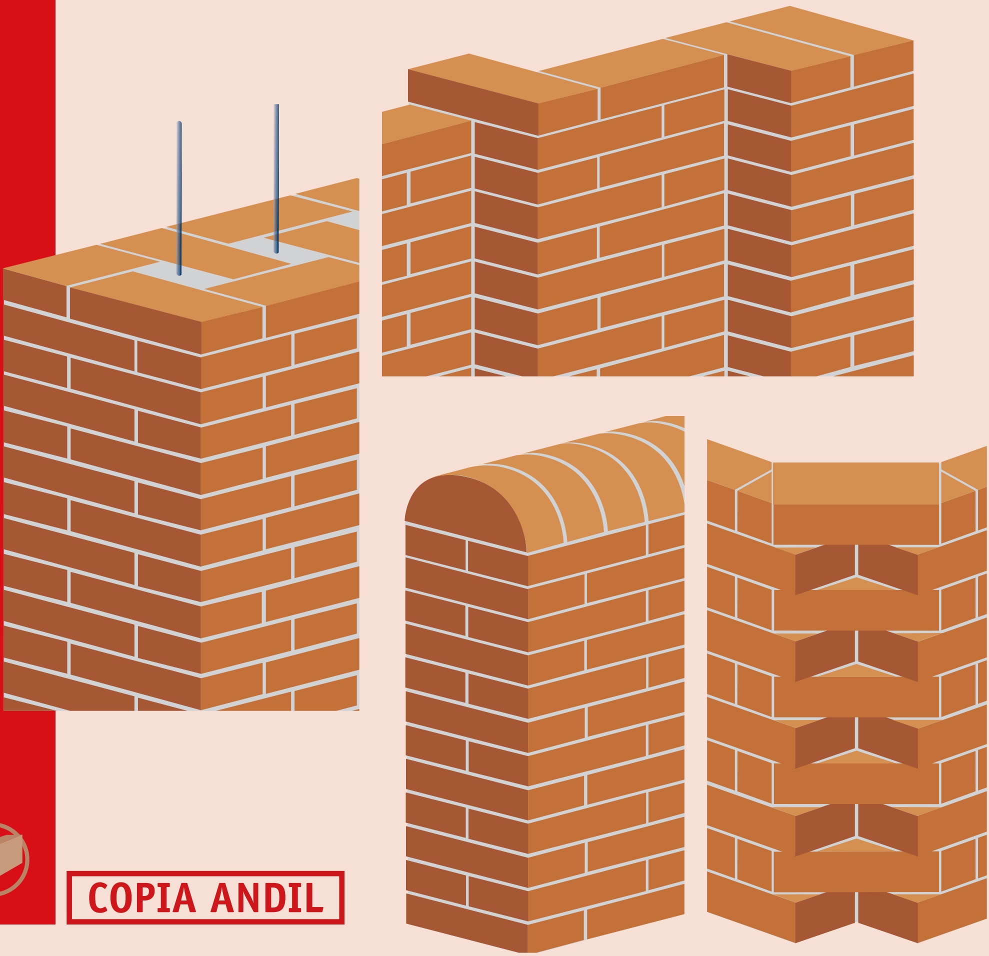
Solutions and correct use of clay facing bricks



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Index

Design tips
Facing brick 3
Types of facing bricks 4
The most frequently used textures 5
Perforated brick walls 6
Circular columns 8
Angles and intersections 9
Arches and platbands 10
String courses 11
Wall ties 12
Expansion joints 14
Thermal insulation 16
Protection from the rain 18
Presence of moisture 19

Precautions on the building site
Storage and protection of the materials 20
Blending of the bricks 21
Wetting of the bricks 22
Bed joints 24
Sample masonry panels 26
The mortar 28
Reference standards 29
Modularity and dry verification 30
Leveling rods and alignments of reference 31
Protection of the masonry 32
Final cleaning 33
The efflorescences 34
The completed masonry 35

Precautions on thermal and acoustic performance
Thermal and acoustic performance of solutions for a facing-brick building envelope 36
Precautions for thermally efficient envelopes 36
Precautions for acoustically protected envelopes 39

This booklet is a vademecum to address properly the main problems and solutions for a correct use of the clay facing bricks.
The first and the second part are extracted from the book by “Il manuale del mattone faccia a vista”, Giorgio F. Brambilla (Edizioni Laterservice, Rome, 2000). The third part is extracted from the book “Prestazioni termiche e acustiche di soluzioni di involucro in laterizio faccia a vista” by Carol Monticelli, with the coordination of Andrea Campioli (Politecnico di Milano) for technological and energetic research, and Simone Secchi (Università degli Studi di Firenze) for the research on acoustic performance.

Translation by Matteo Ferrario

Facing brick

In the wide and varied range of bricks, the ones called facing bricks represent a peculiar type because, besides connoting the architectures of the great masters of all times from a chromatic point of view, they are actually the "business card" of the construction material par excellence: the lateritious.

The facing bricks and special elements represent the ennobling of the common clay bricks for masonries. While the latter were born to be plastered, or in any case cladded, the varied family of the facing bricks is destined to value the aesthetic components (colour, grain size, texture, etc.) of clay. The facing elements are, in fact, used for the construction of:

- brick masonries for exteriors
- brick masonries for interiors
- complex architectural works
- valuable details
- street furniture.

The facing brick is the element that allows the construction of walls, or bodies of a building, directly, according to their definitive architectural configuration, without requiring any further workings or finishing layers; therefore it must present faces with properly shaped and finished surfaces, in such a way as that they can have a fine appearance.

The aim of satisfying these particular aesthetic requirements, to which those of a more strictly technical nature are bound, namely:

- mechanical strength
- thermal insulation
- vapour permeability
- acoustic protection
- resistance to the aggression of external agents
- inalterability over time

explains why the production of facing bricks is made using "valuable" clays, chosen in such a way to ensure optimal aesthetics to the surfaces intended to be left in sight, colour uniformity, dimensional constancy and preservation through time of all the performance characteristic.

From the point of view of the aesthetic characterization of the facing products, the wide variety of types and aesthetic characteristics available on the market nowadays deserves a special architectural interest. All of them can be "worked" on their surface (enameled, pretreated with water repellent substances, engobed, etc.) during the production phase.

According to the production processes, the bricks for masonries can be divided into:

- extruded (full and semi-full)
- moulded in soft paste (manual or mechanized process)
- shaped (dry, semi-dry, wet).

Giorgio F. Brambilla, "Il manuale del mattone faccia a vista", Edizioni Laterservice, Rome 2000.

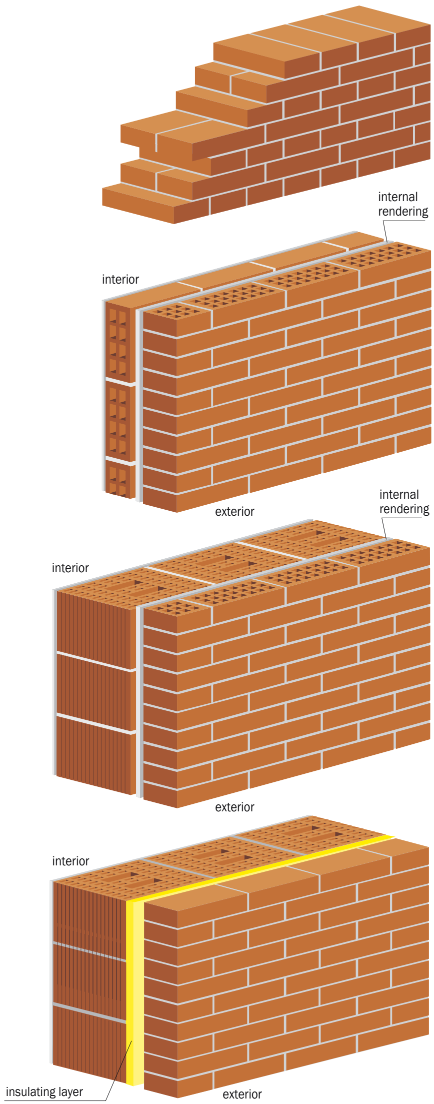
Types of facing bricks

The facing brick is rarely used by itself. Local traditions, performance standards, product innovations, design creativity have resulted in a number of currently used constructive solutions.

The *facing brick* masonries, according to their intended use, can be divided into load-bearing, infill or simple cladding ones. When the facing brick masonry also plays a structural role, it must be calculated according to the rules of Construction Science and in accordance with the current legislation. It is also necessary to dimension the brickwork in such a way as to respect the level of thermal insulation and acoustic protection required by the laws.
In addition to this, depending on the executive methods, the facing brick masonries can be further divided into various types:

- *monolayer*, when built with only one type of brick in the thickness of one or more bricks;
- *double layer wall,* when built in two, or more, layers, generally with distinct functions, which can be mutually spaced by a cavity.

The latter is a type of masonry which presents some undeniable benefits, such as the possibility to correctly execute the dimensioning for structural purposes and to ensure an effective protection against acoustic disturbances, minimizing the thermal losses of the wall. One of the most widespread solutions is undoubtedly that with the external wall made of facing brick and the internal wall made of hollow bricks or clay blocks, with or without insulating material inside the cavity, depending on the climatic zones.



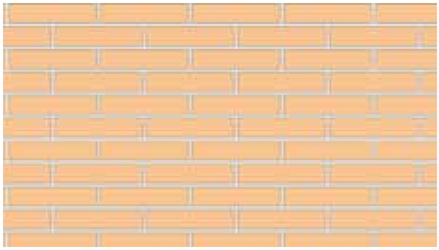
Some of the most widespread types of masonries with facing bricks.

The most frequently used textures

Also the classic "brickwork" can be made in many different ways; while a one brick thick wall imposes a stretcher bond, thicker walls require that the various elements are "tied" to one another: each region of Europe has its own specific traditions.

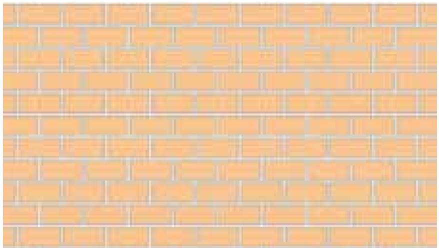
Stretcher bond

This is the arrangement that characterizes the one brick thick wall, with a simple cladding function. The bricks are placed all with their long narrow side exposed. This texture is the simplest and the fastest to be executed since it minimizes the number of vertical joints to be created.



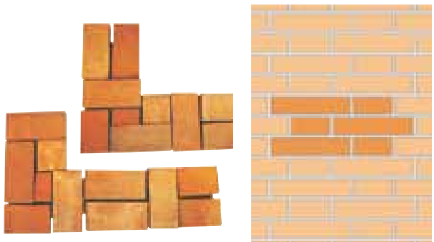
Header bond

This is the arrangement that presents the highest number of vertical joints in the façade and, among all the arrangements for load-bearing brick walls, it is the least strong: this is why it is suitable for not very much stressed brick walls.

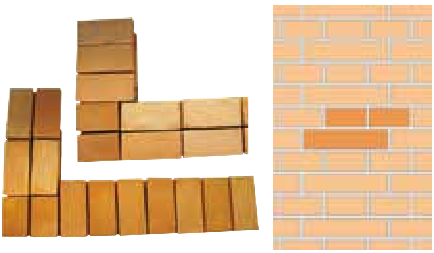


Dutch bond

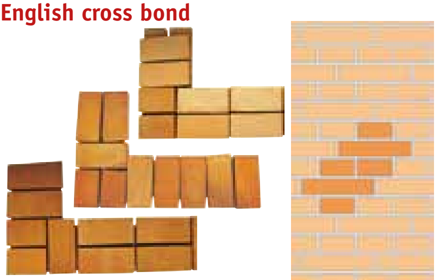
Gothic bond



English bond



English cross bond

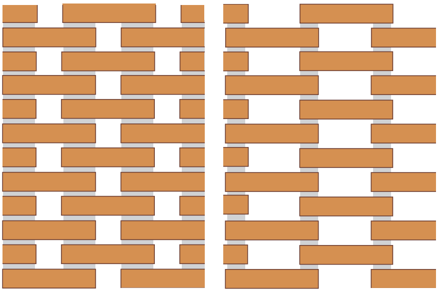


Perforated brick walls

The perforated brick walls, also called pierced walls or brick screen walls, are used for fences or parapets, or to create infill walls for rooms in which the air is expected to circulate. The thinness of the perforated brick walls makes them particularly sensitive to the deformations of the carrying structure (thermal expansion, settlement, etc.): the mortars which join the bricks must be therefore rather elastic, such as, for example, the cement-lime mortars, not excessively rich in cement, or the lime mortars. It is always necessary to work with damp bricks, since the volume of mortar is small compared to that of the brick, and therefore there is a particularly high risk that it will burn itself, thus losing part of its resistance. It is also important that the installer works with great precision and cleanliness, since the irregularities can turn out to be very evident, and the perforated brick walls are difficult to clean.

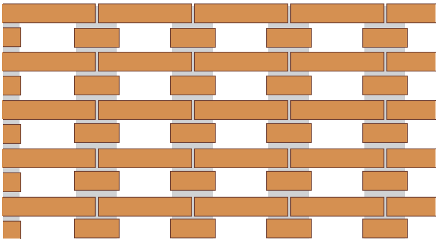
Staggered courses of full bricks

The robustness of the brickwork decreases at the growing of the width of the voids. The bricks are generally overlapped by a quarter, leaving a void with the thickness of one header. Where the perforated brickwork connects with the normal masonry, it is possible to leave voids which are as wide as a quarter of a brick, or it will be necessary to cut by one quarter the bricks of alternate courses of the perimeter brickwork.

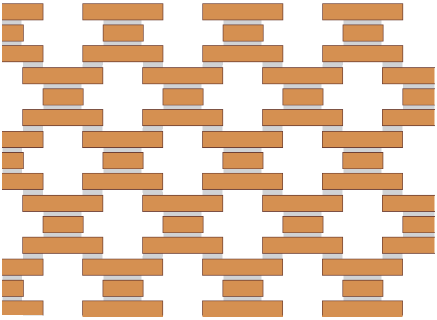


Perforated brick walls in alternate courses

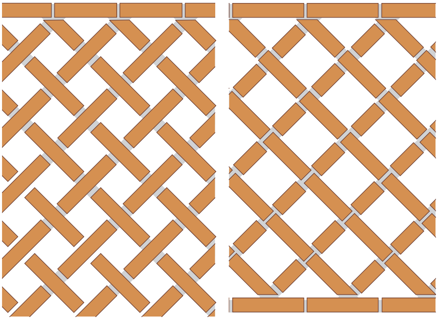
In the most usual version, a course of full bricks is alternated with a course of half-bricks. In this way it is possible to keep the texture of the normal arrangement for cladding walls, with all the pieces laid with their long narrow side exposed (stretchers), and therefore it's easy to insert these perforated brick walls into the masonry texture.



Cross perforated brick walls



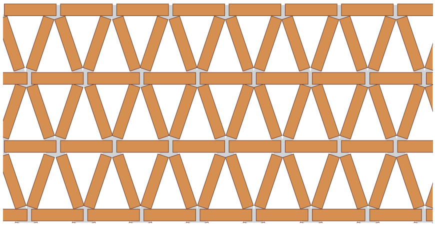
Interweaving perforated brick walls



Perforated brick walls

Diamond shaped perforated brick walls

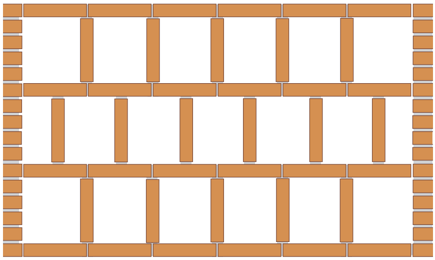
With this arrangement, the horizontal rhythm follows that of the normal masonry texture, while the vertical one is staggered, unless the inclined bricks are not cut to size or the relative mortar joints, almost triangular in shape, aren't slightly oversized.



Perforated bricks with stretchers and soldiers

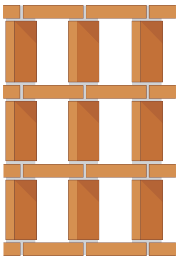
Orthogonal

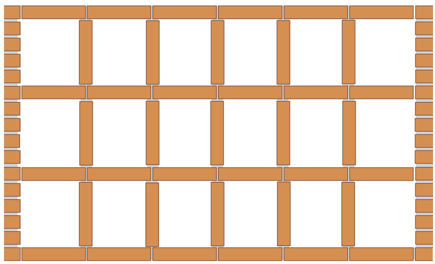
It starts by laying two bricks vertically (soldiers) by means of a small amount of mortar; then it's necessary to proceed by connecting them with a stretcher. A third soldier is then laid, connecting it to the previous bricks by another stretcher and so on, constantly verifying the alignment and the verticality.



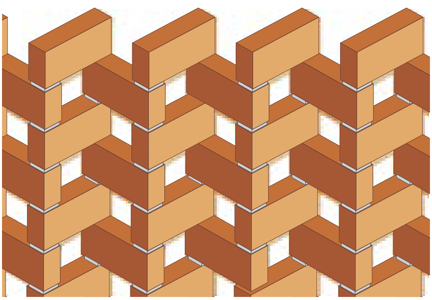
At an angle

The bricks of the course at an angle must be laid with an edge aligned to the front face and the opposite one to the rear face.

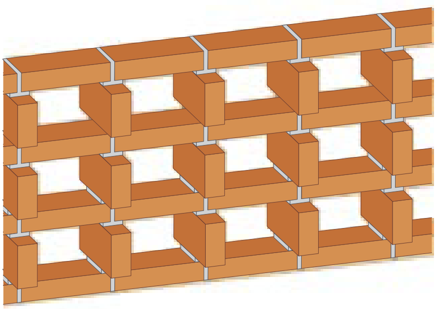




Accordion style



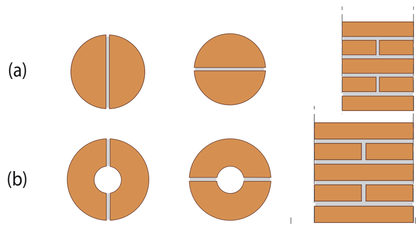
Protruding

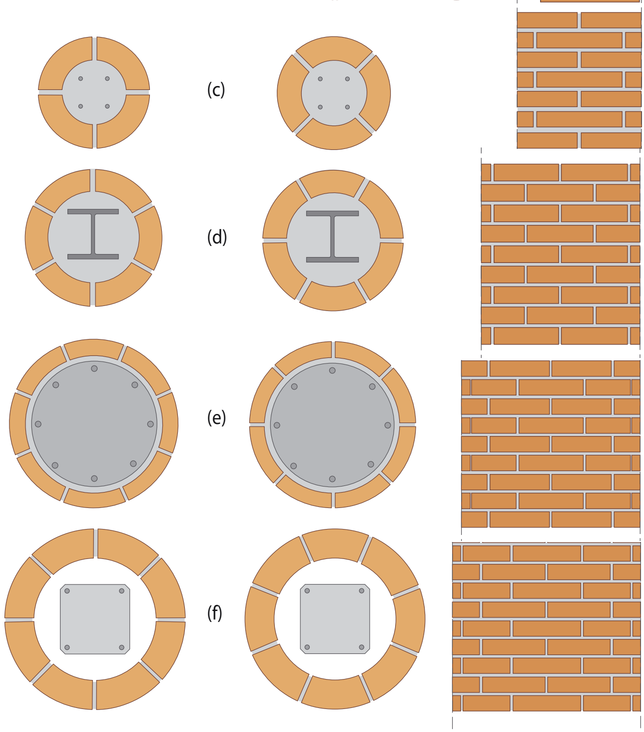


Circular columns

The circular columns in facing bricks, besides giving stability and support to the building, help to modulate the connection to the ground from the point of view of the architectural composition. Some simple precautions can ensure excellent formal results and adequate structural responses.

The circular columns are normally built by using special curved bricks, produced in various curvature radii.
If the bricks act as formwork for the central column in concrete (absolutely not recommended practice for the inconveniences that may arise), it is necessary to proceed with the cast at the rising of the masonry, to avoid the risk of formation of some cavities in the reinforced concrete structure, and to prevent the pillar from being deformed or even slumping at its base, because of the pressure of the concrete which is still fluid; the pressure of the cast may also cause the leakage of mixing water from the joints, resulting in a serious risk of efflorescence, because of the high content of soluble salts in the concrete (which, for this reason, should be as free as possible from its presence): for example, using pozzolanic cement.
It is therefore recommended to always respect an adequate drying time of the mortar joints before proceeding with the cast.
With regard to the regularity of execution, it is necessary to apply the same precautions as described below. (p. 31, *Leveling rods and alignments of reference*).





Types of facing brick columns: (a) with crescent-shaped bricks; (b) with semicircular bricks; (c) with a cast reinforced concrete core; (d) with a steel girder embedded in a concrete casting; (e) with insets to clad a reinforced concrete column; (f) with curved bricks to mask a reinforced concrete column.

Angles and intersections

The resolution of the angle is one of the most delicate problems of construction and composition, especially if it is not a right angle. There are many available solutions: all of them, however, require attention and care both in the design phase and in the executive one.

Right angles

The main rule to be observed in the execution of the angles is the correct toothing of the bricks, easy to make (as long as the dry layout of the masonry has been correctly done before starting) in the one brick thick masonries. In the two or more brick thick masonries, the toothing between the bricks of the angle must be accurately studied in function of the adopted chaining.

Acute and obtuse angles

If the same bricks of the current masonry are used instead of special pieces to create non-right angles, the angles themselves can be made in two ways:

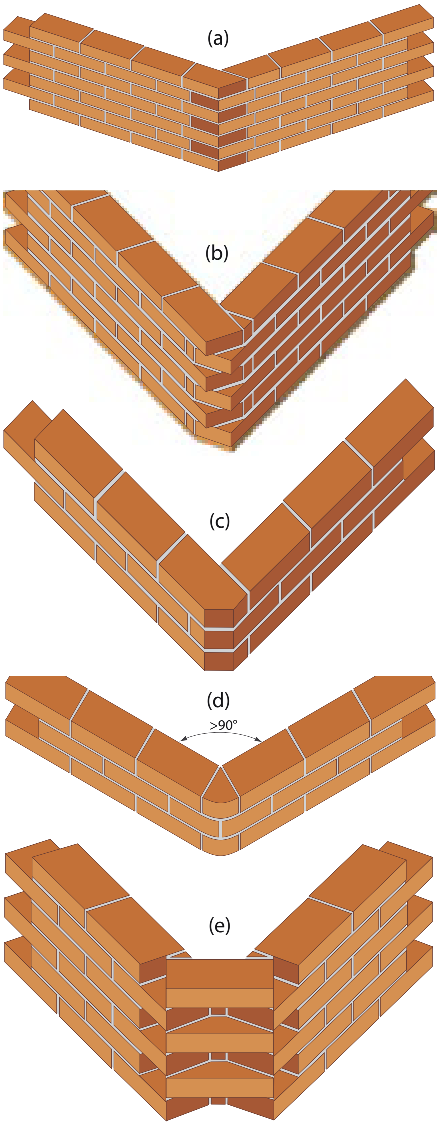
- by cutting the bricks in the direction of the two walls (a) so as to obtain a flat wall, leaving in view the cut faces (a solution which is not recommended for soft-paste bricks);
- by using whole bricks with protruding or re-entrant edges (b). Although far from being a difficult constructive detail, since it very visible, you have to put a lot of care in the finishing of the joints.

Special pieces

The connection between two walls can also be solved by the use of special bricks, both standard and custom-made (c,d). The standard "special" bricks are generally used for right angles, both beveled and rounded.

Complex angles

The angle can also be solved by placing a whole brick on his bisector, thus dividing it into two obtuse angles (e). In alternate courses it will be necessary to close the brickwork with brick insets.

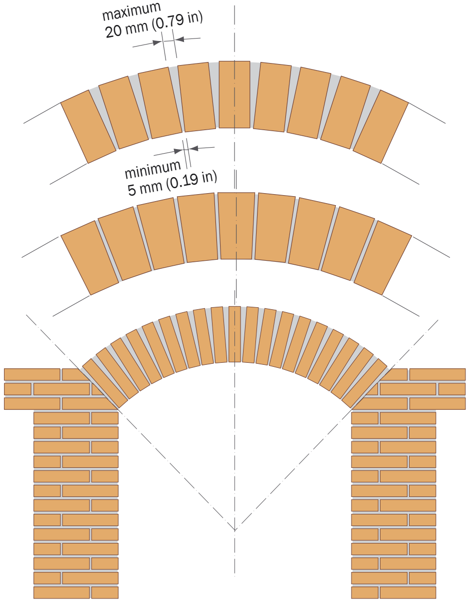


Various solutions of "special" angles.

Arches and platbands

The arch is the great theme of architecture in load-bearing masonry. Although nowadays, thanks to the new materials (steel, reinforced concrete, etc.), it is no longer an inevitable solution, it is used to give a gestural language to the wall, to relate it to the human scale.

The arches are usually made using common bricks. The curvature is obtained by creating wedge-shaped joints: the greater the radius of the curvature, the smaller the difference of width of the joint between the soffit and the extrados. The width of the joints is normally not less than 5 mm (0.19 in) at the narrowest point and not more than 20 mm (0.79 in) at the widest point.



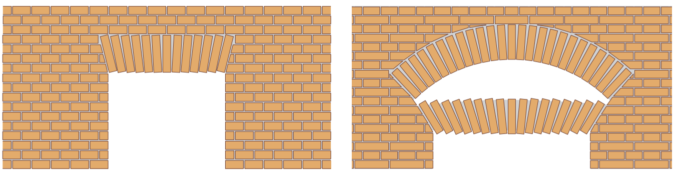
Construction of depressed arches and platbands

For depressed arches and platbands, before beginning the construction of the arch, it's necessary to lay further courses of masonry beyond the line of impost in order to create the inclined planes of impost.

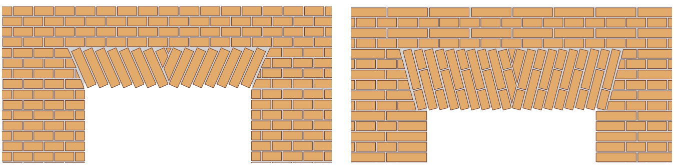
Platbands

The ashlars of a platband are arranged inclined or radially like those of an arch (and therefore it pushes on the abutments); however, the soffit of the platband is flat like that of a lintel.

The platband doesn't require the predisposition of a particular centering but simply the use of a robust wooden plank as a temporary support. The span doesn't normally exceed the measure of one metre and a half (five feet) and the most common configurations have a ratio between radius and span which is between 1 and 2.



Roman style platbands: simple and relieved of the upper weight thanks to a discharging arch (also called relieving arch).



French platbands: simple and heart bond with semi-interlocking behind.

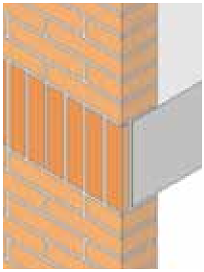
String courses

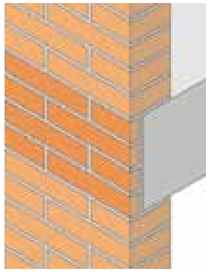
There is a number of reasons, both technological and formal, for wanting to mark a level as “special”: to highlight the position of the floor (which in any case would show itself over time); to “mark” some noticeable heights of the elevation (sills, lintels, etc.); just for the pleasure of enriching, or “measuring” the rhythm of the facade.

The fall of thermal resistance at the level of the floor may cause markings, which become less visible if you adopt a string course of a different colour, or with a different arrangement of the bricks.
The string courses, sill courses, etc, can be executed in four different ways:

- by changing the colour of the bricks;
- varying their arrangemente on the surface of the facade;
- making them protrude or re-enter;
- using different-shaped bricks or specially sawn.

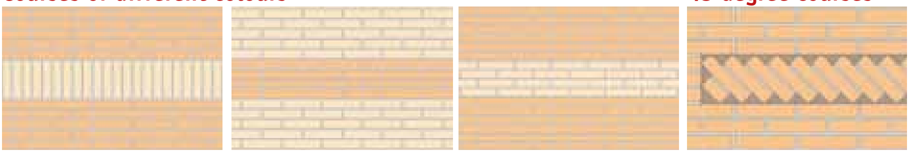
In this case, the batten must be cut while it’s damp (with
abundant clean water) and accurately washed to avoid that the dust which originated may deposit itself on the surface of the same element, with possible consequent variations of shades of colour and difficulties of adhesion (in any case it’s recommendable to require battens and angle bead directly from the manufacturer).



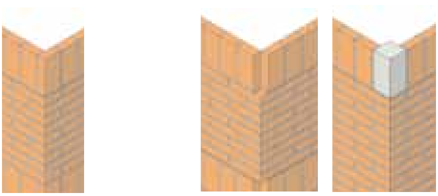


Courses of different colours

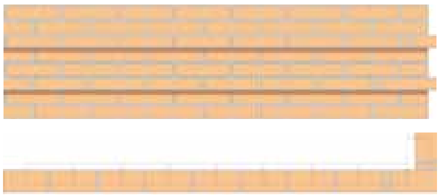
45 degree courses



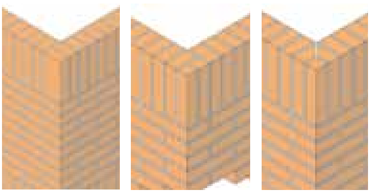
Sailor courses



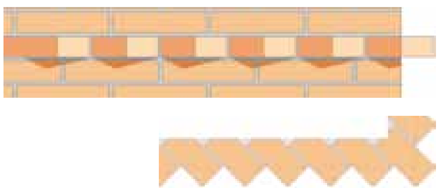
Protruding stretcher courses



Soldier courses



Protruding setback courses

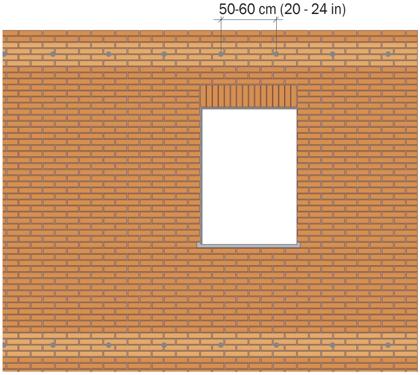


Wall ties

The function of the wall ties is to tie the two walls of a double-layer masonry, so as to create a more stable and resistant whole, especially against the action of the wind.

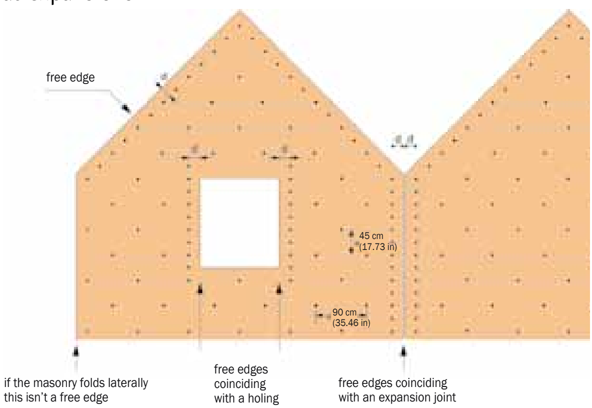
There are two fundamental ways to tie the walls: few robust wall ties at the level of the slabs, or many regularly distributed thin wall ties.
The first method is more simple to be put into practice, but it makes the two walls only partially integral with each other: the second, which ties the two layers of the masonry very well, nevertheless requires a close dimensional coordination between the two brick walls and a greater attention in the executive phase.

The wall ties, also called wall cramps, are normally made of austenitic stainless steel (18% chrome, 8% nickel) but can be also made of galvanized steel, polypropylene or alloy, and they are available in various lengths.
Generally the ties are equipped with a device that prevents the passage of moisture from the external layer of the brickwork to the internal one: for example a washer, which can be given the task of supporting the eventual insulating mat. In particular, in the helical tie, the twist of half a turn, besides acting as a drip, allows differential expansions of the two walls.
If the two faces of the wall are built at different times - as it often happens - it is possible to use ties with one end arranged for the use of chemical or expansion anchors.
A technique whose use is more recent is that of the wall tie with tracks equipped with claw-bars, which must be sunk into the concrete casting: the wall ties are gradually inserted while the facing brick wall is being constructed.



Wall ties at the level of the slabs.

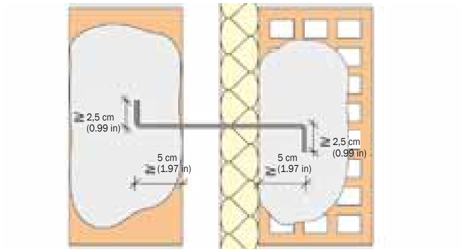
The same kind of track can be fastened to a steel or wooden structure in order to obtain a masonry in which the layers are more integral with each other.



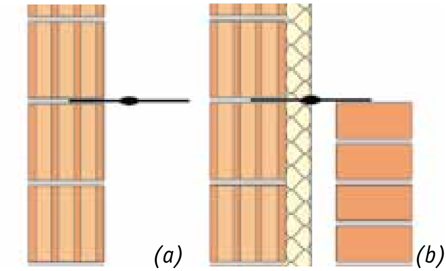
Wall ties distributed at the level of openings and free edges.

Wall ties

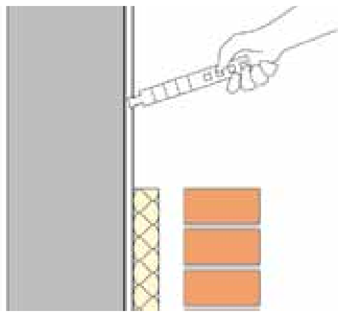
Method of insertion of the wall ties
The wall ties must be placed on a mortar bed and then covered with further mortar. It's a mistake to install them directly on the brick and then cover them with mortar or, even worse, to insert them frontally into a previously made joint.



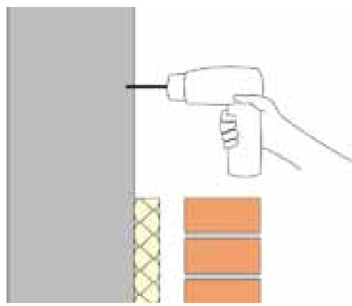
The wall ties must be inserted first into the joints of the internal layer (a) and then into the joints of the external one (b): this requires a careful dimensional coordination between the two masonries, which is not always feasible,
The wall ties, inserted into the internal layer before the installation of the external cladding, must never be bent upwards.



If the internal layer is made of concrete, the wall ties can be inserted into a track which has been previously drowned in the casting...

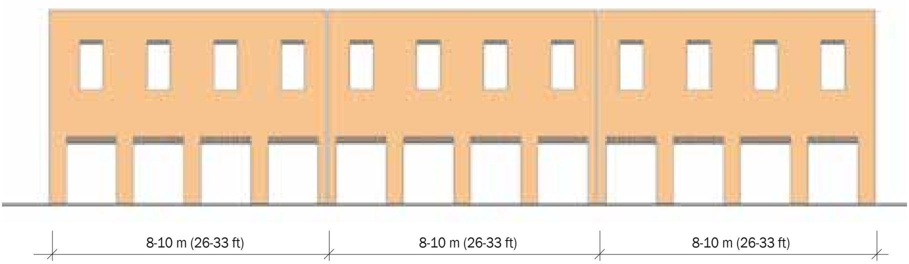


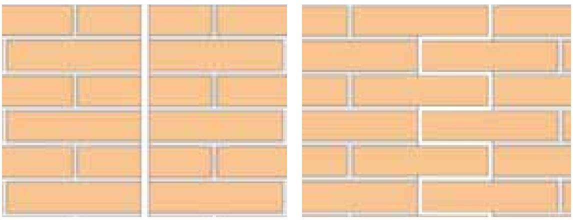
... or by drilling holes on the internal layer, in coincidence with the joints of the external vestment, inside which the wall ties with nogs will be inserted.



Expansion joints

In order to compensate the thermal expansion to which the structure will be inevitably subjected, the facing brick façades must be divided every 8-10 metres (26-33 ft) by a vertical joint (however, a joint every 35-50 metres - 115-164 ft - is enough in the case of reinforced concrete structures).



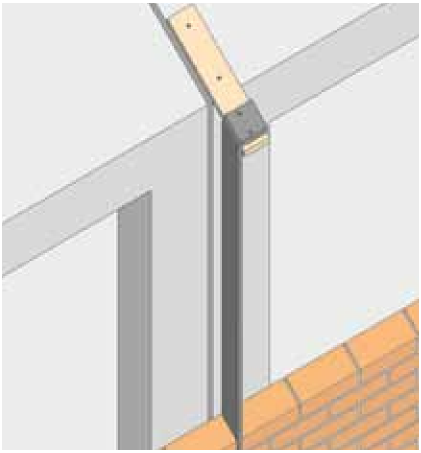


The two basic types of vertical expansion joint for the facing brick masonries: straight and toothed. Both of them must be closed by using an elastic sealant.

During the construction of the wall, in order to prevent the mortar from overflowing into the expansion joint, thus obstructing it, the joint itself must be protected by a filling that can be permanent (elastic and compressible filling) or temporary (rigid filling).

Permanent elastic filling

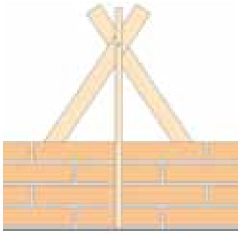
A semi-rigid band in closed cell polyethylene is hung vertically on top. The wall is then built in parallel on the two sides of the joint. The band should be kept some centimetres back from the line of the facade, in order to leave the possibility to seal the joint, once the installation has been completed, with a material which is chromatically homogeneous with the masonry.

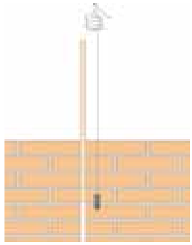


Expansion joints

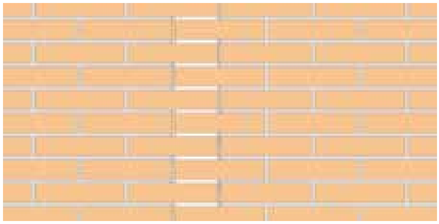
Rigid temporary filling

The straight joint is temporarily "occupied" with a wooden plank, kept in vertical position using some transverses. As the construction proceeds, the plank must be gradually removed; the part of the wall which has already been constructed will bear it, without the need of any other support. However, the verticality must be checked constantly.





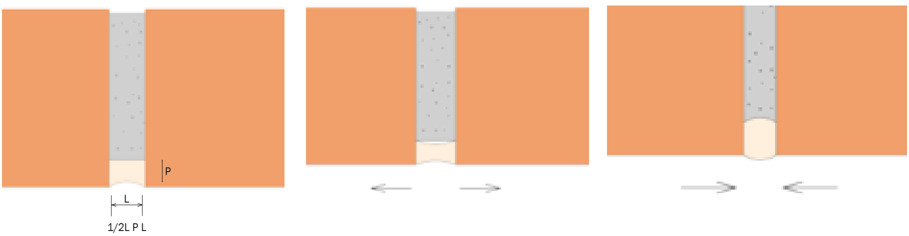
In toothed joints, while the wall is being constructed, it is necessary to interpose tablets, as high as a brick plus the thickness of two horizontal joints, which prevent the mortar from filling the spaces of the expansion joint (both the horizontal and the vertical joints must remain empty). It is good that the tablets protrude from the wall, in order to be easily removable in the end.



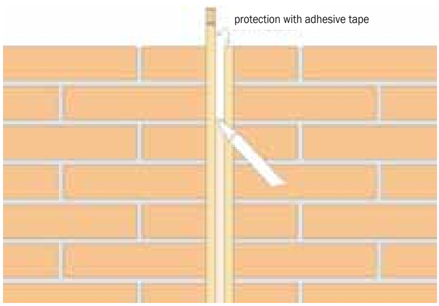
Sealants

Once it has been created, the expansion joint must be sealed with an elastic material. The walls of the joint must be perfectly free from any traces of mortar.

The layer of sealing material must not be too deep, so that it can expand or contract without getting detached from the lateral walls.



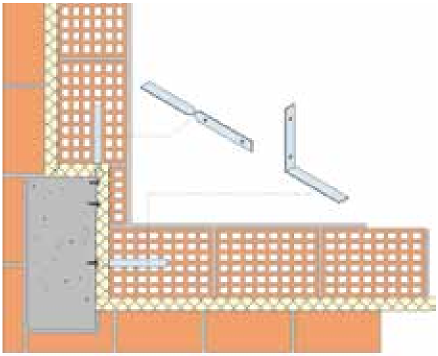
When you apply the sealant, the bricks on the sides of the joint must be protected with adhesive tape: the sealant, once it has been polymerized, is very difficult to remove!



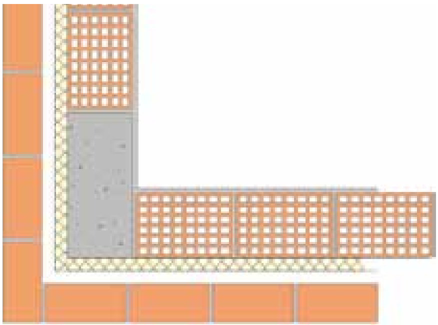
Thermal insulation

Besides being properly designed and constructed, the buildings must offer performances in line with the regulations also from the point ov view of the thermal insulation, and therefore the internal comfort. Forming an additional external layer to the infill wall, the facing brick cladding allows to ensure excellent levels of quality in the inhabited spaces, by means of the stratification and the specialization of the brickwork.

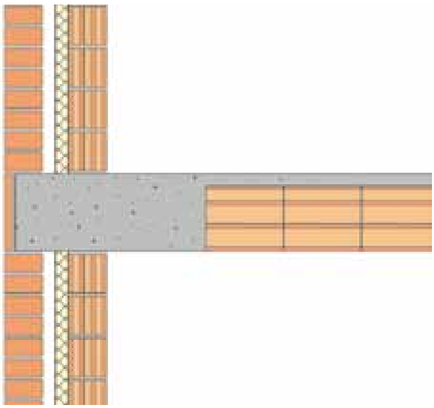
In the case of framed structures, the elimination of the thermal bridge in coincidence with the pillars can be obtained by means of their insulation on the internal side...



... but an undoubtedly more effective solution is the one which provides the placement of the insulation on the outside of the pillars and the presence of a cavity that is capable of disposing eventual moisture and steam.



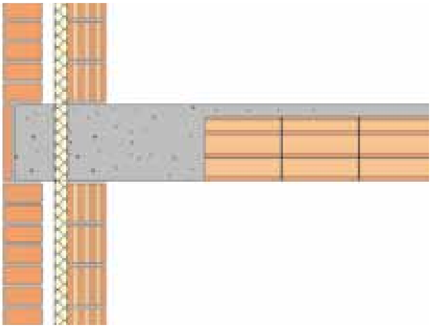
Interrupting the insulation at the level of the slab, there is the formation of a significant thermal bridge. If subjected to a different thermal regime compared to the rest of the wall, it is likely that the batten which hides the slab will assume a different and unwanted coloration; it is therefore recommendable to insulate also the slab with an insulating layer: for example, a mineral fibre sheet.



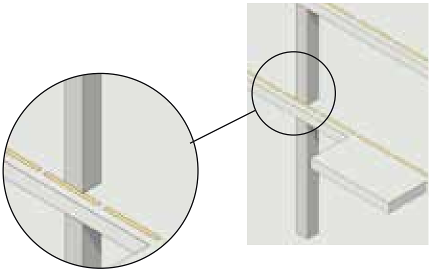
The elimination of thermal bridges allows to prevent energy wastes and subsequent pathologies (see p. 36).

Thermal insulation

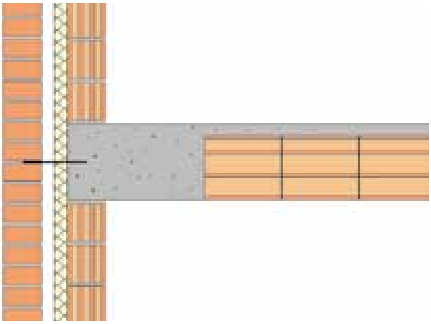
The thermal bridge can be almost completely eliminated by interrupting the slab with an insulating layer...



... for example, by inserting strips of insulating material in the formwork before the casting: the thermal bridge, although substantially reduced, remains in the connection points between the two parts of the slab.

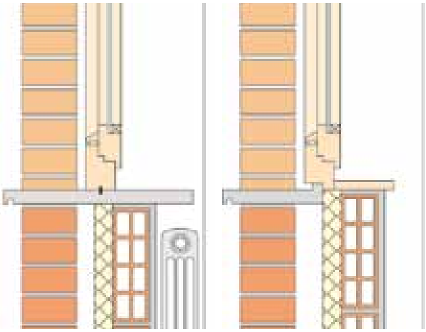


In order to totally eliminate the thermal bridge, the brickwork must be totally removed from the structure, and anchored to it by means of appropriate metal fastening systems (wall ties).



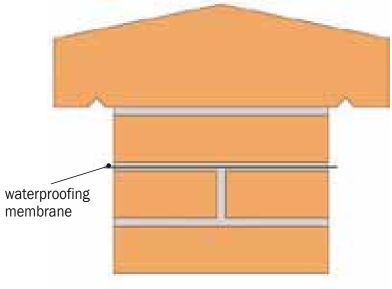
The classic continuous window sill made of stone constitutes a further thermal bridge, worsened by the fact that the radiators are usually placed under the window.

The thermal bridge, in this case, can be effectively eliminated by interrupting the outer sill in coincidence with the insulating layer and placing a separate counter-sill on the internal side (see p. 38).



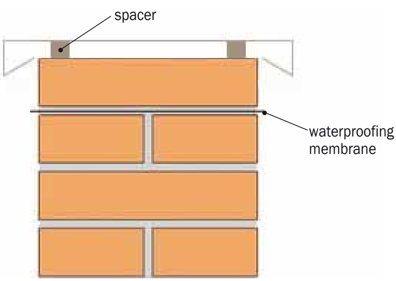
Protection from the rain

In order to avoid annoying efflorescences caused by the penetration of rainwater, there are few and simple adoptable solutions, which however must be carefully executed.

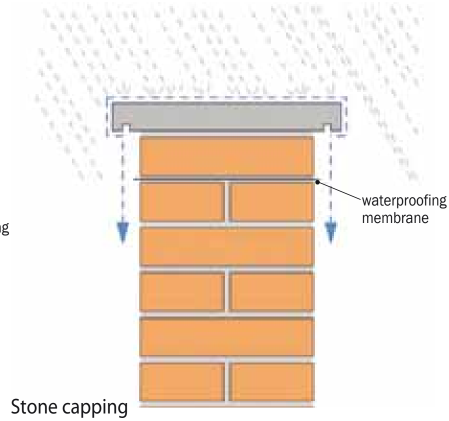


Clay capping

Whatever material of which it's made, the cover must be protruding and it must have a comfortable and efficient drip (it is not recommendable to use extruded bricks).



Metal capping



Stone capping

A solution "in line" with the facade can be adopted only when there is the certainty that the wall will be protected from the rain in any case, or when the climate and the orientation allow it.

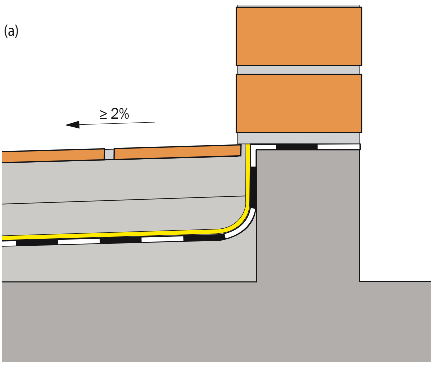
Presence of moisture

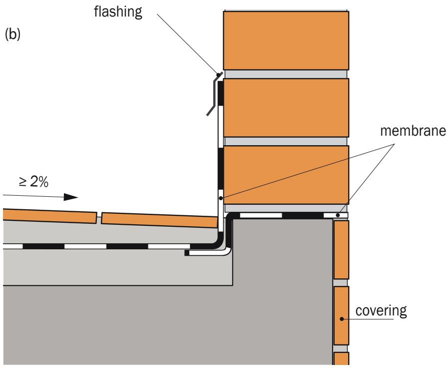
The moisture is not a pathology in itself, but it can be the cause of a lot of problems (efflorescences, blobs, sinkings, etc.), which it's good to prevent. A well designed and well built brickwork will never have such a moisture level as to generate pathologies.

To prevent the capillary rise

The pavement at the base of the wall (a) must have a slope which can remove the rainwater.

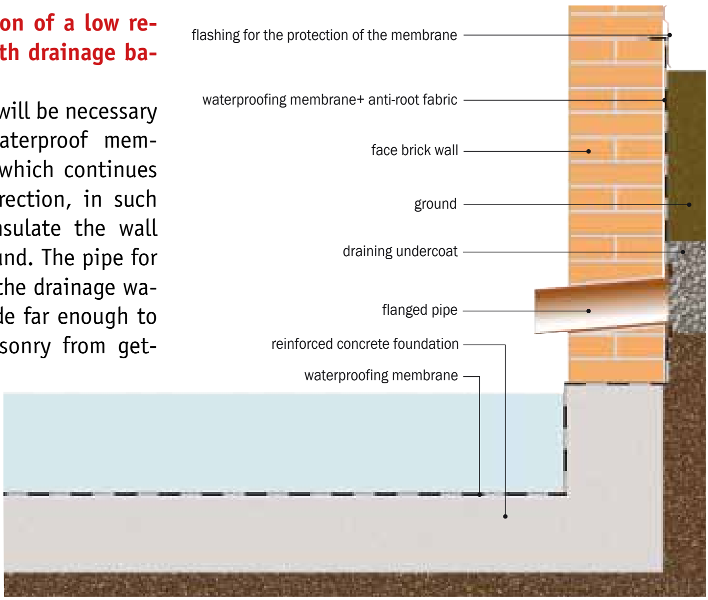
In the case of overhangs or projections (b) at the level of the parapet, it is recommendable to use a protection at the base of the latter.





Correct execution of a low retaining wall with drainage basin

For the basin it will be necessary to install a waterproof membrane covering which continues in a vertical direction, in such a way as to insulate the wall against the ground. The pipe for the disposal of the drainage water must protrude far enough to prevent the masonry from getting wet.



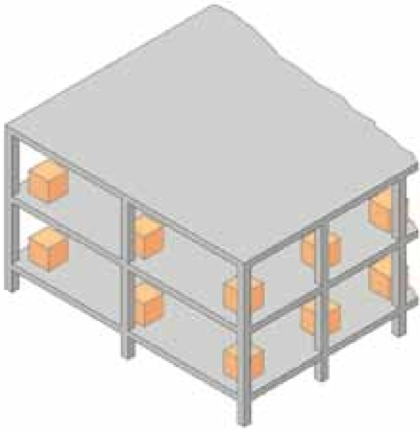
Storage and protection of the materials

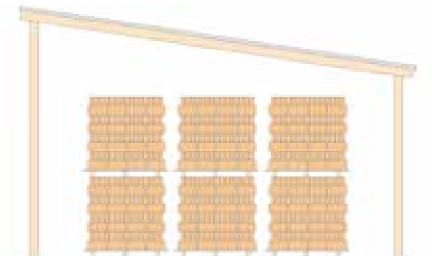
The protection of the materials on the building site is a simple and inexpensive precaution to favour a correct and fast installation and obtain a good final result.

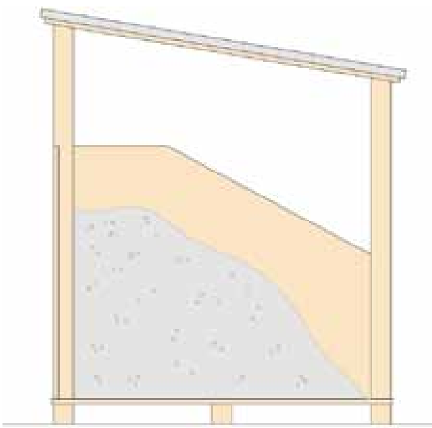
The bricks must be protected from the rain and the dust of the building site by using a canopy. As an alternative, it's necessary at least to cover them with a waterproof fabric. They must be put down on a plane horizontal and dry surface, not in direct contact with the ground, possibly leaving them on the pallet on which they have been delivered on the building site. If the bricks are placed directly on the slabs, it is recommendable to position them near the pillars, so that they won't obstruct the passage and the slab won't be overloaded: a pack of full bricks normally has a weight between 7 and 9 quintals, while a pack of semi-full bricks weighs between 5 and 6 quintals; it's good to ask a structural engineer for a previous consultation anyway.

The packs usually contain 400-450 bricks (a little less than a cubic metre).
Since it is not recommendable to overlap more than two packs, a surface of at least one square metre every 8-900 bricks is required.

The execution of a facing brick wall normally requires sand and binders which are different from the ones used for other works; they must be therefore kept separate from other types of materials and deposited on a solid, clean and dry base. The storage location must also be protected from the rain, especially if there is a risk of frost.





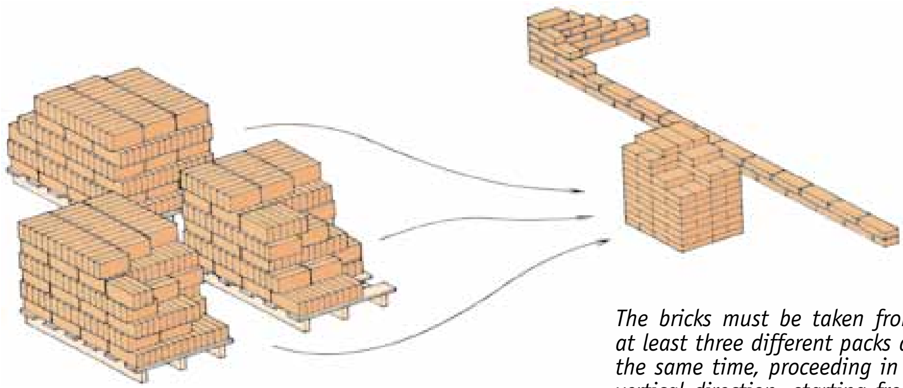


Precautions for a correct protection and installation of the materials on the building site.

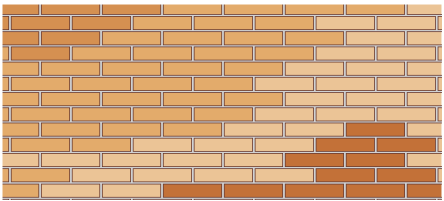
Blending of the bricks

Bricks of the same manufacturing lot, but slightly different from one another, if clustered can create inacceptable blobs or stripes of colour, whose size is unfortunately noticeable only after the removal of scaffolding.

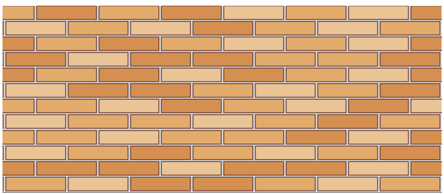
Since the inevitable variations caused by raw materials and by the firing may lead to differences not only in colour but also in size, the blending of the bricks also helps the installer to maintain a regular width of the vertical joints during the construction of the brickwork. Nevertheless, the blending alone may not be sufficient to effectively eliminate the colour variations between lots delivered at different times: this problem can be overcome only by alerting the manufacturer of the overall supply before the works start.



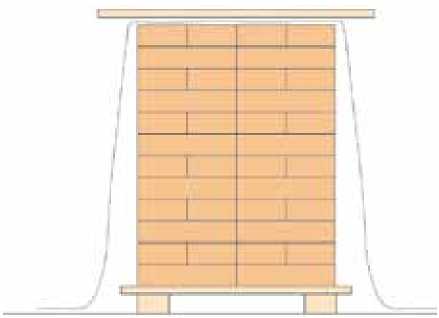
The bricks must be taken from at least three different packs at the same time, proceeding in a vertical direction, starting from an edge, and not by horizontal layers.



Laying the bricks taken from just a single pack may produce a blotchy masonry.



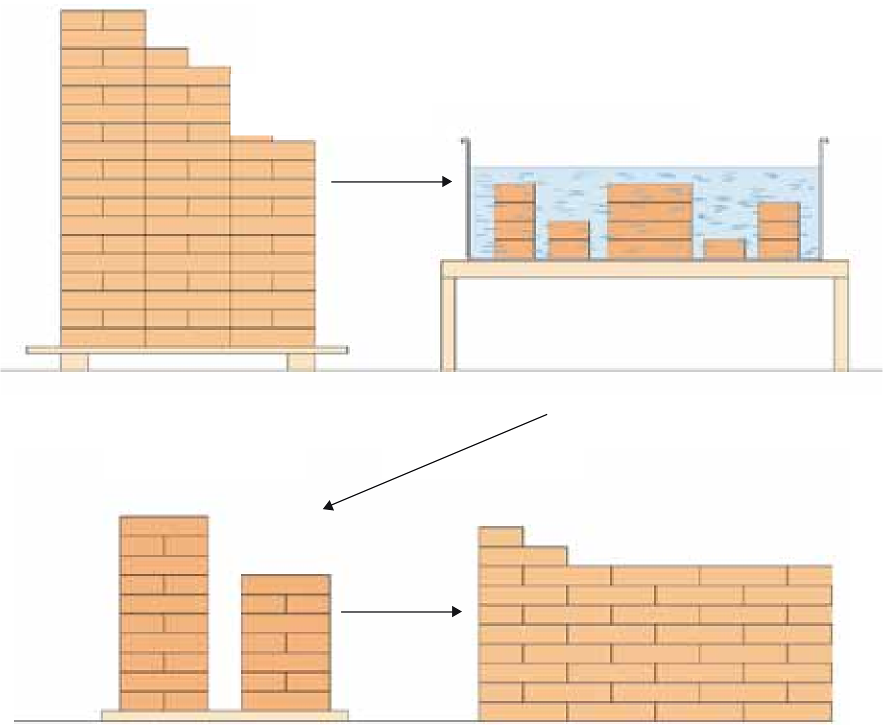
By contrast, a proper blending allows to create a masonry in which possible chromatic irregularities are evenly distributed.



The stacks of bricks must always be kept raised from the ground or the level of the scaffolding, in order to prevent the bricks themselves from getting dirty, and it is also necessary to protect their top with wooden planks and plastic sheets.

Wetting of the bricks

The bricks have a porous structure that absorbs the mixing water of the binder. This characteristic may lead to the "burning" of the mortar, because it subtracts the water required for the hydraulic setting, thus jeopardizing the mechanical properties. The greater the porosity of the brick, its absorption capacity and the ambient temperature, the lower is the relative humidity value of the air, the more evident this phenomenon may become. The installation must therefore be different depending on the season in which it takes place: winter or summer. In order to overcome these problems, when necessary, the bricks must be dampened before being used, in different modalities depending on their absorption capacity. In any case, the laying of facing bricks in the colder months, when the temperature can drop below 0° C, is not recommended. To be absolutely avoided the use of antifreeze additives in the mortar.



Generally, whether they are obtained by extrusion, hand-moulded or produced industrially in soft paste, the bricks must be dampened before being used anyway. The water must be clean and absolutely free of residues of lime, cement or soil. The bricks must be handled with care to prevent them from bumping into one another, with the consequent risk of chipping. The worker who immerses the bricks into the water or takes them out of it must have clean hands (if his hands were dirty with cement, this would end up getting into the water and, from there, it would be absorbed by the bricks).

Wetting of the bricks

Type of brick	Absorption	Winter	Summer
Extruded bricks obtained from clays free of carbonates (usually red bricks)	8-14%	No need of wetting	Irrigation by means of a jet of water on the packs without the packaging
Extruded bricks obtained from clays free of carbonates (usually red bricks)	14-20%	Usually there's no need of wetting, but a check with the sample masonry panel is always recommendable (p. 26)	Irrigation by means of a jet of water on the packs without the packaging
Soft paste and hand-moulded bricks, with low absorption capacity (usually red bricks)	13-17%	Irrigation by means of a jet of water on the packs without the packaging	Wetting by immersion
Soft paste and high absorption bricks (usually pale bricks)	18-25%	Irrigation by means of a jet of water	Wetting by immersion

Methods of wetting suggested according to the types of bricks and their level of water absorption.

In the case of non-uniform wetting, there may be the formation of unexpected differences of colour tones, with a “spot” effect, which will remain even after the drying of the completed brickwork.

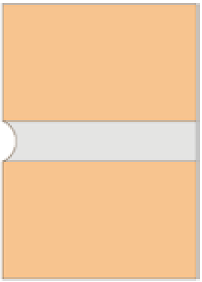
In the case of wetting by immersion, the bricks must be left in the water until the air bubbles stop to come out (wetting until saturation). Removed from the water, the bricks must be stacked nearby the workplace and left to drip for at least a quarter of an hour. If the pre-wetted bricks were laid immediately, they could cause drippings; in addition to this, the layer of water which would remain between the mortar and the brick could cause the adhesion failure between the two surfaces and reduce the resistance of the joint against the infiltration of rainwater.

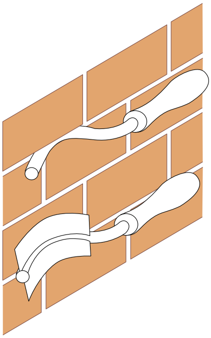
Bed joints

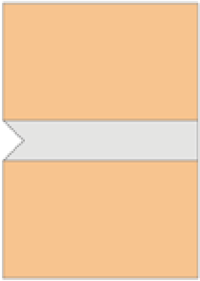
The thickness of the joints is usually around 10 mm (0.39 in), which can be reduced up to 4-5 mm (0.16 - 0.2 in) or increased up to 20-25 mm (0.79 - 0,98 in): very small joints make the brickwork construction very difficult, because it acquires a compact and uniform appearance; very big joints favour the speed of execution but may weaken the masonry and make it more vulnerable to the elements. Even before having an aesthetic purpose, the use of tools for the joints sealing has the primary function of compacting the mortar of joints, so that it adheres to the surface of the bricks.

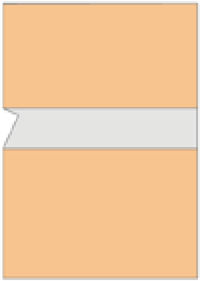
Keyed pointings or key joint pointings

The tool for the execution of this type of joint can be easily created on site, by bending a small, round and smooth, iron bar, with a diameter which is slightly smaller than the thickness of the joint to be made; the round iron bar can also be equipped with a handle and possibly with wings (or tongues), which are useful to keep constant the depth of the joint.



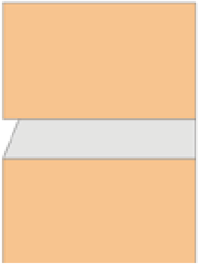






V-shaped joints, struck joints or weathered struck joints

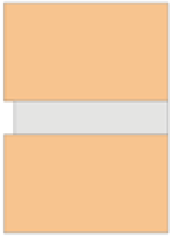
The execution of this type of joint requires only the use of the trowel. You have to slide it with the upper edge against the soffit of the brick above, leaning the blade on the edge of the brick below, with a fixed angle between 45 and 60 degrees.



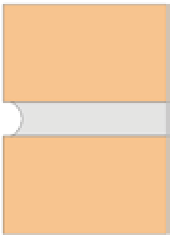
Bed joints

Slightly concave joints

Tools for the execution of concave joints with a rectangular and rounded section. This type of joint emphasizes the regularity of the brickwork and is therefore particularly suitable for extruded bricks, whose edge is perfectly straight.

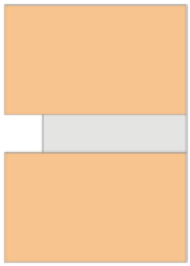


When you slide the tool, you must not press too much, in order not to spoil the facing side of the bricks.

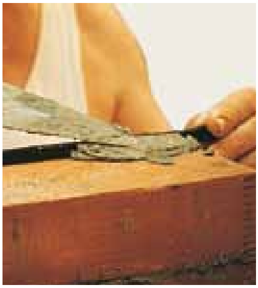


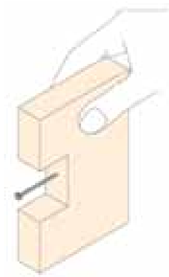
Recessed joints

Small dolly on which is mounted a steel bar with adjustable projection.
As an alternative to the dolly, it is possible to place an iron bar with a square section along the outer edge of the joint, and remove it once the laying is finished. It is fixed to the masonry by using a little bit of mortar every 80-90 cm (about 31-35 in).



A simple wooden shape with a protruding nail driven into it allows to “dig” the joint when it’s still fresh.





Sample masonry panels

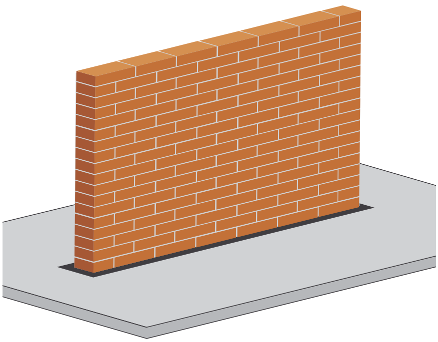
Before starting the works of installation it is always recommended to build on site a sample masonry panel in such a way as to define and check in advance the executive methods, the aesthetic result expected from the project, the quality of the materials to be used and the level of precision and care which is expected from the installer.

A sample masonry panel must be built using at least 100 bricks (almost 2 square metres - about 21 square feet) on a proper plane, and it must be examinable from a distance of about 3 metres (little less than 10 feet) and in good natural light conditions.
The sample masonry panels are extremely useful to:

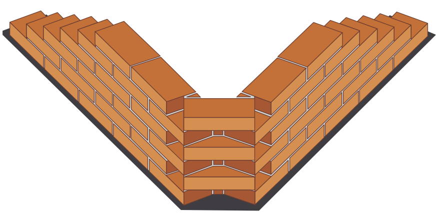
- check the quality and the characteristics of the materials which compose the mortars (such as the granulometry or the type of binder), that must be specific for the facing brick, and therefore presumably different from the ones that are normally used on the building site: this advance check allows the contractor to obtain in time the supplies of the eventually missing materials, thus avoiding the suspension of works when the installations is already started, or, on the contrary, to begin the construction of the first section of the masonry with unsuitable materials (for example a type of sand whose granulometry is bigger than expected) and then continue it with the right ones, causing variations in the colour or in the exterior finish in the same building;

- choose the most suitable type of joint, as well as the colour of the bedding mortar;

- determine a reference sample approved by the designer for the entire period of the works, which the building company can use as a model;

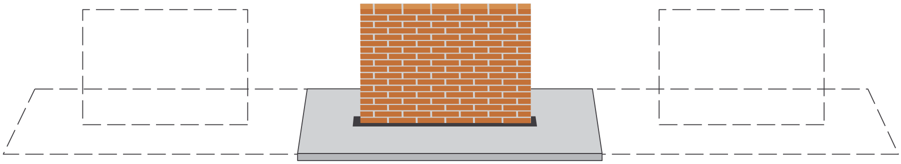


Example of a sample masonry panel.



Example of a corner solution with bricks arranged at 45°.

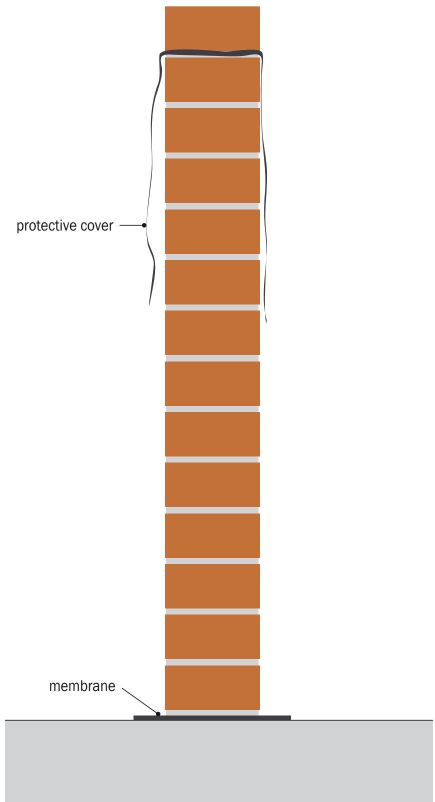
Sample masonry panels



Further sample masonry panels may be requested by the clerk of works if disputes arise. They must be constructed beside the first sample masonry panel, in the same exposure conditions.

- determine an acceptable level of defects, such as small irregularities of the surface, chippings, small stones or particles of lime, which are present in the brick at the time of delivery on site: these assessments must be carried out by examining a proper sampling taken from the delivered lot;
- ensure the regularity and continuity of the work, even in the case of change of the workers.

Even in a small building site, the sample masonry panel must be built at least fifteen days before the date set for the start of installation, so that the building company eventually has the time to get properly equipped, as well as to rebuild the sample masonry panel if the first hasn't been approved.
If the panel must also be used for the choice of the type of brick to be adopted, it has to be built at least one or two months before starting the laying, in such a way as to leave enough time for the order and the delivery of the material.



To prevent the sample masonry panel from deteriorating, it is necessary to build it on a waterproof membrane and protect its top from the rain.

The mortar

The function of mortar in a facing brick masonry is important not only for the solidity of the structure but also for its resistance to rainwater and the resulting chromatic effect.

The mortar is a blend made, in varying proportions, of a binder, aggregates and water, in order to obtain a plastic mixture which has the capability to harden in a more or less long time, depending on the substance which has been used as binder. The aggregate has the task of increasing the volume of the blend, facilitating the passage of the carbon dioxide required for a good setting (or hardening) of the mortar and preventing the volumetric shrinkage with consequent formation of crazes.
The binders, by chemical reaction in the presence of water, cause the union of the particles of aggregates, otherwise inconsistent. The binders which are generally used for the making of the mortars are air lime, hydraulic lime, cement.
Depending on the components which are used, the mortars can be classified into:

- coarse stuff: prepared with air lime
- hydraulic mortars: prepared with eminently hydraulic limes
- cement mortars: prepared with cements
- cement lime mortars: prepared with two or more binders.

Sands of different granulometries.

It's recommended to preferably use mortars with lime only or cement lime mortars, which are generally more plastic, easy to work, with a better adhesion to the brick and with less aptitude for the formation of efflorescences. It is always necessary to be very careful in the use of cements with secondary components which may cause unwanted phenomena of efflorescence. For the normal works, the following dosages are recommended:

- cement lime mortar: from 150 to 175 kg of cement and from 175 to 275 kg of hydraulic lime per cubic metre of dry aggregate, that is one part of cement, one and a half part of lime, six parts of aggregate;
- lime mortar: from 400 to 450 kg of hydraulic lime per cubic metre of dry aggregate, that is two parts of lime per five parts of aggregate.

In any case it is necessary to comply with the related legislation issued by the competent bodies. Silica sand is generally used as an aggregate. It must be clean, it must not contain clayey substances, and its granulometry must range between 0,1 and 3,15 mm. In various parts of Italy, the pozzolan is used instead of sand. Especially in the lime mortar, it ensures high quality performances, giving also the blend its "hydraulicity", that is the ability to have a fast setting also in immersion.
The mixing water must be pure, clear, free from extraneous substances (soluble salts, organic substances, fats). And it's necessary to prepare, from time to time, the amount of mortar which is usable in a time span of about two hours, that is before the start of the setting phenomenon.

Reference standards

In the supplementary general conditions, in addition to the main executive prescriptions which are essential for the success of the work, it is always recommended to indicate the requirements for the materials, taking into account that, in accordance with the Regulation 305/2011, all the facing brick elements must have the CE marking from the manufacturer as provided by the specific UNI EN 771-1 standard.

The Regulation (EU) No. 305/2011 of the European Parliament and of the Council, "laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC", provides that the built works meet certain "essential" requirements, thus ensuring safety and comfort to the users.

In order to meet such requirements, the products must in their turn ensure specific performance characteristics, about which the manufacturer has to inform the market in an unequivocal manner.

As regards the facing brick elements, these requirements are specified in the regulation (UNI EN 771-1, "Specification for masonry units. Clay masonry units").

The compliance with the UNI EN 771-1 and the guarantee of a systematic control in the manufacturing unit, once the DoP (Declaration of Performance) has been issued, allow to mark the products (in accordance with the legal obligations) with the CE mark.

The latter can be printed directly on the material, or on the packaging, or on the documents accompanying the goods on their path toward the market.

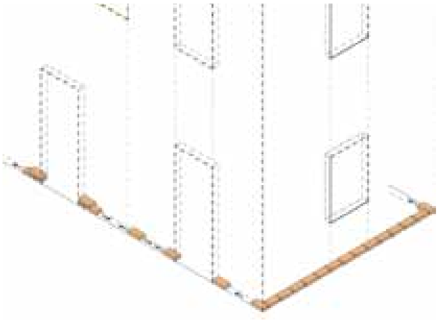
Mechanical resistance and stability
Safety in case of fire
Hygiene, health and environment
Safety in the use
Protection against noise
Energetic efficiency and thermal insulation
Sustainable use of natural resources

Essential requirements of the construction products according to the European Regulation 305/2011.

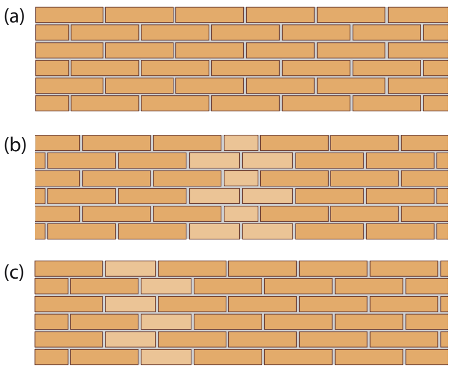
Modularity and dry verification

Before starting with the laying it is necessary to check, by means of a dry verification, if the position of doors, windows and edges coincides with the normal pace of the masonry. If it doesn't, it will be necessary to adjust the width of the mortar joints, or proceed to cut some bricks.

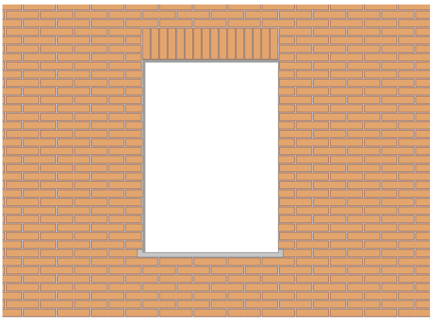
In a facing brick wall it is important that the masonry backgrounds are harmonious and regular. In particular, the perforations of the doors and windows must look perfectly inserted into the masonry texture and not be randomly cut within a regular grid. It is normally possible to make small adjustments of the position of the perforations, depending on the masonry texture. If the size and the position of the windows can't be changed even of few centimetres, the masonry texture must be adapted to these design constraints in such a way that the adjustment which has been done isn't too evident.



The dry test of the bricks before starting the installation allows to check whether cuts of bricks, adjustments of the joints or of the position of perforations, are necessary.



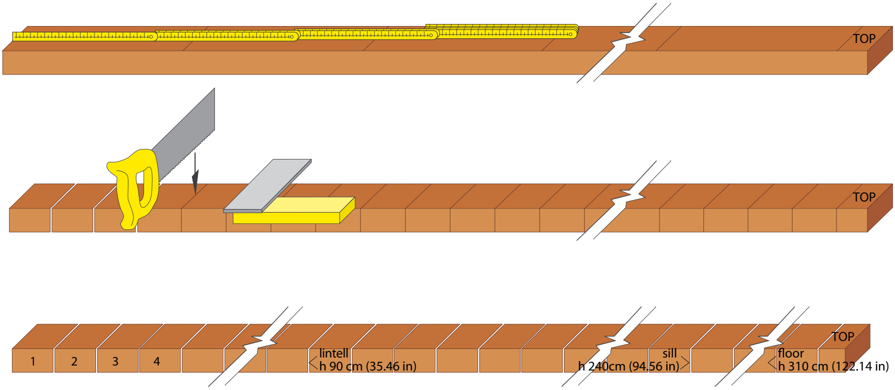
Example of a wall which has been properly dimensioned depending on the pace of the adopted masonry (a). To build the brickwork it's not necessary to cut any brick (if the "half bats" for the extremities have been ordered). The adjustment can be done by cutting the bricks in the central part of the wall (b), or those placed just before the two extremities (c).



To obtain symmetrical abutments it is possible to make an adjustment by inserting a half bat in the odd courses and a couple of three quarter bats in the even courses. This "irregularity" will be uniformly repeated from the bottom to the top of the masonry.

Leveling rods and alignments of reference

In a properly executed masonry, the courses must be equally spaced and perfectly horizontal; the vertical joints must turn out to be aligned on the entire surface of the wall. To obtain this result, it is necessary to use leveling rods to control the pace of the courses in the vertical direction, horizontal alignments of reference to maintain the level of each course and plumb lines to check the alignment of the joints vertically.



Leveling rods

The limited thickness of the brick normally allows to reach with precision any height established by the project, making slight and imperceptible adjustments of the thickness of the horizontal mortar joint.

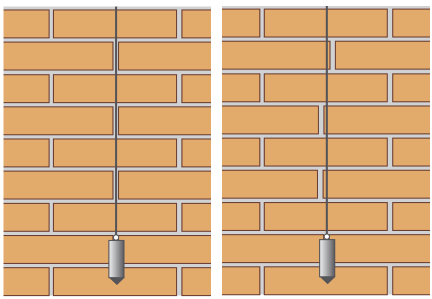
At the beginning of the installation works it is necessary to calculate how many courses are required to reach the heights of the project. Once determined the exact vertical pace, each installer, with the help of appropriately graduated leveling rods, must work as a member of a team, coordinating his own work with that of the others.

Vertical alignments

Even the vertical joints must be well aligned on the perpendicular: it will be necessary to tighten plumb lines at each edge and also at regular intervals of 4-5 bricks.

The exact alignment of the vertical joints must be periodically checked with a plumb line.

The correct and constant execution of the horizontal joints requires the predisposition of leveling rods, which must be carefully preserved and used to adjust the thickness of the joints for each level of the wall.



The non-use of the plumb line for the vertical alignments of reference can seriously compromise the final result.

Protection of the masonry

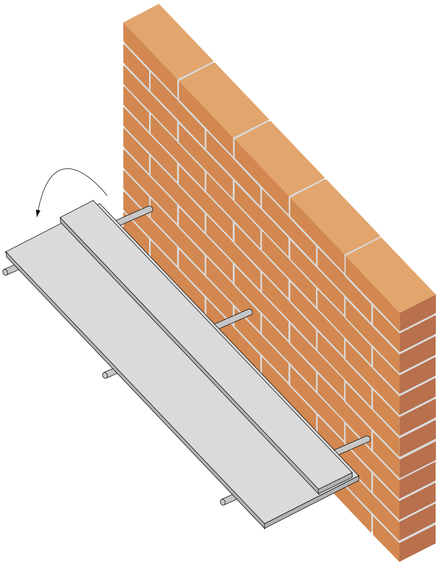
Until the end of the works, the facing brick masonry must be carefully protected from the elements, from the drippings of lime and from bumps and abrasions. Simple precautions during the construction phase avoid problems which are then difficult to solve.

While waiting for the laying of the coping stones (which usually takes place after the installers have completed their work), the top of the brickwork must be protected from the elements, for example by using plastic sheets.

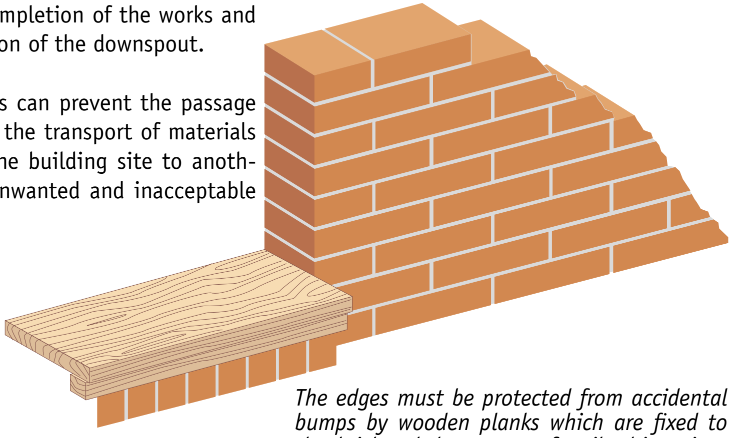
The mortar and the dust which are deposited on the scaffolding must be regularly removed in order to avoid that, drag from the rain, they may cause splattering on the masonry. If the scaffolds are built with wooden planks, in the case of rain, it may be sufficient to turn over the planks.

It's important that water flows which are linked to on-site operations (for example the casting of the slab and its hydration in the setting phase) are rigorously kept far from the masonry.
A provisional pipe can act as a downpipe, preventing the water of the building site from coming into contact with the façade, while waiting for the completion of the works and the final installation of the downspout.

Simple precautions can prevent the passage of equipment and the transport of materials from an area of the building site to another from causing unwanted and inacceptable "chippings".



The planks of the scaffolding must be turned over at the end of the day and in case of rain.



The edges must be protected from accidental bumps by wooden planks which are fixed to the brickwork by means of nails driven into the mortar joints or iron "springs".

Final cleaning

The brickwork must be gradually cleaned while it's still being built, by acting on the mortar splashes as long as they are still fresh. However, in some cases it may be necessary to remove old traces of hardened mortar, drippings of lime or efflorescences which are not soluble in water. These operations must be carefully carried out by experienced installers, using appropriate products, avoiding to damage the brickwork and the other works under or around the brickwork itself.

The solution of buffered acid (a low-aggression acid detergent) to be used for the removal of stains and splashes of hardened mortar, is authorized by the local health authorities according to the use and disposal of toxic products.

Before applying the solution, it is necessary to properly wet the masonry, in order to avoid that the acid is absorbed and may therefore damage the mortar joints. You have to proceed from the bottom upwards, to gradually remove the dust and other deposits, and prevent them from being transported by water and absorbed by the courses below.
The worker who carries out the cleaning must protect himself by wearing eyeglasses and rubber gloves.

After wetting the brickwork until saturation, the acid solution is applied with a brush on the encrustation which has to be removed.
You must let the solution act for some minutes and then intervene with a broomcorn brush (never a metal one, to avoid scratching the bricks), proceeding until the encrustation is removed. At this point, the surface must be abundantly rinsed with clean water, which has to be conveyed far from surfaces and materials that may be damaged by the acid (the discharge into the sewer must be avoided).

In the case of persistent stains, the operation can be repeated with a second application, but without exaggerating in the brushing, in order not to damage the surface of the masonry.

Example of hardened mortar splash which can be removed by using a solution of buffered acid.

The efflorescences

The appearance of more or less extended whitish spots on the surface is typical during the construction of a facing brick wall: however, the problem is almost always destined to disappear naturally with the first rains.

If efflorescences manifest themselves on the masonry, it is possibile to make some simple preliminary checks:
• the adherence of the efflorescence to the bricks;
• the solubility of the substance into the water and, in the negative case, in hydrochloric acid (muriatic acid on the market);
• the flavour, if salty, bitter or insipid;
• the chemical reactivity with hydrochloric acid (effervescence or not).

As a guide, it is possible to list the following cases, with their respective modalities of action:
• calcium sulphate, when the efflorescence is particularly adherent, insoluble in water, without flavour and effervescent in contact with hydrochloric acid; it is normally removed by means of washing with a solution of buffered acid and subsequent, abundant rinsing;
• alkaline (sodium or potassium) sulphate, when the efflorescence is pulverulent, with crystalline needles, branched, very soluble in water and with a salty taste: in a small amount, it disappears over time; it can be removed with a dry technique which includes the use of a broomcorn brush and the subsequent washing;
• magnesium sulphate, with the same caracteristics of the previous one but with a bitter flavour: it disappears over time if present in a small amount; if it is very pronounced it is necessary to resort to a specialist;
• calcium carbonate, rather light but consistent veil, insoluble in water, tasteless, strong effervescence in presence of hydrochloric acid: an efflorescence like this can be removed by means of washing with buffered acid and subsequent rinsing with pure water; in some cases an accurate brushing when the masonry is perfectly dry is enough.
The eventual use of alternative solutions must be preventively “tested” on a small portion of the masonry.

Type of efflorescence	Origin
Sulphates / alkali (sodium and pottassium) chlorides • whitish and pulverulent, salty, soluble in water	– reaction between mortar and brick, brick, cement/lime of the mortar, mortar additives (fluidifying, retardants, anti-freeze, etc.), unclean mixing water, poorly washed sea sand, poorly insulated flue (sulfur compounds in the evacuated flue gases), stored material in contact with the ground, rising damp, acid which is used to clean the wall
Magnesium sulphate • whitish and pulverulent, salty, soluble in water	– bricks, mortar, additives
Calcium sulphate • whitish, adherent, tasteless	– bricks, cement/lime of the mortar, pure mixing water
Calcium carbonate • light but consistent, whitish veil, insoluble in water, effervescent in hydrochloric acid, insipid	– bricks (detectable before the installation), cement/lime of the mortar, marble dust added to the mortar in order to increase its brilliance, particularly hard water
Iron sulphate • oily, reddish, the efflorescence manifests itself in the joints	– bricks

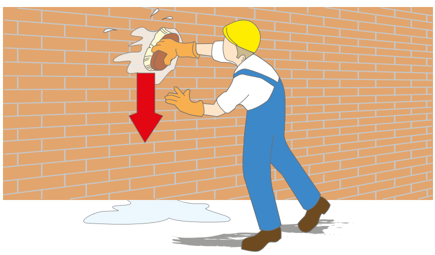
The completed masonry

A facing brick masonry doesn't need any further treatments; and indeed, the aging will give it a better aesthetic balance.

The well designed and well executed masonry, with appropriate materials (bricks and mortars), will never have problems nor require maintenance work.
In some cases, treatments with colourless, waterproofing or water repellent substances are carried out on the finished wall: for example to prevent or remove writings or improvised drawings.
Most of these substances act as water-repellent but, in the normally used quantities, can't pass through or even fill the capillary fractures or the spaces left by an incomplete filling of the joints, which are the main cause of water penetration.
The indiscriminate application of water repellent substances, or other ones with similar purposes, on a brickwork after its laying, may be more harmful than useful.
In fact, these substances can't prevent in any case water infiltrations through the cracks in the badly constipated or badly executed joints with mortars which have too high withdrawals.
Moreover, these substances may even accelerate the delamination of the facing part which has been treated if the abnormal damp rising from the foundation or a transverse migration of water coming, for example, from a not sufficiently protected agricultural land, continues over time.

With these situations, the presence of a layer which is water-impermeable from the outside, while ensuring the transpiration of the wall, may cause a double negative result:
– damage the facing surface, because the soluble salts which are dissolved in water, prevented from emerging on the outside and blocked by the treatment, exert such a pressure as to lead to the unrecoverable delamination of the bricks;
– make the masonry more vulnerable to the effects of frost, given the concentration of salts inside the masonry itself.
Finally, these treatments have a limited lifetime because of their sensitivity to the ultraviolet rays of the sun.

In any case, before any intervention, it is recommendable to contact the manufacturer for any suggestions and precautions to be taken, especially if it comes to low walls or unprotected works.



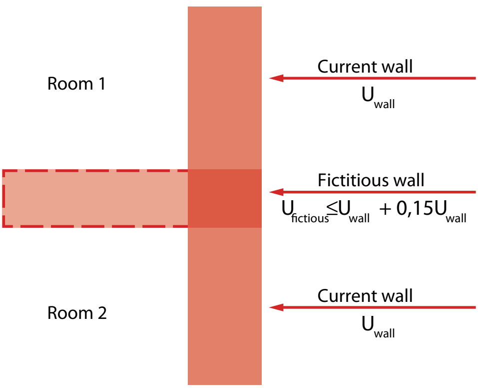
A well executed masonry and an accurate final cleaning are enough to ensure an aesthetic result and a performance over time which correspond to the expectations.

Precautions for thermally efficient envelopes

There are some aspects in the construction of the stratified brickworks, which are often underestimated but decisive for the proper functioning as a regulator of heat flows between the outside and the inside, and responsible of an insulation performance which is quite different from the one provided in the project. Often underestimated by the reference regulations, these aspects must be carefully considered in an accurate and competent design process, especially in the phase of laying of the building components on the building site.

At the scale of the subsystem of the vertical walls, it often happens that the only thermal transmittance value which is considered is that of a portion of the building envelope, without taking into account the effects of the thermal bridges. The U-value just concerns the thermal and technical quality of the proposed constructive solution. In the reality, heavy falls of thermal insulation – thermal bridges, in fact – may occur in the interface nodes between the brickwork and the parts of the building with different functions and between different materials: it is necessary to consider them in order to properly carry out the calculation of the energy demand of the building.

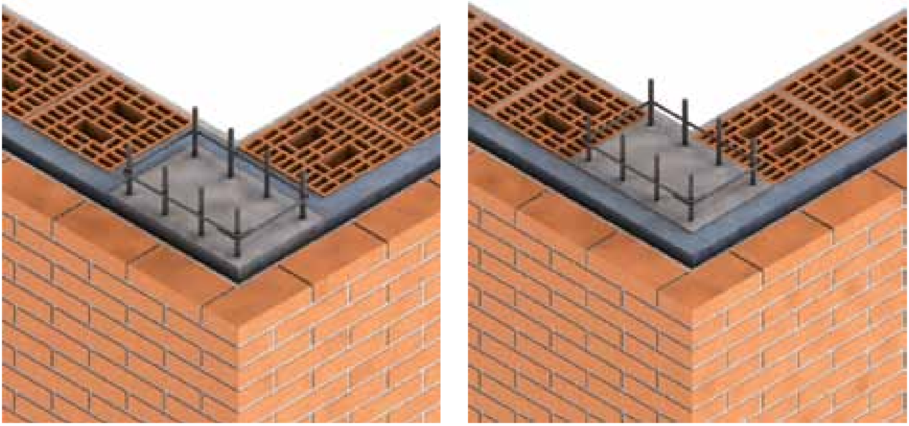
These are peculiar points in which there is a heat flow that goes in various directions, with a consequent deviation of the isotherms which, in the "homogeneously" insulated parts, are parallel; unwanted heat losses and, in the winter period, a decrease of temperature of the internal surfaces of the building, always correspond to them, with negative consequences on the living comfort.



The thermal bridge is the discontinuity of thermal insulation which may occur at the grafts between structural elements (a floor slab with a vertical wall, a vertical wall with another).
The thermal bridge turns out to be correct when the thermal transmittance of the fictitious wall (the part of the external wall in coincidence with the thermal bridge) doesn't exceed by more than 15% the thermal transmittance of the current wall:

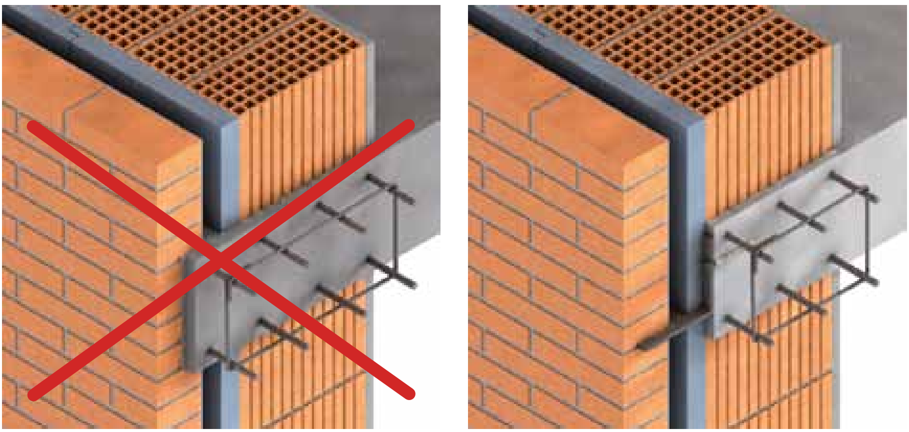
$U_{fictitious} \leq U_{wall} + (U_{wall} \times 0{,}15)$
For example, if $U_{wall} = 0{,}3\ W/m^2K$
then $U_{fictitious}$ *must be less than the value* $0{,}345\ W/m^2K$

Thermal bridge (elaboration of an annex of the Italian legislation).



(A) – Possible solutions for the elimination of the corner thermal bridge.

The thermal bridges can be generated by the following circumstances: thermal inhomogeneity of materials in contact with each other, with thermal conductivities which can even be very different (for example, inside a reinforced concrete and hollow tiles mixed floor or in coincidence with a reinforced concrete pillar in a wall made of a different material); geometric inhomogeneity, when the dispersing external surface is greater than the internal surface that receives heat from the inside (wall corners or intersections, etc.). In most situations, there is a coexistence of thermal bridges caused by both inhomogeneities.



(B) – Possible solution for the thermal bridge at the interface of the inter-floor slab – opaque vertical closure.

(C) – Solving of a thermal bridge in the connection point between the window frame – sill – opaque closure by detachment from the external sill in coincidence with the insulating layer.

Whatever the origin of the thermal bridge, it is essential to understand how to reduce (or even eliminate) the effects or, in extreme cases, how to correct, in the calculation of the heat losses, the transmittance values, considering the negative contributions.
It's necessary to intervene preventively, during the design process and in the construction phase, on this particular points, in order to guarantee a comfortable building. To avoid the formation of thermal bridges, it is necessary that there is a perfect continuity of the insulation between the perimeter wall and the interface nodes, or the interruptions of the wall itself: for example, in the setting point of the inter-floor slab on the vertical external closing, or in the perimeter of contact between a window frame and the opaque vertical closure.
In the specific case of the "stratified" masonries, in which every single component is laid with a precise functional specialization, a correct design and installation are essential for the elimination, or at least reduction, of the thermal bridges.
The laminated walls, even in the case of utilization of "facing" elements, generally provide the presence of an intermediate insulating layer. A correct placement of the latter, in coincidence with the discontinuities of the materials or singular points, allows the elimination of the thermal bridges.

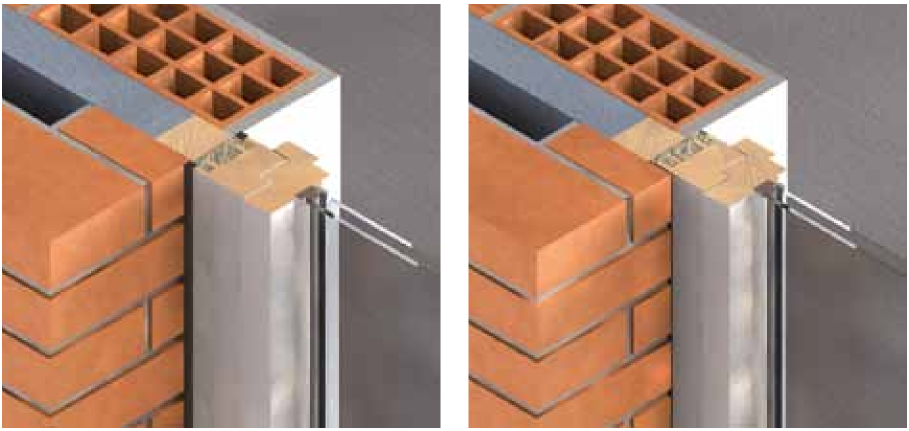
In the case of a building with a framed structure, it is possible to eliminate the thermal bridge between the pillars and the vertical external closure by, for example, letting the layer of insulating material pass inside the pillars themselves, in such a way as to adapt itself to their geometry; a more effective procedure is to make the insulation continue on the external side of the pillars, letting the structure and the resistant layer of the brickwork stratification on the inside of it (figure A).

In the case of the interface between horizontal and vertical external closing, it is necessary to avoid leaving the thermal bridge which is inevitably generated at the head of the slab, and causes subsequent changes of colour and the formation of condensate. This thermal bridge can be eliminated by interrupting the inter-floor slab, in the terminal part towards the outside, with insulating material, which, also in this case, must have the possibility to continue above and below in the brickwork stratification. Technically, you can insert strips of insulation in the formwork before the casting of the concrete. As an alternative, it is possible to follow the method of constructing the horizontal structure and the carrying layer in such a way as that they're completely detached from the external cladding made of brick elements, hooking up the latter by means of metal anchors which are punctually placed in the masonry (figure B): the influence of these anchors on the thermal performance of the brickwork itself, however, is negligible. As regards their influence on the acoustic insulation, a moderate decrease in performance can be noticed at low to medium frequencies. This reduction, normally contained within the uncertainty of measurement, can also be considered negligible in the case of a front wall including windows [1].

In the case of the interface between the perimeter of the window frame and the external vertical closure, it is fundamental to separate the outer sill from the one inside the building, in coincidence with the insulating layer that cuts the thermal bridge (figure C). It is also recommendable to appropriately insulate the vertical closure near the radiators, which are usually placed under the transparent closures; a similar attention must be paid to the boxes for rolling shutters: in this case, it's necessary to intervene on the external side to prevent infiltrations of air and moisture.

Precautions for acoustically protected envelopes

Obtaining good performances in terms of acoustic insulation from building components is a problem which is closely connected with the quality and the methodology of construction of the component themselves. In particular, as regards the acoustic performance of the façades, it is known that incorrect procedures of construction, installation, assembly or junction of the various components (masonries, window frames, shading systems and devices for the passage of air, etc.) can greatly reduce the expected acoustic performance. Some indications for the proper execution of the masonry partitions are therefore listed below.



(D) – "Visible" joint (left) and "rabbet" joint (right) for a window frame.

Junction between the components of the façade

The acoustic performance of the façades strongly depends on the modalities of junction between the various components. In the case of the installation of windows and doors, a particular attention must be paid to the connection between the secondary frame (or subchassis) of the window frame and the wall opening. Two modalities of junction are generally possible: a "visible" or a "rabbet" one. (figure D).
The "rabbet" joint, which can be carried out by increasing the size of the window frame by a few centimetres compared to the window opening in coincidence with the external wall facing of the masonry, generally offers better guarantees of acoustic seal and air tightness.

However, the correct creation of a joint provides the following operational steps [2]:

1. in the case of windows, you have to apply a continuous bead of sealant (for example silicone) in the position of the centreline of the lower transverse; on the ends of the bead it is necessary to provide a slight excess of material, to ensure the barrier effect also at the sides of the sill; in the case of "rabbet" joints, the sealant must be placed also on the two vertical "rabbet" abutments and, if present, also on the upper rabbet;

2. if the joint is "visible", after positioning and fastening the window, it is necessary to apply the support for the bottom of the joint (generally made of polyethylene foam), continuous and with an appropriate diameter, which, once placed in the joint, exerts on the walls such a pressure as to resist to the injection of the expanding sealant and allows to fix the depth of insertion of the sealant, giving it the freedom of expansion or shrinkage.

3. the closing of the joint is carried out using expanding material (generally expanding polyurethane foam or strips of self-expanding material) with the functions of a filler;

4. both the outside and the inside of the joint are sealed with a bead of sealant material (for example silicone).

A similar care is necessary in the mounting of the boxes of the roller blinds which are frequently critical points of considerable relevance for the acoustic performance of the façade.

Air vents

Great problems of acoustic insulation can always be found in the partitions which include air vents or holes of various types. In particular, this usually involves the façades of the rooms where open flame devices are placed (for example, gas cookers, burners, etc.). In accordance with the legislation in force (national laws and UNI CIG 7129 standards), it is necessary that rooms like these are equipped with an air vent on the façade, with a free section of at least 100 cm^2 (15.5 sq in). In addition, different standards recommend the presence of openings for the ventilation also in the façades of inhabitable rooms, in order to allow a natural air change. In order to contain the loss of acoustic insulation, it is necessary that these vents are equipped with sound insulation devices.

Lateral transmission between adjacent interior spaces
One of the most problematic aspects for the obtaining of good acoustic performances by masonry walls is the lateral sound transmission, namely the sound energy transmission that involves the lateral structures of the separation wall (normally placed between distinct units). A particularly interesting aspect in the construction of the double walls made of brick elements is the modality of lateral junction of the double walls themselves with the stratified "facing" wall.

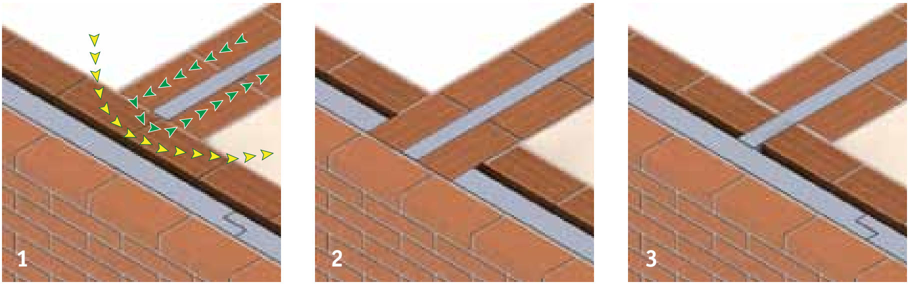
The figure E shows some possible configurations of the joint between a double-layered internal partition and a façade.

The configuration E-1, the most frequently used in the constructions, implies a significant lateral transmission. The internal boarding of the front wall, often endowed with a low superficial mass and not interrupted in coincidence with the structural joint, is an effective route of sound transmission. In addition, this boarding creates an acoustic bridge between the two partitions of the internal wall, contributing to reduce its performance in terms of acoustic insulation.

The configuration E-3 is optimal because it eliminates the thermal bridge which is present in the solution E-2 and greatly reduces the lateral sound transmission through the façade wall. This configuration also allows to eliminate the acoustic bridge between the two partitions of the internal dividing wall.

The solution E-3, more beneficial than the others, can be applied also by interrupting the continuity of the internal boarding of the façade wall after its construction (by cutting it, for example, with a flexible cutting wheel). Then the obtained cut can be eventually sealed with elastic material.

Continuity of the mortar joints and presence of connection between the boardings
The sound insulation performance of a double wall may be seriously jeopardized by the presence of discontinuity in the horizontal or vertical joints between the different constituent elements. In particular, this problem may be recurrent in the walls made of brick with a high percentage of perforation, arranged in horizontal holes. In this case, if the execution isn't



(E) – Some configurations of the connection between the internal dividing wall and the front double-layered wall made of clay elements.

carried out with care, the vertical joints may turn out to be only partially filled with mortar. The existing discontinuities, creating acoustic bridges, significantly reduce the acoustic performance of the wall.

In the case of double walls, the addition of a layer of plaster on the side facing the cavity of one of the two boardings contributes to improving the sealing of all the joints, besides positively increasing the mass of the wall.
Also the rigid connections between the two boardings of the double wall can reduce the acoustic performance, creating points of transmission of the vibrations and making the behaviour of the wall similar to that of a monolithic wall. However, as already highlighted for the façade walls, the influence of this performance decrease becomes less relevant, since the transmission of the noises can be attributed primarily to the windows and to the points of the connection between the various components of the façade itself.

Sound-absorbing materials
Given that in the choice of insulating materials to be placed inside the cavity of the facing brick walls the aspects which prevail are the ones connected to the thermo-hygrometric behaviour of the overall stratification, from an acoustic point of view it is recommendable to prefer the materials characterized by appropriate sound-absorbing properties.

The double brick walls have an acoustic behaviour which is mainly determined by the law of the total mass, because the decoupling between the two boardings (and therefore the possibility to operate according to the principle of the decoupled dual system) is normally influenced in a negative way by the side junctions and the eventual elements of connection between them.
For this reason, from the point of view of the acoustic insulation, the eventual materials (thermo-insulating) placed inside the cavity have the function to attenuate the acoustic reverberation inside the same cavity, but not to act as an elastic element of structural decoupling between the layers of the wall.

The nature and thickness of the material to be placed inside a cavity must be chosen according to the offered coefficient of absorption. Fibrous materials or porous open cell materials only ensure good sound absorption values. On the contrary, the closed-cell materials are often characterized by low values of the coefficient of absorption and therefore they are not suitable to provide a significant contribution for the purposes of the acoustic performance.

[1] Hall R, Hopkins C.and Turner P., The effect of wall ties in external cavity walls on the airborne sound insulation of solid separating walls, ICA, Roma, 2001.
[2] UNI 11296 (2009), Acustica. Linee guida per la progettazione, la selezione, l'installazione e il collaudo dei sistemi per la mitigazione ai ricettori del rumore originato da infrastrutture di trasporto.

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