar membrane glued to the plaster
7. Tile adhesive mortar
8. Tiles
9. Waterproof reinforcement strip




**Cross-section detail of the base of a wall with cladding in wet rooms - 1/10e [5] p.31**

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Water-resistant block (Léém Compressed Block, limesand block)4. Sand-cement mortar (minimum thickness 2cm)
5. Optional decoupling strip (thickness 5-10mm)
6. Air gap
7. Lining framework detached from the masonry and insulation if necessary
8. Hydrophobic plasterboard
9. Primer and resin applied in two coats
10. Tile adhesive and tiles
11. Waterproof reinforcement strip

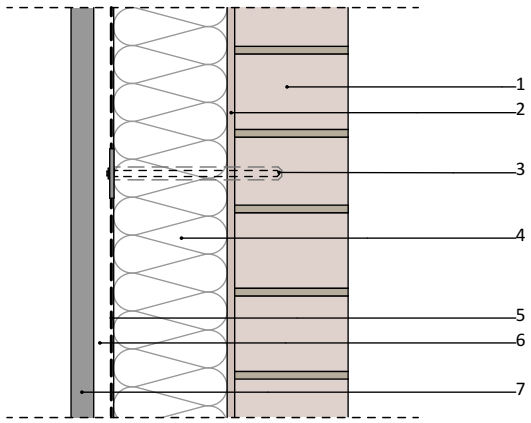
# 5.2 Details for loadbearing walls

## 5.2.1 Exterior wall

### a. General wall composition

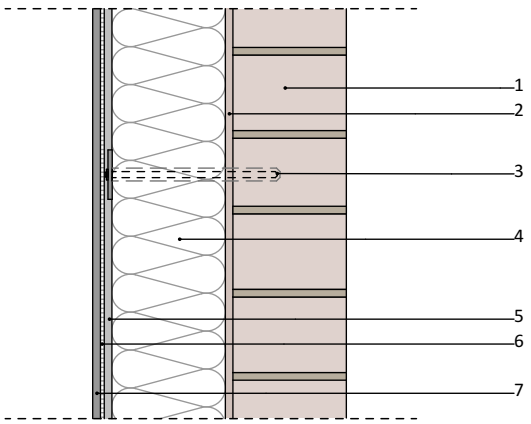
Details illustrating the general composition of an exterior infill wall. These details have been hygrometrically validated by Buildwise through WUFI calculation, see section 3.3.4 .

**Loadbearing inner leaf of a cavity wall**



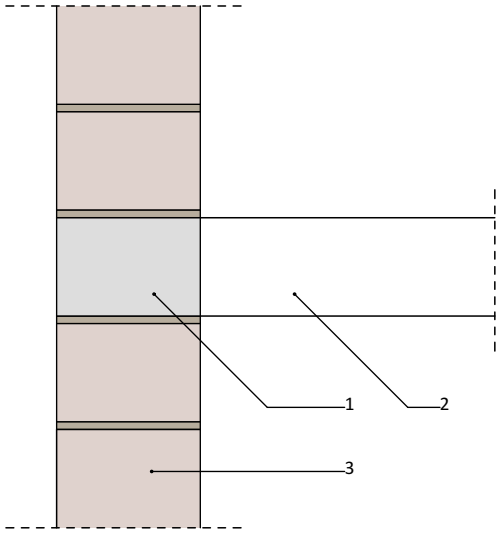

1. Léém Moulded or Compressed Blocks (14 to 29cm)
2. Léém Earth Plaster or Léém Adhesive Mortar for airtightness
3. Insulated insulation plug
4. Insulation compatible with wall buildup (vaopour permeable)
5. Waterproof vapor-open rainscreen
6. Air gap
7. External cladding

**Loadbearing exterior insulated wall in an ETICS system**

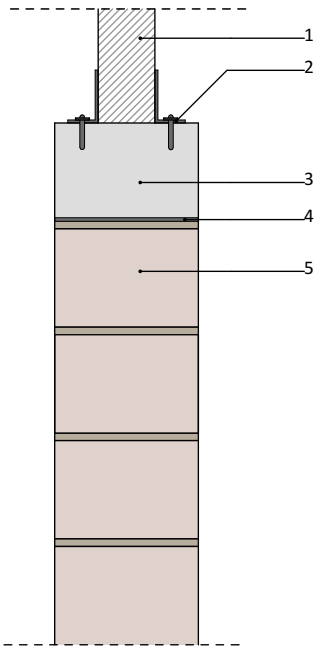



1. Léém Moulded or Compressed Blocks (14 to 29cm)
2. Léém Earth Plaster or Léém Adhesive Mortar for airtightness
3. Insulated insulation plug
4. Insulation compatible with exterior rendering
5. Reinforced mortar
6. Reinforcement
7. Primer, finishing plaster and finishing paint

**Cross-section of ring beam for floor plate or roof attachment [2] p.52**




1. Ring beam
2. Wooden or concrete slab
3. Léém Moulded or Compressed Block




1. Wooden beam
2. L-shaped metal fastener
3. Ring beam
4. Waterproof membrane if in situ concrete
5. Léém Moulded or Compressed Block

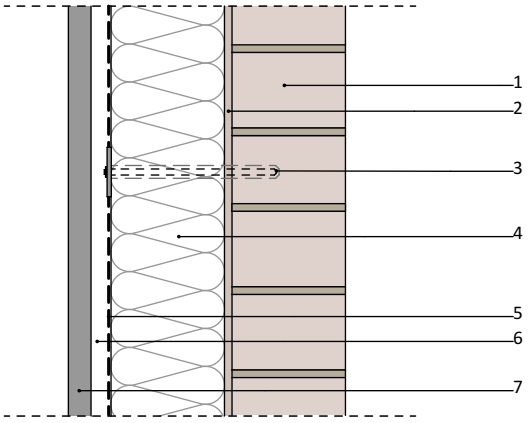
# 5.3 Details for non-loadbearing walls

## 5.3.1 Exterior infill wall

### a. General wall composition

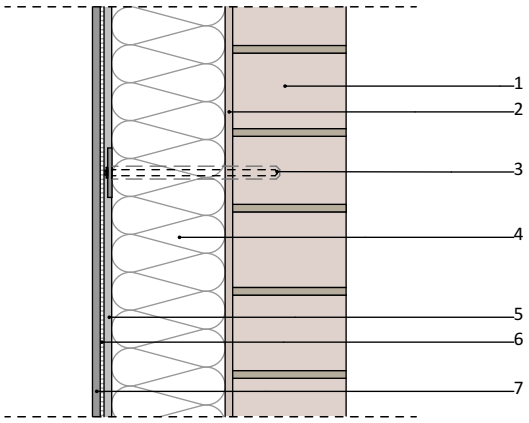
Details illustrating the general composition of an exterior infill wall. These details have been hygrometrically validated by Buildwise through WUFI calculation, see section 3.3.4 .

**Non-loadbearing inner leaf of a cavity wall**




1. Léém Moulded or Compressed Blocks (14 to 29cm)
2. Léém Earth Plaster or Léém Adhesive Mortar for airtightness
3. Insulated insulation plug
4. Insulation compatible with wall buildup (vaopour permeable)
5. Waterproof vapor-open rainscreen
6. Air gap
7. External cladding

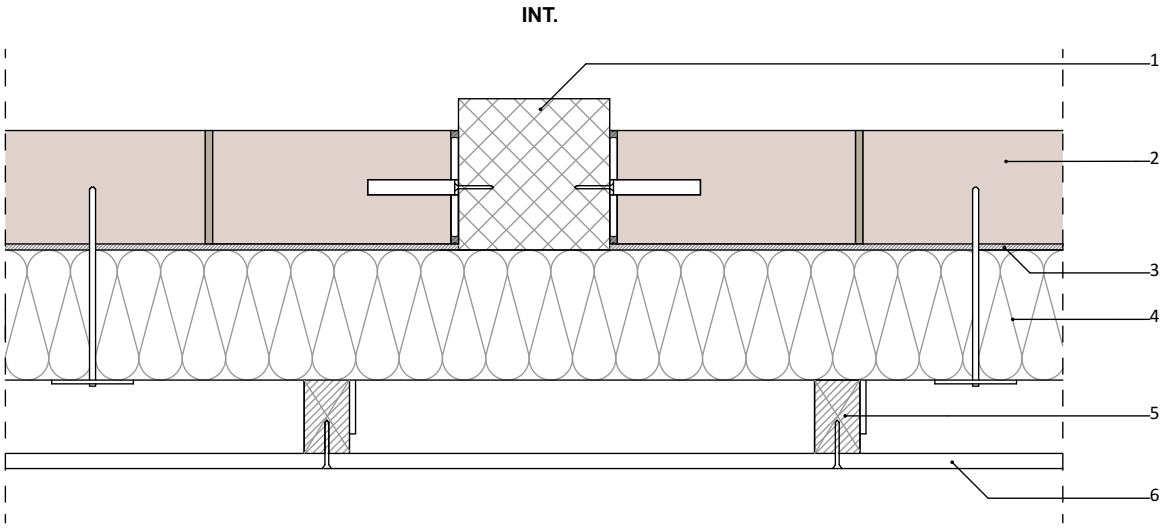
**Non-loadbearing exterior insulated wall in an ETICS system**




1. Léém Moulded or Compressed Blocks (14 to 29cm)
2. Léém Earth Plaster or Léém Adhesive Mortar for airtightness
3. Insulated insulation plug
4. Insulation compatible with exterior rendering
5. Reinforced mortar
6. Reinforcement
7. Primer, finishing plaster and finishing paint

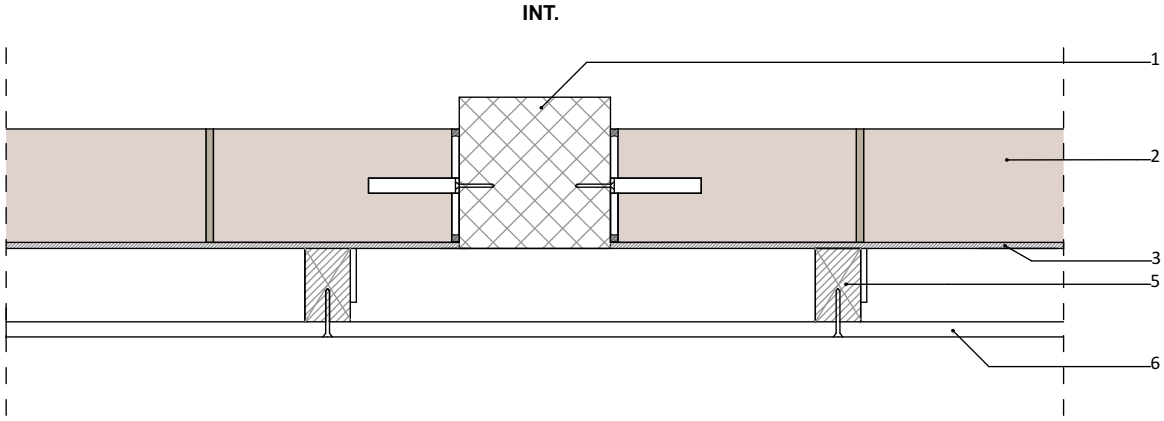
# b. Specific wall compositions

**Case A : Plan view with external insulation and plaster on the exterior face - 1/10th [4] p.6**



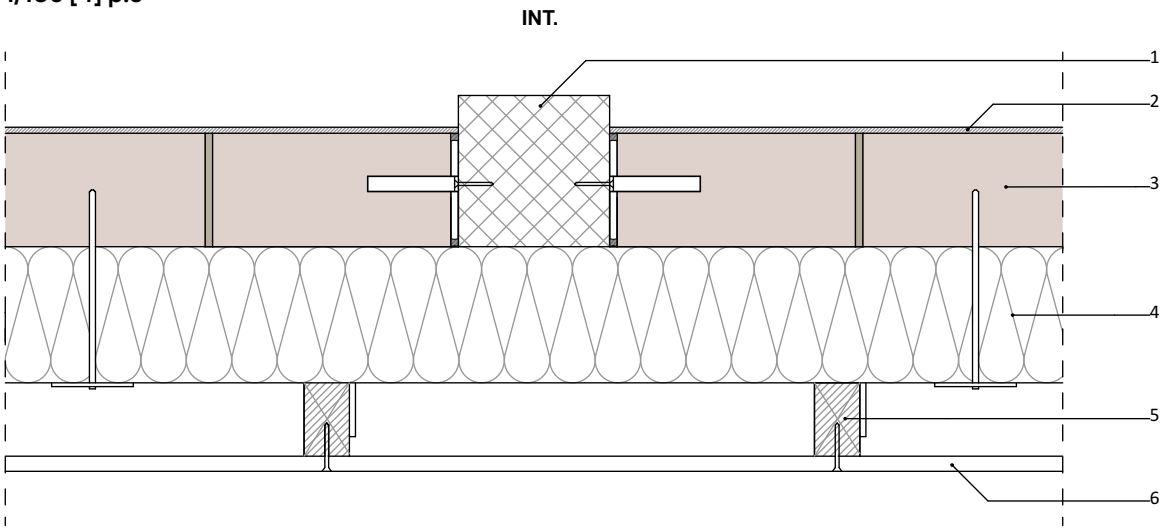

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Léém Clay Plaster on Léém Moulded or Compressed Blocks
4. Insulation
5. Secondary structure of external facing + ventilated air gap
6. Exterior cladding

**Case A : Plan view without external insulation, and plaster on the exterior face - 1/10e [4] p.6**



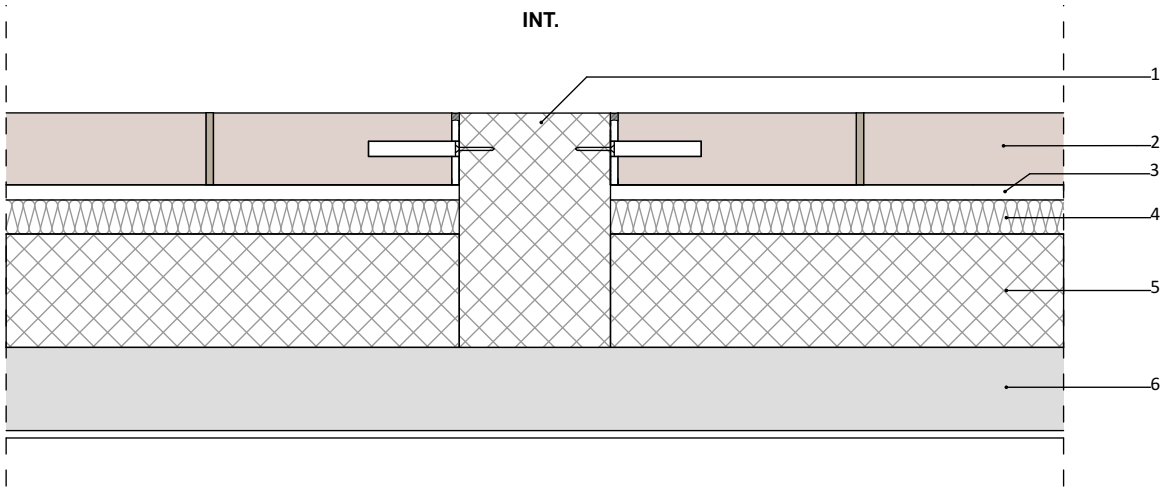

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block
3. Léém Clay Plaster on Léém Moulded or Compressed Blocks
4. Secondary structure of external facing + ventilated air gap
5. Exterior cladding

**Case A : Plan view with exterior insulation and plaster on the exterior face of Léém blocks masonry - 1/10e [4] p.6**



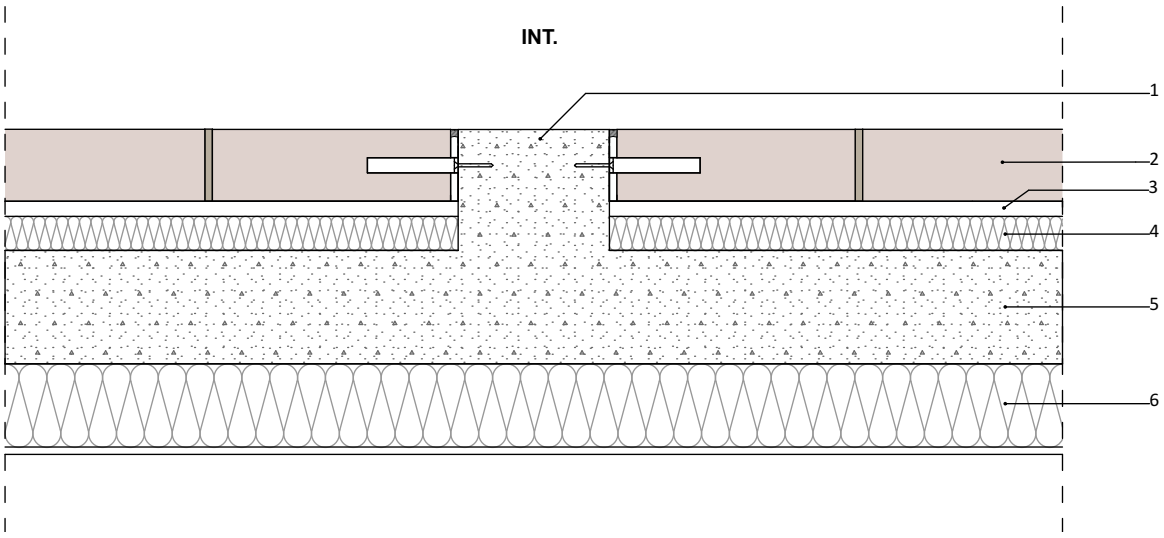

1. Reinforced concrete or timber frame column
2. Léém Clay Plaster on Léém Moulded or Compressed Blocks
3. Léém Moulded or Compressed Block infill
4. Insulation
5. Secondary structure of external facing + ventilated air gap
6. Exterior cladding

**Case B : Plan view with main framework column holding the cladding in place - 1/10e [4] p.7**



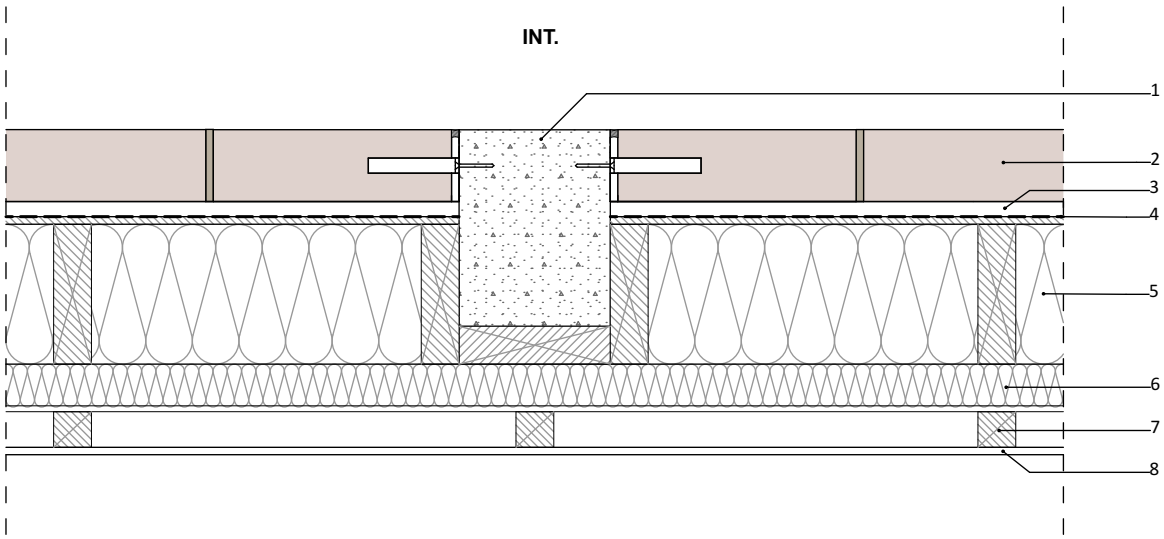

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Ventilated or non-ventilated air gap
4. Insulation if necessary
5. Masonry or timber infill / envelope wall - support for exterior cladding
6. Exterior cladding

**Case B : Plan view, with concrete framework and rendered external insulation pannels - 1/10e [4] p.7**



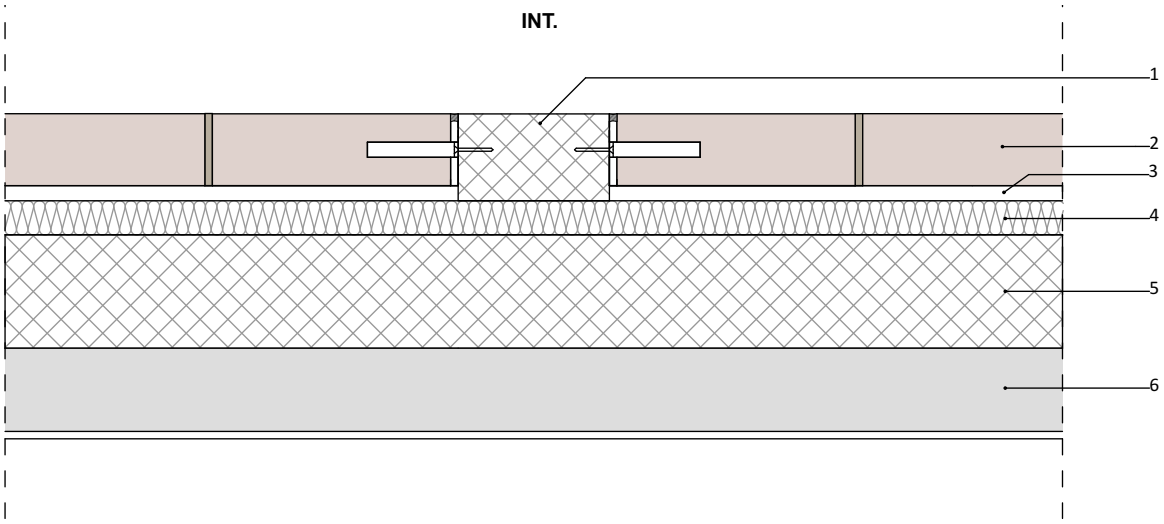

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Air gap
4. Insulation
5. Reinforced concrete wall
6. Insulation + plaster adapted to the substrate

**Case B : Plan view with concrete framework and timber-frame façade - 1/10e [4] p.7**



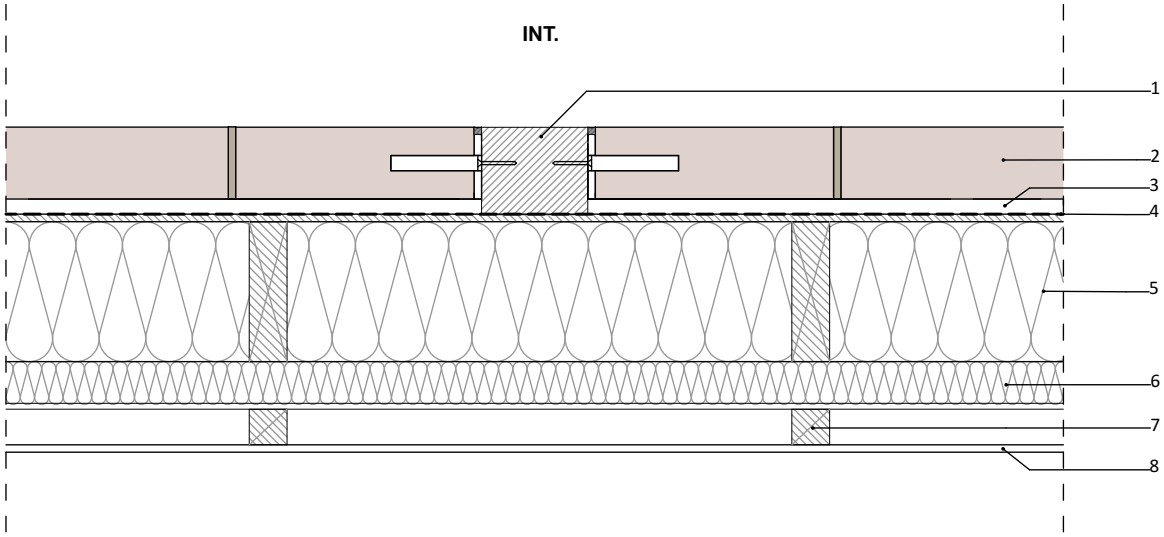

1. Reinforced concrete or timber frame column
2. Léém Moulded or Compressed Block infill
3. Air gap
4. Vapour barrier
5. Timber-framed facade
6. Additional insulation + rain barrier
7. Secondary structure supporting the cladding + ventilated air gap
8. Finishing cladding adapted to the substrate

### Case B : Plan view with secondary framework column and interior infill masonry -1/10e [4] p.7

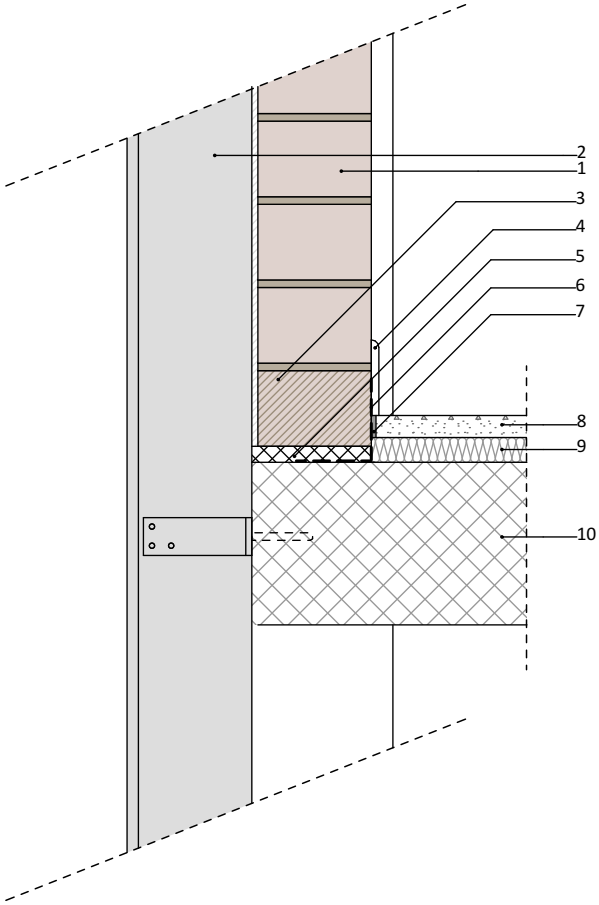



1. Reinforced concrete or timber frame column separated from the envelope wall
2. Léém Moulded or Compressed Block infill
3. Ventilated or non-ventilated air gap
4. Insulation if necessary
5. Masonry or timber envelope wall - support for external cladding
6. External cladding

### Case B : Plan view with secondary timber frame and timber framework wall -1/10e [4] p.7

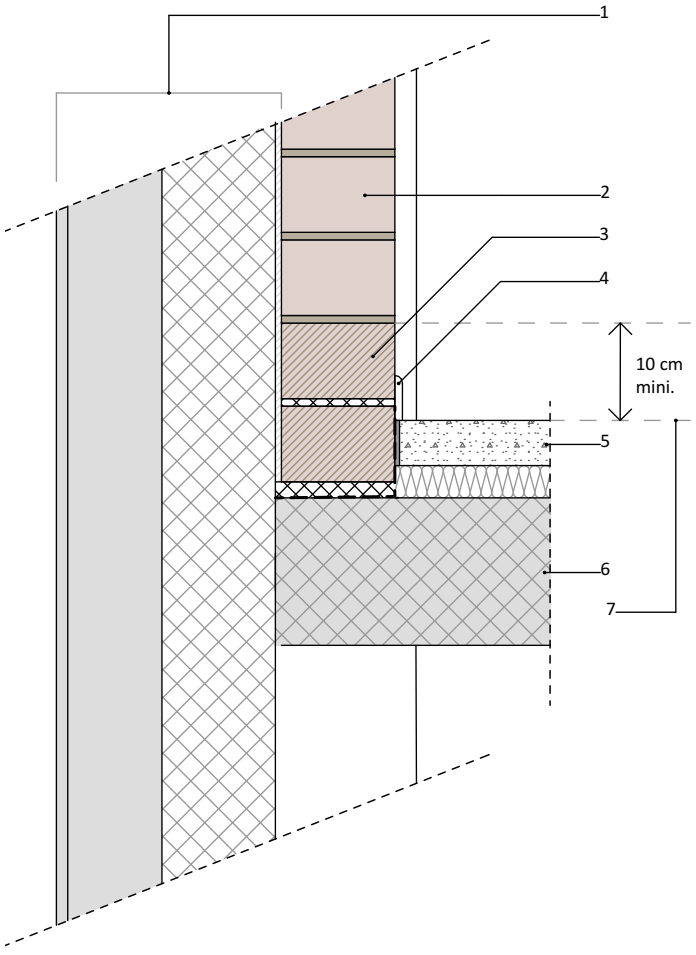



1. Timber frame secondary column
2. Léém Moulded or Compressed Block infill
3. Air gap
4. Vapour barrier
5. Timber-framed facade
6. Additional insulation + rain barrier
7. Secondary structure supporting the cladding + ventilated air gap
8. Finishing cladding adapted to the substrate




## Cross-sectional detail of junction at floor level with floating screed - 1/10e [4] p.28

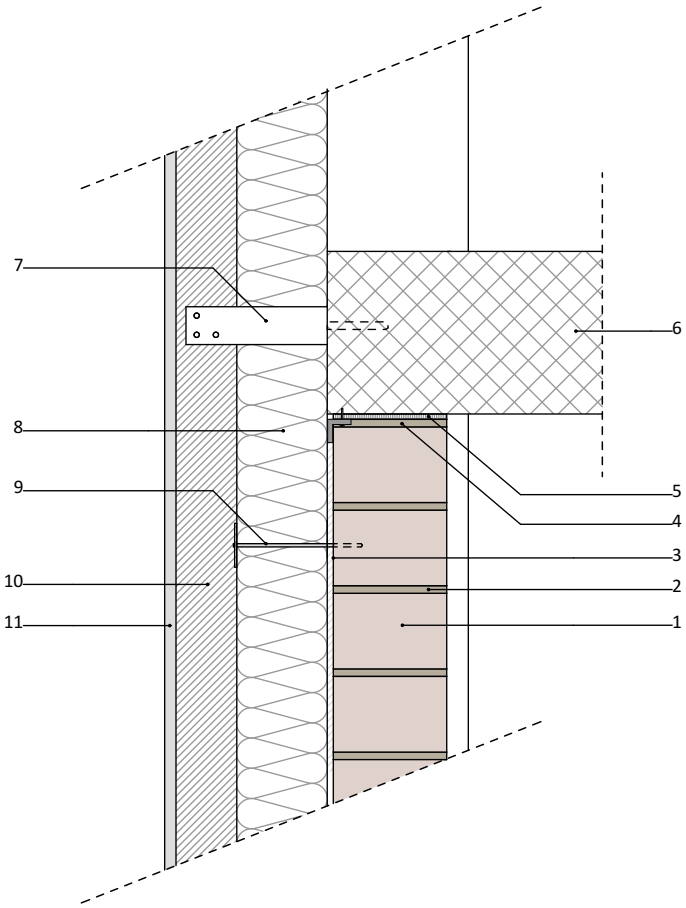
1. Léém Moulded or Compressed Block
2. External wall complex
3. Water-resistant block (Compressed Léém block, sandlime block...)
4. Skirting
5. Sand-cement mortar (2cm min)
6. Waterproof barrier extending at least 2cm above the finished floor level
7. Decoupling strip
8. Floating screed on insulation
9. Insulation
10. Reinforced concrete or wood floor




## Cross-sectional detail of the treatment of the foot of a masoned wall in a damp room with a floating screed - 1/10e [4] p.28

1. External wall complex
2. Léém Moulded or Compressed Block
3. Water-resistant block (Compressed Léém block, sandlime block...)
4. Skirting / baseboard
5. Floating screed
6. Reinforced concrete or wood floor
7. Level of finished floor

## c. Wall head - connection with upper floor

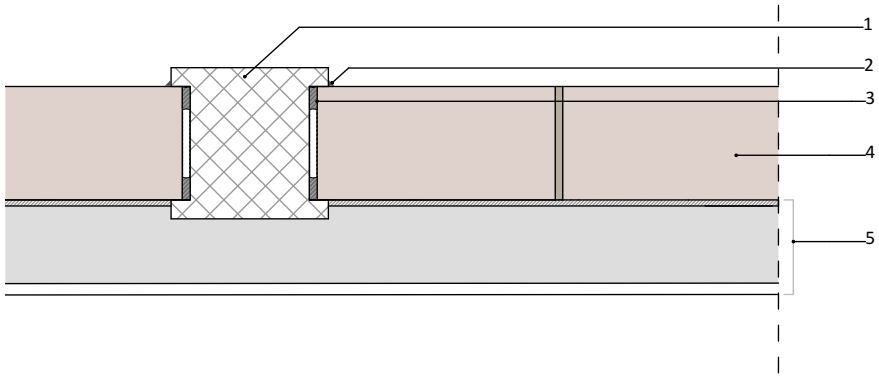



**Cross-sectional detail of top connection with acoustic improvement using angle iron (case A) - 1/10e [4] p.28**

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Léém Clay Plaster to improve airtightness
4. Acoustic enhancement angle
5. Decoupling strip
6. Reinforced concrete or wood floor
7. Secondary frame fastening bracket
8. Insulation
9. Insulated insulation plug with roset
10. Secondary frame
11. Exterior cladding

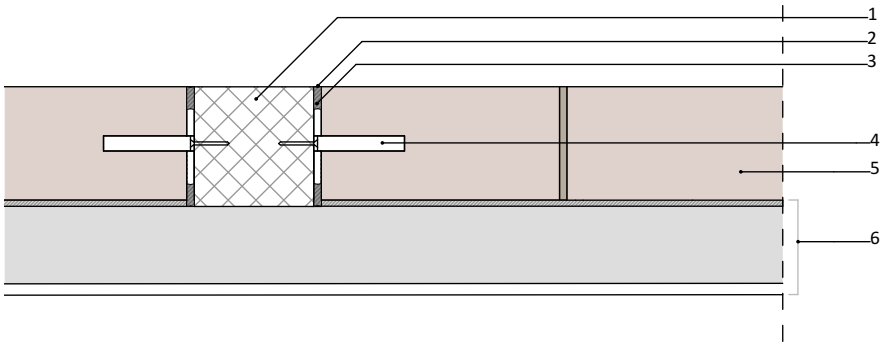
## d. Junction between infill wall and structural frame

**Plan view of the connection between masonry and framing column with expanding foam tape - 1/10e [4] p.34**




1. Stiffeners (load-bearing or secondary structure)
2. Elastic kit
3. Expanding Foam tape
4. Léém Moulded or Compressed Block
5. Exterior wall complex

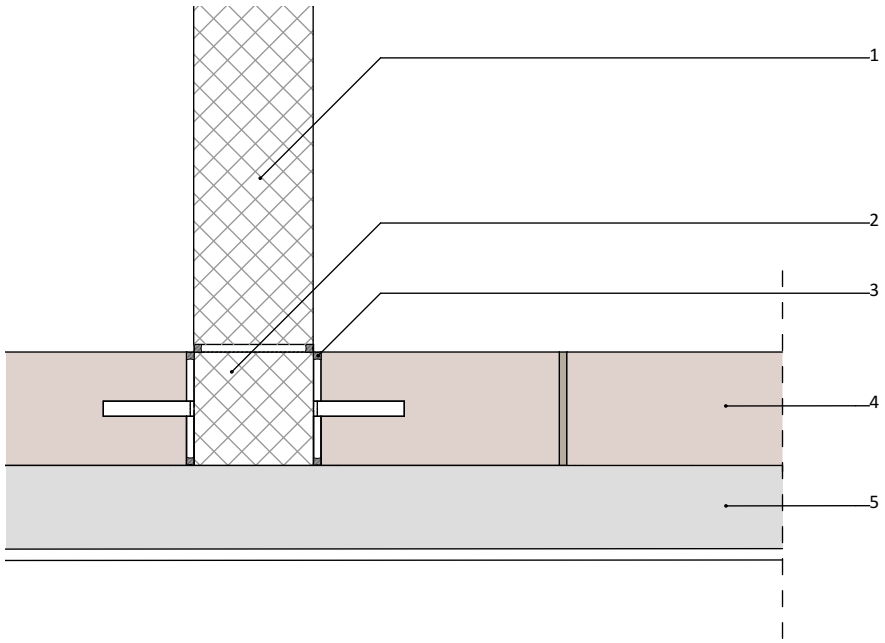
**Plan view of the connection between masonry and stiffener using anchors - 1/10e [4] p.34**




1. Wood or concrete stiffener
2. Elastic kit
3. Expanding foam tape
4. Metal anchor connecting the masonry to the stiffener
5. Léém Moulded or Compressed Block
6. Exterior wall system

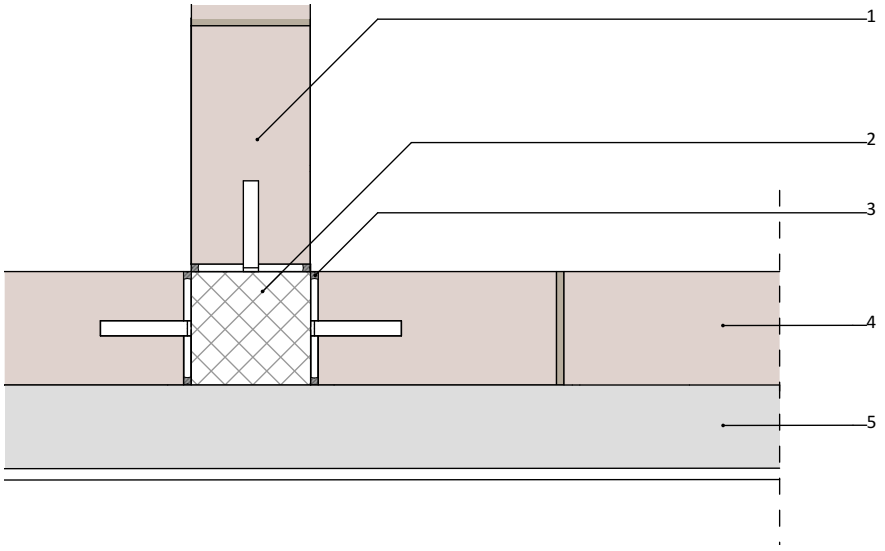
## e. Connection with a wall of a different type

**Plan view of the junction of Léém masonry wall with a partition wall or dividing wall - 1/10e [4] p.36**



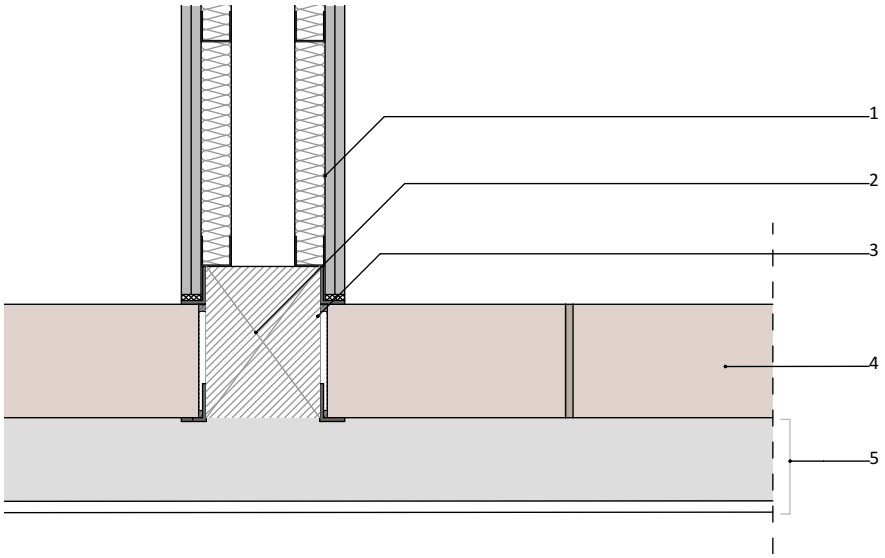

1. Loadbearing wall or partition wall
2. Stiffener
3. Elastic kit and Expanding foam tape
4. Léém Moulded or Compressed Block
5. Exterior wall system

**Plan view of a connection with a Léém Block partition wall - 1/10e [4] p.36**



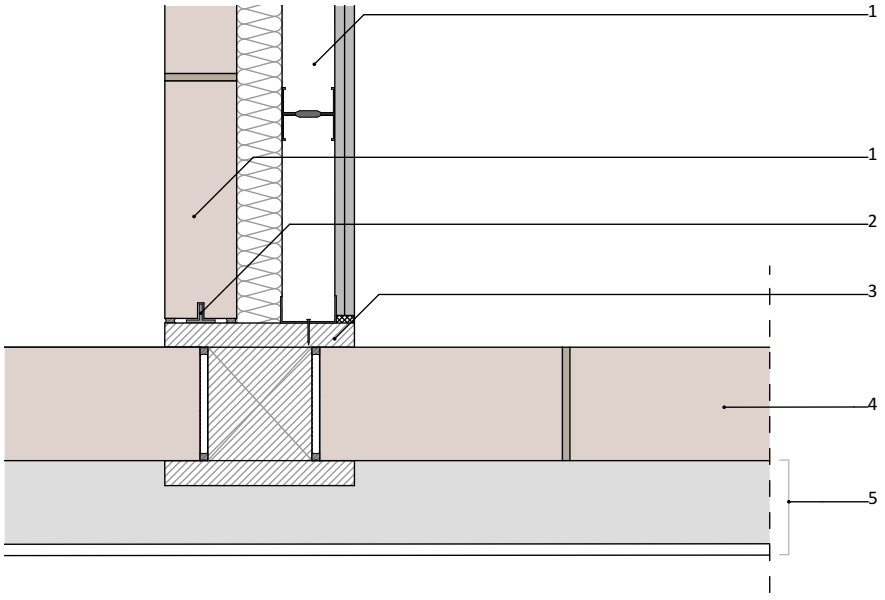

1. Partition wall in Léém Moulded or Compressed Block
2. Stiffener
3. Elastic kit and Expanding foam tape
4. Léém Moulded or Compressed Block
5. Exterior wall system

**Plan view of a junction with a partition made of panels on a framework - 1/10e [4] p.37**



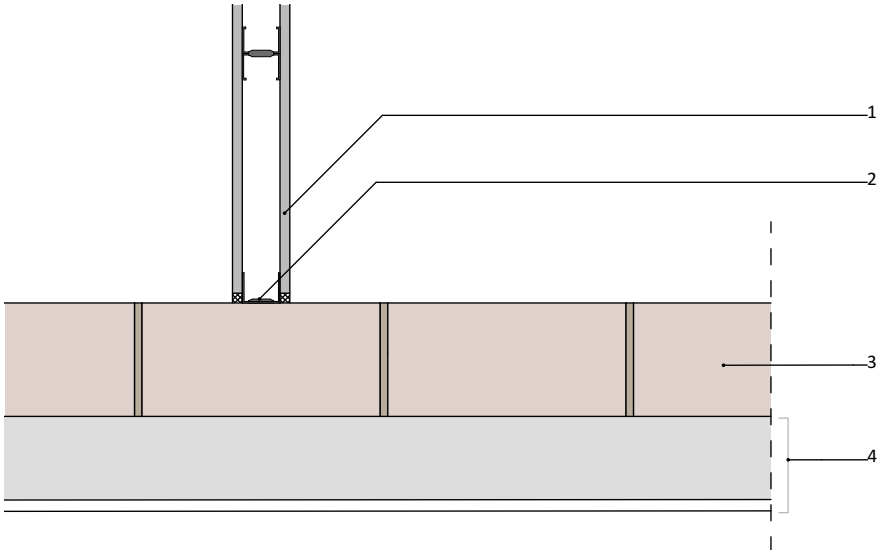

1. Drywall system
2. Stiffener
3. Acoustic enhancement profile
4. Léém Moulded or Compressed Block
5. Exterior wall system

**Plan view of junction with a mixed partition made of Léém Blocks and panels on a framework - 1/10e [4] p.36**



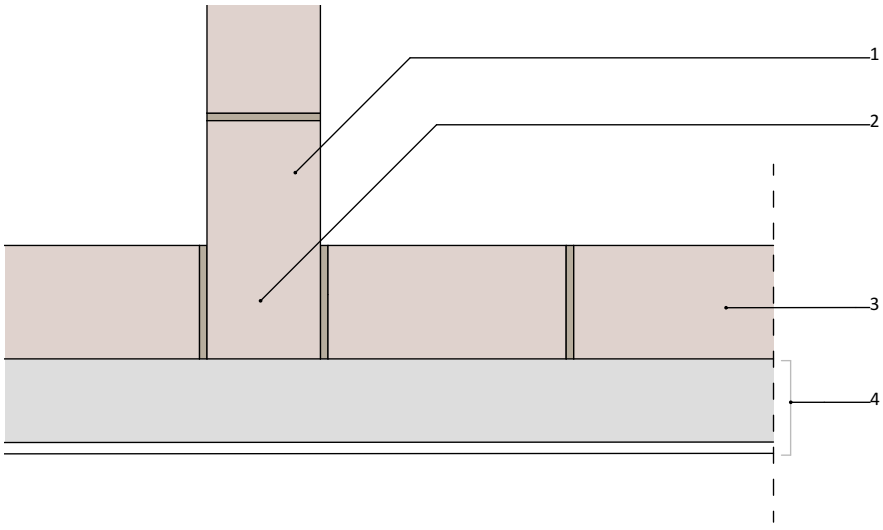

1. Léém masonry with drywall cladding
2. Centrail rib connector
3. Stiffener in wood
4. Léém Moulded or Compressed Block
5. Exterior wall system

**Plan view of junction with a drywall partition - 1/10e [4] p.37**




1. Dry wall partition made of plasterboard on a framework
2. Studs decoupled from the masonry, and flexible sealant
3. Léém Moulded or Compressed Block
4. Exterior wall system

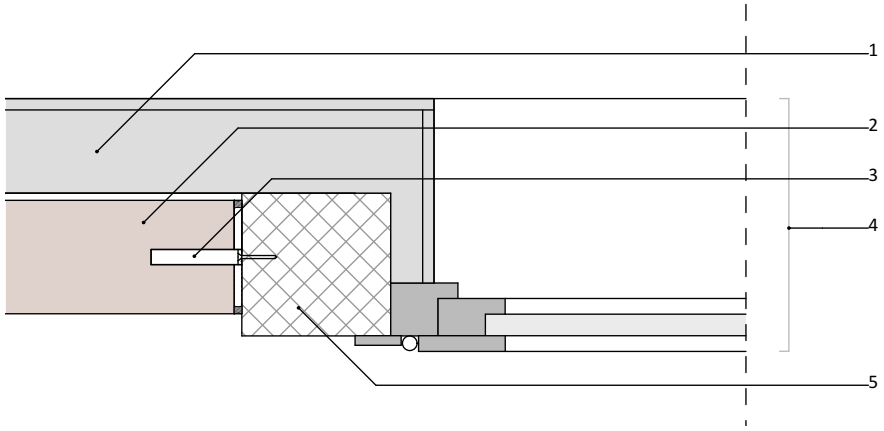
**Plan view of the junction with a Léém Block partition wall using corner bond - 1/10e [4] p.36**




1. Distributive partition wall made of Léém Moulded or Compressed Blocks
2. Harpe shaped corner
3. Léém Moulded or Compressed Block
4. Exterior wall system

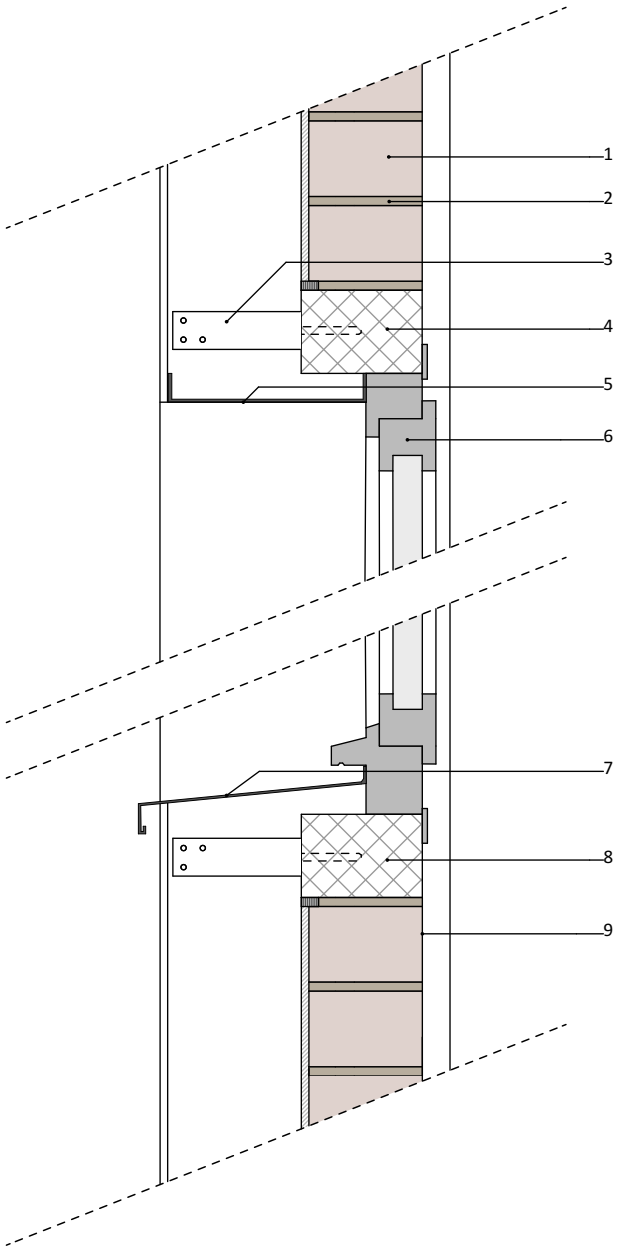
# f. Connection with carpentry

**Plan view of window integration principle (case A) - 1/10e [4] p.39**



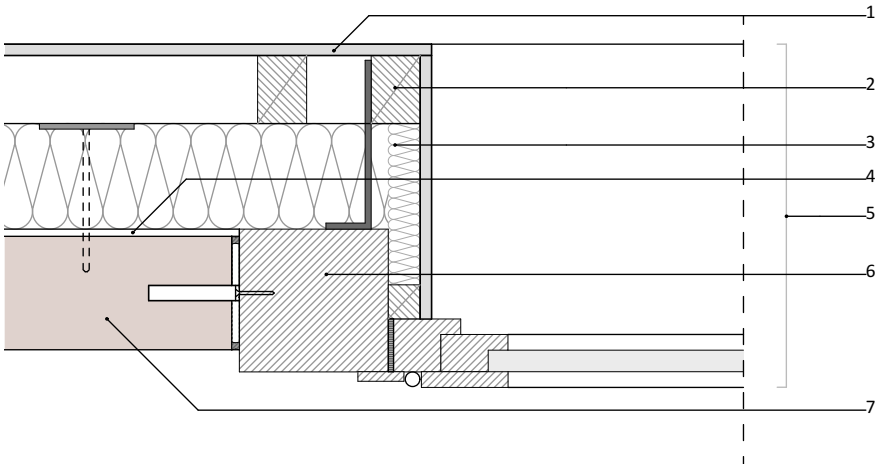

1. Insulation and cladding
2. Léém Moulded or Compressed Block
3. Metal anchor
4. Joinery recessed into the framework, including insulated cladding for the window frames
5. Stiffener

**Cross-section of windown integration principle (case A) - 1/10e [4] p.41**



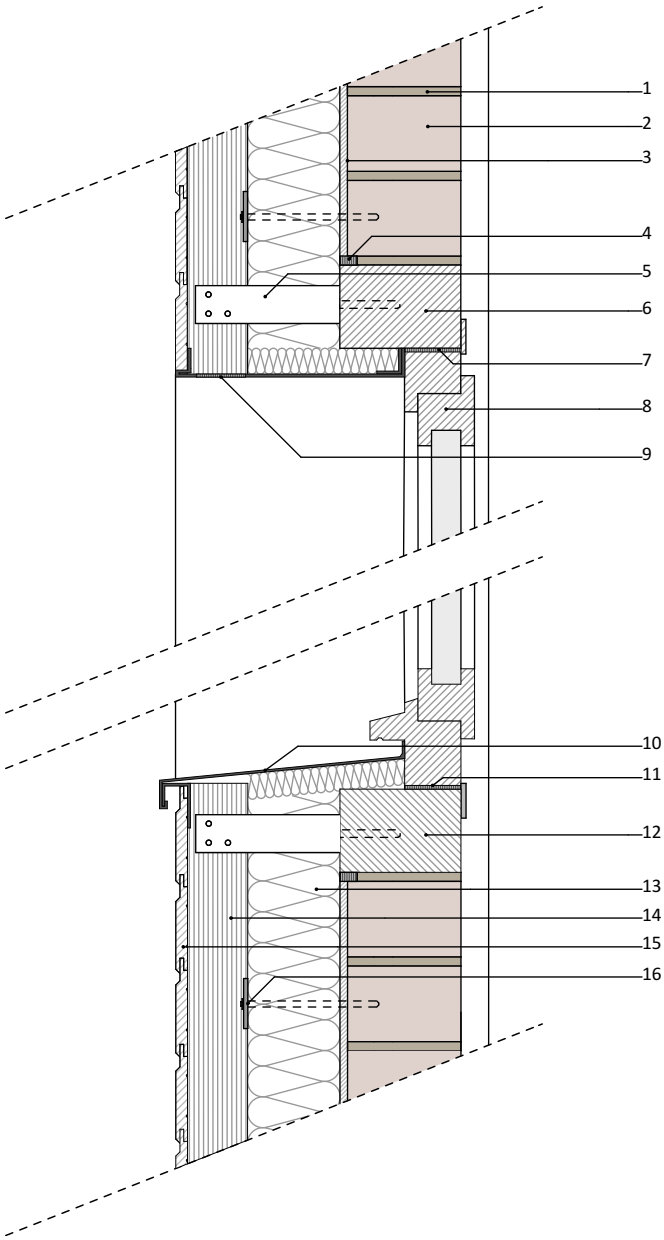

1. Léém Molded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Fastening bracket for the secondary framework
4. Lintel
5. Folded cladding sheet
6. Window carpentry
7. Folded cladding sheet
8. Window sill
9. Window sill in Léém Compressed Block

**Plan view of window integration in timber-framework (case A) - 1/10e [4] p.39**



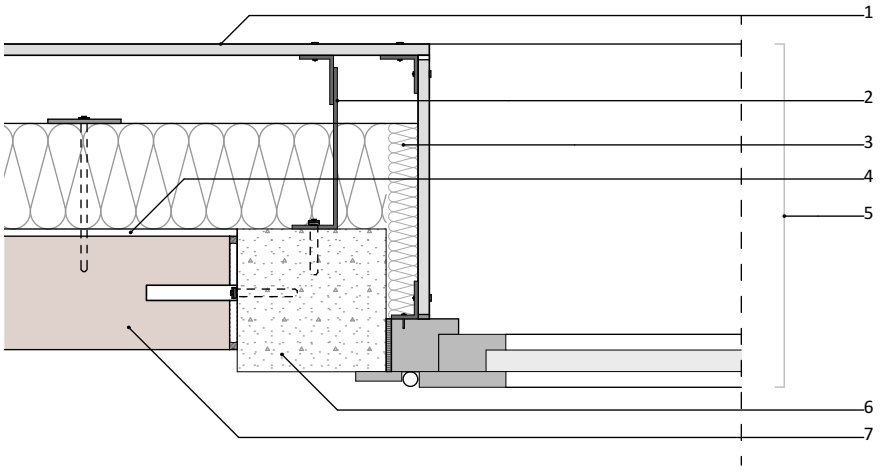

1. Cladding
2. Secondary timber frame
3. Insulation
4. Earth plaster
5. Joinery recessed into the framework, including insulated cladding for the window frames
6. Timber stiffener
7. Léém Moulded or Compressed Block

**Cross-section of windown integration in timber-framework (case A) - 1/10e [4] p.41**



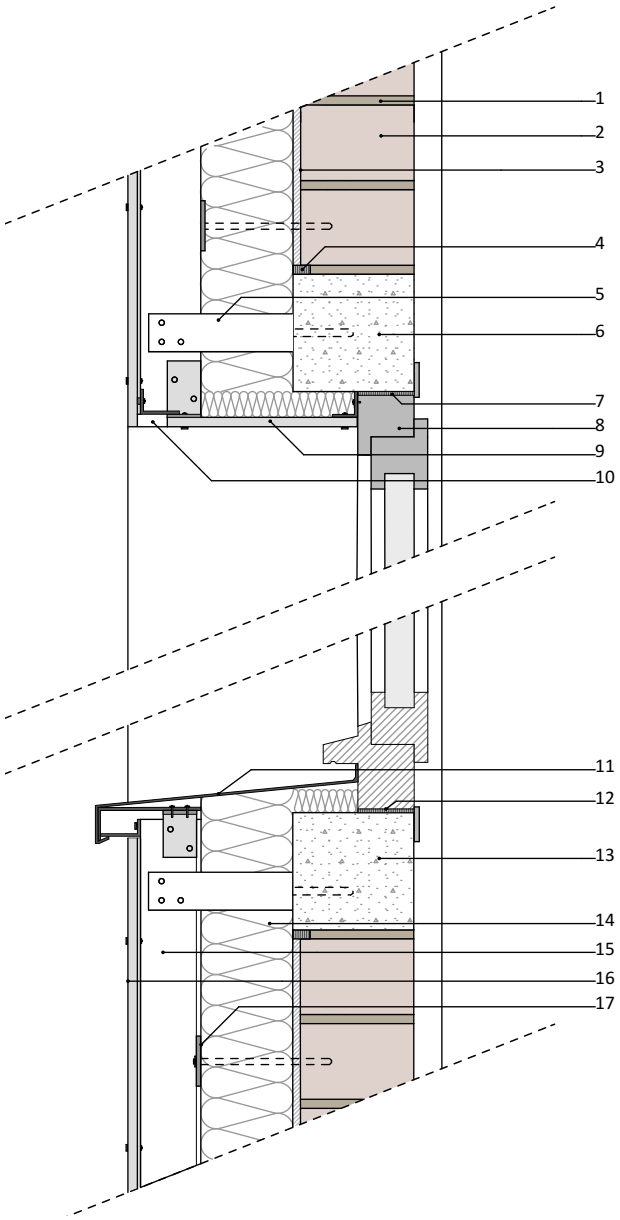

1. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
2. Léém Moulded or Compressed Block
3. Plaster
4. Elastic kit
5. Secondary frame fastening bracket
6. Wooden lintel
7. Caulking
8. Window carpentry
9. Ventilation grid
10. Folded metal cladding sheet
11. Caulking
12. Wooden window sill
13. Insulation
14. Wooden secondary frmework
15. Wooden cladding
16. Insulated Insulation plug with roset

**Plan view of the integration of window in concrete framework (case A) - 1/10e [4] p.40**



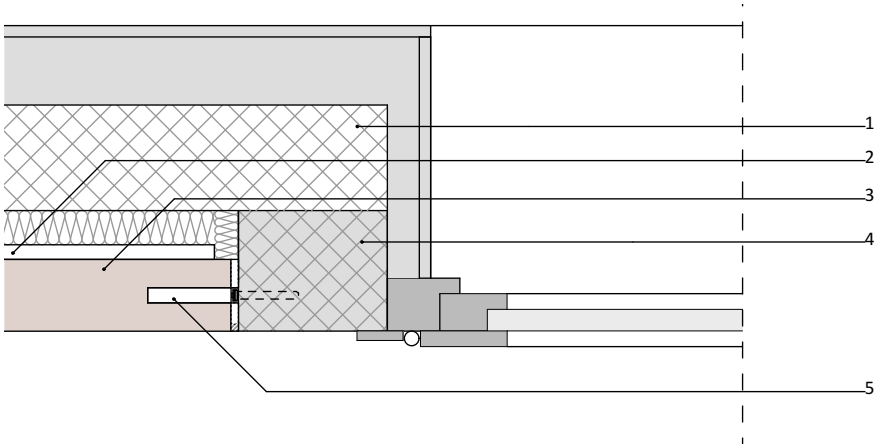

1. Cladding
2. Secondary metal frame
3. Insulation
4. Léém Clay Plaster
5. Joinery recessed into the framework, including insulated cladding for the window frames
6. Concrete stiffener
7. Léém Moulded or Compressed Block

**Cross-section of the integration of window in concrete framework (case A) - 1/10e [4] p.42**



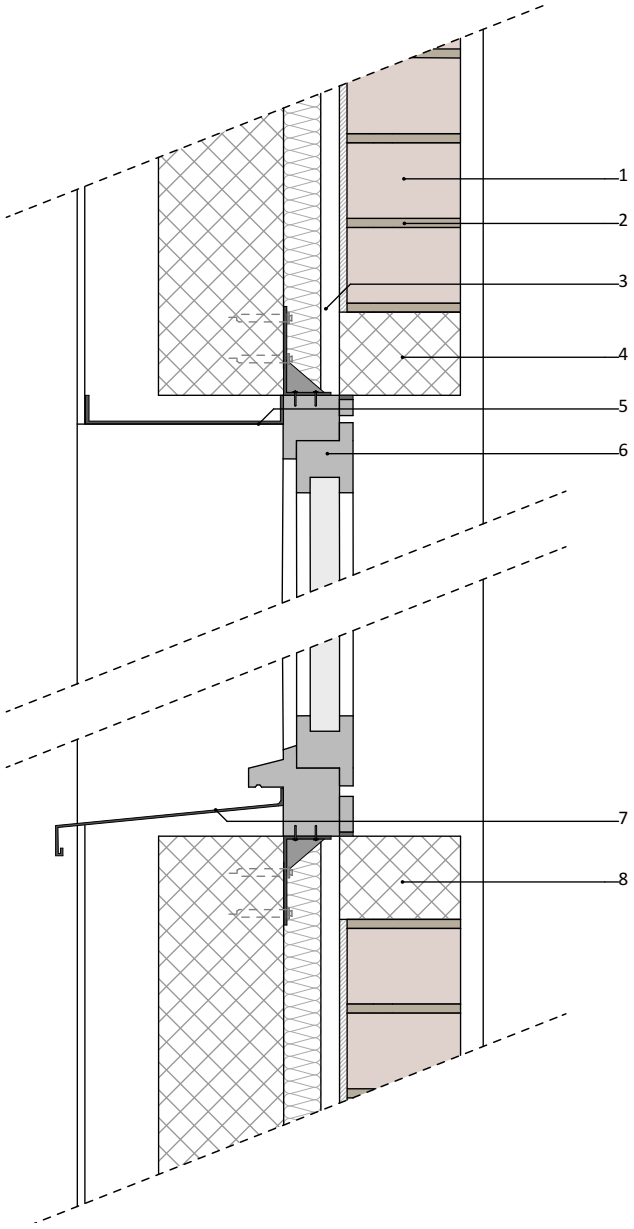

1. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
2. Léém Moulded or Compressed Block
3. Plaster
4. Elastic kit
5. Secondary frame fastening bracket
6. Concrete lintel
7. Caulking
8. Window carpentry
9. Folded metal cladding sheet
10. Ventilation grid
11. Folded metal cladding sheet
12. Caulking
13. Concrete window sill
14. Insulation
15. Metal secondary framework
16. Cladding
17. Insulation fastening clip

**Plan view of window integration principle (case B) - 1/10e [4] p.40**



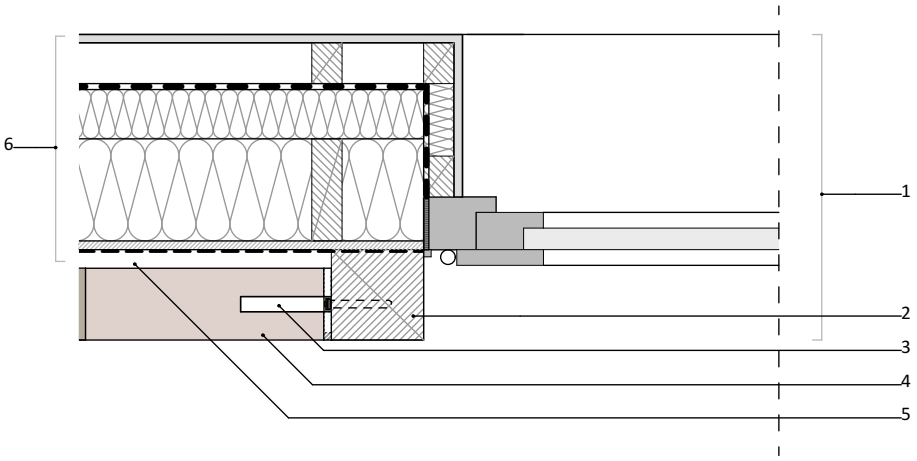

1. Interior wall complex
2. Air gap
3. Léém Moulded or Compressed Block
4. Metal fastener
5. Stiffener

**Cross-section of window integration principle (case B) - 1/10e [4] p.42**



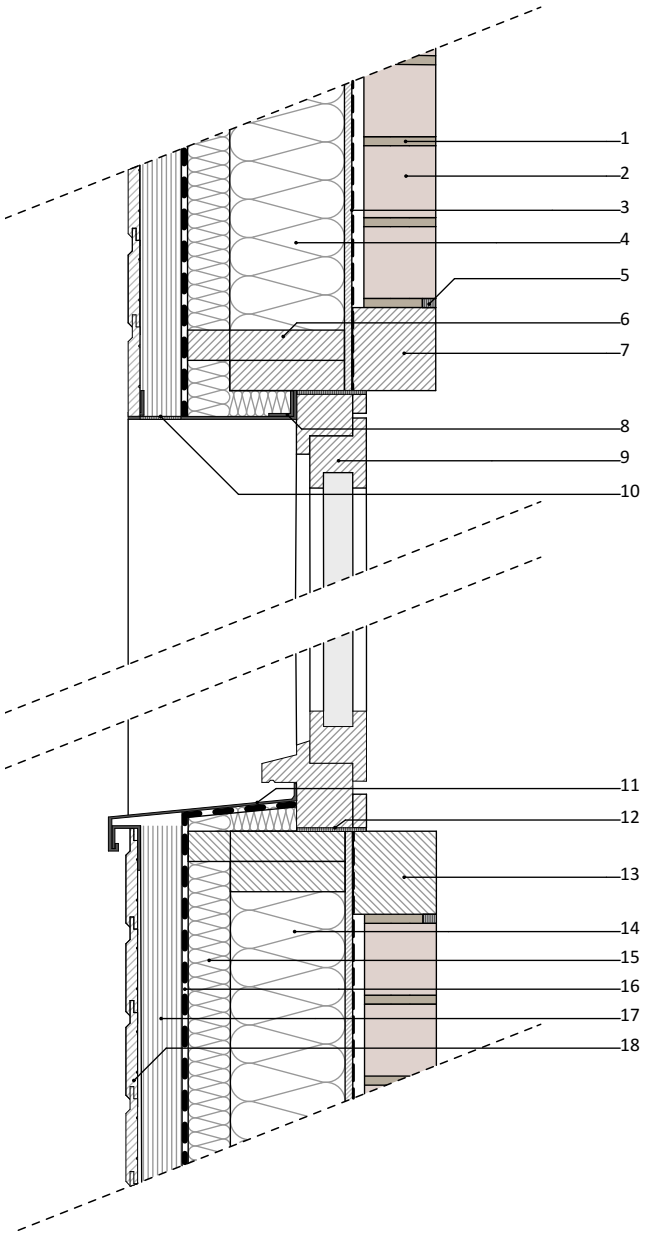

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Air gap
4. Lintel
5. Folded cladding sheet
6. Window carpentry
7. Folded cladding sheet
8. Window sill

**Plan view of window integration in timber-framework (case B) - 1/10e [4] p.40**



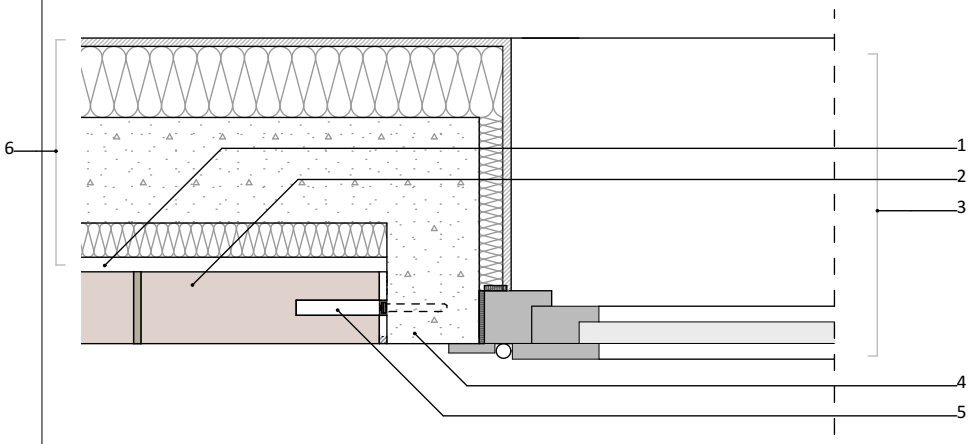

1. Tunnel joinery in the framework, including insulated cladding of window frames
2. Wooden stiffener
3. Metal fastener
4. Léém Moulded or Compressed Block
5. Air gap
6. Timber frame wall

**Cross-section of window integration in timber-framework (case B) - 1/10e [4] p.43**



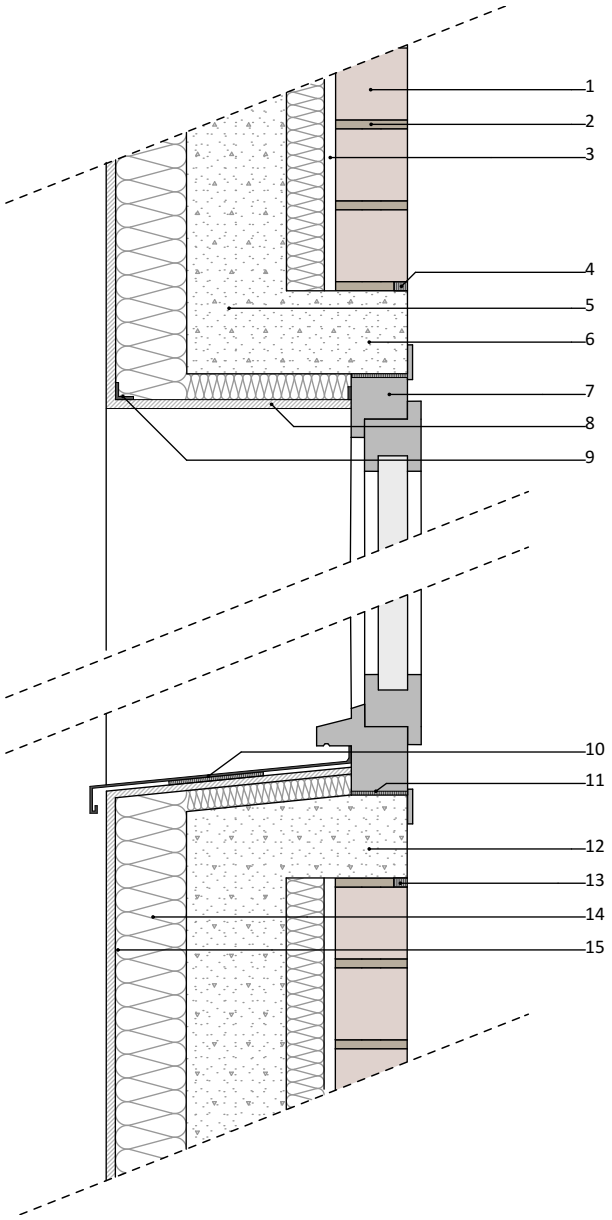

1. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
2. Léém Moulded or Compressed Block
3. Vapour barrier
4. Insulation
5. Elastic kit
6. Wooden framework
7. Wooden lintel
8. Folded metal cladding sheet
9. Window carpentry
10. Ventilation grid
11. Folded metal cladding sheet
12. Caulking
13. Wooden window sill
14. Insulation
15. Complementary exterior insulation
16. Rain screen
17. Wooden secondary framework
18. Wooden cladding

**Plan view of the integration of window in concrete framework (case B) - 1/10e [4] p.40**




1. Air gap
2. Léém Moulded or Compressed Block
3. Recessed joinery in the framework, including insulated cladding of window frames
4. Concrete frame
5. Metal fastener
6. Insulated concrete wall on the interior and exterior

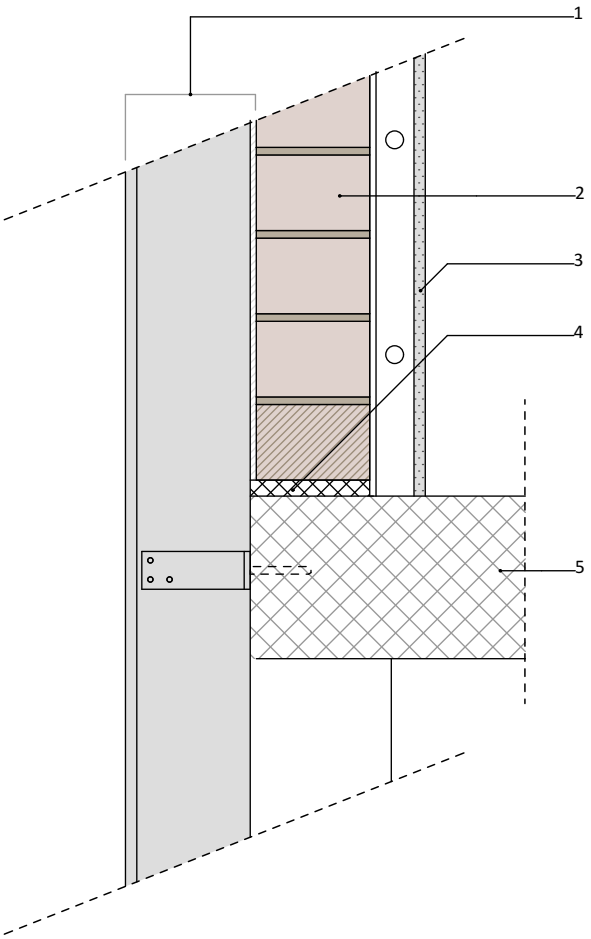
**Cross-section of the integration of window in concrete framework (case B) - 1/10e [4] p.40**




1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Air gap
4. Elastic kit / Sealant
5. Concrete curtain wall
6. Concrete return forming lintel
7. Window carpentry
8. Folded metal cladding sheet
9. Drip edge integrated with the plaster
10. Folded metal cladding sheet
11. Caulking
12. Concrete return forming support
13. Elastic kit / Sealant
14. Insulating panel
15. Exterior plaster

# g. Lining of a Léém Block infill wall

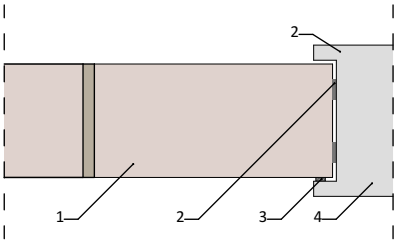
**Cross-section of the principle of Léém block masonry with lining on a framework- 1/10e [4] p.46**




1. External wall complex
2. Léém Moulded or Compressed Block
3. Slab-on-frame lining
4. Sand-cement mortar (2cm min)
5. Reinforced concrete or wood floor

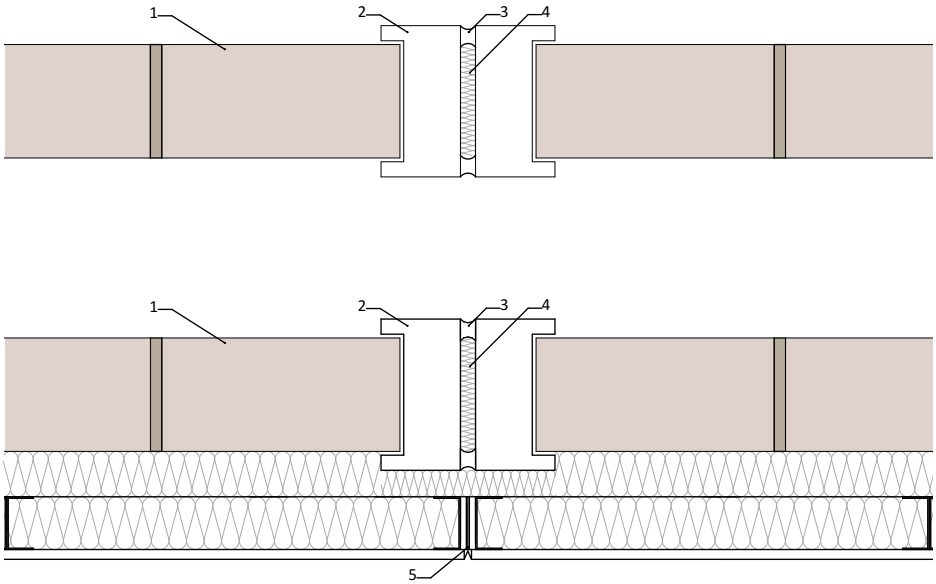
## 5.3.2 Interior infill wall

**Interface not filled with mortar between Leém masonry and wooden or metal stiffener - 1/10e [7] p.133**




1. Léém Moulded or Compressed Block
2. Pre-compressed Elastic kit Expanding foam tape strip if acoustic requirements are required
3. Sealant joint if acoustic requirements are required
4. Stiffener

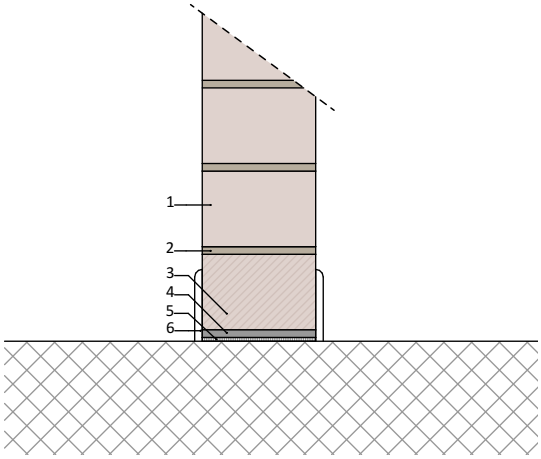
**Plan view of the extension of a shrinkage or expansion joint in Leém Block masonry - single partition wall / lined partition wall / double partition wall- 1/10e [5] p.24**




1. External wall complex
2. Léém Moulded or Compressed Block
3. Slab-on-frame lining
4. Sand-cement mortar (2cm min)
5. Reinforced concrete or wood floor

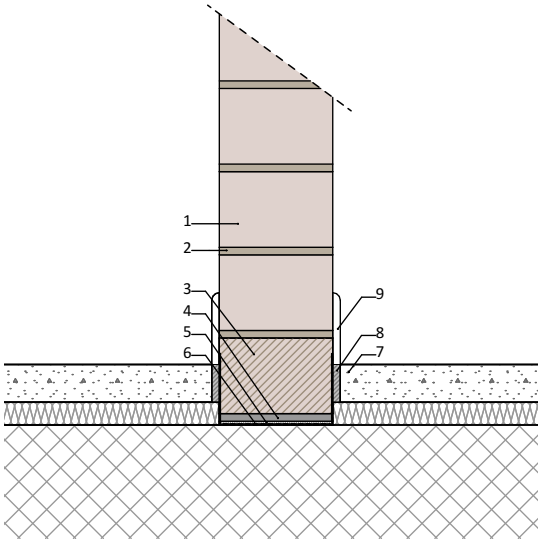
## 5.3.3 Distributive partition wall : simple partition

### a. Wall base - connection with the floor and foundations




**Cross-section of junction on finished floor - single partition wall / lined partition wall / double partition wall - 1/10e [5] p. 27**

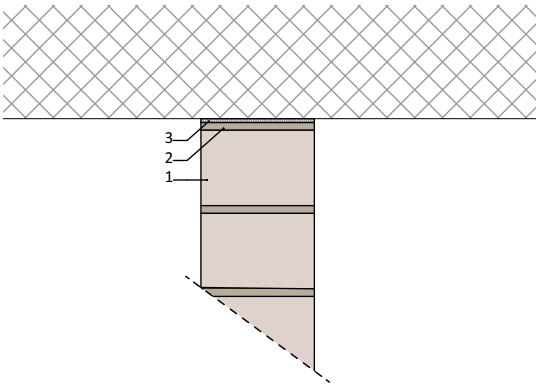
1. Léém Moulded or Compressed Block
2. 2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Water-resistant block (Compressed Léém Block, sandlime block,...)
4. Sand-cement mortar (minimum thickness 2cm)
5. Decoupling strip (thickness 5-10mm)
6. Baseboard




**Cross-section of junction with floating screed - single partition wall / lined partition wall / double partition wall - 1/10e [5] p.28**

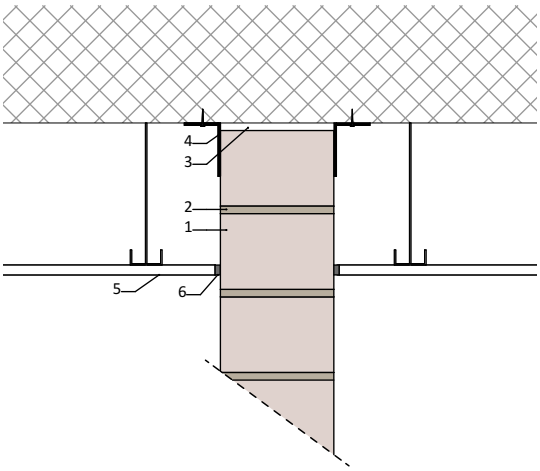
1. Léém Moulded or Compressed Block
2. 2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Water-resistant block (Compressed Léém Block, sandlime block,...)
4. Sand-cement mortar (minimum thickness 2cm)
5. Decoupling strip (thickness 5-10mm)
6. Waterproof barrier extending at least 2cm above the finished floor level
7. Floating screed laid after the partition wall
8. Perimeter caulking
9. Baseboard

## b. Wall top - connection with the upper floor




**Cross-section of ceiling junction - 1/10e [5] p. 25**

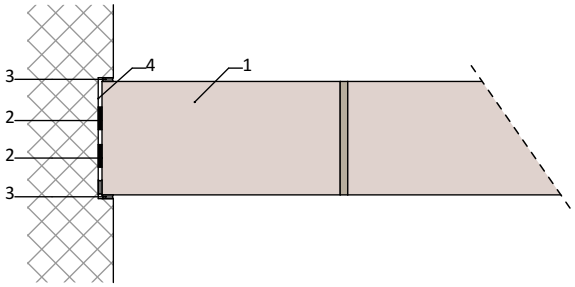
1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Optional decoupling strip (thickness 5mm)




**Cross-section of angle joint with suspended ceiling - 1/10e [5] p.26**

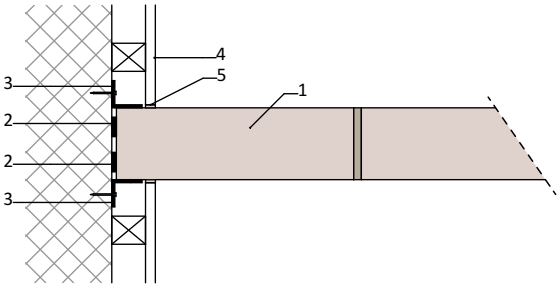
1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Void or filling with wool or earth mortar with an optional resilient strip if acoustic performance is required
4. Steel angle or wooden batten fixed to the shell
5. False ceiling
6. Elastic kit

## c. Connection with a cladding wall of a different type




**Plan view of the junction with a wall of a different type - single partition - 1/10e [5] p. 28**

1. Léém Moulded or Compressed Block
2. Expanding foam tape tape if acoustic and/or fire performance is required
3. Sealant joint if acoustic and/or fire performance is required
4. Opening recess in the concrete wall

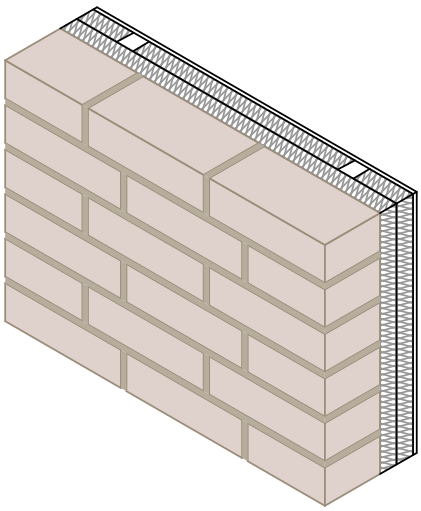



**Plan view of the junction with a wall of a different type - single partition - 1/10e [5] p. 28**

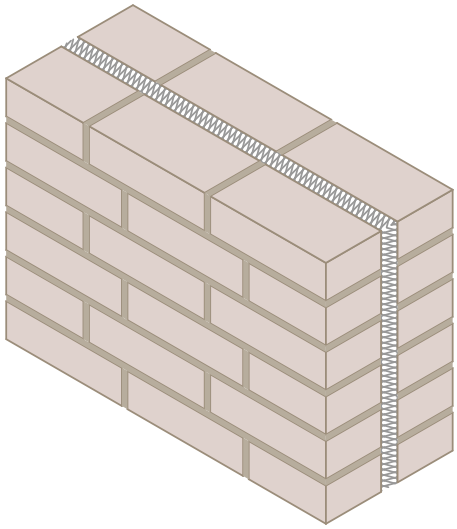
1. Léém Moulded or Compressed Block
2. Expanding foam tape tape if acoustic and/or fire performance is required
3. Angles fixed to the masonry
4. Wall lining of different types
5. Elastic kit

## 5.3.4 Separative partition wall : double partition and lined wall

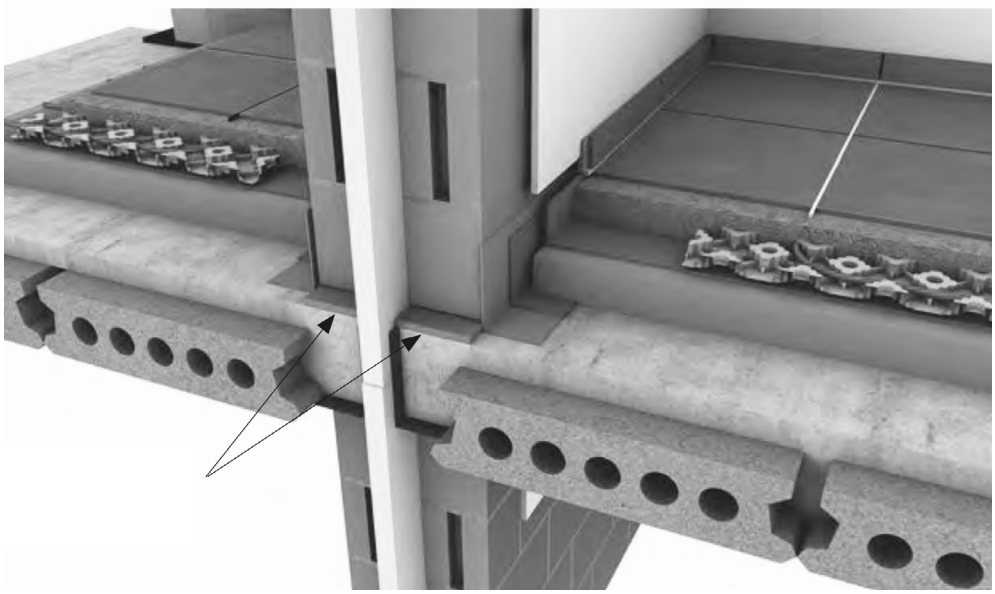
### a. Wall composition



**Example of a lined partition wall in Léém masonry [5] p. 5**



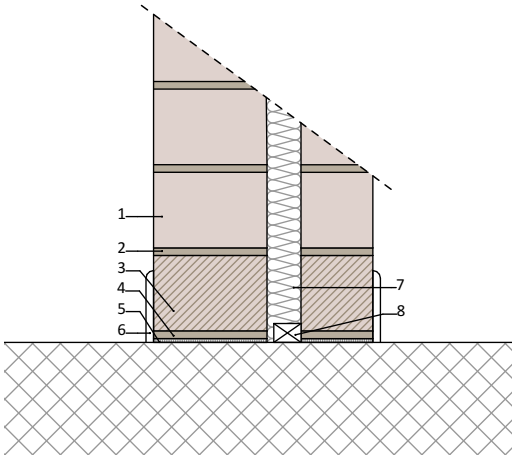
**Example of a double partition wall in Léém masonry [5] p. 5**



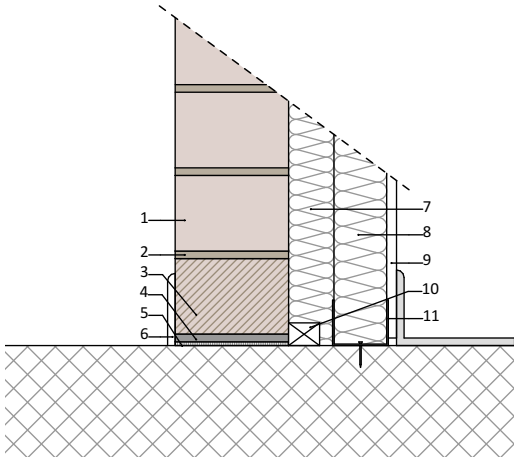
**3D detail of acoustic double separating wall with floating screed [6] p. 47**

# b. Wall base - connection with the floor and foundation

**Cross-section of junction on finished floor for improved acoustic performance - double partition wall / lined partition wall 1/10e [5] p. 27**

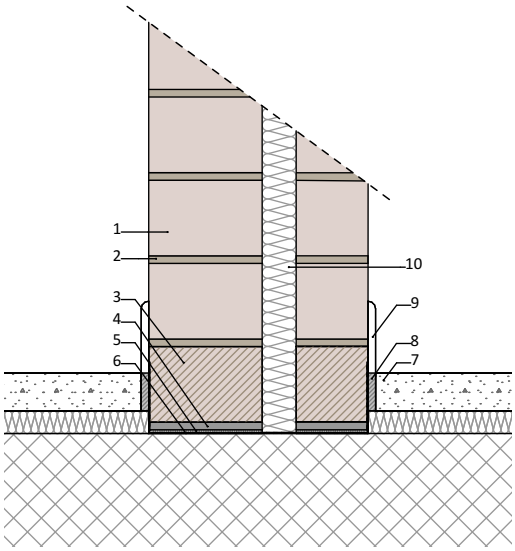



1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Water-resistant block (Compressed Léém Block, sandlime block,...)
4. Sand-cement mortar (minimum thickness 2cm)
5. Decoupling strip (thickness 5-10mm)
6. Baseboard
7. Insulation
8. Wooden batten fixed to the shell

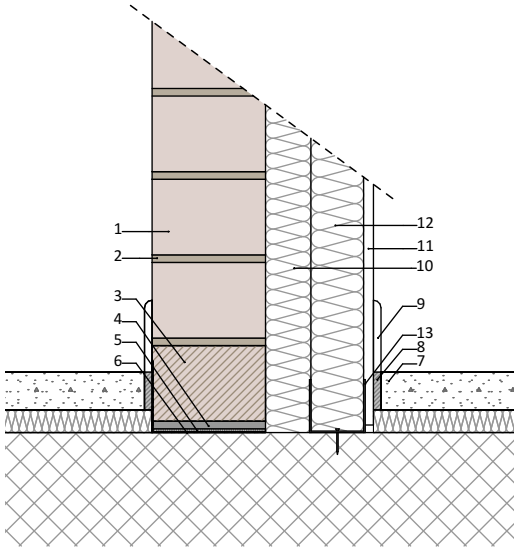



1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Water-resistant block (Compressed Léém Block, sandlime block)
4. Sand-cement mortar (minimum thickness 2cm)
5. Decoupling strip (thickness 5-10mm)
6. Baseboard
7. Insulation
8. Sliding frame stud in the floor track
9. Plasterboard cladding
10. Wooden batten fixed to the shell
11. Floor-mounted track

**Cross-section of junction with floating screed - double partition wall / lined partition wall 1/10e [5] p. 28**



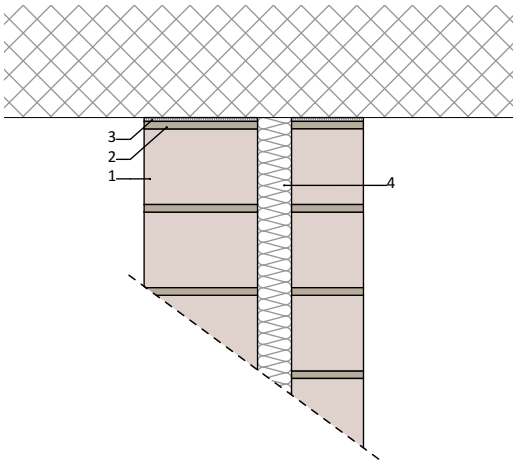

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Water-resistant block (Compressed Léém Block, sandlime block,...)
4. Sand-cement mortar (minimum thickness 2cm)
5. Decoupling strip (thickness 5-10mm)
6. Waterproof barrier extending at least 2cm above the finished floor level
7. Floating screed laid after the partition wall
8. Perimeter caulking
9. Baseboard
10. Insulation



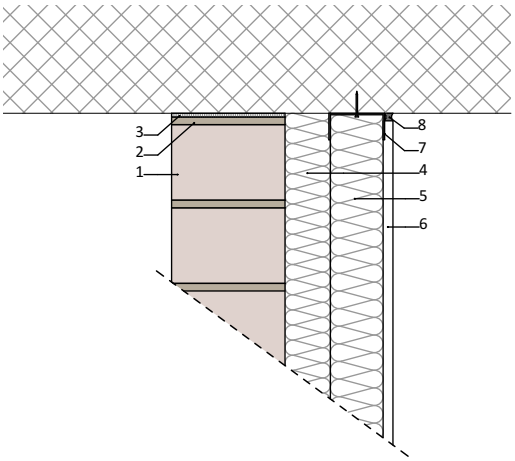

1. Léém Moulded or Compressed Block
2. Mortar
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
sandlime block,...)
4. Sand-cement mortar (minimum thickness 2cm)
5. Decoupling strip (thickness 5-10mm)
6. Waterproof barrier extending at least 2cm above the finished floor level
7. Floating screed laid after the partition wall
8. Perimeter caulking
9. Baseboard
10. Insulation
11. Plasterboard cladding
12. Sliding frame stud in the floor track

# c. Wall top - connection with the upper floor

### Cross-section of the junction with the ceiling - double partition wall / lined partition wall 1/10e [5] p. 25

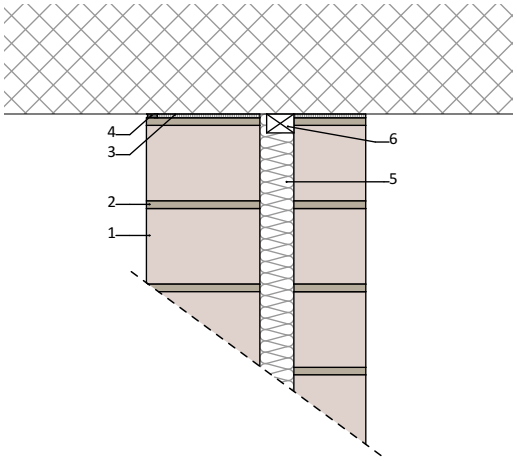



1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Optional decoupling strip (thickness 5mm)
4. Insulation

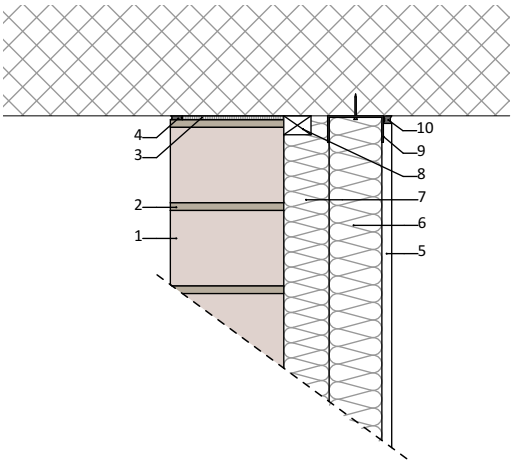



1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Optional decoupling strip (thickness 5mm)
4. Insulation
5. Sliding frame stud in the ceiling track
6. Plasterboard cladding
7. Ceilling-mounted track
8. Elastic kit

### Cross-section of the junction with the ceiling for improved acoustic performance - double partition wall / lined partition wall - 1/10e [5] p. 25



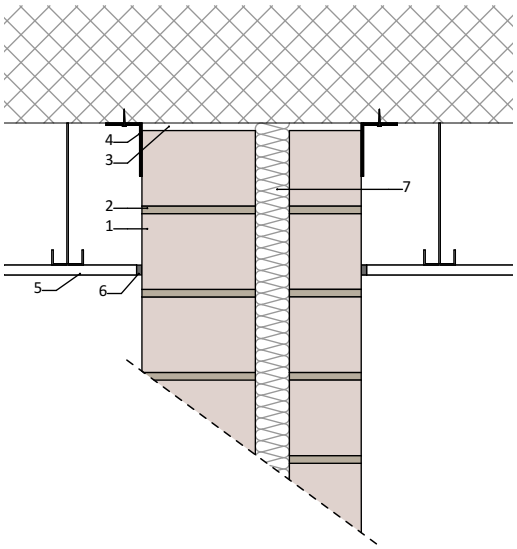

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Optional decoupling strip (thickness 5-10mm)
4. Sealant joint
5. Insulation
6. Wooden batten fixed to the shell



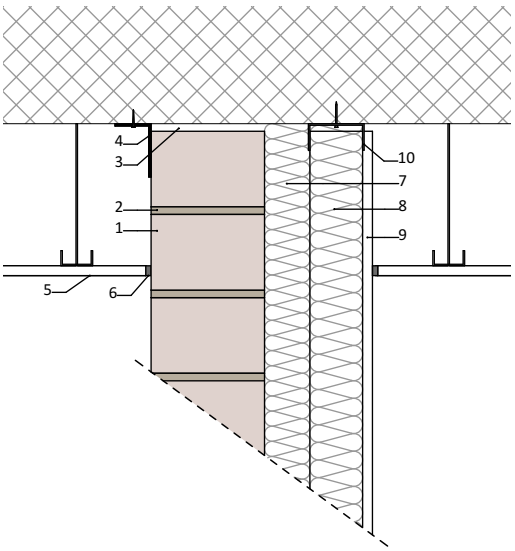

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Optional decoupling strip (thickness 5-10mm)
4. Sealant joint
5. Plasterboard cladding
6. Sliding frame stud in the ceiling track
7. Insulation
8. Wooden batten fixed to the shell
9. Ceiling-mounted track
10. Elastic kit

## c. Wall top - connection with the upper floor

**Cross section of junction with angle irons to suspended ceiling - double partition wall / lined partition wall - 1/10e [5] p. 26**



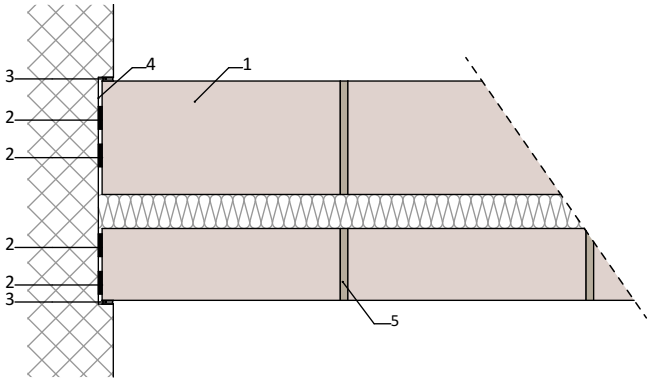

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Void or filling with wool or earth mortar with an optional resilient strip if acoustic performance is required
4. Steel angle or wooden batten fixed to the shell
5. False ceiling
6. Flexible joint
7. insulation



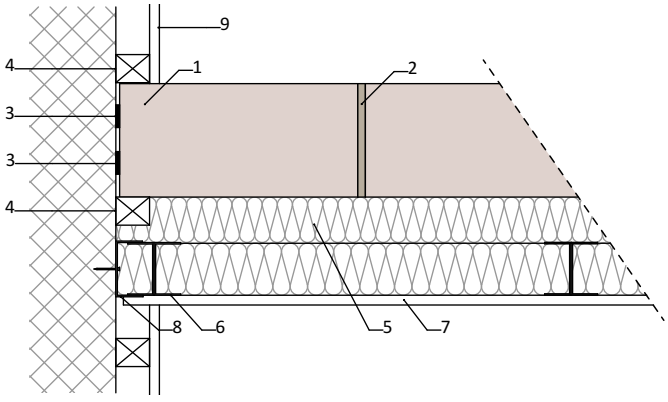

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Void or filling with wool or earth mortar with an optional resilient strip if acoustic performance is required
4. Steel angle or wooden batten fixed to the shell
5. False ceiling
6. Flexible joint
7. insulation
8. Sliding frame stud in the ceiling track
9. Plasterboard cladding fixed to the studs but not to the ceiling track
10. Ceiling-mounted track

## d. Junction with a wall of a different type

**Plan view of the junction with a wall of a different type - double partition wall / lined partition wall - 1/10e [5] p. 29**




1. Léém Moulded or Compressed Block
2. Pre-compressed Expanding foam tape tape if acoustic and/or fire performance is required
3. Sealant joint if acoustic and/or fire performance is required
4. Opening recess in the concrete wall

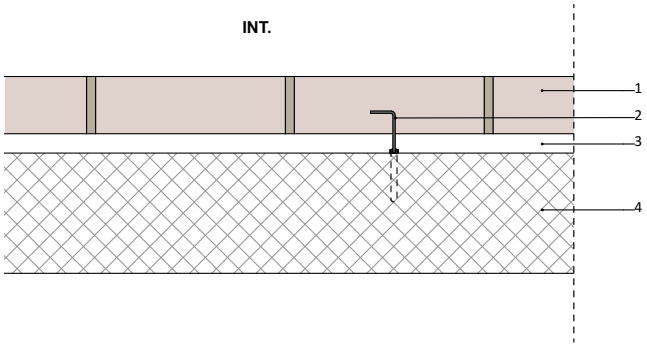



1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Pre-compressed Expanding foam tape tape if acoustic and/or fire performance is required
4. Wooden batten fixed to the shell
5. Insulation
6. Sliding frame stud in the wall-mounted track
7. Plasterboard cladding
8. Wall-mounted track
9. Wall lining of different types

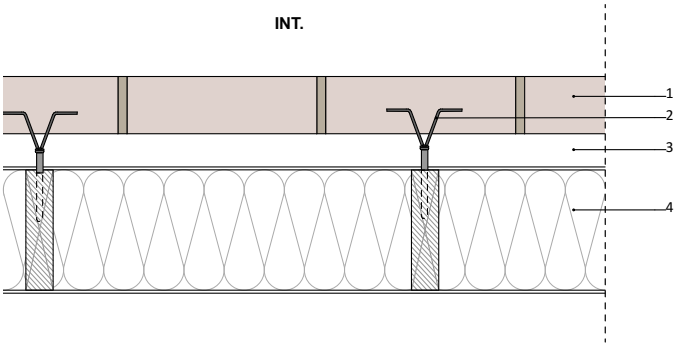
## 5.3.5 Interior cladding wall

### a. Wall composition

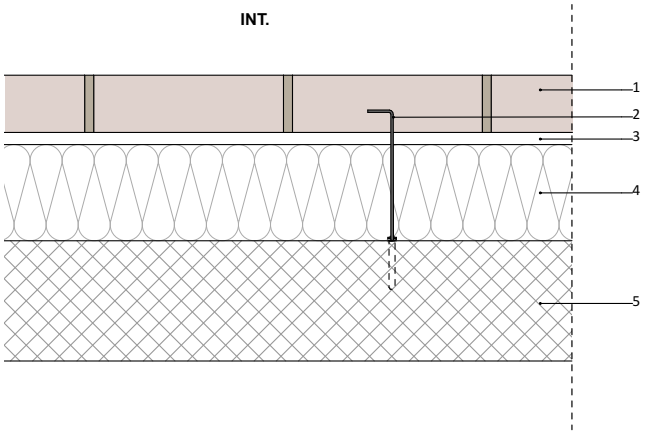
**Schematic diagram of masonry cladding in Léém Blocks [3] p.5**



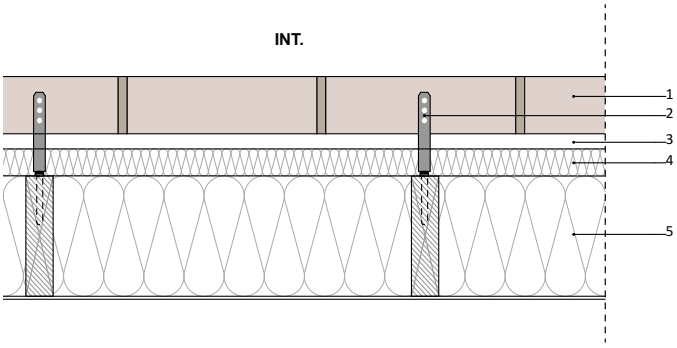

1. Cladding with Léém Moulded or Compressed Blocks
2. Metal anchor
3. Air gap
4. Supporting wall, optionally with exterior thermal insulation




1. Cladding with Léém Moulded or Compressed Blocks
2. Metal anchor
3. Air gap
4. Supporting wall in timber frame, optionally with exterior thermal insulation

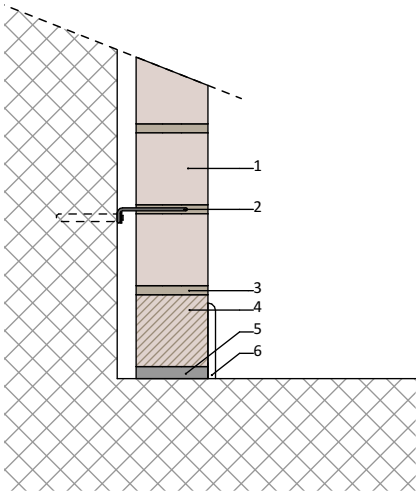



1. Cladding with Léém Moulded or Compressed Blocks
2. Metal anchor
3. Air gap
4. Interior thermal insulation
5. Supporting wall, optionally with exterior thermal insulation



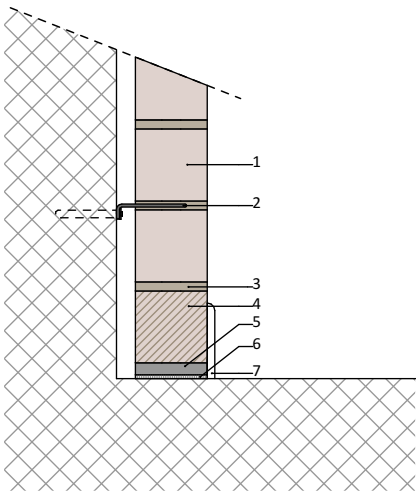

1. Cladding with Léém Moulded or Compressed Blocks
2. Metal anchor
3. Air gap
4. Interior thermal insulation
5. Supporting wall in timber frame, optionally with exterior thermal insulation

## b. Wall base - connection with the floor



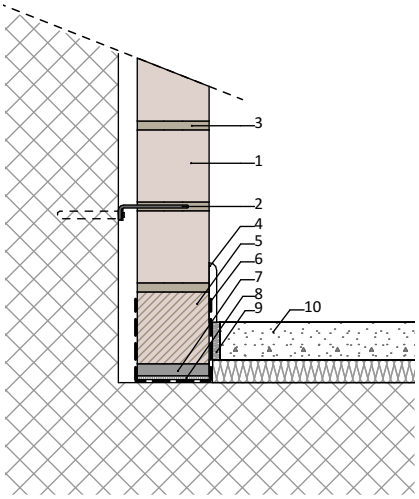

**Cross-section of junction on finished floor - 1/10e [3] p.22**

1. Léém Moulded or Compressed Block
2. Metal anchor
3. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
4. Water-resistant block (Compressed Léém Block, sandlime block...)
5. Hydraulic binder-based mortar
6. Baseboard




**Cross-section of junction on finished floor (with uncoupling strip) - 1/10e [3] p.22**

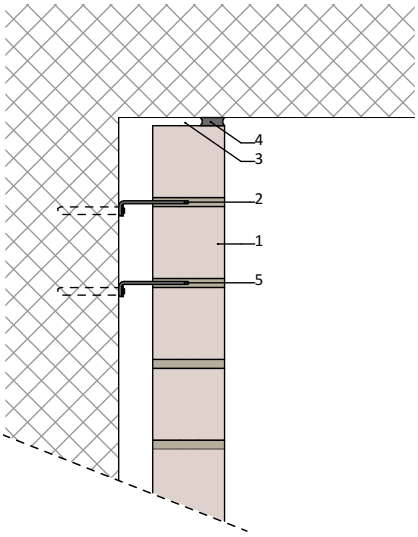
1. Léém Moulded or Compressed Block
2. Metal anchor
3. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
4. Water-resistant block (Compressed Léém Block, sandlime block...)
5. Hydraulic binder-based mortar
6. Decoupling strip (thickness: 5-10mm)
7. Baseboard




**Cross-section of junction with floating screed - 1/10e [3] p.22**

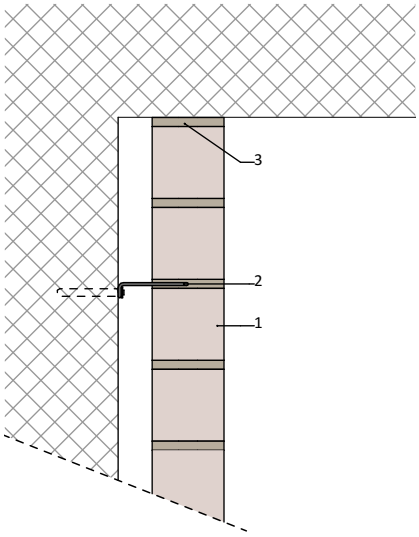
1. Léém Moulded or Compressed Block
2. Metal anchor
3. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
4. Baseboard
5. Water-resistant block (Compressed Léém Block, sandlime block...)
6. Waterproof membrane extending at least 2cm above the finished floor level
7. Hydraulic binder-based mortar
8. Decoupling strip (thickness: 5-10mm)
9. Perimeter insulative strip
10. Floating screed

## c. Wall top - connection with the upper floor



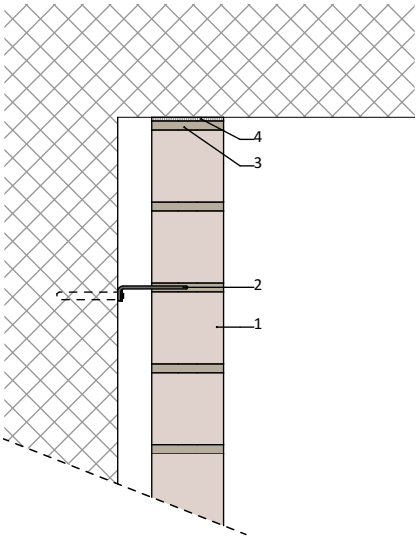

**Cross-section of junction with void at head of cladding - 1/10e [3] p.23**

1. Léém Moulded or Compressed Block
2. Metal anchor to reinforce the head of the facing
3. Void
4. Sealant elastic kit




**Cross-section of the mortar junction at the head of the cladding - 1/10e [3] p.23**

1. Léém Moulded or Compressed Block
2. Metal anchor to reinforce the head of the facing
3. Léém (Adhesive) Mortar or bastard mortar with Léém Additive

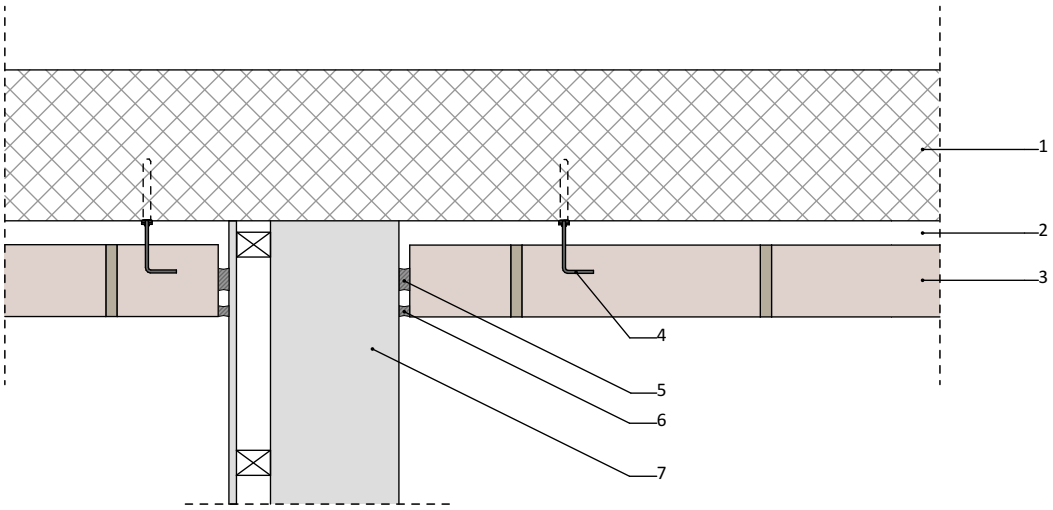



**Cross-section of the junction with a decoupling strip at the head of the facing - 1/10e [3] p.24**

1. Léém Moulded or Compressed Block
2. Metal anchor to reinforce the head of the facing
3. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
4. Decoupling strip

## d. Junction between cladding wall and wall of different type

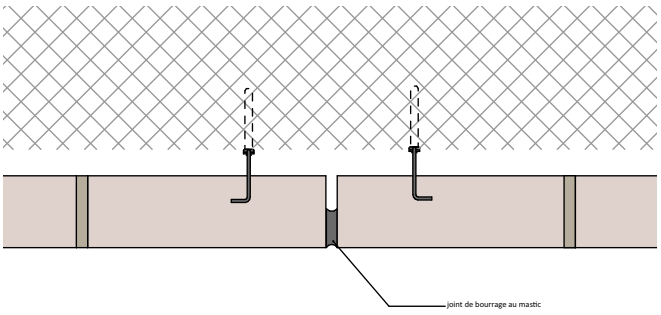
**Plan view of the uncoupled junction with a perpendicular vertical wall - 1/10e [3] p.24**




1. Load-bearing wall
2. Air gap
3. Léém Moulded or Compressed Block
4. Metal anchor
5. Optional pre-compressed expanding foam tape
6. Optional elastic kit
7. Partition wall

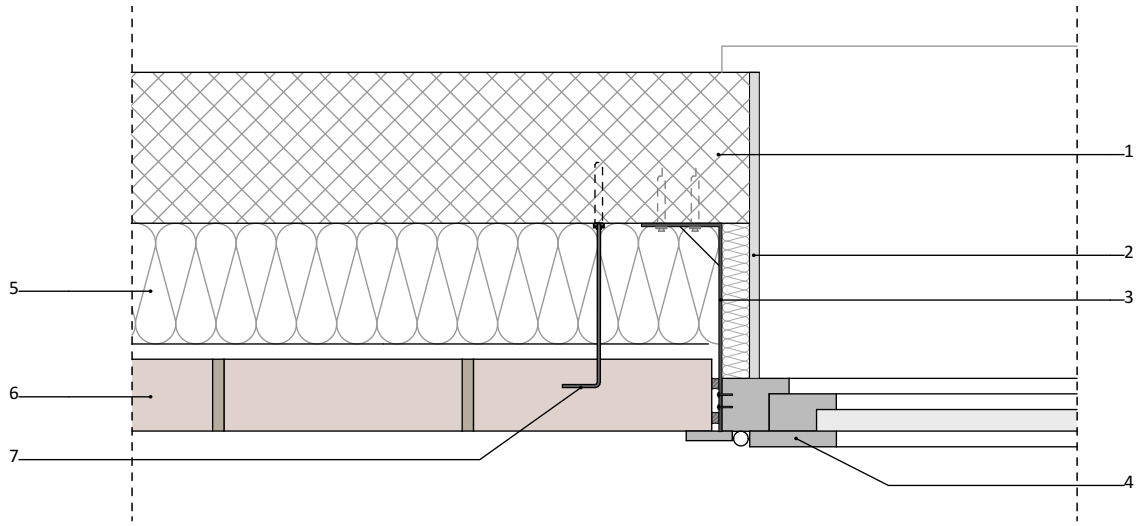
## e. Junction between cladding walls

**Example of a split joint treatment plan - 1/10e [3] p.24**



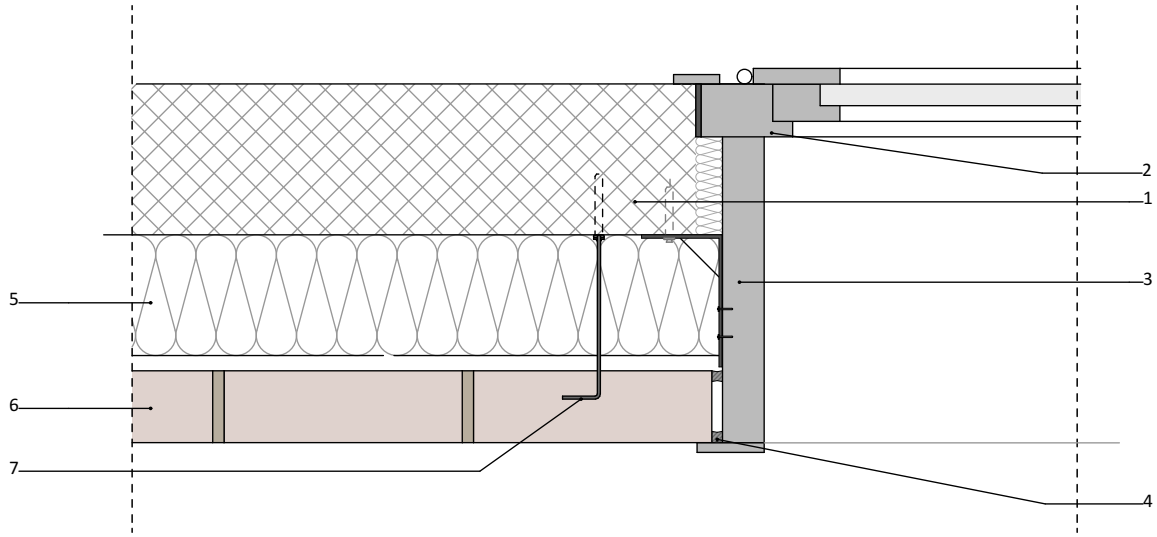

Sealant joint

## Cross-section with carpentry on the inner face of the cladding (with bracket fixing in the wall) - 1/10e [3] p.29

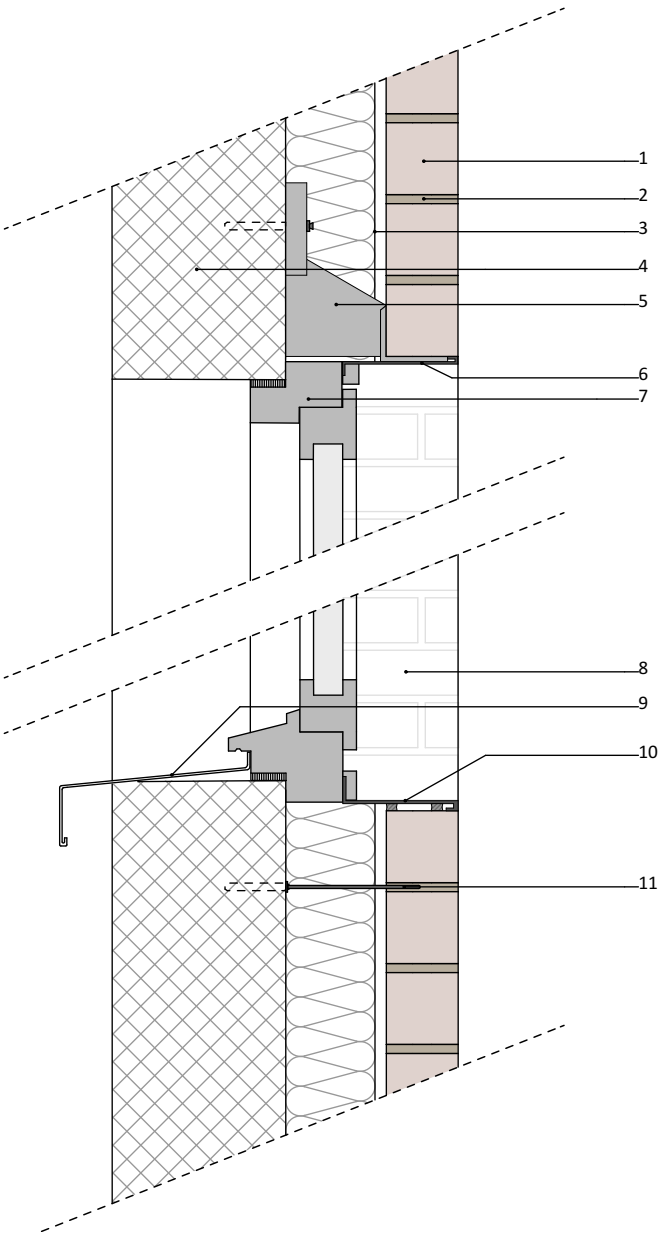



1. Supporting wall
2. Insulated cladding of the panel and insulation layer
3. Joinery fixing bracket
4. Joinery inside the wall lining, connected to the supporting wall with fixing brackets + flexible sealant and cover joint for treating the junction with the Molded Compressed Léém Block cladding
5. Air gap + insulation
6. Léém Moulded or Compressed Block
7. Metal anchor

## Cross-section with carpentry on the outside of the supporting wall - 1/10e [3] p.29

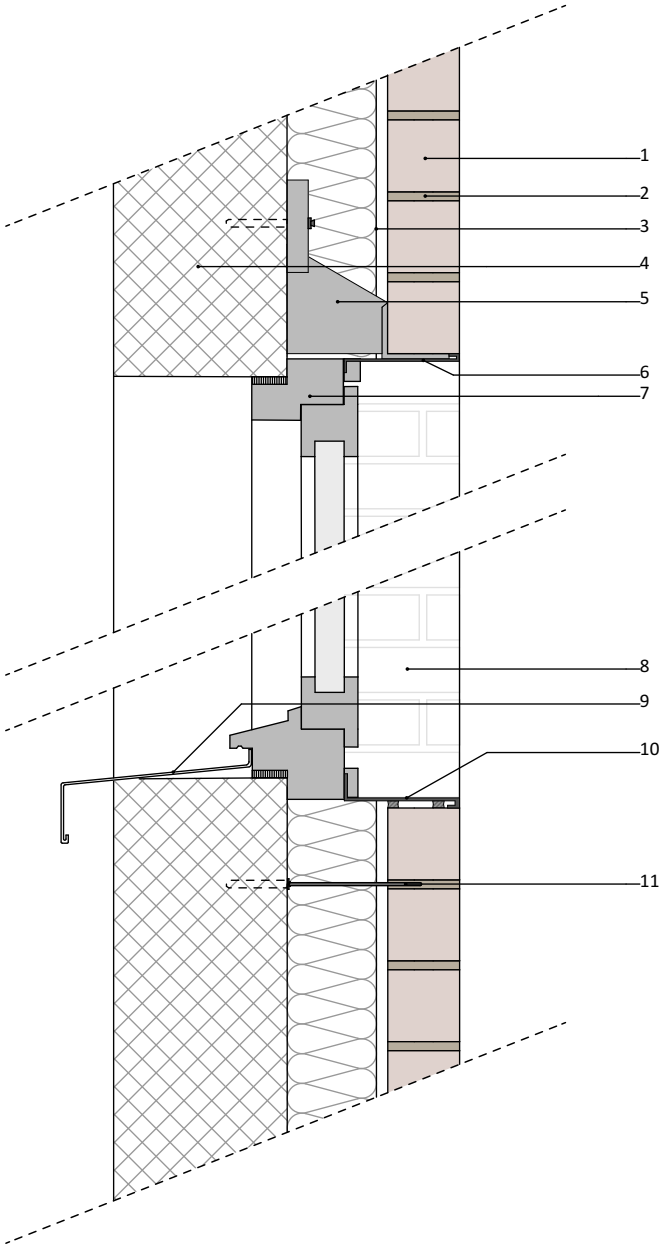



1. Supporting wall
2. Tunnel joinery on supporting wall
3. Cladding of the frame + fixing bracket to the supporting wall
4. Flexible sealant + cover joint
5. Air gap + insulation
6. Léém Moulded or Compressed Block
7. Metal anchor




**Cross-section of a wall with internal insulation - lintel and spandrel extended into the cladding - carpentry or inner surface of the cladding (fixed to the supporting wall with a bracket) - 1/10e [3] p.30**

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Metal anchor
4. Concrete or timber lintel + flexible sealant underneath and joint cover
5. Load-bearing wall
6. Joinery on the inner face of the cladding, attached to the load-bearing wall with fixing brackets
7. Metal flashing for window sill treatment
8. Fixing bracket for the joinery
9. Concrete or timber sill + flexible sealant and joint cover




**Cross-section of a wall with internal insulation - lintel and sill not extending into the cladding - carpentry applied to the support - 1/10e [3] p.30**

1. Léém Moulded or Compressed Block
2. Léém (Adhesive) Mortar or bastard mortar with Léém Additive
3. Insulation + air gap
4. Load-bearing wall
5. Lintel support bracket
6. Folded sheet metal for lintel cladding
7. Surface-mounted joinery on the load-bearing wall
8. Léém Moulded or Compressed Block facing jamb
9. Metal skirting board for window sill treatment
10. Folded sheet metal for sill cladding + flexible sealant
11. Metal anchor

# 6. Bibliography


[1] Confédération de la construction en terre crue, *Guide des bonnes pratiques: Briques de terre*, Octobrer 2020.

[2] Briques Technic Concept (Titulaire et Redaction), *ATEx A 2957 Murs porteurs*, October 2021

[3] SCIC Cycle Terre (Titulaire), CRAterre / AE&CC / ENSAG / Université Grenoble Alpes (Redaction), ATEx A 2991 Parement intérieur, February 2022

[4] SCIC Cycle Terre (Titulaire), CRAterre / AE&CC / ENSAG / Université Grenoble Alpes (Redaction), *ATEx A 2990 Maçonnerie de remplissage*, May 2022

[5] SCIC Cycle Terre (Titulaire), CRAterre / AE&CC / ENSAG / Université Grenoble Alpes (Redaction), *ATEx A 2911 Cloisons*, May 2021

[6] CSTC, *NIT 271 - Exécution des maçonneries*, February 2020

[7] Cycle Terre, *Guide de conception et de construction,* May 2021

[8] Institut allemand de normalisation, *DIN 18940 Maçonnerie porteuse en terre crue*, October 2022

[9] Morton Tom, *Earth Masonry : Design and Construction Guidelines*, Feb 2008

[10] Schroeder Horst, *Sustainable Building with Earth*, October 2015

[11] Wienerberger, *Rouge. La force*, August 2018

[12] Klinge Andrea, *The Relevance of Earthen Plasters for Eco Innovative, Cost-Efficient and Healthy Construction*, January 2019

[13] Klinge Andrea, *Naturally ventilated earth timber constructions*, June 2016

[14] SIPIZ, et Terrabloc, *Rapport d'essai Nr. PB 128 001 2022 (Blocs)*, October 2022

[15] SIPIZ, et Terrabloc, *Rapport de test Nr. PB 128 001 2021 (Plaques)*, July 2021

[16] Empa et Terrabloc, *Rapport d'essai n° 5214027285 (Terraplac)*, July 2021

[17] Dachverband Lehm, *V. Lehmbauregeln. 3. Auflage, Vieweg + Teubner*, October 2008

[18] Institut allemand de normalisation, DIN 18945: Blocs de terre - Exigences, essai et étiquetage, December 2018

[19] Institut allemand de normalisation, DIN 18946: Mortier de terre pour maçonner - Exigences, essai et étiquetage, December 2018

[20] Graham, C.W, Movement coefficients of CEB units, June 2005

[21] Sutton Andy, *Unfired clay masonry*, October 2011

[22] CSTC, NIT 284 *Les enduits intérieurs*, November 2022

[23] Guillaud Hubert et al., *Traité de construction en terre*, January 2006

[24] AFNOR, *XP P13-901: Blocs de Terre crue*, March 2021

[25] CSTC, *NIT 255 Etanchéité à l'air*, December 2015

[26] UBAtc, *Agrément technique*, https://butgb-ubatc.be/fr/deliverables/national-technical-approval-atg/, consulted in August 2023

# 7. Acknowledgements and credits

As mentioned in Section 1, this Léém Earth Block Guide is a compilation by BC materials of the most recent research publications, technical approvals and norms in Germany and France, updated with specific extra research and experience by BC materials and Buildwise related to a Benelux context. It would not have been possible without the specific input of following people. Thank you to

In Belgium, Lou Ricome and Lori Reding for the valuable work and input on the guide, Buildwise for the permission to reproduce schemes and tables from the NIT for general masonry.

In France, Elodie Wallers, Teddy Dusausaye and Paul-Emmanuel Loiret of Cycle-Terre for their valuable exchanges and permission to use many schemes and details related to earth block masonry, Eugenie Crété and Dr. Mathilde Chamodot and Arnaud Misse of CRAterre and Sophie Bioul of AMACO for facilitation of the work on those schemes and details and sharing experiences of making the Cycle-Terre Guides.

In Switzerland, Rodrigo Fernandez and Laurent de Wurstemberger of Terrabloc for valuable input on vibrocompaction for Compressed Earth Blocks.

In Germany, Dr.-Ing. Christoph Ziegert and Dr.-Ing. Horst Schröder for valuable input on DIN-norms and EPD-framework, and Ing. Stephan Jörchel of Dachverband Lehmbau for his facilitation.

This Guide has been funded by the EU - NextGeneration EU fund.

Funded by the European Union
NextGenerationEU

We have done our best to make clear all references of text and images in this guide. Please contact us on info@bcmaterials.org if you discover unreferenced or wrongly referenced text or images.

All images from bibliographic references [2,3,4,5,7] have been kindly provided by Cycle-Terre and CRAterre and reworked by BC materials.

All content in this guide which has been created by BC materials is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. Please contact us first if you would wish to use this content for commercial purposes.