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Recovery of the building heritage through the NEB lens:
Ground-to-panel connection in refurbishment works on masonry buildings using CLT construction systems

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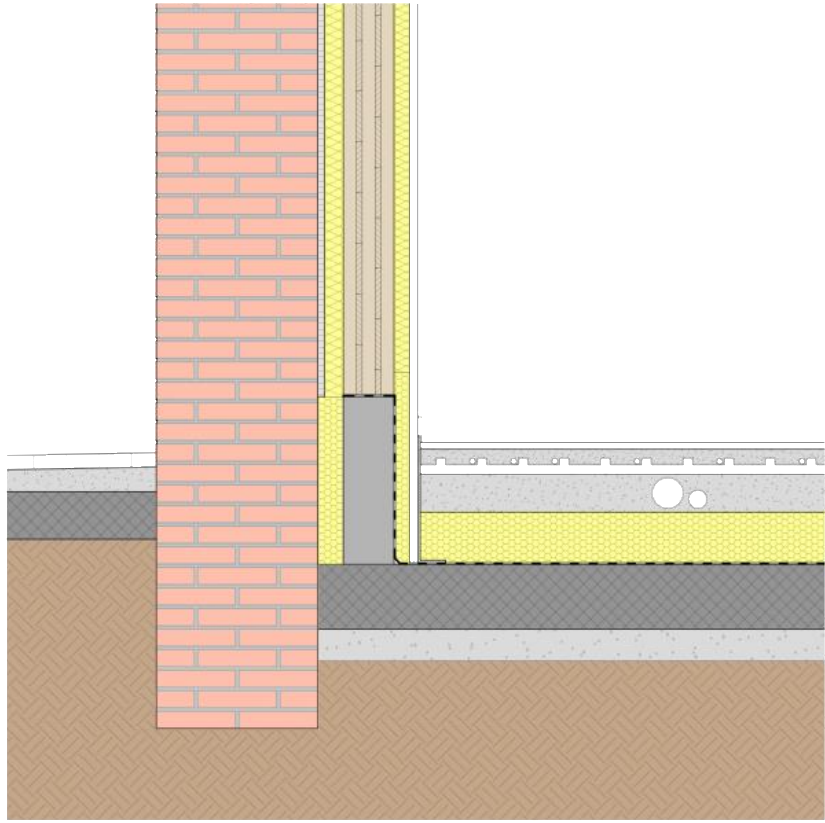
DIPARTIMENTO POLITECNICO DI INGEGNERIA E ARCHITETTURA

GROUND-TO-PANEL CONNECTION IN REFURBISHMENT WORKS ON MASONRY BUILDINGS USING CLT CONSTRUCTION SYSTEMS



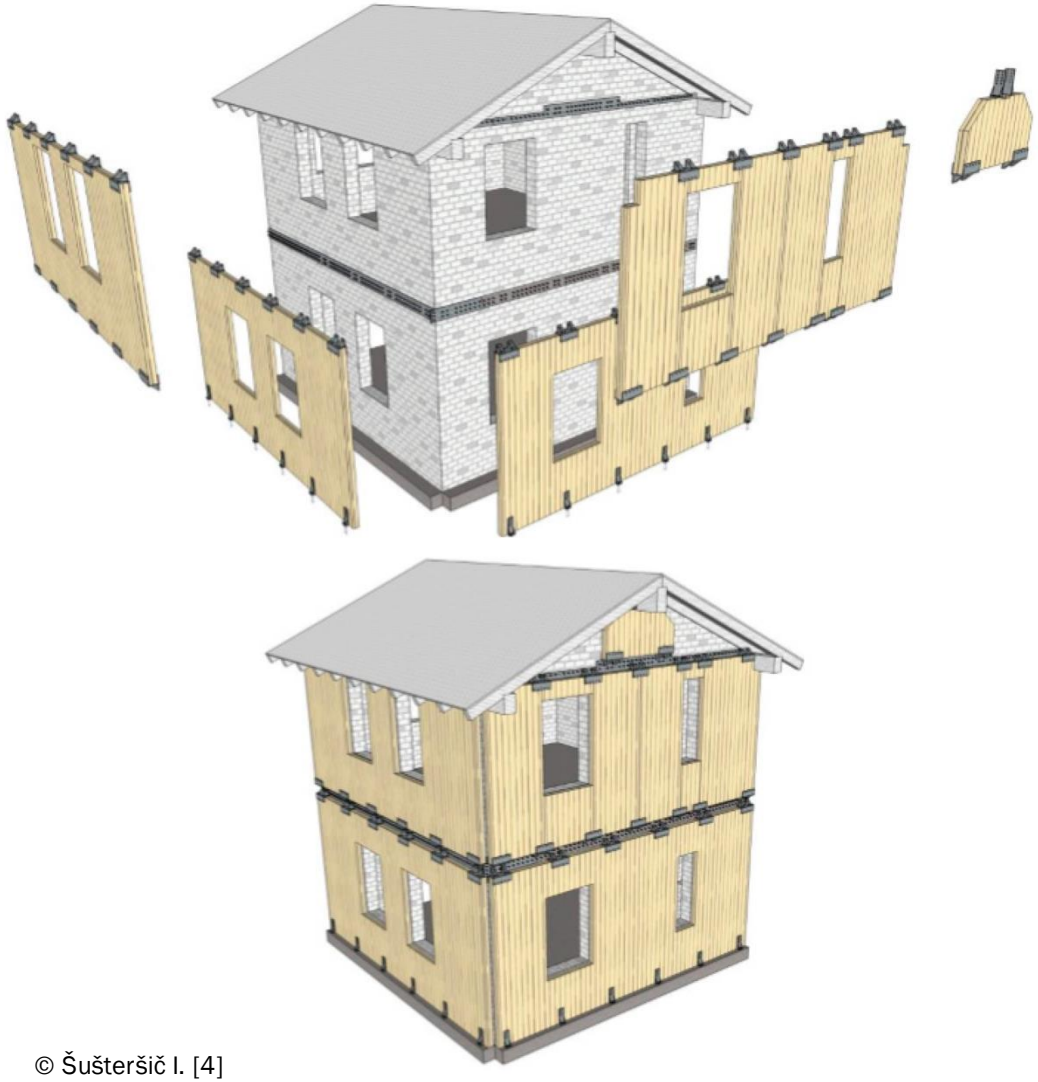
PH.D. ING. E. PEZ

TOPICS

- Types of renovation work on existing buildings using CLT panel construction systems
- Main issues in defining the connection between the ground and timber structures
- Technological analysis of the main connection solutions

CLT FOR RETROFITTING EXISTINGS BUILDINGS FROM OUTSIDE

- To simultaneously improve the critical issues of seismic behaviour, energy consumption and thermo-hygrometric comfort in existing buildings
- Suitable for buildings that do not have architectural features of particular value
- The external load-bearing envelope made of CLT panels stabilises and reinforces the existing internal structure, in particular by increasing its resistance to horizontal forces
- Thanks to their low mass, CLT panels do not contribute significantly to additional seismic stress
- Possibility of using high-level prefabrication to facilitate the assembly and installation phases, reducing the time required



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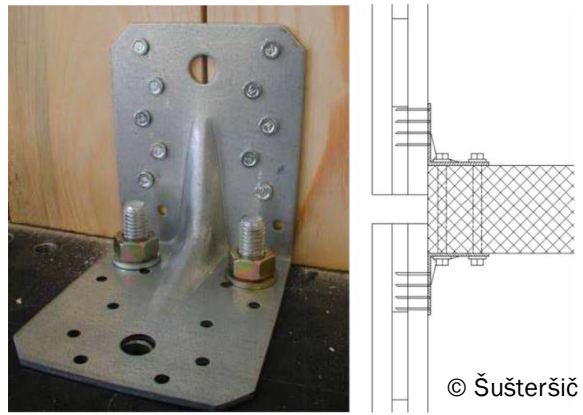
CLT FOR RETROFITTING EXISTINGS BUILDINGS FROM OUTSIDE

- Unlike most of conventional methods for seismic retrofit, users may remain in the building even while the works are being carried out
- Contribution to the sustainability of buildings by reducing consumption and contributing to CO2 storage, extending the life of existing buildings
- Floor connections between CLT panels and framed structure



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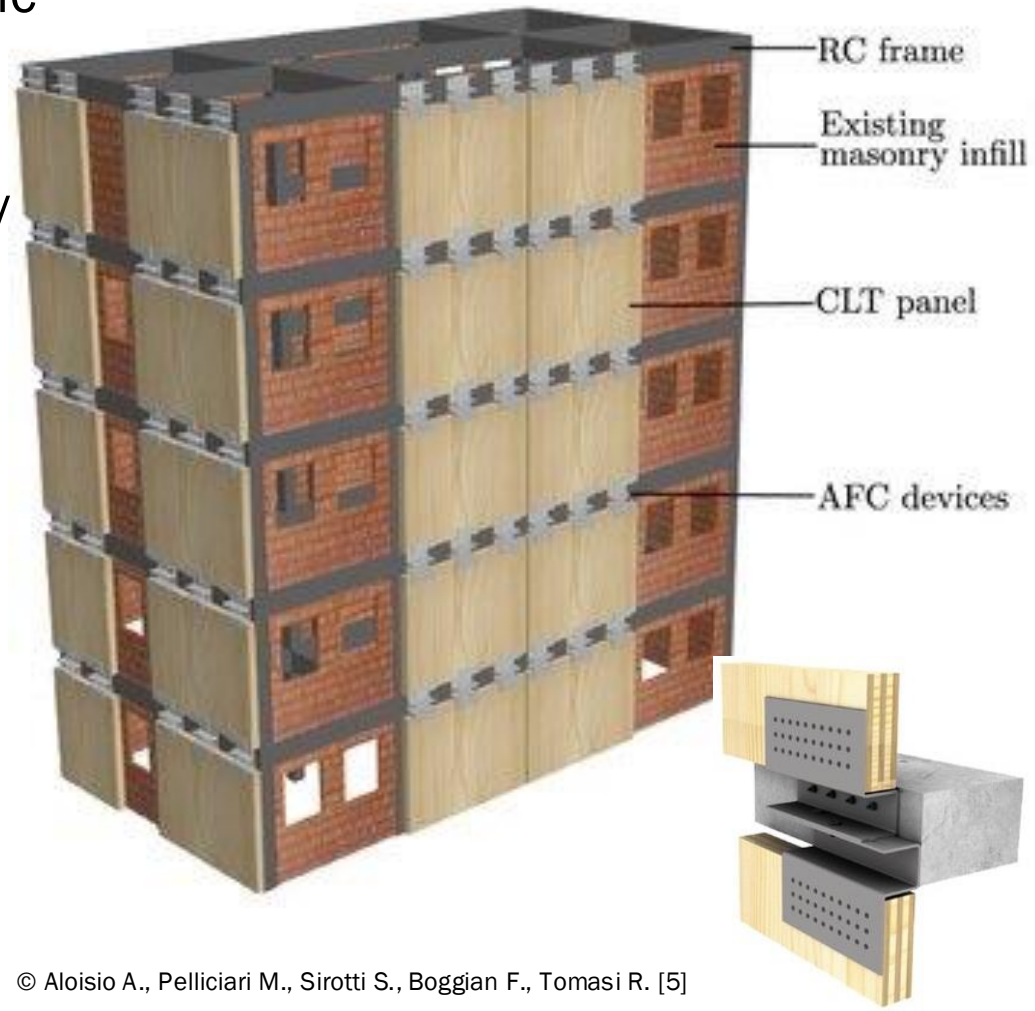

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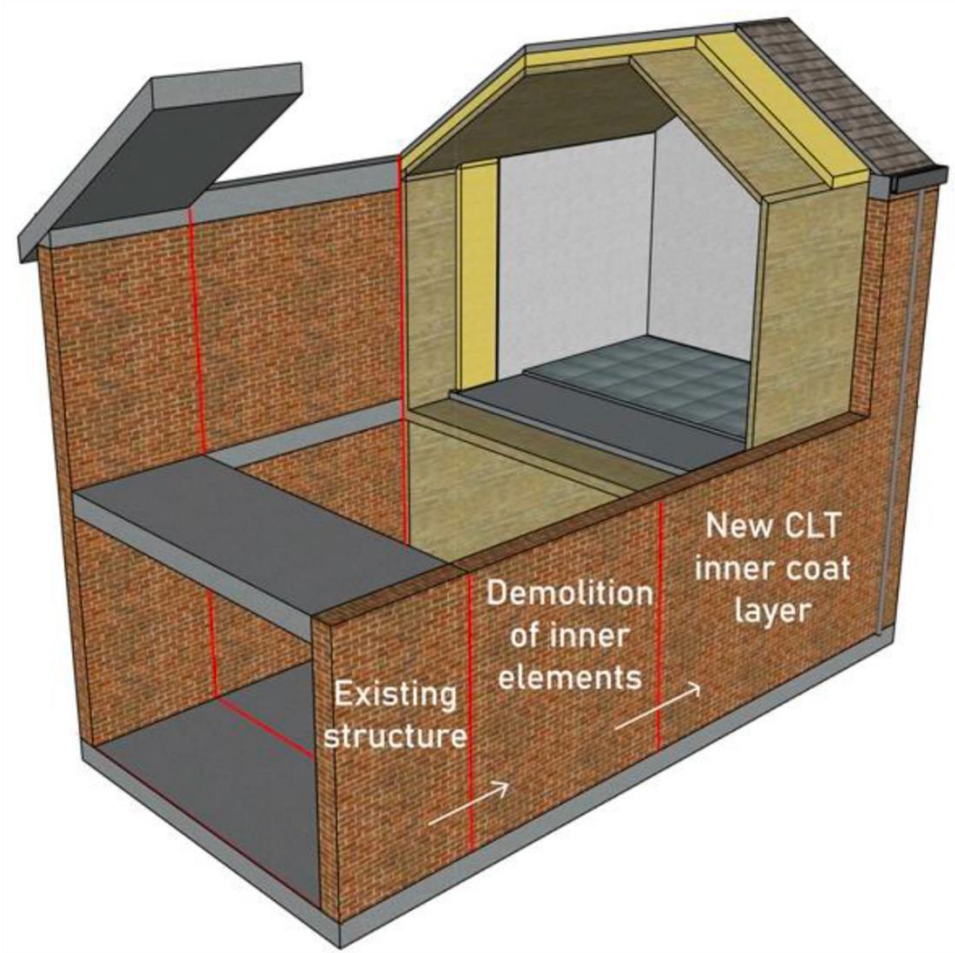
CLT FOR RETROFITTING EXISTINGS BUILDINGS FROM INSIDE

- To guarantee performance and functional levels comparable to new buildings with certain construction times
- For buildings subject to partial historical and architectural restrictions limited to the façades
- The procedure is performed in several stages:
  - Stabilisation of existing structures to be preserved
  - Controlled demolition of horizontal structures
  - Reinforcement of foundation structures
  - Construction of the internal ‘box’ using widespread prefabrication techniques
- Possibility of using high-level prefabrication to facilitate the assembly and installation phases, reducing the time required



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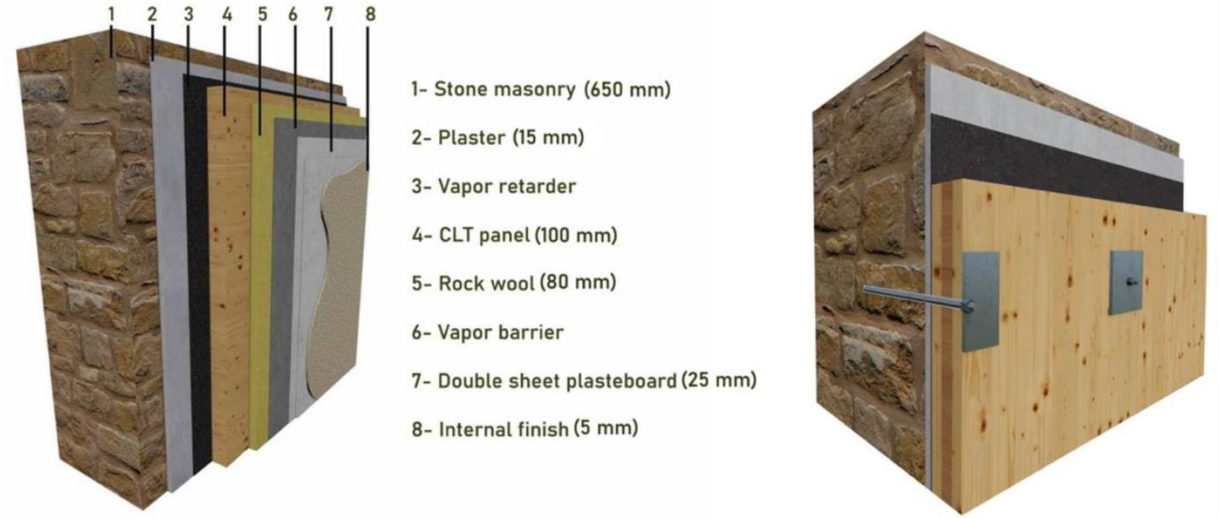
CLT FOR RETROFITTING EXISTINGS BUILDINGS FROM INSIDE

- Preventive consolidation of existing masonry characteristics with jet grouting (for vertical bonding)
- Various solutions for coupling CLT panels and masonry:
  - Floor fixings with resin-coated bars and counterplates
  - Distributed dry fixings



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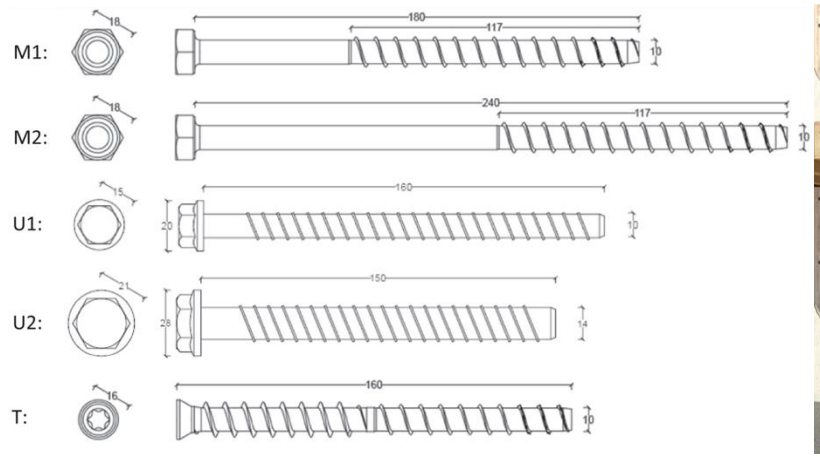

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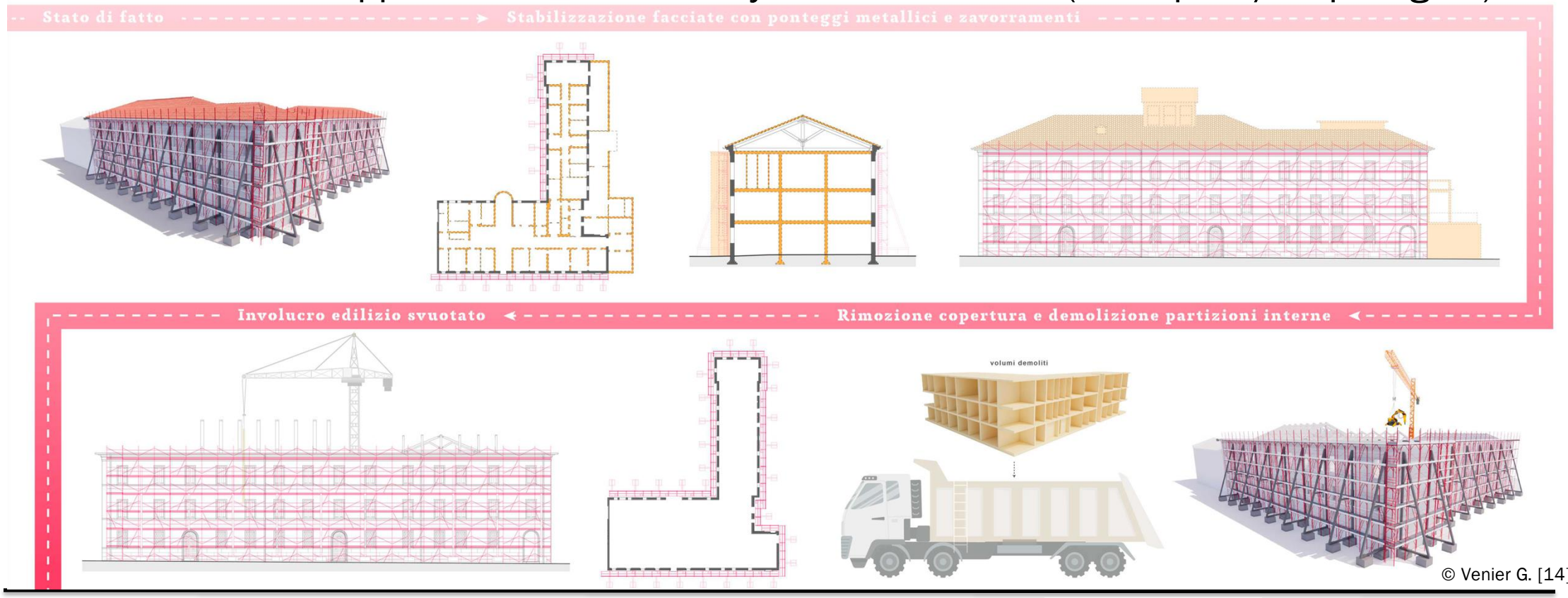
FAÇADISM PROCESS

- Installation of temporary support and stabilisation structures for the façades
- Controlled demolition/dismantling of the roof
- Controlled demolition of internal partitions
- Construction of support structures for any excavation work (micropiles/diaphragms)



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FAÇADISM PROCESS

- Construction of new foundations and new basement floors using R.C. technology
- Reconstruction of above-ground floors using CLT technology, coupling with the existing envelope and consolidation
- After the emptying operation, the actions on the masonry are reduced to its own weight and the action of earthquakes and wind
- Irregularities in the composition of the masonry and in the geometric structure may lead to a risk of instability
- The emptying operation is usually combined with excavation to create underground floors and recover space (e.g. for garages, car parks, etc.) in areas already densely occupied by buildings

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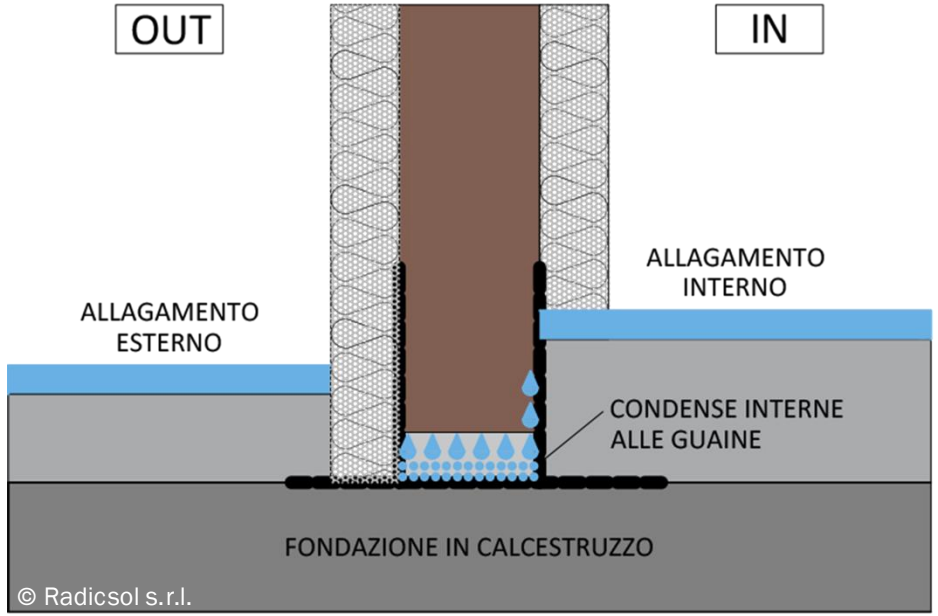
MAIN ISSUES OF GROUND-TO-PANEL CONNECTION

- The ground connection is the most complex detail in terms of execution, as it must simultaneously satisfy the following requirements:
  - Structural
  - Durability
  - Energy efficiency
  - System flexibility
- Transition element between construction techniques with different execution tolerances
- Fundamental for the durability of the wooden structure:
  - Moisture from the outside (rainwater)
  - Rising damp (mixing water/waterproofing defects in reinforced concrete)
  - Moisture from the inside (broken plumbing, interstitial condensation)



FUNCTIONS OF GROUND TO CLT PANELS CONNECTION

- During installation
  - Ensuring a perfectly level and tight contact point between the timber panel and the foundation element
  - Facilitation of the exact positioning of wall elements
  - More efficient mechanical connection

- During the operational life of the building
  - Transfer of stresses
  - Thermal insulation of the wall against the ground
  - Ensuring the durability of timber components

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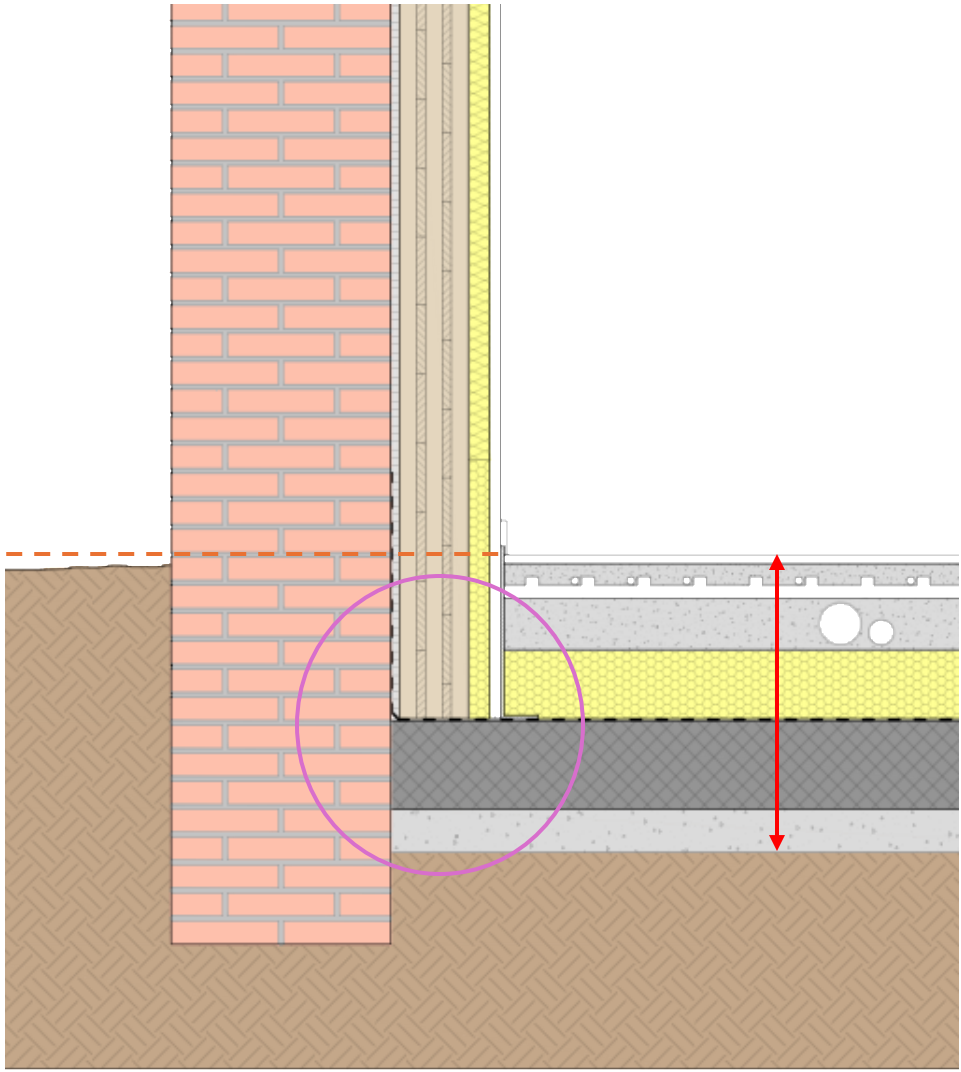
LIMITING FACTORS FOR CLT PANEL POSITIONING

- Limited permissible difference in height between the interior and exterior of the building for the criteria for overcoming architectural barriers
- Configuration of foundation works
- Thickness of the stratigraphy of ground floors



TYPES OF GROUND TO CLT PANELS CONNECTIONS

- Planar installation
  - directly on foundation element (bedding in thixotropic mortar)
  - with levelling screed

- With intermediate element
  - Traditional R.C. kerb (cast-in-place)
  - R.C. kerb with disposable formwork
  - Prefabricated R.C. kerb
  - Timber kerb
  - R.C. kerb + Timber kerb
  - Metal kerb
    - Steel
    - Aluminium

GROUND-TO-CLT PLANAR CONNECTION

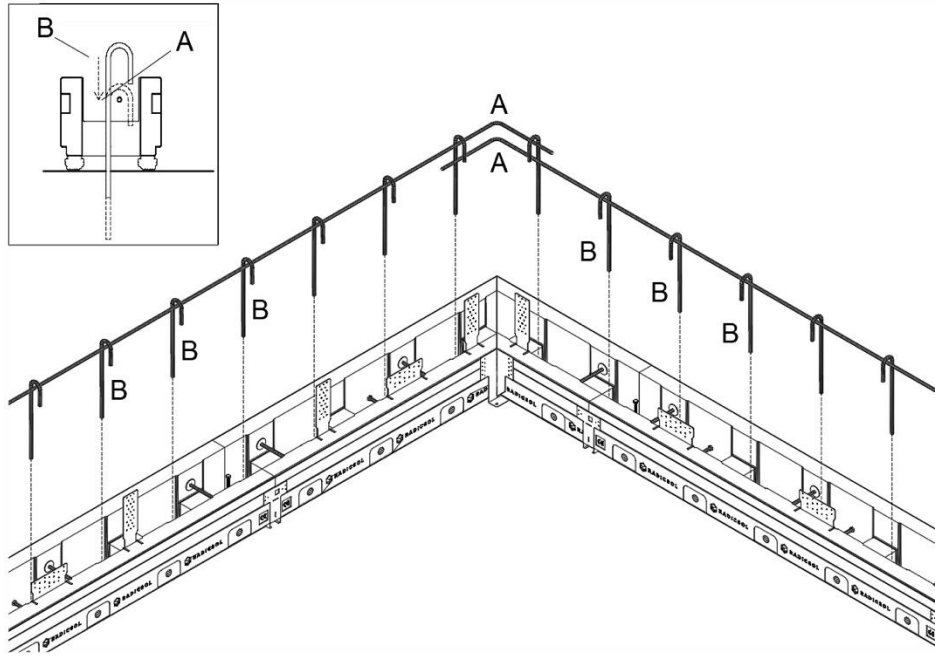
- This solution is only possible with a suspended slab, with a sufficiently high positioning height in relation to the ground level.
- The panel is laid on top of the waterproofing membrane.
- The flat geometry facilitates optimal positioning of shear angles and hold-downs.
- If the support surface is uneven, it is still necessary to lay a bed of non-shrink mortar.
- The panel is positioned below floor level.

GROUND-TO-CLT CONNECTION WITH CAST-IN-PLACE KERB

- R.C. cast-in-place kerb
  - Connecting bars from the foundation works
  - Particular care is required when setting up the formwork to obtain a level surface
  - It is necessary to carry out an accurate survey of the works carried out before proceeding with the installation of the formwork for the kerb
  - The width of the kerb is equal to or slightly greater than the size of the CLT panel
  - Precautions to ensure the waterproofing of the cast joint
  - Kerb to be waterproofed to prevent moisture transfer to the CLT panel
  - Does not completely exclude compensation levelling

GROUND-TO-CLT CONNECTION WITH KERB USING DISPOSABLE FORMWORK

- Disposable EPS (Expanded Sintered Polystyrene) formwok
  - Solves the problem of condensation moisture at the base of CLT panels
  - Built-in levelling brackets
  - Simple formwork modification procedures
  - Provisions for pipes crossings
  - Compensates for irregularities in the slab/structural laying surface without subsequent compensation casting
  - Connections to foundations with resin-coated bars
  - Proprietary brackets



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GROUND-TO-CLT CONNECTION WITH R.C. KERB

- R.C. cast-in-place kerb built after installation of CLT panels
- Use of proprietary anchoring brackets integral with the reinforcing bars, which also support the panel until the kerb is completed
- After casting, the brackets are embedded in the concrete and able to distribute tensile stresses directly to the reinforcing bars

GROUND-TO-CLT CONNECTION WITH R.C. KERB

- R.C. cast-in-place kerb built after installation of CLT panels
  - Steel pillars fixed to the CLT panels before installation, equipped with adjustment systems to allow levelling of the panel installation height
  - Bituminous membrane applied in to the lower surface of the panel before installing steel pillars
  - No external brackets are used for casting

GROUND-TO-CLT CONNECTION WITH LARCH BEAM

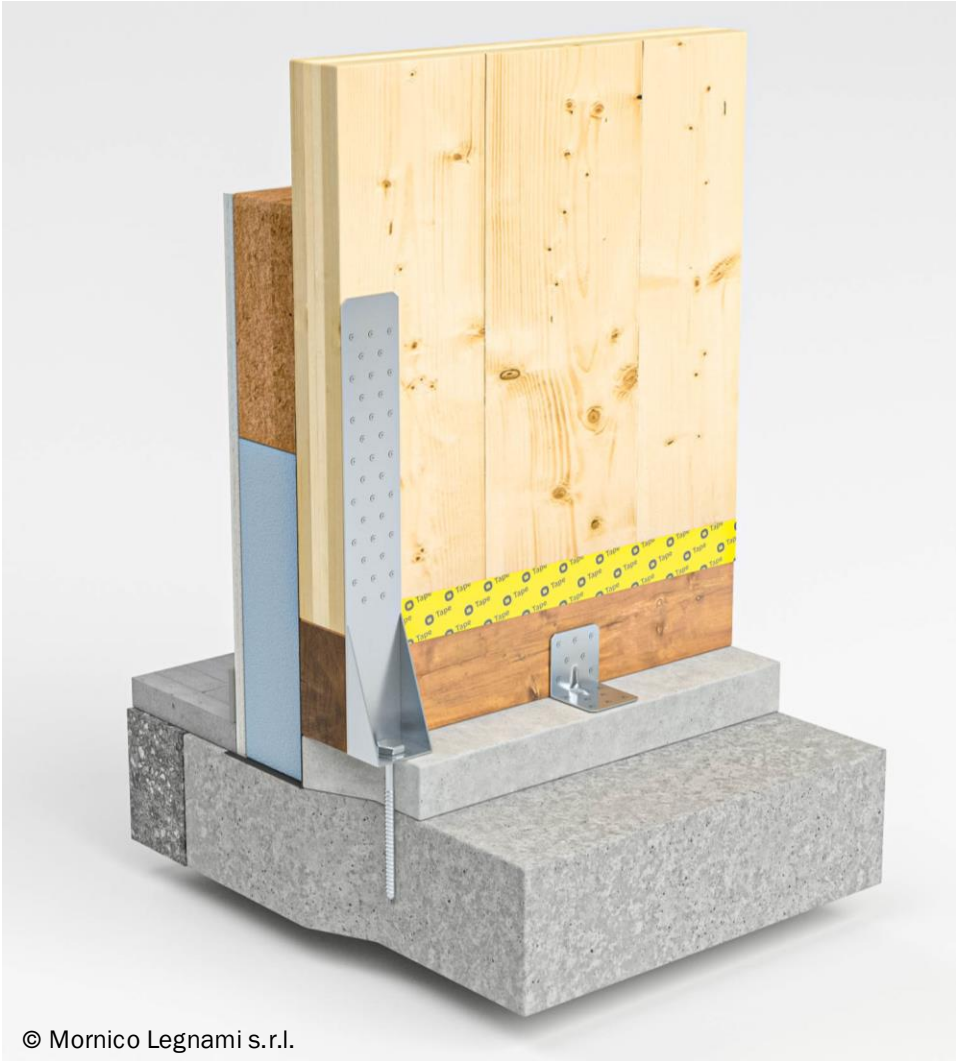
- Timber kerb
  - Greater durability of the wood species chosen for the beam
  - Vertical load limitations resulting from reduced compressive strength perpendicular to the fibres
  - Beam laid above the waterproof layer
  - Direct support with non-shrink mortar (expansive – thixotropic)
  - To compensate for irregularities in the slab/structural laying surface
  - To provide continuous support for the panel

  - Durability at risk if not properly designed

GROUND-TO-CLT CONNECTION WITH RC KERB + LARCH BEAM

- Elevation with R.C. kerb and larch beam together
  - Greater flexibility for connections between panels and larch beams (compared to reinforced concrete kerb alone)
  - Greater protection against moisture infiltration (internal/external) or capillary rise
  - Greater flexibility in absorbing irregularities in the floor surface due to the presence of multiple interfaces

  - Higher costs
  - Lower structural effectiveness



GROUND-TO-CLT CONNECTION WITH VENTILATED STEEL KERB

- COR-TEN steel profile
  - Creates a barrier against rising damp
  - Allows for ventilation and removal of any excess moisture contained in the CLT panel due to reduced contact on the underside of the panel
  - Allows for regular monitoring of the connection even during the life of the structure
  - Requires completion casting with non-shrink mortar (expansive - thixotropic)
  - For tensile strength, integrated or standard hold-downs can be used

GROUND-TO-CLT CONNECTION WITH ALUMINUM KERB

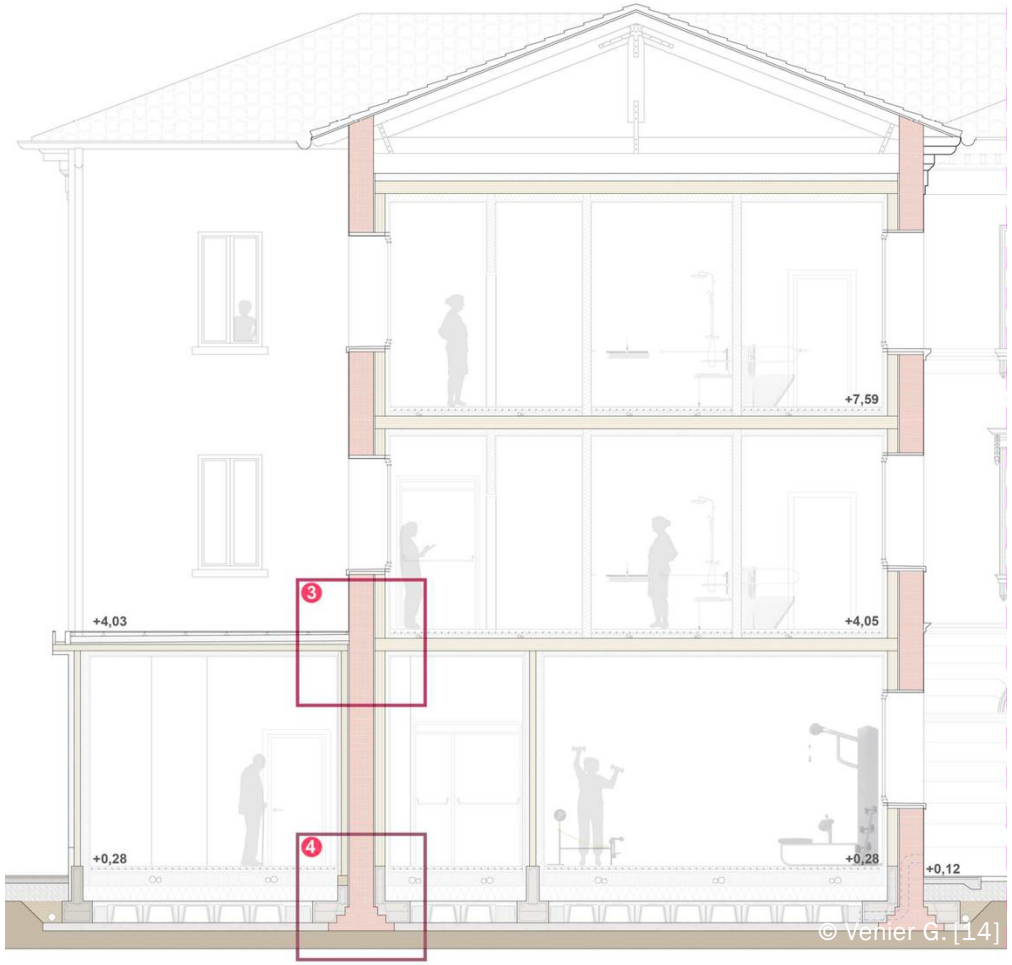
- Extruded profile with high mechanical performance
  - Completely impermeable to water and vapour
  - It can be easily drilled and cut directly on site
  - Its geometric configuration incorporates provisions for anchoring
    - Shear and traction blades for fixing the CLT panel
    - Vertical holes for housing threaded bars for connection to the foundation
  - Support to the foundation compensated with non-shrink mortar

GROUND-TO-CLT CONNECTION WITH ALUMINUM KERB

- Lowered extruded profile
  - Levelling of the CLT panel support surface before installation
  - Barrier against rising damp
  - Pre-drilled holes for connections to the foundation and panel
  - Side channels for housing temporary levelling brackets
  - Direct support on non-shrink mortar bed (expansive – thixotropic)
  - Distributed connection to the panel, compatible with hold-down brackets

EXAMPLE OF RESTORATION WITH EXTENSION

▷ Two different solutions for supporting CLT panels



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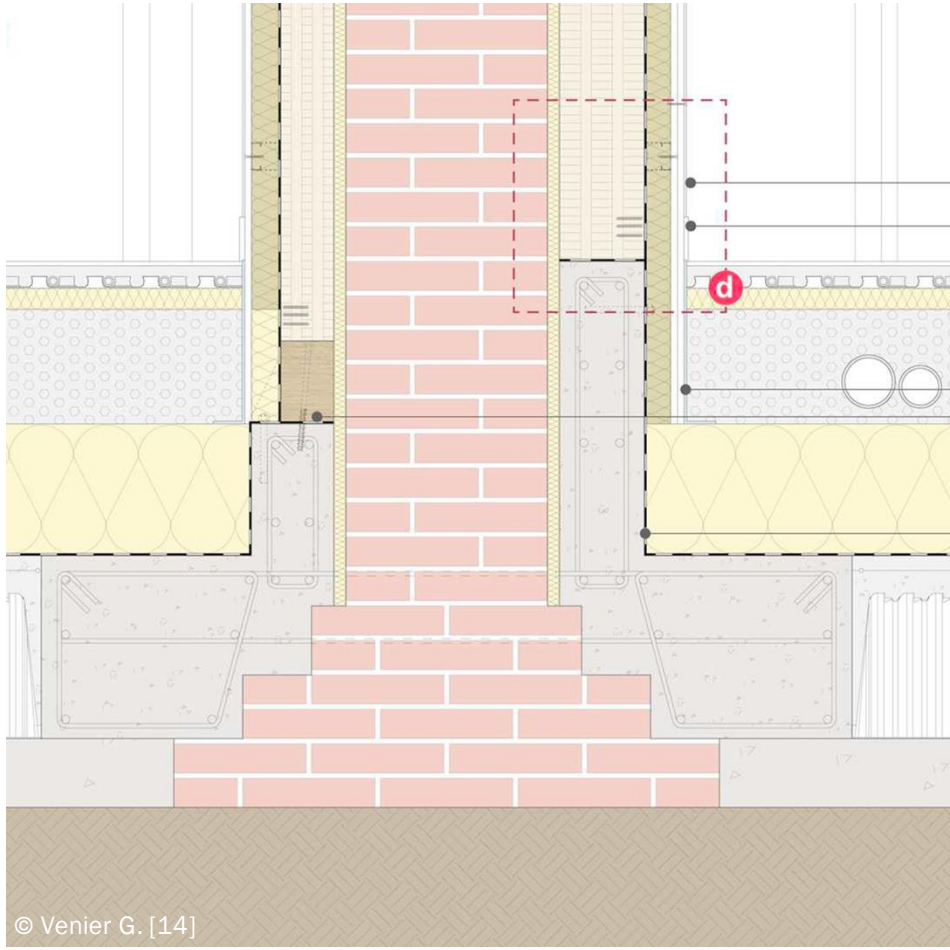

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