Recommendations of use and laying for Clay Pavers

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- **Guidelines for laying rigid paving**

MALPESA

Types of Paving

Rigid paving

Rigid paving with CLAY PAVING BLOCKS involves laying the units on a mortar bed, prepared on top of a rigid base, and securing them with mortar joints.

Clay paving blocks laid as rigid paving are advisable in the following cases:

Paving with a gradient of over 9%.

Areas where the continued presence of water is expected, such as vehicle washes, swimming pool and shower area surrounds, premises where the paving needs to be washed frequently with high pressure waterjet, etc.

When the desired effect is that of wide joints, or when wide joints are required for other reasons.

Flexible paving

The system of flexible surface course construction with clay paving consists of laying the paving blocks on a bed of coarse sand, pre-compacted without agglomerates, subsequently filling the joints with finer sand and then compacting once again.

Apart from the cases mentioned above in which rigid paving is advisable, flexible paving with CLAY PAVING BLOCKS is recommended for the following reasons:

The use of sand represents a reduction in costs, both in materials (mortar is not used) and in labour (production per man/hour rises considerably).

Expansion joints are not required in this type of paving, and this results in a surface continuity which improves the aesthetic appearance and allows the designer greater freedom when creating spaces.

The most suitable model of block laid on a well calculated bed will produce road paving totally guaranteed to withstand heavy vehicle traffic.

It facilitates any subsequent work which may need to be carried out on the paving. It is particularly useful when repairs have to be carried out on utilities networks buried beneath the road surface, as the units which have to be pulled up can be re-laid in the same positions. This avoids the “patching” which often occurs with other types of paving.

The paving can be used immediately, without having to wait for the binding materials to gain the necessary strength.

Guidelines for laying Flexible Paving

This section offers a series of useful tips for designing, supervising and executing clay paving on sand beds to produce flexible surface courses designed to withstand both pedestrian and heavy vehicle traffic.

Flexible paving. Advantages

The system of flexible surface course construction with clay paving consists of laying the paving blocks on a bed of coarse sand, pre-compacted without agglomerates, subsequently filling the joints with finer sand and then compacting once again.

The laying of clay pavers exclusively with sand has a number of advantages which make it advisable in most cases, the only exceptions being steep slopes (over 9% gradient), areas exposed to the frequent, intense presence of water such as vehicle washes, swimming pool surrounds, etc., (where it is advisable to fill joints with mortar or paste), and cases in which the designer wishes to exploit the aesthetic effect of wide joints filled with mortar. In all other cases, we recommend sand-based flexible surface courses for the following reasons:

1) The use of sand represents a reduction in costs, both in materials (mortar is not used) and in labour (production per man/hour rises considerably).

2) Expansion joints are not required in this type of paving, and this results in a surface continuity which improves the aesthetic appearance and allows the designer greater freedom to work with space.

3) The most suitable model of block laid on a well calculated bed will produce road paving totally guaranteed to withstand heavy vehicle traffic.

4) It will also facilitate any subsequent work on the paving. This is particularly useful when repairs have to be carried out on utilities networks buried beneath the road surface, as the units which have to be pulled up can be re-laid in the same positions. Not only does this represent an economic saving, but it also avoids the typical "patches" that can be seen on other types of paving.

5) The paving can be used immediately, without having to wait for the binding materials to gain the necessary strength.

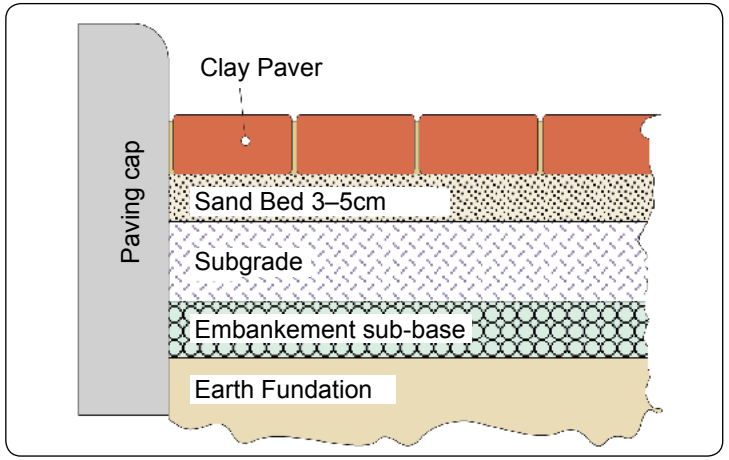
Road composition

To ensure the correct functioning of any type of paving, a suitable roadbed must be laid for the type of load to be supported. The paving will last much longer if proper attention is given to the base and the sub-base. The natural sub-soil over which it is to be laid should also be thoroughly examined.

The roadbed section should be designed according to the type of traffic expected. The following elements are usually laid beneath clay paving:

- Earth foundation.
- Embankment sub-base.
- Base course of artificial ballast, concrete or cement gravel.
-Sand/grit bed.

Apart from these layers, clay pavers may also be laid over any resistent structure such as slabs or flagstones. Mastic sub-bases may also be used.



A. Earth foundation

The earth foundation is made up of the natural material already existing on the site, duly cleared and flattened in line with the project's planned slopes.

If the land is classed as unsuitable for use as an earth foundation according to the conditions laid down in the PG3 General Road Regulations, it will be substituted or consolidated.

Care must be taken to eliminate soft areas and to establish ground levels that will avoid the accumulation of water during construction work.

B. Embankment sub-base.

It is advisable to include this layer whenever the paving is to support heavy traffic. In pedestrian areas, depending on the earth foundation and the type of infrastructure being designed, this embankment sub-base may also be considered necessary.

The material to be used will be natural aggregate produced from quarrystone or natural gravel, rubble, graded earth soil or local materials lacking clay, marl or foreign elements.

Its maximum size will not exceed 1/2 of the thickness of each tier. The grading curve for natural ballast will correspond to one of the following:

Accumulated weight passing fraction (% in mass)

Sieve aperture	Type of natural ballast*		
UNE-EN 933-2 (mm)	ZA25	ZA20	ZAD20
40	100	—	—
25	75 – 100	100	100
20	65 – 90	75 – 100	65 – 100
8	40 – 63	45 – 73	30 – 58
4	26 – 45	31 – 54	14 – 37
2	15 – 32	20 – 40	0 – 15
0.500	7 – 21	9 – 24	0 – 6
0.250	4 – 16	5 – 18	0 – 4
0.063	0 – 9	0 – 9	0 – 2

** The ballast is classified according to the maximum nominal size, defined as the aperture size of the first sieve to retain more than 10% in mass.*

The material will be non-plastic and equivalent to sand of a higher grade than 30 (EA > 30).

Its supporting capacity will be that corresponding to a CBR ratio higher than 20.

Once the material has been laid on site it will be properly dampened prior to compaction. The post-compaction density must be over 95% of the maximum density obtained in the Modified Proctor Test.

C. Subgrade

Special care must be taken during the execution of this layer to avoid even the slightest deviation from the projected grade level. If this ocurrs it may produce discontinuity in the sandbed which will affect the uniformity of the surface paving, especially during the compaction stage.

Any of the following materials, correctly constituted, may be used:

1) Artificial ballast

The material to be used will be either quarrystone or natural gravel, in which case the proportion retained by a 5 UNE sieve filter should have 75% of its weight made up of elements with two or more fractured sides for heavy traffic, or 50% in all other cases. It will contain no organic material, dust, clay or any other potentially harmful material. The material will be non-plastic and equivalent to sand of a higher grade than 35 for heavy traffic and 30 in all other cases.

The aggregate grading curve will correspond to one of the following PG-3 profiles:

Accumulated weight passing fraction (% in mass)

Sieve aperture UNE-EN 933-2 (mm)	Type of natural ballast* ZN (40)	ZN (25)	ZN (20)
50	100	—	—
40	80 – 95	100	—
25	60 – 90	75 – 95	100
20	54 – 84	60 – 85	80 – 100
8	34 – 63	40 – 68	45 – 75
4	22 – 46	27 – 51	32 – 61
2	15 – 35	20 – 40	25 – 50
0.500	7 – 23	7 – 26	10 – 32
0.250	4 – 18	4 – 20	0 – 11
0.063	0 – 9	0 – 11	0 – 11

** The ballast is classified according to the maximum nominal size, defined as the aperture size of the first sieve to retain more than 10% in mass.*

Once the material has been laid it will be properly dampened prior to compaction, which should obtain 100% of the maximum density obtained in the Modified Proctor Test. It is sometimes advisable to top dress with sand and re-compact to avoid later losses in the sandbed. Alternatively, a layer of geotextile material may be intercalated.

2) Cement gravel

The aggregate used in the mixture will come from quarrystone or natural gravel. Its grading will correspond to one of the profiles described in the PG-3:

Accumulated weight passing fraction (% in mass)

Sieve aperture UNE-EN 933-2 (mm)	Type of cement gravel GC25	GC20
40	100	—
25	76 – 100	100
20	67 – 91	80 – 100
8	38 – 63	44 – 68
4	25 – 48	28 – 51
2	16 – 37	19 – 39
0.500	6 – 21	7 – 22
0.063	1 – 7	1 – 7

The aggregates used will be non-plastic and equivalent to sand of a higher grade than 30 (EA > 30).

They will contain no organic material, and the proportion of clay lumps will be lower than 2% of the weight.

The cement used will have a strength of 32.5 N/mm^2, and the cement dosing will not exceed 4.50% in weight of the total aggregate content.

The compressive strength of 7 day old samples, manufactured on-site with the mold, and the Modified Proctor compaction will not be lower than 35 kg/cm^2.

The execution procedure will follow PG-3 recommendations, and

special care will be taken to dampen the support correctly in order to avoid segregation while the mixture is being transported. The work should preferably be carried out without interruption, but if any considerable interruptions should ocurr, the corresponding day work joints should be effected.

Compactation will be carried out on one single tier, and it is recommended that 100 %, and in no circumstances below 97%, of the maximum Modified Proctor Density for the cement mix be obtained.

Once compaction has been carried out, the gravel layer will be kept wet and a later spray of bituminous binder is recommended. 0 – 5 mm of sand should then be sprinkled over the the surface.

3) Concrete

It is recommended that mass concretes with typical strengths no lower than 100 kg/cm^2 be used. Aggregates of a maximum size of 40 mm and which comply with the specifications of the EH standard can also be used.

Special care should be taken during execution to dampen the support correctly, or alternatively plastic membranes should be intercalated to prevent the mix from dehydrating. The surface will be smoothed over with a "straight edge", avoiding major bumps and hollows but without needing to achieve a perfectly smooth finish. Any necessary expansion and day work joints will be incorporated at this stage. Finally, the concrete will be correctly cured by whatever methods are considered convenient.

D. Sand bed

The use of well washed natural sand is recommended. Its grading will be between 5 and 0.4 mm, and no more than 10% of it should comprise material which exceeds or falls below these limits. Coarse natural sands generally produce good results.

Levelling and sand compaction

The material will not contain more than 3% of clays and lime, and will be completely free of harmful foreign elements and salts.

The post-compaction thickness of this layer will be between 3 and 5 cm.

Before beginning to spread sand in an area, the borders and other elements designed to contain the paving will already have been laid, together with any drainage facilities necessary to remove leachate water.

Flexible clay paving slabs ultimately perform like impermeable paving, because dust and dirt clog up the joints and impede the passage of water. They are therefore designed to have surface drainage systems. To avoid any possible saturation of the sandbed during the earliest phase of use before the base course is impermeable; however, allowances may be made for its drainage. As a precaution, geotextile membranes are laid between the sand and the drainage element to avoid possible settling thrugh loss of sand.

The loose, uncompacted sand will be spread out in a uniform layer, to the height at which, after compaction, the established grade level will be obtained. The usual method for leveling this layer is to use wooden screeds on which the grade levels have been marked.

Another workable system for spreading this layer, and one which improves work performance, is to level the sand with a vibrating screed.

The sand is pre-compacted using tamping rollers or vibrating plates.

It is always preferable to lay less sand than that required and to add more, if necessary, when the tier has been pre-compacted. When the amount added reaches a certain level it can be compacted again.

Laying the pavers

The paving blocks are laid on top of a layer of sand which has been previously graded and compacted, in accordance with the planned paving design. The pavers used will be classified in terms of their transverse breaking load, as T4 pavers.

By combining the different patterns possible using the different models of varying formats and colours, paving design possiblities are multiplied. For road surfaces designed to withtand heavy vehicle traffic, layouts involving paving with continuous joints are not advised, especially if the joints are parallel to the road's longitudinal axis. For this type of requirement, a herringbone layout is very suitable. The unit is either laid parallel to the road axis or turned at 45^0. Complementary units are available for this purpose, avoiding the need for difficult mitering at the edges of the units.

When designing flexible road surfaces with Malpesa clay paver, sufficient planning of slopes and surface drainage elements should not be overlooked. The transverse slope gradient must never be lower than 1%, with slopes of at least 2% being recommended. When designing stretches with gradients greater than 9%, it is advisable to use rigid paving.

The best results are obtained using paving from various packets at the same time. This minimises the effect of any small differences in the calibre or tone of the pieces

The layout of the paving must be perfect; to this end, take the units needed and place them where they are to be laid, with real joint separation, in order to position the containing borders so that they correspond as much as possible with complete paving units; if this operation is carried out correctly, it will avoid the unnecessary cutting of units which will raise construction costs and decrease the overall quality of the finish.

It is not advisable to lay pieces smaller than a quarter of the size of each paver. Edges should be created using half or three-quarter pieces.

The ideal joint between pavers is between 3 and 5 mm. Pieces should never be laid without any joint between them. These dimensions may be slightly modified to maintain a correct alignment. Alignment will be checked systematically using straight edges, string or any other suitable method. The level of the paving will also be watched. To this end, the leveling points will be marked on screed boards, which will serve as a reference for running string or straight edges over the surface.

Adapted joint

Abutting

The paving blocks will be laid without stepping on the layer of sand. The work is done from the part of the paving that has already been laid. Every effort must be made, therefore, not to concentrate weight in the shape of piles of material or groups of workers near the work area.

The paving should not be laid on a wet or excessively damp sand bed. To avoid problems in case of rain, it is advisable not to spread sand layers over areas which are too large to be covered in one day.

One of the great advantages of flexible paving is the speed of its execution. To improve work performance we recommend the following:

• Lay the paving blocks simply by dropping them onto the sand bed and aligning them approximately. After advancing over a stretch of two to three metres, any imperfections in the completed section can be corrected by placing a board against the edge of the free border and knocking the units into position using a hammer or mallet. For herringbone layouts, capping units can be laid provisionally to provide a straight line on which the board can be rested, or alternatively a sawtooth-shaped piece of wood can be used that will fit into the spaces.

• If it is necessary to correct imperfections in panels boxed in between already built containing borders and the method described above cannot be used, or to line up units in sections where one of the joints is continuous, retainers and levers can be placed in the joints. They will easily move the paver courses into the correct position. Here, it is only necessary to make sure that these tools have been inserted in such a way so as not to chip the edges of the units.

Final screeding

The laying of pavers

Aligning pavers

Filling joints

• When units are being laid by several personnel at the same time, and especially if it is a herringbone layout, they should preferably atlternate their positions. This will serve to offset differences between different operator batches.

Such a system will not only increase the work rate, but will also noticeably improve the final result, because the slight differences in grade between the units and the inaccuracies in their postioning will be absorbed.

If the underlying sandbed has been well levelled, it will not be necessary to check the level of the paving precisely, unit by unit, because the subsequent compacting process will correct any minor irregularities which may exist. It is, however, desirable that no units are left sticking up too much. This is easily avoided by tapping down any edges which may be sprojecting before compaction. This will avoid breakages during tamping.

Once a sufficient stretch of paving has been laid, the joints should then be filled, using salt-free sand between 0 and 2 mm thick. The use of ground lime sand is unadvisable, since it usually has a high dust content which would spoil the surface of the paving. Cleaner sands facilitate the filling of joints, but may result somewhat loose initially, only binding together with the passage of time. Sands with moderate lime content improve this initial sealing of the paving. The sand is spread over the paving, and then swept until the joints are satisfactorily filled. Excess sand is then removed from the surface to be compacted.

Before compacting, the paving should be in place and completely secure. Compacting should not be carried out within a metre of unbordered edges. The type of compactor will depend on the size of the job. For smaller sections vibrating compactors can be used with plates made of neoprene or any other material which absorbs the impact on projecting corners, which could chip the paving edges.

For larger areas, better performance is obtained using vibratory roller compactors. As a precaution, a sheet of felt or other material which will reduce direct impact must be spread over the paving like a carpet. The useful strength to be exerted by the roller in order to achieve the required level of compaction without damaging the units will, in any case, have to be checked. The elements used must transmit a useful force of between 50 and 75 kn/m^2 at frequencies between 60 and 100 Hz. Two or three passes are usually required to compact the paving correctly. After each pass the state of the joints should be checked, adding more sand as this enters the grooves.

After compacting, the levels of the pavers are checked and any units which are out of line are corrected. Unfilled joints are top dressed. When the excess sand has been removed, the paving should be wetted to facilitate the bonding of the aggregate. When this has been done, the paving is ready for use.

Compacting pavers. Use vibrators with rubber bases, or spread out a blanket as shown in the photo to avoid chipping.

Guidelines for Laying Rigid Paving

Clay paver laid as rigid paving is advisable in the following cases:

• Areas with a gradient of over 9%.

• When pavers under dimensions of 10x10x5cm, 20x5x5cm, or a similar width-length ratio, are being used.

• Areas where the continued presence of water is expected, such as vehicle washes, swimming pool and shower area surrounds, premises where the paving needs to be washed frequently with high pressure waterjet, etc.

• When the desired effect is that of wide joints, or when wide joints are required for other reasons.

This type of paving is not suitable for use in areas expected to withstand continuous traffic, especially of heavy vehicles.

According to the preparation of the support, the recommendations given for the earth foundation and embankment sub-base for flexible paving also apply here.The paving should have a mass concrete flooring as a base, the thickness of which will depend on the loads it must bear. Reinforcement can be added if considered necessary. It is especially important to respect grade levles with minimum tolerances.

Joints should be at least 8 mm wide. The pavers to be used will not have separators, as these would only create discontinuity in the mortar joint. We also recommend units with unchamfered edges.

When the length of the sides is more than 5m, preplanned expansion joints will be left along the whole perimeter. Separation between expansion joints will not exceed the same disatance (5m), and the resulting sections should preferably have ostensibly equal sides. In areas subject to sharp temperature changes these dimensions may have to be reduced to 4m. An attempt should be made to match the paving joints with those of the base. It is also necessary to place joints where the paving meets solid elements, such as control boxes, lamp-posts, pillars and any other element anchored to the base.

A layer of mortar of about 3cm cm should be spread over the concrete. An M-15 mortar is recommended (dosage 1:3 or 1:1/4:3 if limestone is added). The mortar should be laid with a hard consistency.

It is advisable to use paving from several packets at the same time, taking them in vertical batches, in order to minimise any slight difference in calibre or tone. It is extremely important to lay out the paving previously, taking into account the real dimensions of the pavers and joints, to avoid having to cut awkward pieces, and to mark the lines and reference levels which will serve as guides.

The paving should be laid on the mortar layer using a rubber mallet and metallic or wooden rules with which the pieces in each stretch are levelled out. It is important for the pieces to be partially absorbed into the base mortar, ensuring lateral fastening until the joints are filled.

When the pavers are correctly lined up and leveled, the joints will be filled using mortar prepared with the same dosing as that used for laying but with a softer, more fluid consistency. Spouted recipients such as jugs can be used in order to keep the blocks as clean as possible.

Try to avoid staining the pavers during the jointing process, and stains should be cleaned immediately with clean rags or cloths, without

spreading mortar over the surface of the unit. Despite this advice, however, mortar stains will inevitably be left on the ceramic surface. The paving will therefore later be cleaned, once the joint mortar has hardened sufficently not to break away. Remains of set mortar are cleaned as follows:

1) Wet the surface to be cleaned with clean water. This will reduce the suction of the mortar joint.

2) Using a mixture of one part commercial hydrochloric acid and five to ten parts water, clean the paving. The mixture can be applied either at pressure (the fastest method and that which gives the most uniform results) or by scrubbing with a scrubbing brush.

3) Rinse with abundant water, preferably using high-pressure water jet machines, to remove any dirt and acid residue.

When the cleaning is finished and the mortar is cured the paving is ready to be used.

Rigid block paving is also possible, using dry mortar for both the bed and the joints.

The advantage of this system is the improved lay yield and improved paver performance in terms of joint fissures, which means slightly larger surface areas can be laid. The disadvantage is that more cleaning work is required.

The mortar dosage to use is the same as for paving with wet mortars. Poor mortars are not advisable, for although their use on the bed and joints between pavers allows for larger surface areas, it is difficult to clean the paving without affecting the jointing mortar.

The dry mortar base should be spread and smoothed as indicated for sand bases, except for precompacting.

The pavers should be laid on the mortar base, tapping them with a rubber mallet to ensure they sink lightly into the mortar bed. Check they are flat with spirit levels.

Once a sufficient amount has been laid, hydrate the mortar several times to ensure it sets fully and evenly.

Having hydrated the base, wait for the paver surface to dry before completing the jointing. This makes it easier to apply the mortar, with a cleaner finish.

The dry mortar should be spread over the paving, and then be brushed until the joints are filled to a satisfactory level. It is important to remove as much material as possible from the paver surface before hydrating the joints.

The paving then needs to be watered, either by sprinkler or jet, taking great care to avoid washing the joints.

The surface should then be given an initial cleaning, using damp cloths or mops to remove any mortar stuck to the pavers. This should be done with great care and before the mortar has finished setting.

After this first clean, water the paving for as long as necessary to ensure the mortar sets and cures correctly.

Once the rejointing mortar has reached the right strength, a final clean should be given, using the same system as for paving with wet mortar.

Watered final