Made in Italy
100%
NATURAL
COTTO

Clay flooring tiles & pavers: products and applications

INDEX

This booklet is short guide to know the clay flooring (terracotta tile and brick paving) and to learn the basilar rules for a good construction and maintenance. Text and images are taken from: Antonio LAURÌA, "Le pavimentazioni in laterizio. Mattoni, sestini e pianelle di cotto", edizioni Laterservice srl, Roma 2008

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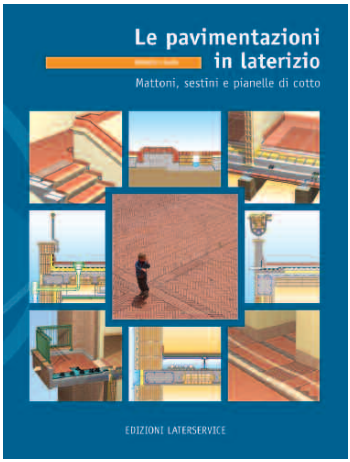
CLAY FLOORING TILES & PAVERS

In the vast family of clay products, the flooring ones (such as bricks, "sestino" laths and "cotto pianelle" (Italian traditional terracotta tiles), thanks to their intrinsic aesthetic qualities, excellent technical performances and renowned al along considered lasting reliability, have been the perfect solution for the indoor and outdoor coatings. They are the familiar materials, distinctive elements and identity factors of the Italian landscape.

The paving elements together with the fairfaced bricks are the most precious clay components. Their versatility makes them perfect not only for outdoor spaces (street furniture, squares, sidewalks, draining floorings, etc), but also for interiors (floors, hand rails, wall bases, etc.). They often become the building "skin" (as cladding for balconies, terraces, rooftops, etc.), being time after time inserted in complex works, fine details, in new constructions as well as in restorations and renovations. Clay floors give stability and beauty to the surface where people live, they characterize the space, and protect from weather conditions and subsoil stresses. Among the technical characteristics it is worth mentioning:



A. Laurìa, "Le pavimentazioni in laterizio. Mattoni, sestini e pianelle di cotto", Edizioni Laterservice, Rome 2008.

- slip resistance;
- step-sound control and thermal comfort, due to mass properties;
- vapor permeability;
- biocompatibility and eco-compatibility;
- durability;
- no toxic reaction to fire;
- dimensional and chromatic variety.

These qualifications are assured by the accurate selection of raw materials used in the production phase, through the use of refined ground clay and a carefully and constantly quality controlled production stage. Depending on size and types we can group the paving clay products in, "cotto" tiles, bricks, "sestini" (laths), finishing elements and special pieces, in a huge range of colors and sizes. Depending on shaping process, they can be classified as *extruded* and *molded* (handmade or mechanically).

CONVERSION TABLE	
1 mm (millimeter) = **0,03937 in** (inches)	**1 cm²**(square centimeter) = **0,1550 in²** (square inches)
1 cm (centimeter) = **0,3937 in** (inches)	**1 m²**(square meter) = **1550 in²** (square inches)
1 m (meter) = **39,37008 in** (inches)	**1 m²**(square meter) = **10,7639 ft²** (square foot)
1 m (meter) = **3,28084 ft** (feet)	**1 in²**(square inch) = **6,4516 cm²** (square centimeters)
1 in (inch) = **2,54 cm** (centimeters)	**1 ft²**(square foot) = **929,03 cm²** (square centimeters)
1 ft (foot) = **30,48 cm** (centimeters)	**1 ft²**(square foot) = **0,0929 m²** (square meter)

Terminology and definitions

Nomenclature

It is not difficult to notice that, like other furnace products, also for paving artifacts the seeking of identity and visibility has led the different companies to put on the market products named with uncertain if not ambiguous terminology. For example we can note the improper use of expressions such as "handmade" (very often without the quotation marks) or the more prudent "hand type" for soft paste molded products made with highly mechanized processes; not to mention the not glazed ceramic tiles sold with terminology which uses words such as "cotto", or the attribution of terms such "tavella" or, "tavellone" (hollow flat tiles) for squared shaped solid cross section elements used for flooring. Some confusion comes also from the use of many terms used to indicate the thin cut elements and the lack of a common nomenclature for minor sized products; furthermore something that doesn't help at all to make things easier is the double expression - "clay floors" and "cotto floors" - to indicate the same product by the raw material and production process points of view. In conclusion, even the UNI standards define products terminology e typologies with some margin of uncertainness that doesn't help and even less guides to a systematic reference. These, however, even if with no explicit terms, distinguish between "flat" products and "squat" products. In such a complicated context, before continuing with the explanation of the different types of products for clay paving, it is useful to formulate a terminology which, starting from the quoted UNI standards rules, could help to carry out the parameter adjustment more satisfactorily for the different products on the basis of easily identifiable factors with some immediacy by the designer.

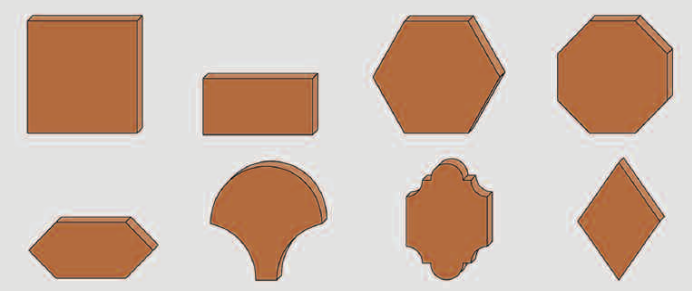
Firstly, we can identify two big families of products:

a) "cotto" tiles;
b) paving bricks.

"Cotto" tiles

The Italian term "pianella" indicates a "plate" shaped for flooring (that is to say with length and width larger than its thickness), with wear side of different shapes, dry and rigidly laid, above a drain layer or on top of punctiform support (see The laying paragraph), used both for interiors and exteriors. Other two special pieces can be grouped in this typological family: the "tozzetto" and the lath. The "tozzetto" is a square little "pianella" usually used together with tiles of different shapes, most commonly octagonal; the lath is a very long tile with rectangular cross section, very often in the typical 1 to 4 ratio between width and length. The recourse to the completion term of sort ("di cotto") would not be necessary because the term "pianella" itself sufficiently defines clay plate shaped products used for floorings.

Terminology and explanations



Main shape for "cotto" tiles. From left to right (above): square, rectangular, hexagonal, octagonal; (below) lozenge, lily, Provencal, rhombus.

However, considering the vast diffusion, nationally and internationally, of the term "cotto" to indicate the material used to making fine clay artifacts, for fairfaced brickworks, and more in particular for flooring artifacts ("pavimento in cotto"), and considering in addition the necessity for manufacturers to protect from a commercial point of view this term from an improper use, as it sometimes happens in other sectors, we consider worthwhile hereinafter to use this term as a qualification factor together with the name that defines the artifact.

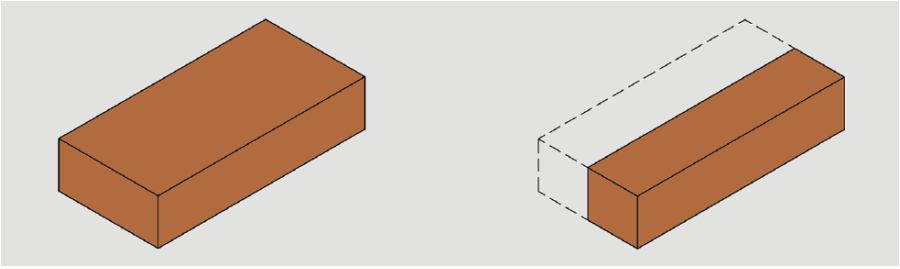
We preferred to use the completion term "cotto" instead of "clay", because in the popular opinion (and often for field's experts too) the term "clay" could more easily define semi finished product such as whole and hollow bricks, blocks, hollow bricks, hollow flat plates, etc.

P. Tacci. Handmade "cotto" tiles floor in the Mantua State Archive.

Flooring bricks

This particular kind of products defines flooring elements with a 'squat' shape, with rectangular or similar wear side, laid both with flexible and rigid method and mainly used for exterior spaces even for driveways.

Terminology and definitions



Brick paving (left) and "sestino" (right). In the first case, the ratio between wear sides surfaces is 1 to 2; in the second case it is 1 to 4.

The type includes the minor size "sestino" the shape of which results from the longitudinal cut of the base element, usually with square section or very close to square. In this case we chose to specify the application field ("paving"), in order to distinguish these artifacts from those used for walls (curtain-walls or traditional), instead of the material because the term "brick" designates – without further specifications – univocally and expressively clay elements.

N. Korteweg e N. Zimmerman. Clay paving of the entrance to the Bergen op Zoom (NL) hospital.

Relevant legislation

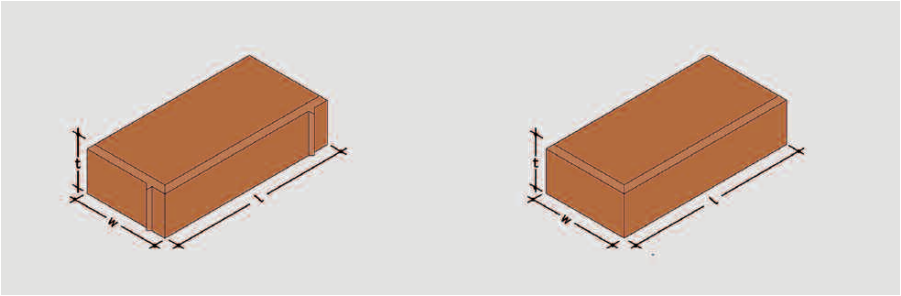
The relevant regulations

The technical requirements and procedures for the flooring clay products' conformity-check are regulated by two UNI EN rules:

1. the 1344 ("Elements for clay floorings. Requirements and test methods");
2. the 14411 ("Ceramic tiles. Definitions, classification, characteristics and marking").

The first one regulates the "elements for flooring and clay accessories" based on thickness ratio, laying technique and purpose sector.

The UNI EN 1344 defines the "element for clay flooring" as a "unit able to satisfy a specific shape and dimensional requirements used for the floors surface layer and made mainly out of clay or other clayish material, with or without additives, shaped, dryed and cooked at a temperature high enough to get a long lasting ceramic product"; an "accessory" is a unit specially shaped in order to satisfy a particular function in the completed floor (...)".



Size of the flooring elements. On the left, for flexible laying only; on the right, for both rigid and flexible laying (from UNI EN 1344).

In particular, it refers to:

- elements in a rectangular or different shape, to be used mainly for outdoor spaces;
- elements with a thickness not smaller than 40 mm and with length/thickness ratio not bigger than 6, laid on a sand substrate with tight joints filled with sand, addressed both for vehicular and pedestrian circulation (flexible construction way);
- elements with thickness not smaller than 30 mm laid on mortar substrate on rigid stand with mortar filled joints, usually addressed to pedestrian circulation (rigid construction method).

RELEVANT LEGISLATION

The "ceramic tiles" are explicitly excluded from the application field of the rule, regulated by the UNI EN 14411/2004. Length, width and thickness are respectively designated by the initials l, w, t; the unit is millimeters following this order.

The elements can be shaped with a chamfer (bevel) on the edges around one or more surfaces of the flooring product addressed to be the wear side. The spacer lug nuts– small protruding edges on the side face of the flooring elements which occupy the joint thickness – are for flexible laying method only. According to the rule for the rigid laying method, the units of the floor must be separated by a 10 mm mortar joint only.

The UNI EN 14411/2004 defines and provides terms, requirements and criteria of marking for the "ceramic tiles" exclusively made via extrusion and dry-pressing techniques.

The "ceramic tiles" are grouped on the basis of shaping method and water absorption grade. In particular, the extruded clay flooring products could be grouped in classes AII and AIII according to their absorption capacity, from 3÷4% to 15%; the molded ones belong to class CIII. In the rule EN 14411/2004 there is no application restriction for the different types of products relating to technical-marketing current classifications and to groups based on middle water absorption class AII (AIIa and AIIb).

Shaping method	Water absorption classes (E) (ISO 10545-3)			
	low	medium		high
	GROUP I E ≤ 3%	GROUP II_a (*) 3% < E ≤ 6%	GROUP II_b (*) 6% < E ≤ 10%	GROUP III E > 10%
A extrusion	group AI (appendix A)	group AII_{a-1} (appendix B) group AII_{a-2} (appendix C)	group AII_{b-1} (appendix D) group AII_{b-2} (appendix E)	group AIII (appendix F)
B pressing	group BI_a E ≤ 0,5% (appendix G) group BI_b 0,5% < E ≤ 3% (appendix H)	group BII_a (appendix J)	group BII_b (appendix K)	group BIII (°) (appendix L)
C (#) other shaping methods	group CI	group CII_a	group CII_b	group CIII

Legend:

(*) Groups AII_a and AII_b are divided into two parts with different product specifications
(°) Group BIII relates only to the glazed tiles
(#) Category not covered by UNI EN 1441/2004 which relates to molded soft paste artifacts

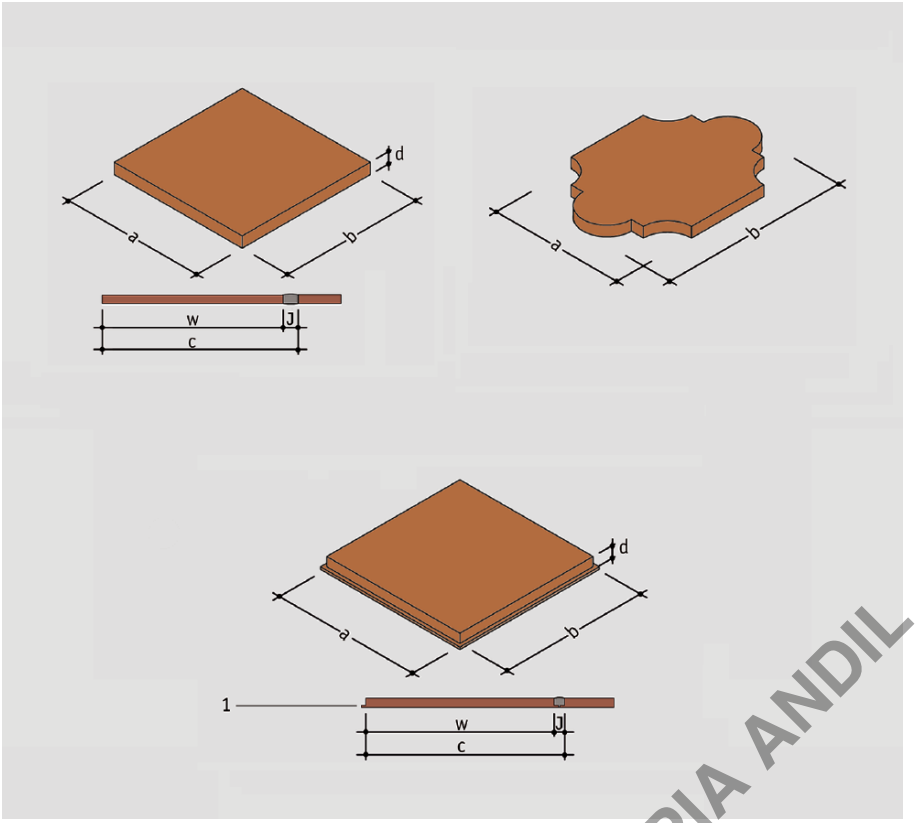
Classification for ceramic tiles based on water absorption grade and shaping method, by UNI EN 14411/2004. The application field of clay products has been highlighted in light blue. The performance specs are specified in appendix C, E and F of the rule.

Relevant legislation

With regard to morphological aspects, the rule deals with rectangular or other shape small thickness products. Length, width and thickness are indicated by initials a, b, d and expressed in millimeters following this order.

The dimensions description is for rectangular tiles only; for not rectangular tiles, the dimensions that are given, if asked, are the ones of the smaller circumscribed rectangle.

The tiles may present protrusions on some of the edges (side spacers) so that in the laying phase they can be separated by a distance not minor than the joint's width.



(Above on the left) Description of the coordination dimension (C), it results from the sum of the particular dimension and the joint's width (J), and the manufacture size (W) in the case of tiles with no side spacers (from UNI EN 14411/2004). (Above on the right) Description of the dimensions for not rectangular elements (from UNI EN 14411/2004). (below) Description of the coordination dimension (C) and of the manufacture size (W) for elements with side spacers (1) (from UNI EN 14411/2004).

Relevant legislation

Observations

From the cross reading of topics dealt in the UNI EN 1344 and in the UNI EN 14411/2004, we can deduce that the non extruded clay products - such as soft paste molded (handmade or mechanically made) products -, with a thickness smaller than 30 mm, are not regulated; furthermore, we can deduce that the "ceramic tiles" (besides their shaping technique and their water assumption grade) are defined by a thickness not bigger than 30 mm too, since for bigger thicknesses the element should be grouped in the class "clay elements" for which, as discussed, there are different regulations and requirements.

Product typology/Legislation parameters				Legislation
Thickness	Layng method	Setting	shaping method	
≥ 40 mm	**flexible**	**pedestrian/vehicular**	extrusion molded	**UNI EN 1344**
≥ 30 mm	rigid	**usually pedestrian**	extrusion molded	
< 30 mm	rigid	usually pedestrian	**extrusion**	**UNI EN 14411/2004**
< 30 mm	rigid	usually pedestrian	molded	-

Recap chart of the topics of interest for clay flooring products from UNI EN 1344 and 14411/2004 and from scientific literature: in bold, regulations indications; in gray, not explicitly regulated specs; last row, unregulated products.

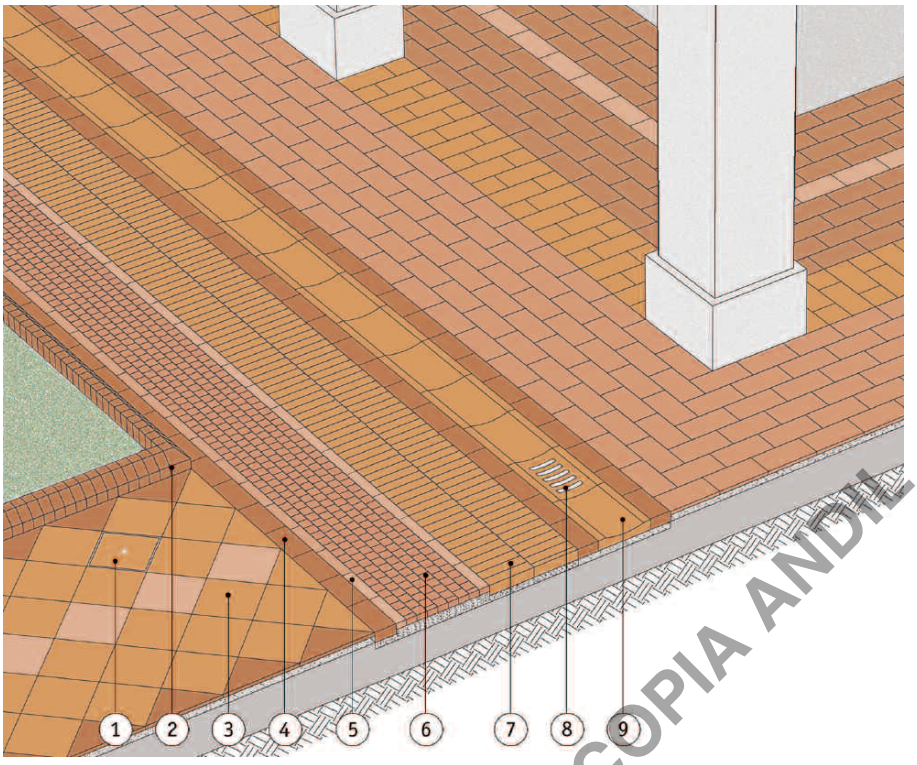
Handmade "cotto" tiles floor.

Typologies and sizes

Typologies and sizes

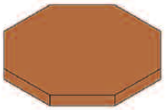
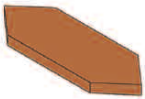
Starting from the two identified typologies - "cotto" tiles and flooring bricks -, some charts which gather the main shapes on the Italian market with the main formats are shown below . These charts represent a summary of a larger work made on the technical documentation (catalogues and web sites) taken from some of the main national manufacturers. The dimensions, expressed in millimeters, are defined in the following order: thickness [T], length [L], width[W].

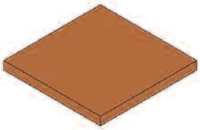
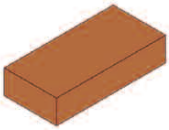
For not square or rectangular shaped "cotto" tiles, the dimensions given are the ones of the smallest regular circumscribed rectangle. In this case, all the products found have been listed because no prevalent formats have been identified in the Italian market. The particular kind of "cotto" tiles shaped by rounding the four corners of a square or rectangular element can be put in the group of the octagonal "cotto" tiles.



Different typologies of clay flooring elements.
Legend: **1**) manhole; **2**) curb; **3**) "cotto" tile; **4**) flooring brick; **5**) lath; **6**) "tozzetto"; **7**) "sestino"; **8**) drainage grid; **9**) logline.

Typologies and sizes

Element	Formats [mm] t	l	w
HEXAGONAL "COTTO" TILE 	12	290	250
	13	290	350
		350	300
	14	290	250
	20	290	290
		350	350
	25	290	290
		350	350
	25	220	70
		140	120
	30	230	130
		255	145
	33	300	250
	35	300	250
OCTAGONAL "COTTO" TILE 	12	300	300
	13	300	300
	14	300	300
	15	300	300
	16	400	400
	20	300	300
	24	400	400
	25	300	300
		400	400
	30	320	260
	33	265	265
	35	310	310
LOZENGE "COTTO" TILE 	13	200	--
	25	200	
		250	---
		300	
	25	230	110
		280	130
	30	200	135
		250	70
		320	250
		330	200
	33	365	175
	35	300	150
		340	140
RHOMBUS "COTTO TILE" 	20	180	100
	25	230	140
	33	395	108
PROVENCAL "COTTO TILE" 	25	280	200
	25	245	185
	33	270	185
LILY "COTTO TILE" 	33	320	320
	48	240	240

Element	Formats [mm] t	l	w
SQUARE "COTTO" TILE 	13	300	300
		200	200
	13	300	300
	14	200	200
		250	250
		300	300
	15	300	300
	25	300	300
		200	200
		300	300
	30	200	200
		300	300
	40	400	400
	45	400	400
RECTANGULAR "COTTO" TILE 	13	300	150
	14	300	150
		360	180
	15	300	150
		360	180
	25	300	150
		300	150
		360	180
	30	300	150
	34	400	200
"TOZZETTO" 	25	100	100
	35	130	130
LATH 	13	280	60
	15	270	
	25	280	70
	30	270	60
PAVING BRICK 	55	250	120
	70	250	120
"SESTINO" 	40	280	70
	40	295	70
	60	260	60

Italian market's usual formats of main typologies: ""cotto" tiles", "tozzetti", laths, bricks and "sestini".

FINISHING ELEMENTS AND EXTRAS

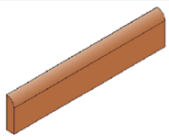
Clay main natural color's chart.

Finishing elements and extras

Usually, the different clay manufacturers, offer a bigger selection of products inserting in it finishing elements which can assure the fine finishing of both interior and exterior floors, and can avoid performance falls at the critical points, or in any case at delicate points. These elements can be grouped in three main groups:

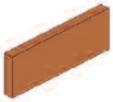
- skirting board elements;
- staircase elements;
- elements for the outdoor /street furniture.

As regards the staircase elements, faced with a large number of available formats found in the source analysis (it is been impossible to find two companies which makes products with the same size), we decided to report, about thickness, length and width, the gap between the minimum and maximum. Even in the case of the finishing elements for the outdoor /street furniture, we thought not to report the formats, because every single company deals with these elements' dimensions according to the ones of the floor to be done. As regards the street furniture elements, it is needed to notice that, at a national level, the offer is still quite poor, both from a typological and format points of view, if compared with the British market, German's or Spanish's, just bordering the comparison in the European scene.

Skirting	Shaping method	Formats [mm] t	l	w	Colors
	extrusion	15	300÷400	80	- strawyellow
	molded	18	320 ÷ 330	80	- rose
	molded	20	300 ÷ 310	80÷135	- red

Skirting board: prevalent formats based on shaping technique and most common colors.

FINISHING ELEMENTS AND EXTRAS

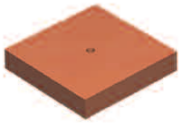
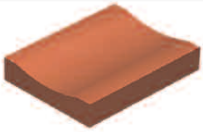
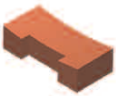
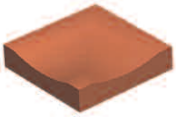
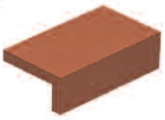
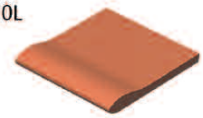
Elements for staircases	Shaping method	Formats [mm] t	l	w	Colors
TREAD 	extrusion	13÷50	250÷1400	330÷360	- strawyellow
	molded	30÷55	120÷1150	280÷370	- rose
					- red
RISER 	extrusion	14÷25	250÷300	120÷140	- strawyellow
	molded	30	240÷300	120	- rose
					- red
STEP SKIRTING 	extrusion	10÷17	180÷200	120÷140	- strawyellow
	molded	18÷25	182÷185	440÷445	- rose
					- red

Staircase coating: range of dimensional parameters and main characteristics.

Coordinated system: extruded curved clay tread, riser and skirting.

Elements for intermediate step (on the right) and angular (on the left), made out of handmade molded clay.

FINISHING ELEMENTS AND EXTRAS

Elements for outdoor / street forniture			
Elements	Shaping method	Purpose	Colors
MANHOLE 	molded	element for wells covering; can be inspectable or not	- rose - tobacco
LOGLINE 	extrusion molded	element for rain wash water collecting; can be finished with openings functioning as drain	- strawyellow - rose - red - tobacco
DRAIN 	molded	element which allows the flow of rain and wash water to severage	- strawyellow - rose - red - tobacco
LOGLINE WITH DRAIN 	extrusion molded	element with both logline and drain function	- strawyellow - rose - red - tobacco
LOGLINE CONNECTION 	molded	element placed in the loglines direction change points; it can be with two or three ways	- rose - red - tobacco
CURB 	extrusion molded	element used for bordering paths, roads, windenings, flowerbeds, ect.; it forms a slight height increase compared to the floor level	- strawyellow - rose - red - tobacco
END ELEMENT 	extrusion molded	element used to link the floor height difference	- rose - red - tobacco
SWIMING POOL CURB 	extrusion molded	element used for bordering the floor from the water	- rose - red - tobacco

Main finishing elements for exterior: purposes and main characteristics.

The laying

In general terms, the laying of the floor surface layer needs a series of technical-practical and operational tasks which, starting with the project, leads to the ready to use completed floor. Furthermore, in the case of clay floors, usually, in between the laying phase and the usability there is one more operational stage: the treatment.
The main figure that directs the laying program phases and complete the floor must be a specialized professional: the layer. Both before and during the executive phases, the professional layer has to deal with other figures of the building process (the client, the designer, the work director, the construction site chief, the contractor, the security supervisor, the manufacturer, etc.) and, when needed, with the specialists who will deal with the treatment. It is not infrequent for the flooring products manufacturers themselves to be directly engaged in the laying process. This eventuality becomes necessary in the case of delicate restoration works and desirable when, facing very large surfaces to be floored, a supply of material is needed with characteristics of homogeneous appearance or in case many special custom pieces are required. About this we must highlight how the communication with the manufacturer, which should have started during the design phase already, is supported in our Country by the high level of artisan vocation which still qualify the clay flooring sector; this represents an added value that, together with the versatility of material itself and of the production processes (just think about the flexibility of the handmade production), virtually allows the designer to create different solutions with no limits but the budget or the production and technical feasibility related to the manufacture.

The clay flooring artifacts can be laid with two main techniques:

a) the flexible technique (typically used for exterior floors);
b) the rigid technique (suitable for both interior and exterior floors).

Stages	Activities
preliminary	1. Design analisis and surfaces' geometry check
	2. Environment conditions chek
	3. Construction site organization and material storage and check
	4. Laying surface check and praparation
	5. Laying dry tests
	6. Material preparation for compensation layer and joints
executive	7. Flooring artifacts laying
	8. Expansion joints installment
	9. Grounding
	10. Cleaning and protection of the paving surface

Synthetic chart of the procedures for the laying of a floor.

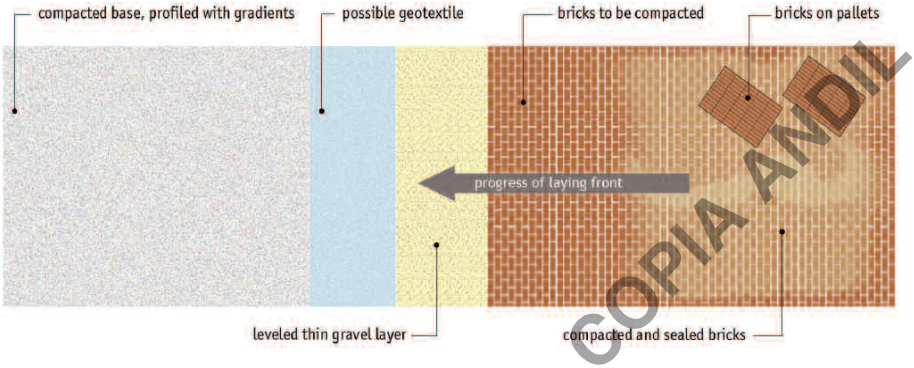
Laying on flexible layer

The laying on flexible layer consists in manually putting flooring bricks or "sestini" on a layer of sand or thin gravel ("risetta") of constant thickness and appropriate particle size, proceeding then with consolidation of the flooring surface and complete filling of the joints with sand. The blend of inert material used for the bedding layer must be protected from weather conditions, in order to avoid both an excessive drying and an excessive humidification. Its humidity grade must be consistent all over the laying surface planned to be floored in the working day.

Riddle [mm]	Passing mass	
	not channeled traffic	channeled traffic
9,50	100	100
4,75	95÷100	95÷100
2,36	80÷100	75÷100
1,18	50÷85	55÷90
0,60	25÷60	35÷70
0,30	5÷30	0÷35
0,15	0÷10	0÷5
0,075	< 3	0÷0,3

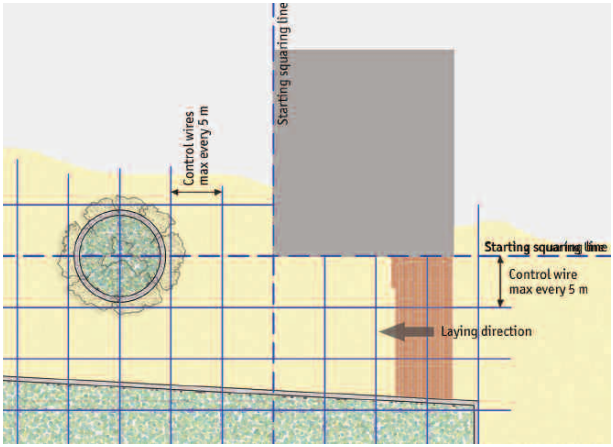
Particle size composition of the bedding layer.

An optimal humidity grade value is 6%. The thin gravel thickness at soft state varies from 35 to 50 mm. Due to the consolidation the inert material blend will shrink by 20 to 30%; due to this drop the thickness of the bedding layer will set up around 25÷40 mm. In the case that a connection with an existing floor is needed, in order to adjust the settlement the new floor will be afterwards subjected to, due to operating loads, its height, after the consolidation, should be higher than the existing floor's. The bedding layer must have a constant and homogenous thickness all over the surface to be paved: it is absolutely discouraged to correct deviations from planarity of the laying plane adjusting its thickness. The inert material which the bedding layer is made of must be laid in parallel to the line of progress of the laying front, without being subjected to any consolidation. The thin gravel coat, same as the screeding and leveling, is usually done manually. The bedding layer, once laid and leveled, should not be subjected to any kind of alterations: for these reasons workers are not allowed to step on the surface.



In flexible type floorings the elements laying progress takes place through complete executive stages.

LAYING ON FLEXIBLE LAYER



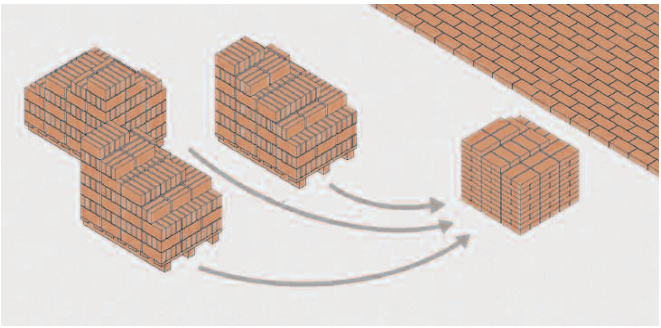
Example of orthogonal grid for regularity test of laying in an outdoor flooring.

The first row installment follows the reference generating line which must be done very carefully.
The not yet consolidated portions of the floor are reserved to the circulation of the workers only for the supply of the elements needed to make the laying front progress. The artifacts' stocks for the working day must be kept on completed and consolidated portions of the floor; from there small amounts of elements will be carried by the installers with wheelbarrows or carts, in the proximity of the laying front. Loading the new floor with heavy loads before the consolidation and joint filling process are performed may cause the local sinking of single elements or even generate their horizontal dislocation, with the resulting risk for the edges to chip.

In order to get appropriate color uniformity, it is advisable to select the artifacts from three different stocks at the same time, proceeding vertically, from one edge and not by horizontally (in fact the elements location inside every package matches their position in the furnace during the cooking process).

Techniques for achieving a regular width of the joints. Above on the left, brick flooring with spacer lug nuts. Below on the left, "sestini" laid on sand bedding by using "T"shaped disposable plastic spacers.

Laying on flexible layer



The flooring artifacts mixing, within the same batch, in the construction site is an efficient method to compensate little size and/or tone differences due to the production process.

The professional layer, after having completed the installation of all the artifacts, will spread over the surface a first layer of sand using brooms. The sand spread must be done carefully, avoiding sudden movements which may cause dislocation of the pieces. Through this first operation, the elements get blocked, even if lightly, in their seat preventing from the risk to get chipped during the following operation of consolidation. This operation is performed by mechanical means such as vibrating plates or rollers; in order to prevent the surface from damages it is necessary to use rubber coated rollers and vibrating plates with a no-metal plate or at least coated with a plastic or rubber pad. In order to prevent the tiles alignment from being altered by vibrations due to absence of opposition on the free side of the laying field, the consolidation must be stopped at least two meters away from the open laying front. Prior to compaction, the flooring artifacts must have, at the interface lines with existing flooring and with continuity solutions such as manholes or drain grids, an additional thickness in order to match the sand drop that happens after compaction; this gap has to be increased by 5÷10 mm considering the set up that the floor will be subjected to by the operating loads. Moreover it should be noted that as regards to the height of the loglines (small ditches to allow rainwater and/or wastewater and similar to be drained), the floor surface, as a result of compaction, shall have a gap of 3 to 6 mm.

Riddle [mm]	Passing mass [%] natural sand
4,75	100
2,36	95÷100
1,18	70÷100
0,60	40÷75
0,30	10÷35
0,15	2÷15
0,075	0÷5

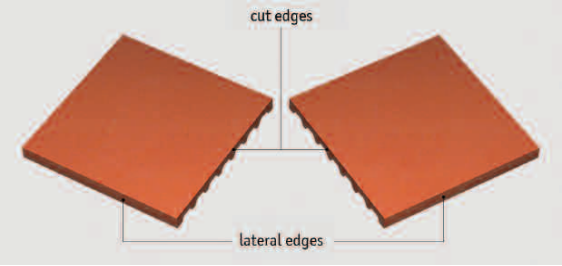
Sand particle size composition for joints clogging.

Once compaction has been completed, the joints filling will be performed by sprinkling sand over the surface of the new pavement, spreading evenly with brooms and repeating the process with vibrating machinery to facilitate its settling into the joints. Once verified the clogging of the joints, excess of sand will be removed by sweeping the surface and sprinkling with water in order to remove the dust that has settled during the laying operations. Once the cleaning of the surface has been performed, the paving is ready to be put into operation.

Laying on rigid layer

The rigid laying of a clay floor consists in manually placing the single elements on top of a mortar or glue layer with constant thickness (bedding layer), operating then the clogging of the joints with grout, very liquid mortar, earthenware mortar or sealants. With the rigid laying, the flooring bricks and "cotto" tiles become irreversibly a whole with the media through the bedding layer. The laying on mortar requires a bedding thickness between 30 and 40 mm; the laying on mortar requires a bedding thickness between 2 and 5 mm (if the glue is a "thin" layer type) and up to a 10÷15 mm (if the glue is a "thick" layer type) according to the thickness of the elements to be laid.

Equal environmental terms given, a pavement laid on mortar dries more slowly than one laid on glue; this difference is inevitably reflected on waiting times that elapse between the completion of the installation and execution of the treatment works. As regards the artifacts, we need to specify that the extruded "cotto" tiles, which come in couple on the construction site ("Spaccatelle") or already separated in the case of the square format, for lengthwise weaves should always be placed in the direction of the cut.



In the lengthwise laying, the extruded square shaped "cotto" tiles must always be place matching the artifacts' cut side.

Laying on mortar

Usually the mortar is prepared on site, but on the market there are some available and al ready dosed mortars to which it is sufficient to add the right amount of water in order to get the paste. The inert elements must be characterized by a wide and varied particle grading curve, in order to ensure a good compaction of the mortar with respect to the unit's volume; they should not contain significant levels of fine fraction of clay and organic matter. In regard to the binders to be used for the composition of the mortar, it can be observed that those based on cement are characterized by high performance and more shrinkage during the ripening stage compared to hydraulic lime mortar or bastard mortar. In particular, they have a rapid development of the mechanical strength and have a good durability; they are suitable for spaces subject to heavy operating loads and display a low porosity. The hydraulic lime mortars, thanks to their elasticity, have a special ability to absorb small deformations due to thermal shock and media flexibility. As regards the binder part of the bastard mortars, it is typically composed by a mixture of cement and hydraulic lime in order to combine and take advantage of the respective qualities.

Laying on rigid layer

Usually for interiors the clay artifacts are laid on bastard mortar; on the contrary for exteriors they are laid using cement based mortar, depending on the method of installation and the severity of operating conditions, 150÷250 kg of cement R325 per cubic meter of sand. The laying on a bed of mortar can be employed for bricks and “sestini” and “cotto” tiles; in particular, it is recommended for those molded artifacts (hand-made or "hand type") characterized by a more sensitive geometrical irregularity.

The laying on mortar can be carried out according to two techniques:

a) “dusting”;
b) “masonry”.

The “dusting” technique consists in forming a mortar layer of constant thickness on the surface to be floored; since the mortar has a "wet sand" texture type it will be beaten and leveled in order to obtain a perfectly flat surface. The dose of cement will be about 150 kg per sand cubic meter. The sand should have, preferably, the following particle sizes: coarse portion (4÷6 mm) equal to 40-60% of the volume’s unit; middle portion (3 to 4 mm) equal 25 to 45% of the volume and the fine portion (0 to 3 mm) equal to 20÷25% of the volume; in order to promote adhesion, the surface must be previously moisturized. After having applied and leveled the mortar layer and moistened it with sprinkled water by a painter brush or by nebulizer, cement powder will be spread over the laying surface. Then the laying can start. The clay artifacts characterized by high porosity (such as, for example, the ones formed in the mold) will be pre-wet with clean water, preferably by soaking; one precaution is to remove the excess of water from the surfaces using sponges or wet rags. Once the artifacts have been placed over the mortar bed, they are beaten separately, preferably using hammers with rubber or plastic heads. The aim of such a procedure is to settle the artifacts and make them adhere to the substrate and to achieve maximum coplanarity with the adjacent elements.

Floor with “sestini” laid with “dusting” technique.

Laying on rigid layer

The "dusting" laying allows the execution of floor portion up to 30 square meters; due to this prerogative, at the end of the laying of the artifacts on a portion, it is possible to use both the manual and the mechanical beating of artifacts. Once the beating has been done, the laid floor must be sprinkled with water; this procedure is necessary in order to hydrate the bedding mortar and the cement powder so that the gripping process can start. Once the wetting of the floor has been performed and the plastic spacers have been removed, the floor is ready for the execution of the joints clogging. The "masonry" laying technique consists in bricking up with mortar every single flooring clay element on the laying surface; the work progresses punctually, one element after the other, creating the bedding and at the same time laying the artifact. Compared to the "dusting" laying, in this case the mortar will have a greater amount of binder (200÷250 kg of cement per cubic meter of sand), while the sand will be of a smaller size (from 0÷3 mm). Similarly to what happens with the realization of a traditional brick masonry, this laying technique requires the wetting of each element in clean water, to 'put' the mortar on its rear face, and finally to perform the beating of each artifact while placing it. Since with this technique, as a result of the beating, the exciding mortar comes up through the joints, the clogging of the joints is - at least partially – performed at the same time of laying with the same material used for the bedding layer. The mortar that, conversely, may overflow, should be removed promptly with a trowel and with soft sponges. The "masonry" laying is the most suitable for the realization of floorings made from molded elements, characterized by quite large thickness, high porosity and not infrequently, especially in large sizes, from significant morphological and dimensional irregularities. Indeed, on the one hand this techniques allows substantial room for adjustments of the artifacts and compensation of the biggest geometric differences and on the other hand it simplifies the cleanup operations of the clay surface thanks to the particular system of joints clogging so that it is not necessary to cover up the paving surface with grout.

"Masonry" laying technique.

Laying on glue

In the laying on a bed of glue - used for laying the "cotto" tiles -, the bedding layer is made with chemical adhesives. The adhesives (or glues) are prepackaged mixtures made out of several constituents, marketed in various types of product. Same as mortars, adhesives ensure complete adhesion of the flooring artifact to the media, through the

Laying on rigid layer

Laying of hand made "cotto" tiles on glue bedding layer.
phase of gripping and hardening.

Since the reduced thickness of the adhesive layer allows a limited compensation of morphological and dimensional defects of the artifacts, the "glue" technique is suitable for products characterized by a satisfying geometric regularity. The high bond strength of adhesives can be used suitably for the laying of clay artifacts that have undergone water-repellent treatments.

The main types of adhesives for the laying of clay floors (and ceramic tiles in general) available on the market are (UNI EN 12004/2003):

1. powder of cement adhesives (the most widespread);
2. adhesives in dispersion;
3. reactive adhesives.

All of the three types are suitable both for interiors and exteriors. In the "glue" laying, of both "thin" layer and "thick" layer types, the flooring artifacts require only a slight dampening by sprinkling.

The main construction phases of a floor on a bed of glue can be summarized as:

1. spreading of a uniform layer of adhesive on the laying surface using suitable toothed-trowels. In order to increase the cohesion between the base and the coating, it is also possible to apply a layer of glue on the face of contact of the tile, using trowels with tooth's thickness equal to slightly more than a half of the total thickness of the layer of glue; this technique is always advisable for large format artifacts;
2. placing of the clay artifacts on the surface to be paved in the right times, depending on the gripping time of the adhesives used. In order to prevent the glue from creating a film superficially due to prolonged contact with the air, the time frame indicated by the manufacturer and packaging label must be strictly followed. In order to obtain a regular width of the joints, plastic spacers may be employed, as in the case of "dusting" laying;
3. beating of the clay artifacts, after these have been placed on the bed of glue in a uniform manner, to be beaten individually with a rubber or plastic headed hammer, so as to eliminate voids in the bedding layer and restrict the gaps

CLOGGING OF THE JOINTS AND CLEAN UP

between the elements on the planking level.
After having laid the artifacts on the bedding layer and having beaten them, the floor is ready for the clogging of the joints. This operation, in the case of rigid laying, should be performed at least 24 hours after application of the full floor: this time is required for the bedding material to reach the consistency needed to avoid the sinking of the artifacts caused by the transit of the installers. Before the start of operations, it is advisable to damp the pavement surface. The clogging of the joints in the clay floorings is performed with grout, very liquid mixtures of sand and cement, earthenware mortars and prefabricated sealants.
Effectively it is possible to conduct this operation by:

1. *complete coating* of the pavement surface (most used tecnique);
2. *linear filling* by pouring the mixture directly into the joints.

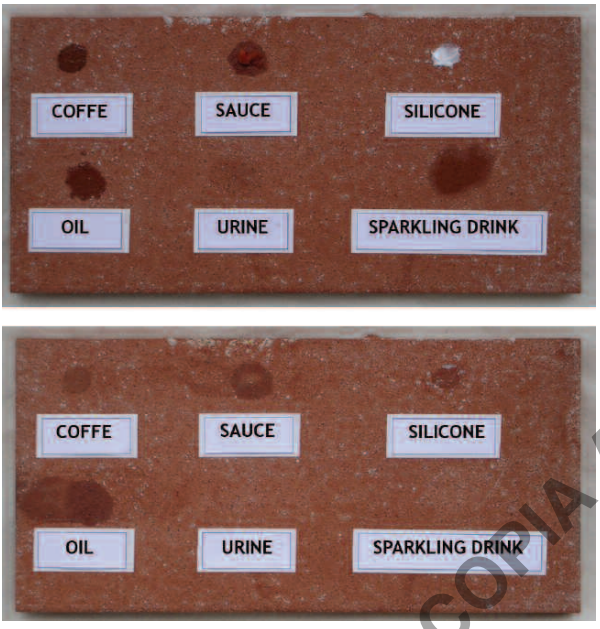
The clogging of the joints by complete coating of the pavement surface is performed by taking good care of making grout pour into the joints up to complete saturation, spreading it by mops with rubber or compact-sponge end, like those used for floor cleaning. The mops swipes over the surface must be repeated until the joints do not 'reject' the mixture, clear sign of their complete filling.

The linear filling of the joints, limiting the surface dirtying to the edges of the elements only, is advisable for more porous artifacts, but it takes time and accuracy in the execution and can be performed in the case of next to 10 mm wide open joints only. Operationally, the casting is carried out manually through strainers with spout, funnels or, alternatively, with syringes similar to pastry bags. The cleaning of traces of filling material from the surface of the clay must be done while clogging. The traces of filling material must be removed immediately with, for example, fine and dry silica sand, a-plenty sprinkling on floor area and then rubbing it in a robust way, manually or, more effectively, mechanically. Scrubbing with sand ensures a radical cleaning of the clay surface and the removal of residues left by the materials used for the clogging of the joints. At the same time, the sand strengthens the joints themselves penetrating inside them and becoming a whole with the material used for clogging; the action of 'reinforcement' is particularly effective if the clogging has been performed with grout only, a mixture of cement and brick dust.

In order to obtain an accurate work, after cleaning it is advisable to wipe the floor surface with a sponge or a wet pad, so as to immediately check the success of the sealing of the joints. The cleaning of the clay paving with sawdust is strongly discouraged because this can release oils and tannins that can stain the artifacts and tone down the joints irretrievably. Once the cleaning of the floor has been performed, before the start-up or waiting for the treatment, a good practice would be to protect the floor from damages or dirtying using wool or cotton bleached towels which do not affect breathability.
The use of cardboard sheets is not advisable because this material, if wetted, may release substances that can create stains and leave difficult to remove halos.

The treatment

The clay is, by its nature, a material with a marked ability to interact, directly and indirectly, with the surrounding and the materials and substances which it comes in contact with, manifesting inevitably and severely on its surface damages that may occur and design or installation mistakes. This 'sensitivity' to environment depends basically on its characteristic of being a "full body" porous material, with no protective layers, such as glazing, which aim essentially to hide less noble substrates. Appearance and substance coincide in clay and give the material a unique ability to age, together with the possibility to be regenerated by removing the worn surface patina. Clay's main features lie in its 'sincerity'; these features - depending on the perspective - may rise opposite judgments, since they can all be considered either factors of strength or weaknesses. The clay floorings for interiors, which combine high level of sanitation, high exposure to staining agents and relevant aesthetic expectations by the users, require, in addition to a competent design and an accurate and responsible conduct by the installer and all other operators involved in their execution, one more processing stage: *the treatment*.
Thus, clay artifacts -with the exception of pre-treated ones, of which a greater spread can be foreseen for the future- cannot be considered "finished", ready to use products but like other flooring materials of our tradition, such as wood, stone and marble or gravel, they require an intervention of finishing before completion.



Stain test on a not treated "cotto" tile. Above, at test starting; below, after about three hours of activity of staining agent. As can be noticed, some substances have been totally absorbed by the material; later on, a certain reduction of the halo will concern also the others.

Operating stages

Introduction

The clay floorings treatment is done through the following stages:

1. flooring analysis;
2. cleaning of the paving field;
3. correction of water absorption (stain-resistant) and finishing.

Following, these stages are synthetically described.

Flooring analysis

Once the floor has been laid according to the correct manner of execution, it must be protected from damages that may occur on site. In order to do so- pending the completion of the finishing work on walls and ceilings, and that the clay reaches the required humidity level - the floor must be adequately protected with sheets that do not affect breathability. The use of products with hydrophobic properties (much diluted vegetable oils or water-based siloxane emulsions) placed before laying, reducing the adhesion with extraneous agents, certainly provides some protection from stains (sealants, paint, plaster, etc.) and a safer and faster removal of them.

Being the last process performed on the flooring, the treatment plays a dual role: it is influenced by the stages that preceded it (from design choices to realization care to protection and prevention measures applied) and *appreciably* affect the appearance and functions of the coating layer.

In general, the treatments can in some cases only and very partially make up for any deficiency and defect in the flooring system. Unfortunately, it is more likely that a treatment which is incompatible with the nature and with the specific characteristics of the floor, becomes a trigger cause or concomitant cause of degradation. That is the reason why, beyond obvious difficulties, it is nonetheless essential that the treater, if different from the installer, gets the information about the intrinsic characteristics of the pavement in order to perform its work in a conscious way.
It would be advisable for the treater, in case of doubts on the characteristics of the clay artifact, to contact directly the manufacturer. Possible corrective actions to be performed during the treatment may interest both flooring artifacts and joints. When, for example, the "cotto" tiles display a surface with undesired tone differences (because considered too showy or because, due to an inaccurate laying, have been concentrated locally), it is possible to mitigate the effect by using darkening finishing products. Products with mid or dark tone can also be used in the presence of leaks with spots of color (in this case, the pattern of the joints may then be adjusted with pigmented buffering).

Operating stages

Washing and cleaning of the floor

The aim of the floor area washing - stage which starts the treatment - is to remove mortar, glue or grout remains and other construction site spots. Between the laying and the washing phase it is necessary that the time required to reduce the moisture on clay artifacts' surface down to values close to 25% (the detergent action, in fact, is much more effective if it occurs on a "cotto" tile with the lowest possible content of humidity) and to let emerge on the surface the saline efflorescence, has completely elapsed. The determination of the waiting time is influenced by many factors: the material used for the bedding layer and its thickness, the type of shaping, the nature of the wear surface (whether ordinary or protected with breathable hydrophobic substances), the presence of layers of water tightness and the temperature and humidity conditions of the intervention site. Usually, for artifacts laid on glue or mortar with synthetic binders with low release of water, regardless of the type of shaping, the average waiting time is 7 to 10 days depending on the weather conditions; for artifacts placed on mortar, in hot and dry environment, the waiting time should be 10 days for every cm of thickness of the artifact and 15 days if the environments is cold and humid. These waiting times must be doubled if in the flooring system there are waterproof functional layers.

Traditionally, the washing is performed with hydrochloric acid - commercially known as muriatic acid, a substance known for its toxicity and its aggressiveness - diluted in water (in the ratio of 1 to 10 up to 1 to 5 in the case of acid at the higher concentration). Due to the high reactivity of the hydrochloric acid with carbonates, it is advisable not to leave the acidic solution on the floor for too long (possibly no more than 2 to 3 minutes) in order to prevent damages or joints down tones.

Even if the acid wash is effective against most of the dirtying substances fallen on the clay floor during the construction phase (cement grout, lime residues, lime based painting, salt efflorescence, rust, etc.), nevertheless there are certain types of dirt that need other kind of reagents in order to be removed. For example, in the case of stains caused by pollution, mold or algae, caustic soda in water solution is usually effective; in the case of residues of plaster containing synthetic components, turpentine or nitro thinners are indicated; in case of sulfation dark stains, specific alkaline pullers are required. The rinsing with pure water follows the washing; both procedures can be performed manually or, preferably, by single brush and water vacuum. Some of the reagents mentioned have the advantage to be particularly cheap, but they are very harmful from a toxicological and ecological points of view. In addition, if the rinsing water is not removed immediately (for example, by water vacuum), it may cause a certain re-absorption of removed dirt. For these reasons, detergents in water solution with almost comparable efficacy, which are safer both for the operator and for the environment, have been created; these, moreover, thanks to special surfactants, maintain the particles of dirt removed in suspension, facilitate their elimination in the rinsing phase and reduce the consumption of water.

Operating stages

Finally, we must remember that the use of certain reagents may have undesirable consequences in the treatment phase. For example, if the treatment chosen is the one performed with vegetable oils, it is necessary to avoid the washing of the floor area with caustic soda. This - being chemical alkaline par excellence, raising the pH of the floor, can lead to saponification of the oil, jeopardizing the job.

Correction of water absorption

After washing, it is prudent to wait at least 10 to 15 days before proceeding with treatment. This time interval (during which the floor should not be walked on, or be subjected to any kind of work) is required in order to verify the possible occurrence of efflorescence, and that being the case, the washing must be repeated, otherwise, the work can continue. In order to comply with the porous nature of clay, enjoy its texture and prevent certain degenerative phenomena, the correction of the water absorption must be performed by using "breathable" products, that is to say with products capable to prevent the ingress of liquids, but at the same time, that allow, even if to a lesser extent compared to the original condition, the discharge of vapor. In other words, the aim is to confer to the clay the repellency to water and staining substances, but not the complete impermeability.

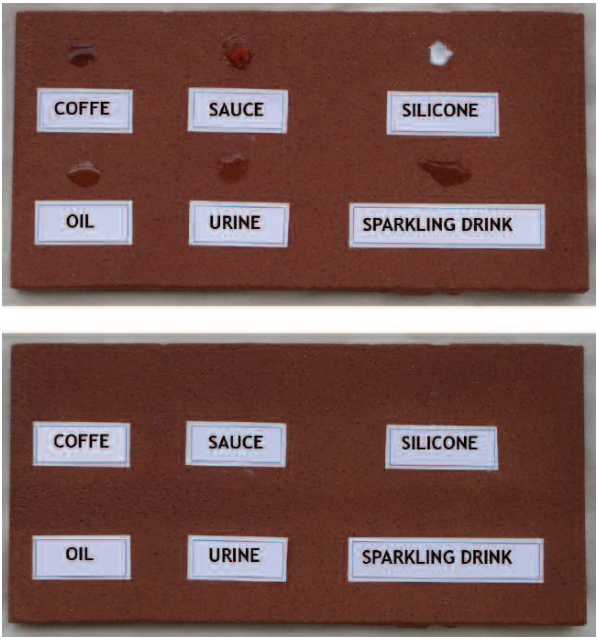
Therefore, film-forming treatments are not recommended since they create a continuous patina on the floor surface: in fact even if they would be able to ensure to the clay artifact an excellent stain resistance, far superior to the one which can be obtained by the breathable products, they would distort irreparably its nature.
The breathable treatments can be divided into two broad categories:

1. traditional treatments;
2. innovative treatments.

The first ones consist, principally, in blends based on vegetable oils. In the group of traditional treatments type, we can put also treatments done with neutral or pigmented waxes. Usually, 24 hours after a first layer of liquid wax has been laid, 2 additional layers of paste wax are added (2÷3 hours away from each other). The work will be completed by a layer of liquid renewable wax. The dosage of the components and procedures for preparation of these crafts have always been jealously kept secret, but the ancient mixtures, despite the obvious differences from area to area, were typically composed by the following components: raw linseed oil, drying substances, diluents, plus possibly hardening substances (such as natural resin). One of the solutions handed down from the past was about mixing the raw linseed oil with natural pine turpentine, with lead based driers, verdigris and ash lye. Nowadays some compounds inspired by this ancient recipe are available on the market, with the difference that they contain a small percentage driers (usually 5% less) and lighter metals such as calcium, cobalt and manganese.

Operating stages

The knowledge of the ancients, outcome of centuries of experience made through mistakes, thoughts and imperceptibles improvements, was, unfortunately, hastily set aside and we have gradually lost track of the old recipes. As a consequence, only the main component of the linseed oil based mixtures remained (as evidenced, for example, in some price lists of Civil Engineering Office), sometimes proposed diluted with white spirit or turpentine. In recent years only, as part of an approach to construction more attentive to the human interaction with the environment, weak signs of recovery of attention to the ancient compositions can be seen, but the path ahead is just at its start and, in order to produce scientifically reliable and effective results, it should be walked through together with the last operant craftsmen, historians, restorers and chemists.



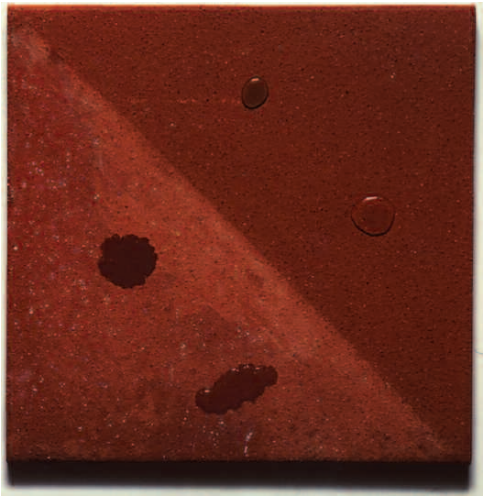
Staining test on an extruded "cotto" tile treated with two coats of a solution of raw linseed oil and 50% of turpentine. Above, at the start of the test: below, after about three hours of stay of the staining agent. As can be noted, at the end of the test the surface appears to be completely clean from stains and haloing.

The vegetable oils based mixtures must be laid (with brushes or rags) through multiple coats (usually two or three, depending on their viscosity and the porosity of the clay), until complete rejection. The intervals between a layer and the other depends on the type of oil used (the cooked one is much more viscous than the raw) and by the presence and percentage of solvents or driers: in general terms, we can say that the raw oil linseed, drying in deep very slowly, requires waiting times much longer than the cooked one (at least 48 hours compared to 8 hours of cooked linseed oil). On the other hand, the high speed of resinification of the cooked linseed oil requires a certain experience by the professional in the coating stage, in order to avoid the formation of streaks and hard to remove annoying overlaps.

Operating stages

The principle of the traditional stain-resistance treatments can be described as follows: greasing preventively and uniformly the clay surface with an oily substance capable of saturating the most superficial pores (oils penetrate for a few tenths of a millimeter, depending on the porosity of the artifact), further staining substances and water too do not penetrate and/or are not visible. Such treatments include, often, a surface finishing which consists, usually, in two or more layers of liquid or paste natural waxes, with or without pigments. The choice depends primarily on the aesthetic guidelines (if a more natural and opaque look is desired, the waxes are definitely not recommended), even if it has important consequences on stain resistance (the protective wax is particularly useful in the early operating days of the new floor), on functionality (slipperiness enhancement), on durability (wear reduction) and, above all, on the maintainability of the floor (the wax must be periodically regenerated). Waxes, in the end, inevitably and significantly reduce the vapor permeability of the clay artifact and, for this reason, they are used on inter-storey interior flooring only. The finishing with beeswax (in the most traditional version) can be applied after 10 days from the linseed oil based solution coating, and the number of coats depends on the porosity of the artifact and on the desired aesthetic effect to achieve.

The breathable products are based on innovative substances that have a very large range of employment, allowing the professional to calibrate the intervention according to criticalities and scenario peculiarities. According to the solution which they are dispersed in, we can group these products into two main categories: solvent based products and water based products. If compared to the second ones, the solvent-based products ensure a deeper penetration capacity and, therefore, a higher durability.



"Cotto" tile displaying, in the treated part (triangle on the right), the typical "pearl effect".

Operating stages

The water-based products, for their part, are more harmless to the environment and to the professional; they can be applied in the case of not perfectly dry floor surfaces too and since they dry out more slowly, it is easier to lay them and they are more evenly absorbed by clay.

The innovative products are based on a very different stain resistance principle if compared to the traditional products' one. While penetrating into the clay, they fill the most outward cavities, forming a barrier that inhibits the passage of water due to the high surface tension that these substances activate in contact with it, though allowing vapor diffusion. The high surface tension of the interface makes the staining substance take, in contact with the surface of the treated clay, a characteristic spheroid shape ("pearl effect"). Among the products on the market we can mention the copolymers and fluorinated siloxane compounds. The first ones can perform finishing function too or, more commonly, must be protected by a renewable finishing layer. In this second case, in order to improve the adherence of the finishing layer, it may be necessary to lay a primer on top the stain resistant product. The siloxane compounds act as deep water-repellent and, therefore, stain resistance can be achieved only with the preparation of a surface protective layer; work is completed by a layer of renewable liquid wax. These, once penetrated into the material, give rise to chemical reactions (due to inner residual humidity and silicates contained in the clay structure) which guarantee a strong attachment to the cavities' walls and to the internal meatus' walls.

The penetration capability of the siloxane compounds depends on the type of molecule, on the solution (if water based or solvent based) and on the porosity of the clay, varying from a few tenths of a millimeter for extruded products, less absorbent, up to 1÷2 mm for more porous molded products. When, in this second case, also for economic reasons, it is desired to limit the penetration of the product within the material, a retaining bottom can be layered prior to the water resistant product.

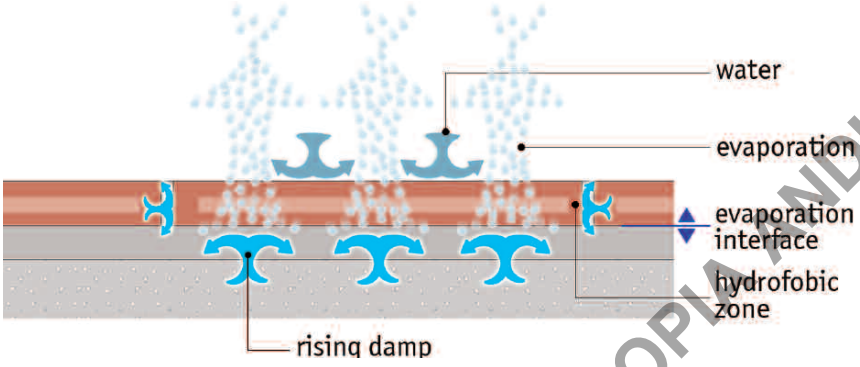
Treatment		Products	Stain resistance principle
Waterproofing		Synthetic resins (polyurethane, epoxy, polyester, etc.).	Creation of a surface film water, stain and vapor resistant
Transpiring	traditional	Vegetable oils based mixtures + (optional) natural wax finishing .	Saturation of the surface pores and achievement of water-oil repellency
	innovative	Fluorinated copolymers + gripping layer + finish with emulsions of hard waxes and resins	Surface impregnation and achievement of water-oil repellency
		Siloxane compounds + natural and synthetic paste waxes stain resistant mixtures layer, with solvent + finish with liquid waxes	

Synoptic table of the stain resistance principles and products used with regard to the type of treatment.

Typologies of paving and related treatments

The operational stages of treatment previously analyzed do not fit to all kind of floors. The problems about treatment in situ, in fact, is limited to floorings with coating layer laid with rigid technique only; moreover, it is influenced by the microstructural characteristics of the clay and must be modulated depending on the setting and the typology of flooring since the nature of aggressive agents and their direction of penetration in clay artifacts depend on these factors.

In the *external paving* on soil, the clay artifacts are exposed to ingress of aggressive substances from the outside (from above) and inside (from the bottom and sides). From above the staining substances (such as oils, greases, paints, pollution etc.) come, but also the rain water that can imbibe more porous artifacts with the dual effect of mobilizing the contained minerals, bringing them to the surface, and to cause breakage due to frost; rain water can be absorbed by the material also laterally, through the joints, depending on their porosity.
From below and laterally moisture too penetrates the artifacts going back up by capillarity with more or less high concentrations of salts subtracted to the soil and to functional layers which constitute the floor, including the coating layer.
Clearly, in external pavings on soil, a water repellent treatment exclusively limited to the wear surface of the artifact would leave the other sides of the perimeter vulnerable to penetration of saline solutions. Even though breathable, these treatments slow down the evaporation of water capillary risen or absorbed through the joints, with the risk of triggering freezing phenomena. And not only that. They may, in some circumstances, determine the "under skin" crystallization of the salts mobilized by water (crypto-efflorescence), a phenomenon that generates on the clay surface high mechanical tensions that can cause breakage and chipping. The same degenerative phenomena may also affect the outdoor paving of technological units



In scenarios where there is a risk of humidity rising from the bottom and/or sides, the stain protection (water-oil repellent) must be supported by a depth protection covering all sides of the artifacts, made before the laying the floor. In inter-storey slabs floorings, however, it is sufficient to provide the stain protection only.

Typologies of paving and related treatments

(balconies, terraces, loggias, stairs, etc..), due to the rising of the water possibly penetrated below the coating layer and retained by the sealing layer, and the interior floors on soil, in which the rising damp can reach the coating layer not only through the surface in contact with the soil, but also through the bearing walls.

Therefore, when it is not possible to be sure that no water can get access to the artifact from different sides but from the wear one, it is preferable to refrain from any kind of treatment limited to the pavement surface only, targeting the inhibition or delay of evaporation of water.

If a stain protection of the floor is desired (for example, in open spaces designed for cooking or eating, in entry paths, in external staircases, etc.), the only truly secure system is to *submit in advance*, *during the production stage*, the artifacts to a hydrophobic protection which affects the *whole element*.
Plus, this kind of treatment also provides clear benefits to dry-laid artifacts (on spacers or on drainage layer).

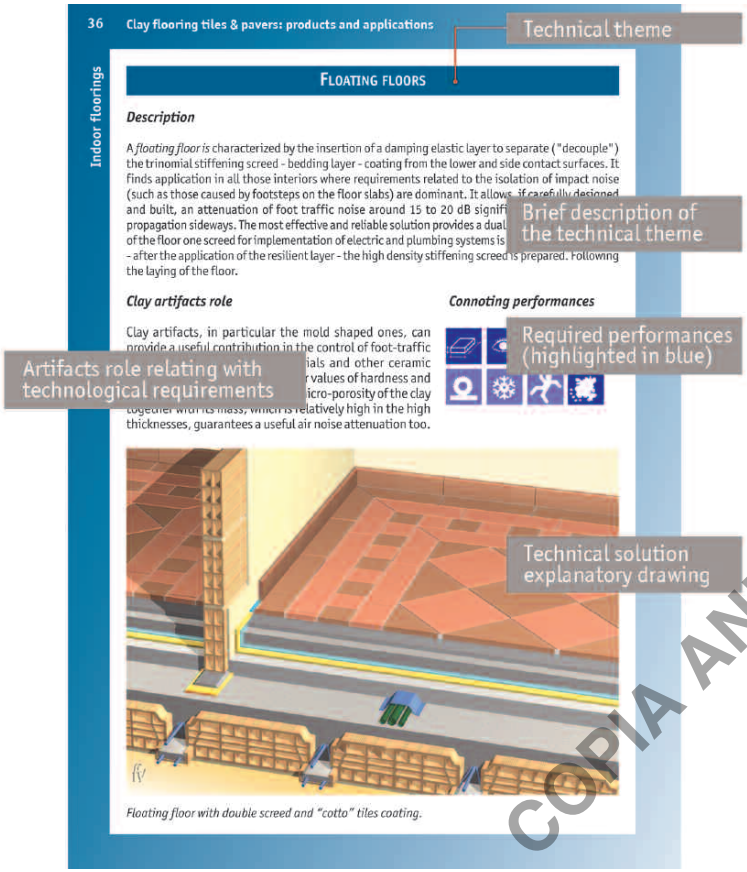
About the products, siloxane water-based emulsions are currently mainly used, applied by immersion or by spray gun (the first technique is generally used at the factory, and the second one mainly in situ), but similar results can be achieved with very dilute solutions of raw linseed oil.

Extruded "sestini " floor with siloxanes in aqueous solution based water-repellent protection.

POSSIBLE APPLICATIONS

The data-sheets repertoire in this section summarizes, through text descriptions and graphics (icons, perspectives and cross sections) addressed to the designer, complex technical information of the possible application solutions. Here are shown, briefly, some of the most significant scenarios in which "cotto" tiles and flooring are used.

Each data-sheet is divided into two parts: in the first - introductive part- the analyzed technical theme is briefly described (giving the definition, indicating where and when it can be used and how it is done); following, the positive contribution that the clay flooring artifacts can offer and their intrinsic performance characteristics. Finally, an explanatory three-dimensional drawing of the specific technical solution is presented.

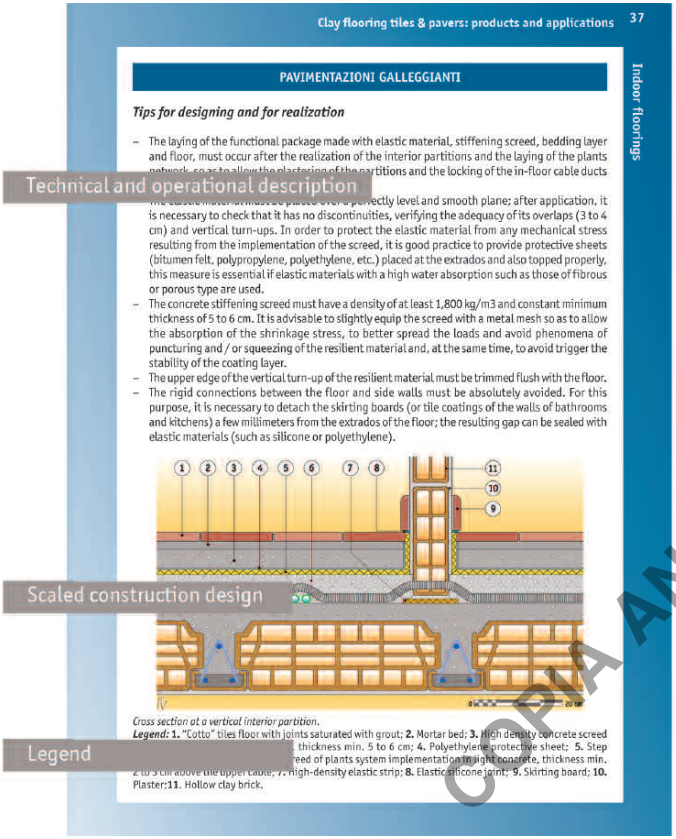


Layout of the first part of the data-sheet.

Possible applications

In the second part of the data-sheet, the technical solution is examined in depth; operational guidelines and suggestions addressed to the designer, the site supervisor and the contractor are given, as well as a scaled construction detail together with the legend of the materials to use.

Legend of the main expected benefits of clay artifacts used in the technical solution.



Layout of the second part of the data-sheet.

Floating floors

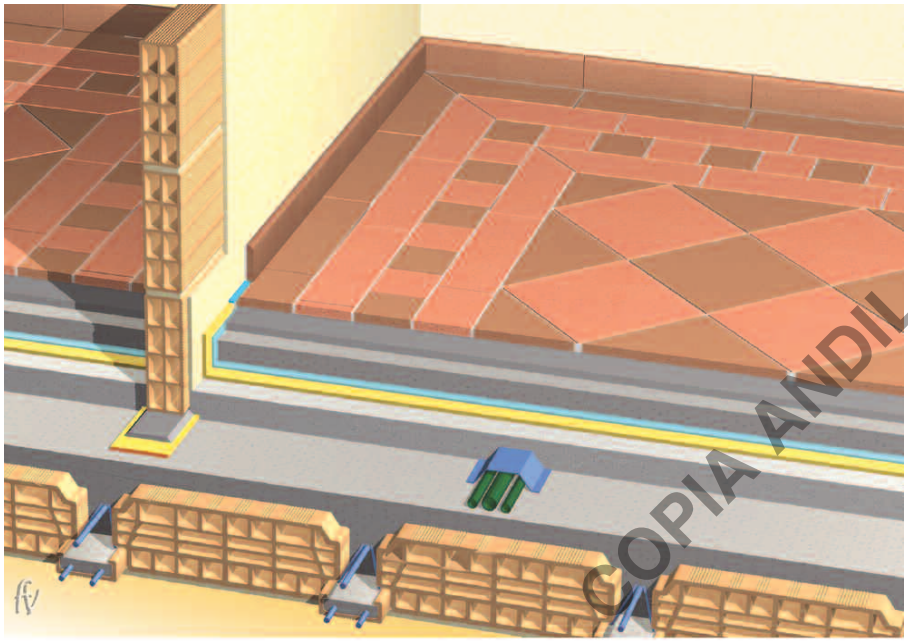
Description

A *floating floor is* characterized by the insertion of a damping elastic layer to separate ("decouple") the trinomial stiffening screed - bedding layer - coating from the lower and side contact surfaces. It finds application in all those interiors where requirements related to the insulation from impact noise (such as those caused by footsteps on the floor slabs) are dominant. If carefully designed and built it allows an attenuation of foot traffic noise around 15 to 20 dB, significantly reducing noise propagation sideways. The most effective and reliable solution provides a dual screed: at the extrados of the floor one screed for implementation of electric and plumbing systems is built and on top of that - after the application of the resilient layer - the high density stiffening screed is prepared. Following the laying of the floor.

Clay artifacts role

Clay artifacts, in particular the mold shaped ones, can provide a useful contribution in the control of foot-traffic noise. Compared to stone materials and other ceramic materials, they have, in fact, lower values of hardness and acoustic impedance. The natural micro-porosity of the clay together with its mass, which is relatively high in the high thicknesses, guarantees a useful air noise attenuation too.

Connoting performances

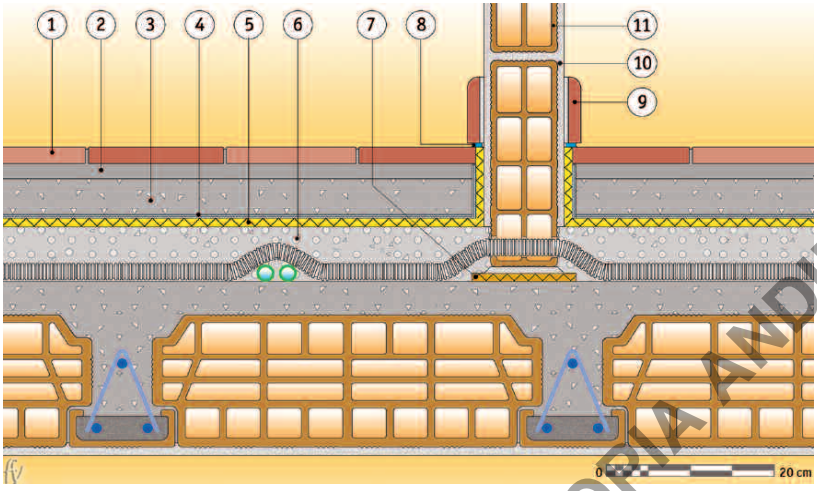


Floating floor with double screed and "cotto" tiles coating.

Floating floors

Tips for designing and for realization

- The laying of the functional package made with elastic material, stiffening screed, bedding layer and floor, must occur after the realization of the interior partitions and the laying of the plants network, so as to allow the plastering of the partitions and the locking of the in-floor cable ducts into the screed.
- The elastic material must be placed over a perfectly level and smooth plane; after application, it is necessary to check that it has no discontinuities, verifying the adequacy of its overlaps (3 to 4 cm) and vertical turn-ups. In order to protect the elastic material from any mechanical stress resulting from the implementation of the screed, it is good practice to provide protective sheets (bitumen felt, polypropylene, polyethylene, etc.) placed at the extrados and also topped properly, this measure is essential if elastic materials with a high water absorption such as those of fibrous or porous type are used.
- The concrete stiffening screed must have a density of at least 1,800 kg/m^3 and constant minimum thickness of 5 to 6 cm. It is advisable to slightly equip the screed with a metal mesh so as to allow the absorption of the shrinkage stress, to better spread the loads and avoid phenomena of puncturing and/or squeezing of the resilient material and, at the same time, to avoid trigger the stability of the coating layer.
- The upper edge of the vertical turn-up of the resilient material must be trimmed flush with the floor.
- The rigid connections between the floor and side walls must be absolutely avoided. For this purpose, it is necessary to detach the skirting boards (or tile coatings of the walls of bathrooms and kitchens) a few millimeters from the extrados of the floor; the resulting gap can be sealed with elastic materials (such as silicone or polyethylene).



Cross section at a vertical interior partition.
Legend: **1.** "Cotto" tiles floor with joints saturated with grout; **2.** Mortar bed; **3.** High density concrete screed possibly reinforced with wire mesh, thickness min. 5 to 6 cm; **4.** Polyethylene protective sheet; **5.** Step sound insulation elastic layer; **6.** Screed of plants system implementation in light concrete, thickness min. 2 to 3 cm above the upper cable; **7.** High-density elastic strip; **8.** Elastic silicone joint; **9.** Skirting board; **10.** Plaster;**11**. Floor clay blocks.

RADIANT FLOORS

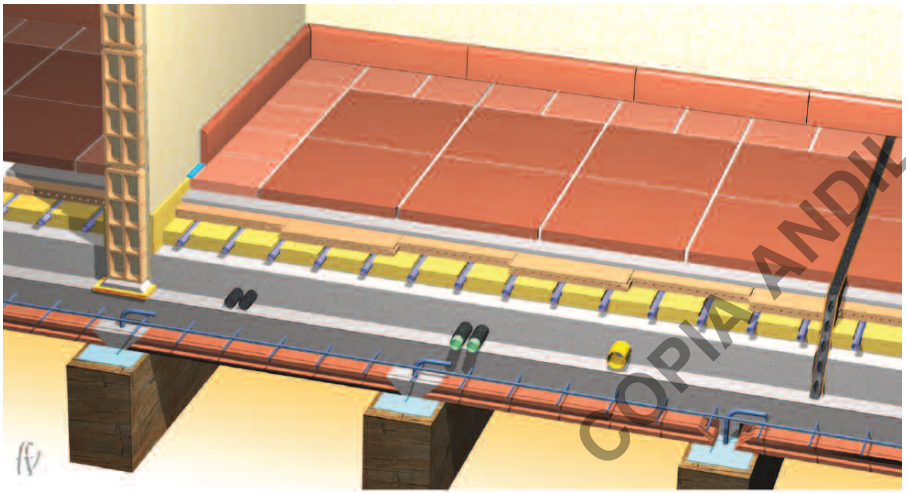
Description

A *radiant floor* is characterized by the integration of the heating system (coils or tubes) with the functional package which composes the flooring. It finds application where, for aesthetic reasons or accident prevention, the presence of radiant equipment on walls is not desired, and especially when the aim is to obtain a higher energy efficiency. In fact, compared to traditional heating systems, this solution allows to keep a lower temperature by 1 to 2 °C. The low water inlet temperature (35 to 40 °C) is also compatible with the use of solar energy, generated by ordinary collectors, and geothermal energy. The solution is recommended for spaces with considerable height, as it allows to maintain the air near the floor constantly warmer. The functional layer that hosts radiant conducts is always placed above the thermo-insulating layer in order to contain heat losses downwards. If provided, the plant system implementation screeds are located below the thermo-insulating layer. Ducts can be integrated in the thermo-insulating panel, or fixed above it with pipe clamping devices; the whole is usually completed with a layer of stiffening screed made of admixture concrete armed with the mesh or, alternatively, with a subfloor.

Clay artifacts role

The clay artifacts, while forming the coating layer, can represent a valid alternative to concrete for the construction of the reinforcing layer, with obvious advantages in terms of thickness, weight and speed of implementation. The clay subfloor allows transmitting heat faster from the radiant ducts to the room and it is an interesting option in the case of spaces used discontinuously.

Connoting performances

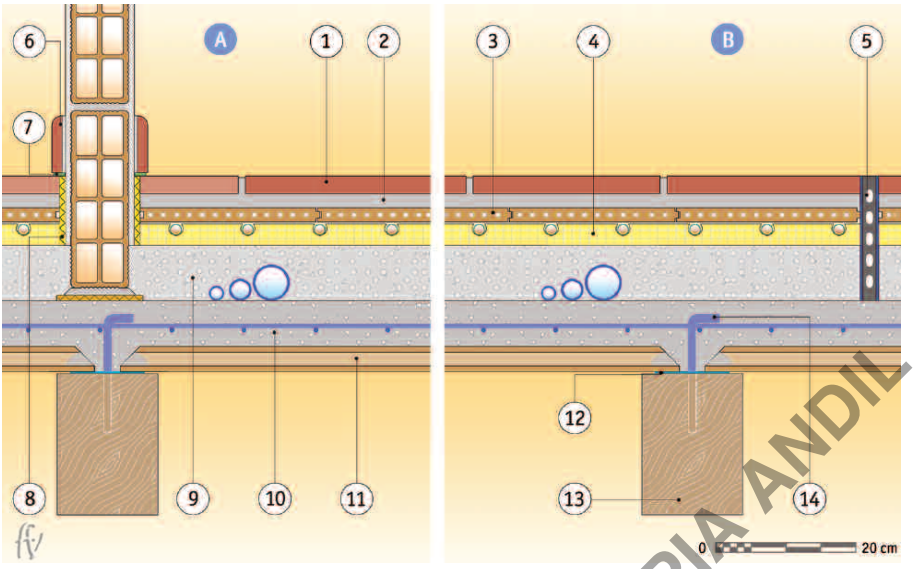


Radiant floor with clay subflooring and "cotto" tiles coating.

RADIANT FLOORS

Tips for designing and for realization

- In the case of discontinuous bearing structures (either metallic or wood), in order to facilitate the integration of the assembly it is advisable to connect the bearing screed's reinforcement to the beams with metal connectors.
- The laying of the functional package the radiant floor is composed by must be done next to the plants system implementation screed, the plastering and the realization of the resilient material strip along the perimetral walls (in order to avoid the step sound to spread sideways).
- The application surface of the heat-insulating panel that contains the radiant pipes must be perfectly level and free of asperities and debris.
- The radiating elements must be placed at least 5 cm from the closures and the vertical structures and at least 20 cm from chimneys and elevator shafts.
- The hollow flat tiles must be dry-laid above the thermo-insulating panel containing the radiant system after interposition of a protection layer; they must be put in opposition of the perimetral resilient material strip.
- In case a greater thermal inertia to the technical solution is desired, thickened "cotto" tiles may be laid as a subgrade.
- The operation of the heating system can start immediately after the gripping of the bedding layer of the floor.



Detail "A" cross section at an internal partition (left). Detail "B" cross section at an expansion joint (right).
Legend: **1.** Thickened "cotto" tiles floor (> 2 cm); **2.** Mortar bed; **3.** Dry-laid hollow clay tiles with shaped edges; **4.** Preformed thermal insulation panel with radiant tubes inserted; **5.** Expansion and control joint made out of EPDM rubber; **6.** Clay skirting tile; **7.** Elastic joint made out of silicone filler; **8.** Polyethylene foam perimeter joint; **9.** Light concrete screed for plants system hosting; **10.** Reinforced concrete slab; **11.** Fairfaced clay hollow flat tile with oblique trim and male-female shaped edges; **12.** Polyethylene sheet; **13.** Solid or laminated wood beam; **14.** Metal connector.

STAIRCASE FLOORS

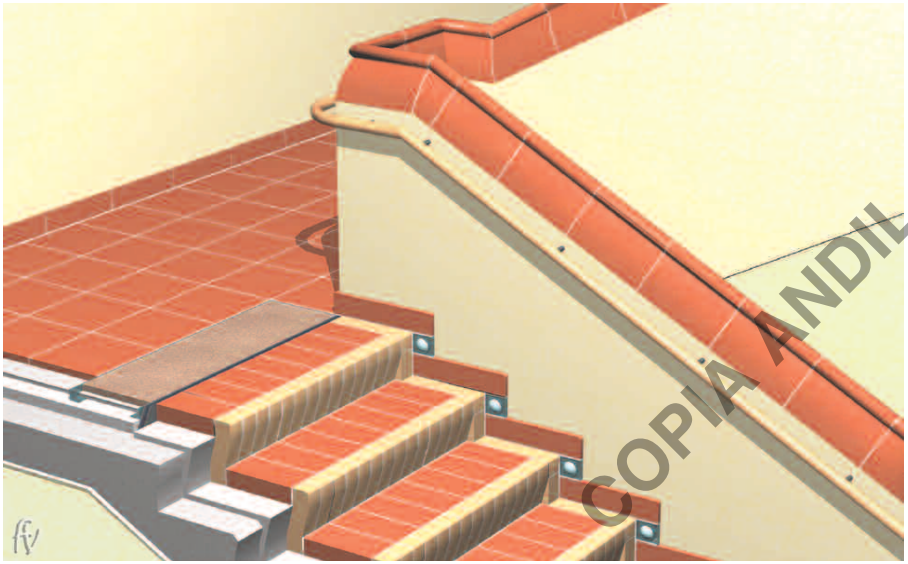
Description

The *staircase floors* must comply with a variety of technical requirements: slip resistance, comfort, space communicativeness, abrasion resistance. A proper tread/ riser ratio ensures a comfortable practicality of the stair and reduces fatigue; suitably shaping the step (for example, by installing continuous profiles inclined inwards), it is possible to extend the tread, reducing the risk of tripping and the extent of damage in case of fall; the step surface must ensure a high slip resistance both in dry and wet conditions; an appropriate design of the coating can help identify the ramps and legibility of the stair geometry by people with impaired sight; proper lighting of the stepping surface, through marker lights placed on the side of the path, can help ward off the risk of falls. In the case of reinforced concrete structure, both on site or prefab, the steps are usually made by casting, together with the slab; the coatings are normally wet-laid.

Clay artifacts role

Connoting performances

The clay artifacts (mostly "cotto" tiles, but also bricks), thanks to their slip resistance skills, versatility and modularity, are always used for the coating of stairs: "cotto" tiles for the coating only of tread and riser; bricks also for molding the steps. Their wear resistance and paste coloring make them recommendable in stairs of public buildings or public use stairs; the wide range of colors allows to meet different aesthetic requirements related to morphological legibility and accident prevention purposes.

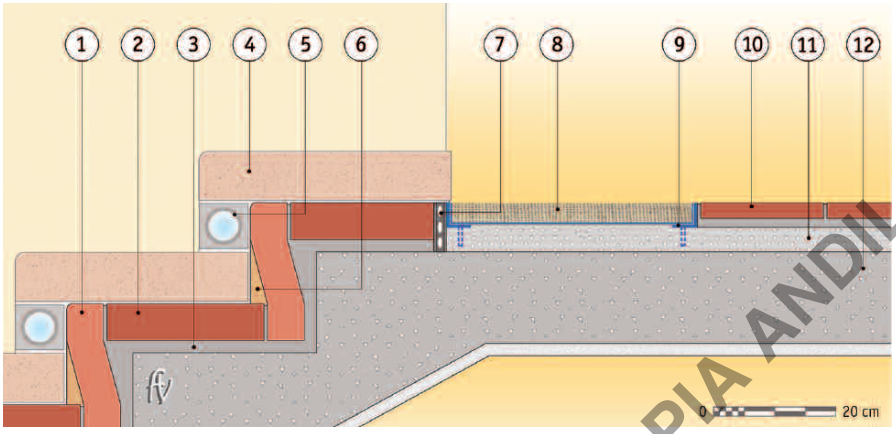


Staircase flooring with continuous profile brick step and step-marker.

Staircase floors

Tips for designing and for realization

- In the sizing of stairs of public buildings or public use stairs the requirements found in regulations for the removal of architectural barriers and fire regulations must be applied. According to the first one, the riser/tread ratio must be adjusted by the Blondel's formula (2r + t = 62÷64 cm) with a minimum tread of 30 cm (24 cm for stairs of private buildings); according to the second one, the minimum riser must be 17 cm, the minimum tread 30 cm. For safety reasons, it is preferable that the step displays a continuous profile with inclined riser such as to form, with respect to the tread below, an angle of 75÷80.
- In the case of steps with shaped profiles, in order to simplify the installation of the skirting, along the perimeter regularization elements (made out of clay, stone or marble) at right angle and continuous profile may be applied.
- In order to facilitate the perception of the steps on the way down, in particular by weak eyesight people, there should be a step marker highly contrasting with the coating of the tread; for the benefit of visually impaired people, 30 cm from the beginning of each ramp a band, perceivable by non sight senses, should be placed on the floor. The step marker must have a high slip resistance also obtained by appropriate surface treatments.
- The coating of the treads, in order to prevent possible stagnation of washing water, must have a slight slope (0.3÷0.5%) towards the outside.
- The adhesives or bedding mortars, as well as the materials used for the sealing of joints, must have a certain degree of elasticity, in order to avoid a too strong constraint that could cause cracks in the floor induced by the elasticity of the bearing structure.
- In the case that uncouth structure of the stair displays irregularities that have not been offset by the thickness of the bedding layer, the tread and risers laying surface must be regularized.



Cross section at the landing.
Legend: **1.** Riser-step marker made with strawyellow colored shaped bricks (special piece); **2.** Red bricks tread; **3.** Mortar bed; **4.** Red brick skirting; **5.** Light marker; **6.** Regularization floor brick strawyellow colored; **7.** EPDM rubber perimeter joint; **8.** Recessed coconut fiber mat; **9.** Aluminum L shaped profiles for the mat housing; **10.** Stair landing floor made with "cotto" tiles on a bed of mortar and with white cement grout joints; **11.** Light concrete screed; **12.** Reinforced concrete bearing structure.

Accessible roofs floorings

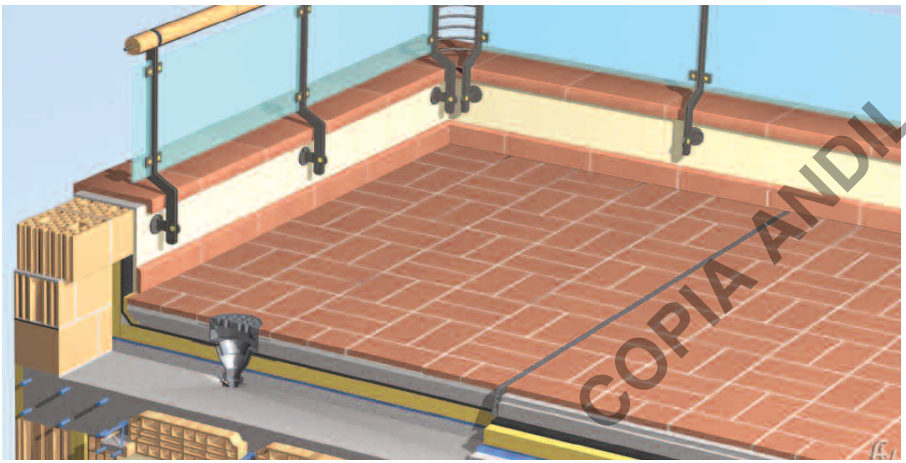
Description

The *accessible roofs floorings* must ensure the fulfillment of several security requirements, usability, appearance, health and maintenance. As in all roofings, however, the main problem is related to water tightness and to water flowing. While water infiltrations affect the functioning of underneath spaces themselves and can trigger serious diseases, water stagnations have a very negative impact on flooring artifacts: they may cause appearance changes (particularly in more porous artifacts), reduce their frost resistance and slip resistance and activate - as a result of the presence, in the same element, of wet and dry areas - internal tensions which not rarely generate breakages and chipping. From a practical point of view, the floor - which must be slip resistant and freeze resistant- can be dry-laid, on a bed of gravel or on disk spacers, or wet-laid, on a bed of mortar or glue. In both cases, the waterproofing layer can be placed on top ('classical' layering) or below ('inverted roof') the thermo-insulating layer. The wet laid floors, because of their particular vulnerability to deformation due to temperature variations and to the shrinking of conglomerates, should be with "open joints"; Furthermore it is essential that they are equipped with suitable devices (deformation joints and sliding layers) which can reduce the constraint between the functional layers and absorb the tensions resulting from dimensional variations.

Clay artifacts role

The microporosity of the clay artifacts is a great quality for the safety and the overall reliability of the flooring system: when wet, they dry quickly, avoiding, during bad seasons, the formation of the thin layer of condensation moisture, one of the main causes of falls due to slipping; in wet-laid floorings, the water possibly penetrated underneath the coating layer and retained by the sealing layer may be disposed quickly, at vapor state.

Connoting performances

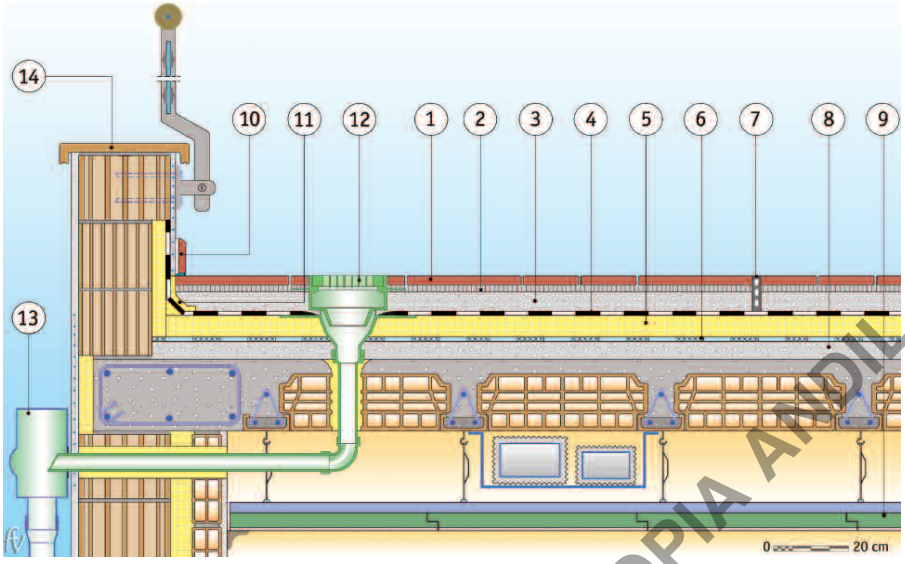


Continue and insulated accessible covering floor coated with "cotto" tiles.

Accessible roofs floorings

Tips for designing and for realization

- The water flow system must be designed carefully in order to avoid stagnation that could trigger diseases and alterations of the appearance of the clay floor and increase its slipperiness. Slopes of the order of 1% can be considered adequate for extruded products, while for the molded ones, which are more porous, it is suggested (as long as there are no legal barriers) at least one half percentage point higher.
- The water-resistant layer, in order to reduce the constraint with the contiguous functional layers, can be laid leaving it independent or thermally fixed by points or by lines (in the case of bituminous sheaths); in correspondence of emerging elements, it should be folded to a height equal to the maximum expected level reached by rain water or melting snow; it should be also carefully connected to the flanges of the main drain.
- The vapor-barrier must always be laid underneath the thermal insulation layer. The thermo-insulating panels must have high density (> 25 kg/m^3) and a compressive strength > 2 kg/cm^2.
- In order to confine the effects of dimensional changes due to temperature or shrinking, expansion and control joints should be installed in central position and/or along the perimeter. The expansion joints at a distance 3 to 5 m in both directions, depending on boundary conditions; the control joints must be placed in correspondence of the emerging elements.
- It is strongly recommended not to apply water-repellent treatments limited to the wear surface of the clay paving only in order to safeguard the breathability of the material and to avoid mechanical stresses determined by frost and by crypto-efflorescence phenomenon.



Section detail at the parapet and at expansion joint.
Legend: **1**. "Cotto" tiles floor; **2.** Glue layer. 3. Light concrete screed; **4.** Bituminous sheath; **5.** High-density thermo-insulating panel; **6.** Polyethylene sheets vapor barrier laid on compensation synthetic fabric layer; **7.** Aluminum expansion and control joint with vulcanized EPDM insert; **8.** Lightweight concrete slope screed; **9.** Pre-finished mineralized wood fibers false ceiling panels; **10.** Untied skirting; **11.** Perimeter deformation joint; **12.** Drain and PVC pipe gutter; **13.** Copper drop outlet; **14.** Clay capping.

Floorings for pedestrian and cycling areas

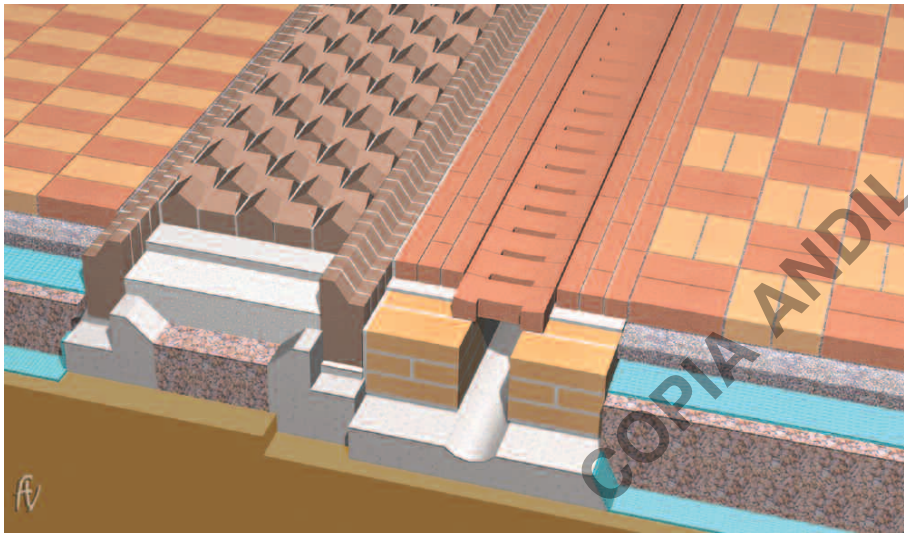
Description

Floorings for *pedestrian and cycling areas* are characterized by the need to support traffic loads despite low intensity, still able to produce, over time, a significant wear action on the coating layer. It should, however, be considered the possibility for these floors to be subjected to the passage of emergency and service vehicles too. With regard to discontinuous floorings, the choice between different options depends on aesthetic reasons (setting, character of the place, color, local traditions, etc.), technical reasons (performance to fulfill) and economic reasons. Among the second ones, resistance to surface actions, resistance to frost, slip-resistance in dry and wet conditions, durability and maintainability are prominent. The flooring system is set directly above the ground and profiled with gradients. The three main technical options are: if the bearing layer is rigid, the coating layer can be laid with both rigid technique (on mortar bed) and flexible technique (on sand and gravel layer), if the bearing layer is of flexible type, the coating layer must be necessarily laid with flexible technique. The flexible laying follows the rules of interlocking floorings.

Clay artifacts role

Technical features of the paving clay artifacts are more than enough a reason to suggest their use for pedestrian urban spaces, but perhaps, aesthetic motivations are even more decisive. The wide range of textures and colors allows to create beautiful settings that give honor to the environment and the time passing and thanks to the material paste color, enhances the esthetic.

Connoting performances

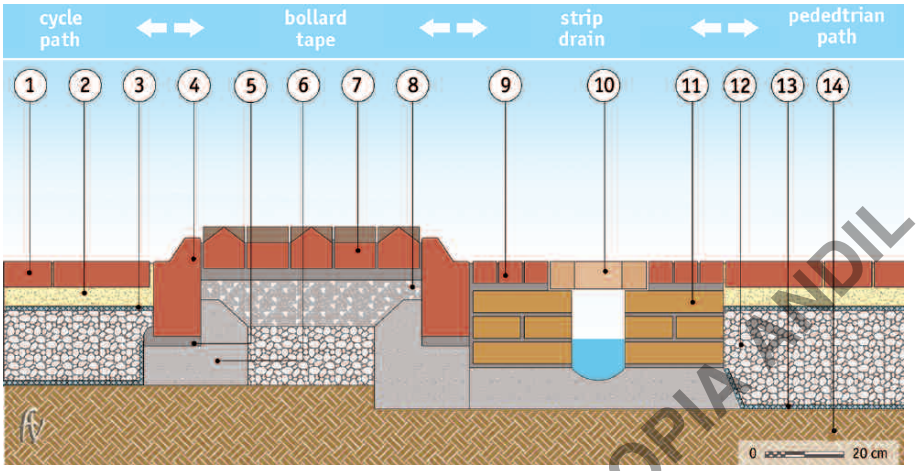


Brick pavings for pedestrian and cycling areas.

Floorings for pedestrian and cycling areas

Tips for designing and for realization

- The soil must be compacted vigorously so as to make it homogeneously tight at all points and profiled with gradients according to the project sections.
- The slope of the floor must be functional to the rapid flow of rainwater and comply with the requirements of the regulations about accessibility; it is necessary to prevent stagnation of water that may cause serious diseases and alterations in the appearance of clay artifacts.
- It is advisable to place the embankment over a geogrid coupled to non-woven fabric and providing a layer of non-woven fabric between it and the sand and gravel layer, in order to prevent the migration of the inert material by gravity.
- To ensure optimum compaction, the mixture the embankment is made of must follow the correct distribution curves. It must be realized by overlapping 10 cm thick layers (each layer must be laid only after the previous one has been compacted) and properly humidified (by watering). The embankment thickness must be calculated taking into account the bearing capacity of the ground and the expected loads.
- The bedding layer must be made with sand mixed with gravel, the grain size should be between 0.3 and 5 mm, but should preferably be inert siliceous from alluvial deposits. The thickness, when compacted, should not exceed 25 to 40 mm.
- The sand joints must be 3 to 5 mm wide, the sand must be natural (quarry sand can cause spots and stains on the clay artifacts); the grain size of the inert material should be between 0 and 2 mm.
- The flooring must be contained laterally by curbs laid on a bed of mortar over a concrete base: this expedient prevents the enlargement of the joints.
- For the sizing of the water collection system it is necessary to take into account the expected loads of water on the intervention area and the area to drain.



Cross section at a bollard tape and bump.
Legend: **1.** Pavers bricks with sand filled joints; **2.** Bed of sand and gravel; **3.** Non-woven fabric; **4.** Clay perimeter curb; **5.** Mortar bed. 6. Support concrete base; **7.** Clay bollards on mortar bed; **8.** Lean concrete base; **9.** "Sestini" laths laid on a mortar bed with joints filled with grout; **10.** Leaning clay drain; **11.** Ordinary bricks on concrete base; **12.** Embankment; **13.** Non-woven fabric paired with geogrid; **14.** Well-compacted soil.

Permeable paving

Description

Permeable pavings are a special type of flexible pavements, designed to reduce the percentage of rainwater that runs off the surface; they are based on the infiltration of water and its storage in the embankment as long as necessary to allow the soil, or special collection devices, to absorb it. Their design requires a preparatory stage time in order to ponder over the permeability of the soil, and the intensity of rainfall in the area of intervention and a totally different structural approach than conventional flexible pavements: the strength of the bearing layer is no longer based on compact aggregates, but on mutual interlocking of large size aggregates. The permeable pavements are mainly used in areas subjected to pedestrian and light vehicular circulation. The two main types are: by total infiltration, if the flood water is gradually absorbed by the ground; by accumulation, if the water, intercepted by coils of drainage pipes, is sent to accumulation basins (and, if necessary, decantation basins), and thereafter slowly released to the public sewer or used for irrigation and domestic non-food use. The first solution is used when the soil has suitable qualities of permeability and the water has no substances which may pollute the groundwater.

Clay artifacts role

Connoting performances

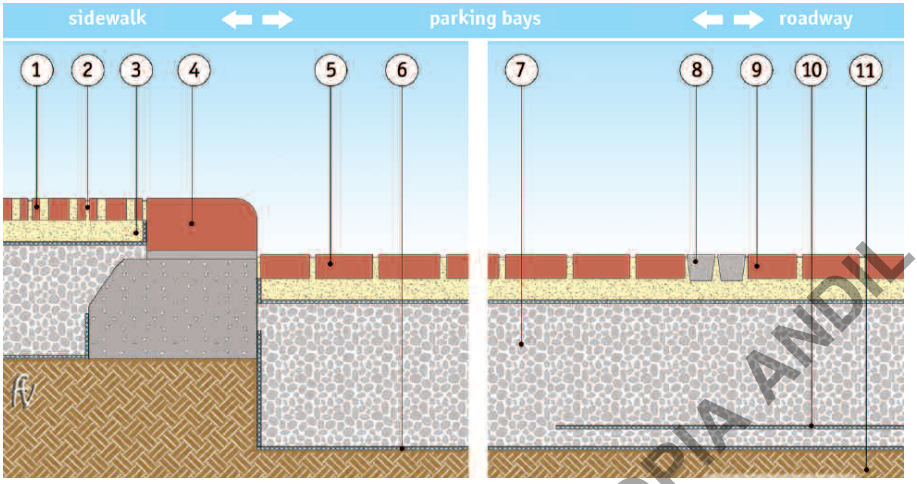
Both ordinary pavement clay bricks and clay brick with special perforations which assist the joints in their drainage function may be employed. With the increase of the percentage of holes in the bricks, the resistance of the elements to the vertical actions decreases, but the use of perforated elements, allowing some reduction in the thickness of the joints, can ensure a more effective self-locking action to the coating layer. In order to compensate the lower mechanical resistance of the perforated artifacts, it is possible to intervene on their thickness and their morphology.

Permeable pavement, total infiltration system, with clay brick coating.

Permeable paving

Tips for designing and for realization

- Permeable pavements are not suitable for surfaces with a >2% slope; the total infiltration types, in particular, are not recommended for soils with low bearing capacity (with CBR index -California Bearing Ratio- <2%).
- The soil must be compacted vigorously so as to make it homogeneously tight.
- In order to ensure good strength and adequate storage capacity, the embankment must contain a tiny fraction of fine particles; the particle size composition should be between 2,36 and 20 mm.
- The embankment must be realized by overlapping 10 cm thick layers (each layer must be laid only after the previous one has been compacted) and properly humidified (by watering).
- The embankment thickness must be calculated taking into account the bearing capacity of the soil, the expected loads and the maximum amount of water that it will be subjected to hold considering the intensity and cyclicality of extreme rainfall events.
- In the case that the paved draining area replenished sewage from adjacent waterproofed surfaces, an additional load of water to be stored in the embankment should be considered.
- Geotextiles membranes and watertight layers must have surmounted joints.
- Both for the laying course and joints sealing, the same inert mixture is used; the grain size must be between 2,63 and 6,3 mm; bedding layer materials should be preferably siliceous, from alluvial deposits; the joints' ones must be natural.
- The laying course's thickness, once compacted, should not exceed 5 cm. The joints must have a width of between 8 to 10 mm.
- The flooring must be contained laterally by curbs laid on a bed of mortar over a concrete base: this expedient prevents the enlargement of the joints.



Cross sections at the sidewalk and the roadway.
Legend: **1.** Brick with high filtering capacity (for pedestrian areas); **2.** Gravel joint 8 mm wide; **3.** Gravel laying course; **4.** Rowlock brick laid side-curb walled on concrete base; **5.** Paving bricks with improved filtering capacity; **6.** Non-woven fabric; **7.** Draining embankment by total dispersion; **8.** Porphyry gray demarcation cubes between the roadway and parking area; **9.** Ordinary paving bricks; **10.** Geogrid for structural reinforcement; **11.** Well-compacted soil.

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