MOVEMENTS JOINTS A FREQUENT SOURCE OF COMPLAINTS

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Nothing is more frustrating to an owner than a newly installed tile covering that develops cracks or worst, the tiles detach completely from the substrate. Typically, these problems become apparent only when the building has already been finished and the occupants have moved in. There are a number of possible causes, but such headaches *can* often be prevented - with movement joints.

Practical experience shows that uncertainties often exist about how to arrange and fill in movement joints in ceramic coverings. Even with professionally laid tiles in countries with high "standards density" - i.e. where standards, codes or guidelines exist for this type of work - an astonishingly high number of errors are committed.

Even today, movement joints are still regarded as "weak points" which are a frequent source of damage to ceramic coverings. This is a commonly held opinion not only for mechanically highly stressed areas or facade surfacings, but also for balconies and terraces, or coverings over floating screeds or heated screeds (i.e. coverings combined with floor heating systems), the success of an installation stands or falls with the movement joints. If they are wrongly arranged or the dimensions are incorrect, movement joints become a frequent source of complaints - complaints that didn't exist earlier, since the use of movement joints only became necessary with the introduction of modern installation methods (thin-set method) and new substrate constructions (like floating screeds combined with floor heating systems).

What are movement joints?

People frequently talk about 'expansion joints', but the expression "movement joints" is better, since - depending on the design - movements occur there in up to 6 different directions (Figure 1). Theory teaches us that flexible movement joints are a technical necessity for subdividing larger tile coverings, or as edge joints between floor and skirting. In a screed serving as substrate, expansion joints must have been placed in the screed directly below the future movement joint in the finished surface.

To answer the above question, one could quote an excerpt from the *Deutsche Industrienorm* (DIN - German Industrial Standard) which, as one of the world's most progressive technical standards, certainly offers reliable orientation. In DIN 18515 Part 1 (external wall surfacings - mortared tiles or paving stones - Principles for planning and execution) "Movement joints" are defined as joints "which permit movement and reduce harmful stresses between parts of a building, sub-areas of the external wall surfacing or structural parts". Very important here is the passage which says that "the positioning and dimensions of the movement joints to be installed to reduce harmful stresses in external wall surfacing must be agreed upon between the planners and those who will execute the work."

In most cases, movement joints are filled with elastic joint sealants. A further possibility is to use the so-called "maintenance-free movement joints", in other words : profiles, but more on these later.

Why movement joints?

Construction elements are subject to changes in shape, and the most frequent causes for changes in shape are drying out of the sub-structure, the loading of construction elements, and changes in either the moisture content or temperature.

Moisture changes :

Green concrete, new building blocks that contain binding agents, and mortar all contain excess mixing water which evaporates over time, causing the produced construction elements to contract. This phenomenon is referred to as "shrinking". Under normal circumstances, the degree of shrinkage can be as high as 0.5 millimeters per meter. Experience shows that, under normal climatic conditions, the shrinking process is basically complete after two years. With massive construction elements and under unfavorable climatic conditions, however, this process can take more time.

Load-dependent deformations :

Load-bearing construction elements are subject to increasing stresses as the building is progressively erected, and then through its actual use. The stress is caused first by the weight of the structure itself, and later by the working load imposed. For vertical construction elements, this leads to a slight shortening, which is described as "creep". Depending on the load, the degree of creep with normal concrete can amount to as much as 0.2 millimeters per meter.

Thermal length changes :

When temperatures increase, construction elements tend to expand, and when temperatures fall, they tend to contract. These temperature change-related processes area called "swelling" (expansion) and "shrinking" (contraction), and they change the dimensions of the construction element.

With the warming of construction elements, "expansion" occurs, with cooling "reduction" (shortening) occurs. The degree of the deformation will differ depending on their expansion coefficient. The expansion coefficient, e.g. for concrete, amounts to 0.01 millimeters per degree Celsius and per meter.

In addition one should also note that the above-mentioned shape changes can occur in combination. Stresses are generated by loads and shape changes of the construction elements, and by the differing behaviors of their raw materials. Theses stresses must be minimized in surface coverings through proper positioning of movement joints.

What types of movement joints are there?

We distinguish four types of movement joints :

•Building separation joints :
Building separation joints, also referred to as structure joints, pass through all load-bearing and non-bearing parts of the building and must be taken over in the covering or in the surfacing at the same point and in the width specified by the architectural plans.

•Field boundary joints :
Field boundary joints (surface control joints) divide the covering and should be installed from the surface of the covering down to the load-bearing substrate, or to the covering of the insulation or the waterproofing membrane.

•Edge joints :
Edge joints, which delimit the covering at the interface with walls or construction elements that penetrate the covering, should be installed like the field boundary joints.

•Junction joints :
Junction joints may be required between coverings or surfacings and adjacent to construction elements as well as fixtures. Generally, they are executed in the same thickness as the covering material, if necessary however, up to the level of the laying surface.

The arrangement of movement joints

Direct bond coverings (rigid bond)
In general, movement joints in ceramic coverings with a rigid bond are arranged:

- over structure joints at the same spot,
- at wall junctions, pillars or other construction elements which penetrate the covering surface (edge or junction joints),
- with continuous, large-span ceilings where negative support moments exist, i.e. directly above supporting beams or load-bearing partition walls,

- at points where the sub-structure materials change,
- at inner and outer corners of the covering,
- with continuous coverings at ceiling level (in general at the lower edge of the ceiling).

The internal stresses caused by the shrinkage of the screed or the laying bed mortar are completely eliminated by the so-called "rigid composite" with the load-bearing substrate. They are not dependent on the size of the screed field, and therefore also cannot be positively influenced (in the sense of stress reduction) by the arrangement of the field boundary joints.

Coverings on separation or insulation layers

These are separated by intermediate layers from the load-bearing substrate, so that the covering structure consisting of screed and surface layer cannot directly transmit tensions and stresses to the load-bearing substrate. In this case - unlike in the composite construction - the important thing is to limit the magnitude of the internal stresses deriving from hindrance of the shrinkage. The most important measures for this are the creation of movement that is as unimpeded as possible and sub-division of the area through movement joints.

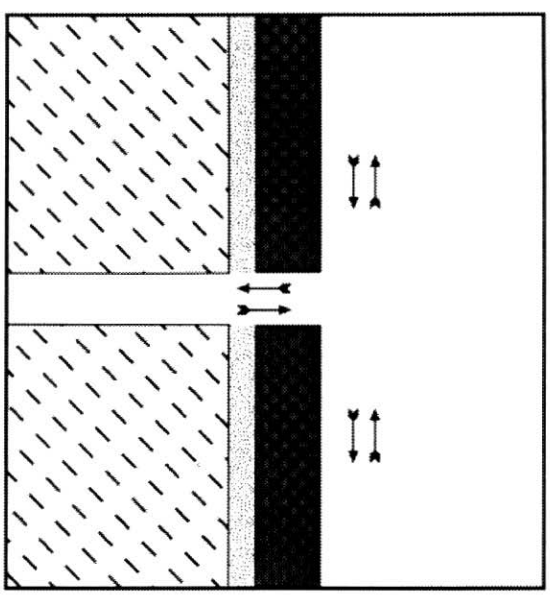


Foto 1
«Movement joint» is better than «expansion joint»; the movement occur - depending on the desing - in up to 6 directions

The friction which hinders the movement of screeds is dependent on the loads imposed. Heavy loads such as shelving and machines can increase the friction resistance so much that they act as a restraint and thus cause crack damage as a result of internal (traction) stresses of the screed due to shrinking. In such cases, therefore, it is logical to separate the impact positions of higher pinpoint or area loads from the other surfaces through the installation of field boundary joints.

Joints are generally necessary with coverings that rest on separation or insulation layers.

- over structure joints on the same spot,
- at wall junctions, pillars or other construction elements which penetrate the floor, as well as at doorways.
- in large annexes of the base layer and in the surface at distances of eight to twelve meters (over insulation layers no more than eight meters). A field size of 40 square meters should not be exceeded.

Experience has shown that such a joint division is especially recommended for heated anhydrous flow screeds and for unheated screeds when shape changes are still expected during the drying process. Movement joints are particularly necessary at the changeovers between screed areas as well as at the changeovers of the covering structure, e.g. at transitions between composite constructions to coverings on separation or insulation layers.

For tile floor coverings and paving stones outside of buildings, the Central Association of the German Construction Industry has issued a Code of Practice according to which there should be a continuous, straight arrangement of the movement joints, depending on the size and layout of the covering surface. The distance between joints depends on the amount of sunlight to be expected and the color of the covering.

According to this Code of Practice, movement joints should be installed at a distance of between 2.5 and 5 meters. The fields thus formed should be as square as possible (something which is indeed true for *all* fields formed by movement joints). The optimal geometry would be a circle, the only figure where the distance from center to outer edge is identical everywhere. With ceramics, of course, this is virtually impossible to achieve. In actual practice, the closest one can come to the circle is the rectangle (Figure 2). As far as possible, the ratio of the sides of the rectangle should not exceed 1 : 1.5. The installation of edge and junction joints which are at least 10 millimeters wide and which extend down to the separation layer or to the drainage layer will eliminate the stressing of the covering layers.

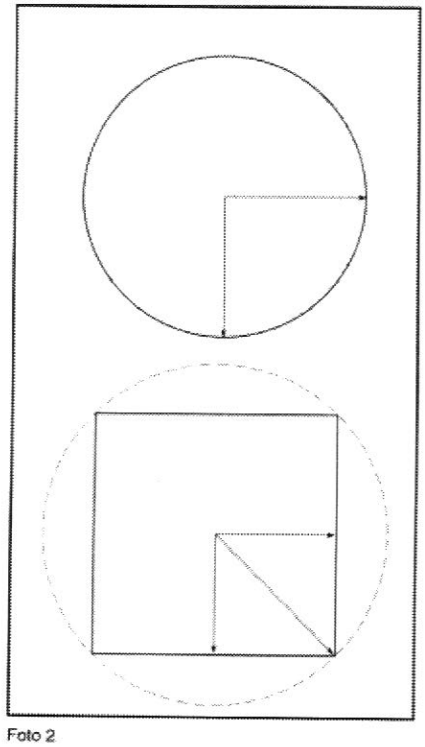


Foto 2
A circle would be the optimal field geometry. The next best is a square

The Central Association of the German Construction Industry focuses in another Code of Practice on the laying of tiles, paving stones and natural stone on heated floor structures. It states that movement joints should be installed in the heated floor structure :

- over existing building separation joints over the same points and in equal width,

- as field boundary (screed fields up to 40 square meters, whereby the side length of the individual fields should not exceed 6 meters) and in doorways, at least 8 millimeters wide,

- as edge joints at all adjacent construction elements and fixtures, whereby one must ensure that movements of at least 5 millimeters are possible.

Remarks on the dimensioning of movement joints - in theory

Movements within the joints must be absorbed as much as possible without causing damage. It is therefore necessary that movement joints be structured elastically, whereby filling in with silicone is regarded as the "conventional practice". DIN 18560 and the Codes of Practice of the Central Association of the German Construction Industry give instructions for how to arrange them.

For the execution of movement joints in floor coverings, the Code of Practice of the IVD applies, while in Germany DIN 18540 in combination with the IVD Code of Practice (II-11) apply for the execution of movement joints for facade surfacings. Accordingly, the joint width b for floor coverings should be not less than 8 millimeters and not more than 15 millimeters. Required joints widths which exceed 15 millimeters should be executed with joint profiles, or mechanically protected with drag sheets when structured with joint sealing material.

The Code of Practice of the IVD ("Elastic joint sealing for facades made of mortared ceramic tiles and paving stones") and the DIN 18540 ("Sealing of external wall joints in high-rise buildings with joint sealing materials") apply for the execution of movement joints on facades.

According to this standard, the joint flanks must run parallel up to a depth of $t = 2 \times b$ (with a minimum of at least 30 millimeters, however) in order to give the backfill material a sufficient grip. The movement joint width on facades amounts to at least 10 millimeters. It should also be pointed out that, for dark-colored facades, where one must count on significant temperature increases during the summer months, the joint widths must be increased by 10 - 30 %.

The joint width must ensure that the acceptable deformation limit of the sealing material is not exceeded, since this would cause the joint to fail, which would be expressed by the cracking or ripping out of a flank. This is a particular threat for the edge joints, i.e. the junction joints between floor coverings on an insulation layer and the wall surfacing. In most cases, the cause here is a joint width which - for reasons of appearance - has been under-dimensioned, or omission of a preliminary treatment of the joint flanks so as to ensure the adhesion of the filling material.

In order to keep the movements occurring in the joint as low as possible, it has proven advantageous in practice to fill the elastic joints with flexible sealing material as late as

possible. In so doing, one must seek to ensure that shape changes of the adjacent construction elements have as far as possible been completed by this time.

And practice . . .

In everyday practice at construction sites, however, it is found again and again that, under today's tight scheduling pressures, this recommendation concerning the latest possible filling of the joints is generally ignored. Another factor is that returning several times to the construction site would generate significant additional costs for the executing craftsmen. Another weak point in practice is the often omitted preliminary treatment of the surfaces to be joined with "primers" which ensure a better flank adhesion. And finally, it is really asking quite a lot from the craftsmen to expect that they will apply all this "joint volume mathematics" in practice. All of these are facts which speak in favor of using maintenance-free movement joints.

The fundamental point is that movement joints should be dimensioned and structured in such a way that they fulfill their function as permanently as possible. And that function is to absorb movements and shape changes of the construction elements adjacent to the joint and the joint sealant. In addition, movement joints in floor covering surfaces - and here above all within coverings exposed to high stresses - must be structured so that the tile or paving stone edges are protected against direct impacts. Among other things, these can be caused by dynamic stresses. This is discussed in greater detail below when the use of profiles is described.

The structure of movement joints with joint sealing material

Until now, joint sealing materials have been used for narrow joint widths, as well as for joints which are exposed to only slight (or no) mechanical stress, e.g. wall surfacings and floor covering joints, junction and edge joints which are exposed to only slight mechanical stress. Most often these are injectable sealing materials, including the alkaline or neutral cross-linking silicones, polysulfides, polyurethanes or acrylates. They are distinguished according to their physical - that is, the plastic or elastic sealing materials - and chemical characteristics, as well as according to the raw material basis, which fundamentally determines their properties.

All materials display deformation possibilities between 5 and 25 %. Without going further into detail on the characteristics (which would lead us too far afield here), the fundamental point is that acidic, i.e. acetate cross-linking systems should not be employed on cement-bound, alkaline-reacting substrates, since otherwise chemical reactions can take place between released components of the silicone and the adhesive surface. One advantage of the silicones is their easy processing, while their disadvantage is a tendency to develop mold on the joint surface over time.

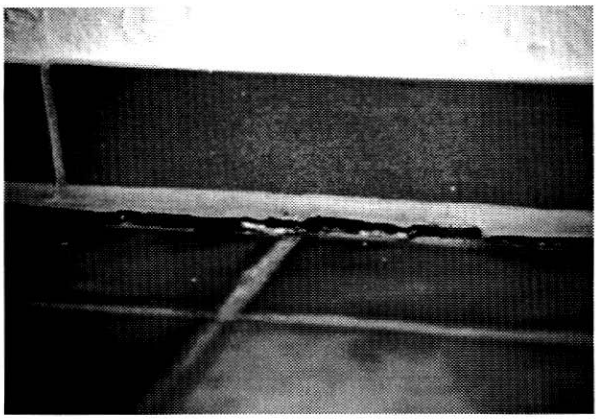
The primary use area of polysulfides are movement joints in facade surfacings. Their difficult, two-component processing is seen as a disadvantage.

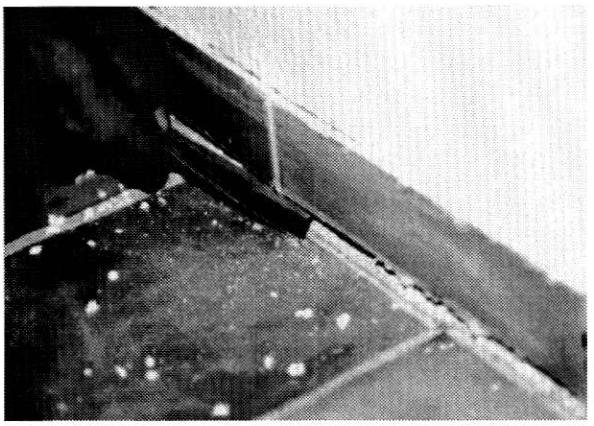
Polyurethanes react sensitively to the effects of UV, and must therefore be protected by stabilizers.

Until the development of a surface skin after their application, acrylates are sensitive to direct exposure to precipitation. Protection against rain is therefore necessary during this period.

Further, it should be observed that certain elastic joint sealing materials tend to release components, which are deposited in the edge area of the joint and on the adjoining surface. There, in combination with soot and dust, they form ugly streaks of dirt. The processing craftsman should therefore pay attention not to use these sealing materials on facades or with marble facades, for example.

Nevertheless, all joints with elastic sealing materials, including even the "simple" silicone joint around the edge of a bathtub, have one thing in common : they can by no means be characterized as "impermeable" and therefore cannot be regarded as an effective waterproofing measure. In addition, they are regarded as maintenance joints. The Code of Practice on "Movement joints in surfacings made of tiles and paving stones" still says literally : "Joints that are filled with elastic joint sealing compounds require maintenance that will depend on the stress to which they are exposed." (Figures 3 and 4)





Torn joints.

Maintenance-free movement joints : movement profiles

This definition contains an obvious contradiction : the movement joints, which are intended to exclude the possibility of later damage, are thus by their very definition executed as "maintenance joints", and accordingly they are "damage joints".

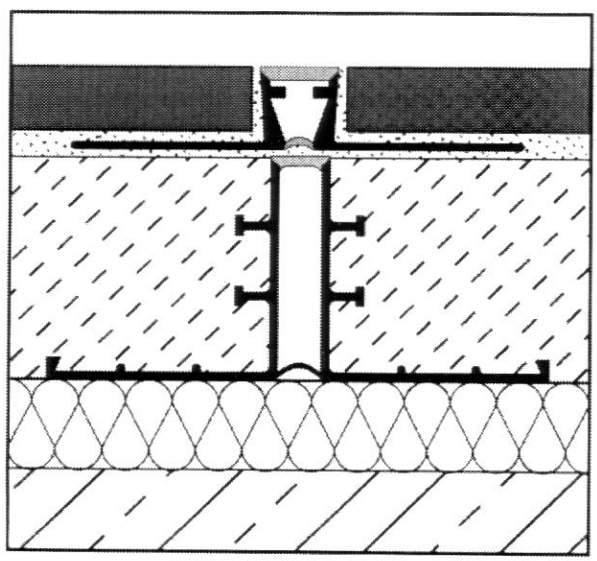
It can therefore be supposed that the "maintenance joint" concept should first of all protect the craftsman against warranty claims from the owners. However, many craftsmen neglect to advise their customers accordingly and express their reservations. As a consequence, the warranty obligation remains willy-nilly on the craftsman. Apart from this warranty aspect, however, the goal of planners and craftsmen should be to offer owners long-term, functional solutions which in terms of technology embody the current state of the art.

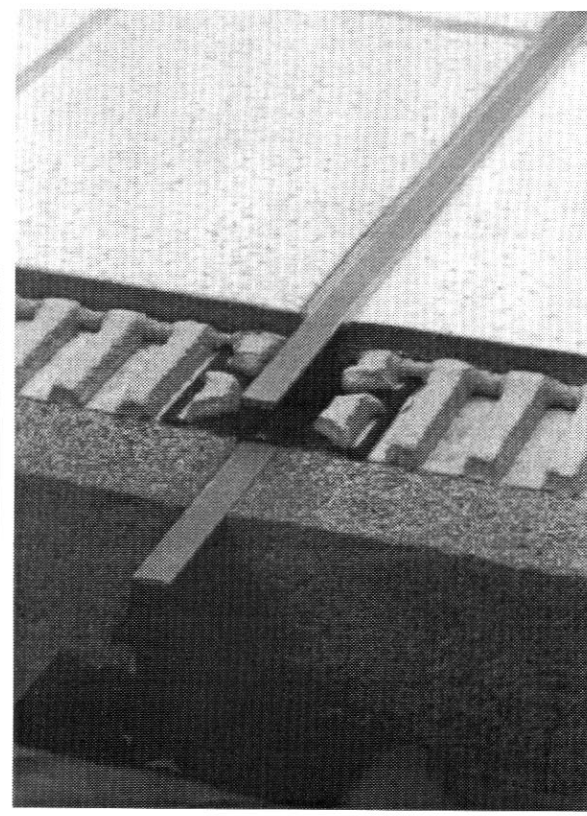
For several years now, one has been able to find on the market for this problem area specially-developed movement profiles, with particular types for the respective application fields of screed, covering, junction and edge joints. They are made of recycled rigid PVC with movement zones of flexible polyethylene.

Screed and surface movement profiles make it possible to arrange the joints in both layers (Figures 5 and 6) one directly atop the other, for the problem with movement joints in ceramic coverings often lies in the imprecise joint arrangement in the substructure. Thus the joints in the screed - often executed merely as a trowel cut or through an interposed strip of Styrofoam - are frequently not properly aligned with the later tile joints.

The movement profiles specially produced for this application area thus make possible a properly aligned arrangement so that the joint pattern can later be perfectly followed in the tile covering. The movement profiles are then laid precisely on top during the fixing of the tiles. They are laterally anchored with the perforated fixing flanges in the tile adhesive under the tiles.

For coverings exposed to heavy mechanical stresses, there are profiles with two brass or aluminum corners, which are connected with one another by a flexible profile made of synthetic rubber. The tiles are laid flush with a small joint against the profile. Such a movement joint permanently ensures a relatively large absorption of movement and protects the tile edges (Figures 7 and 7a).





The joint in the covering runs directly over the screed movement profile-also with the help of a profile

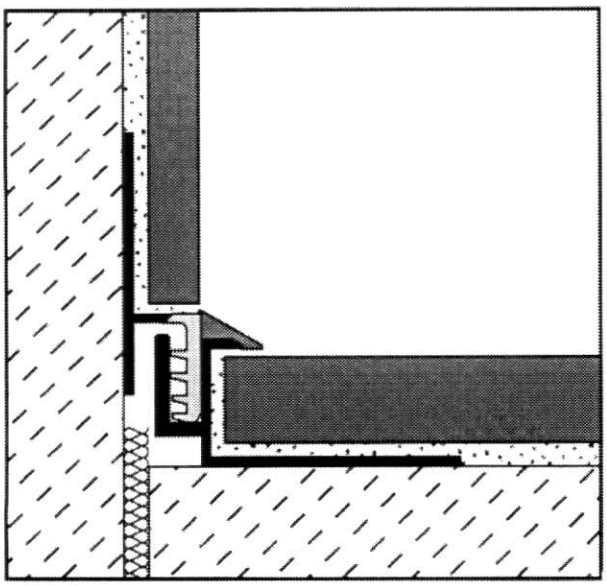
The edge joints between floor tiles and skirting or wall tiles are also movement joints, for these are areas where relatively large movements occur. In light of the dimension permitted under the DIN for the compression of the footfall sound insulating mats with floating screeds of up to 5 millimeters in the built-in state under the floor coverings, there results an edge joint expansion of these 5 millimeters. In addition, horizontal expansion-shrinkage stresses arise through various temperature influences.

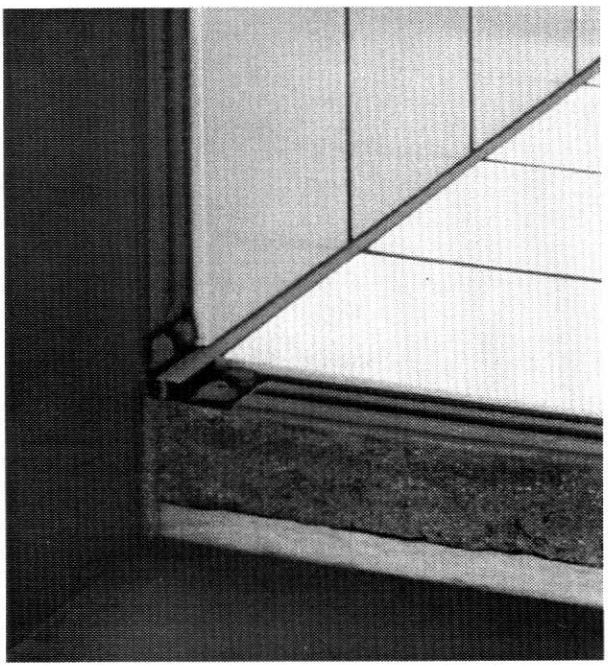
When a built-in floor heating system is added to the overall picture, the different temperatures in the covering construction produce more or less significant buckling and length changes of the covering surface, which also act as movements on the edge joint. If such joints are filled with elastic material, they will inevitably split open. Apart from the ugly appearance, a gaping joint crack opens the way to dirt and cleaning water. Such areas quickly become infested with vermin.

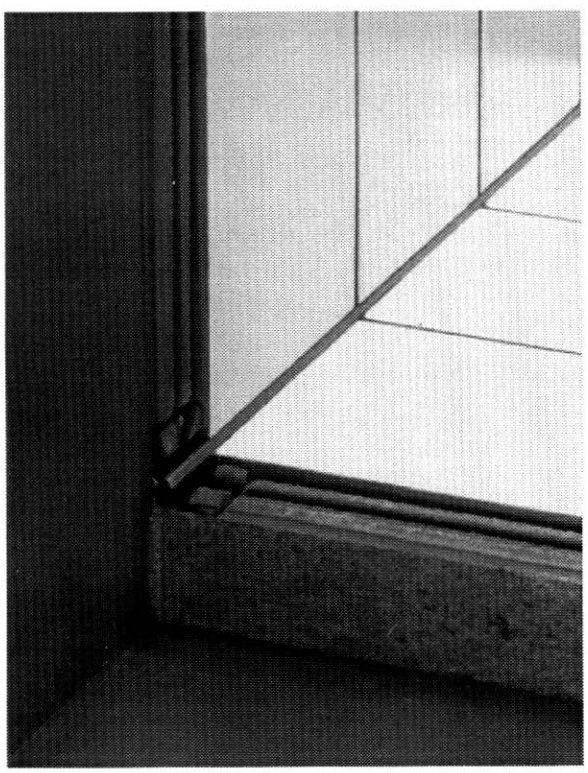
To solve this "corner problem", the market offers corner movement profiles which also combine both rigid and flexible plastic. These profiles consist of two parts which are

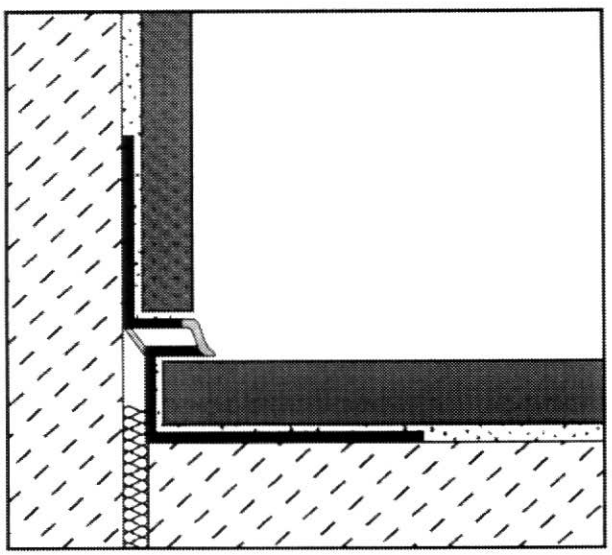
fixed together by a permanently flexible sliding tongue and groove joint. The lower profile part is anchored in the tile adhesive under the floor tiles and the upper profile part in the tile adhesive behind the skirting or wall tiles. The tile edges are covered by a rubber fin. The sliding tongue and groove joint of the profile elements absorb, permanently and maintenance-free, vertical movements of up to 10 millimeters. Horizontal movements are also absorbed. An additional advantage in using these profiles lies in the avoidance of sound bridges through accidental backflow of joint mortar or tile adhesive when skirting, wall or floor tiles are laid (Figures 8, 9, 10 and 10a)

The two-part corner movement profile (8, 9) and a single-part variant (10 and 10a) for use over non-floating screeds and floating screeds without compressible separation layer, or with a pressure-stable insulation layer.







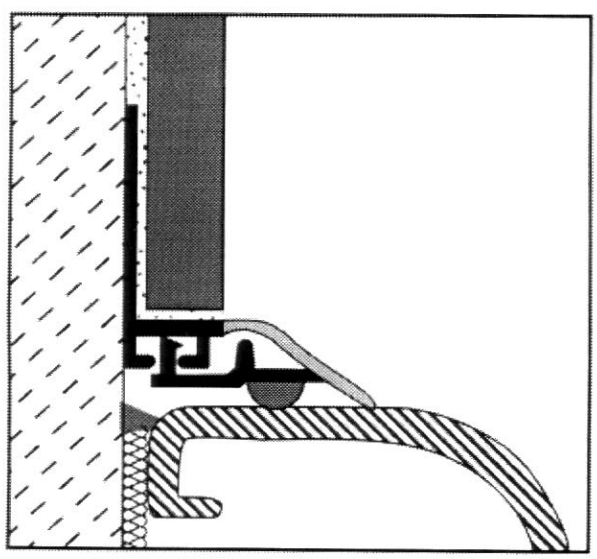


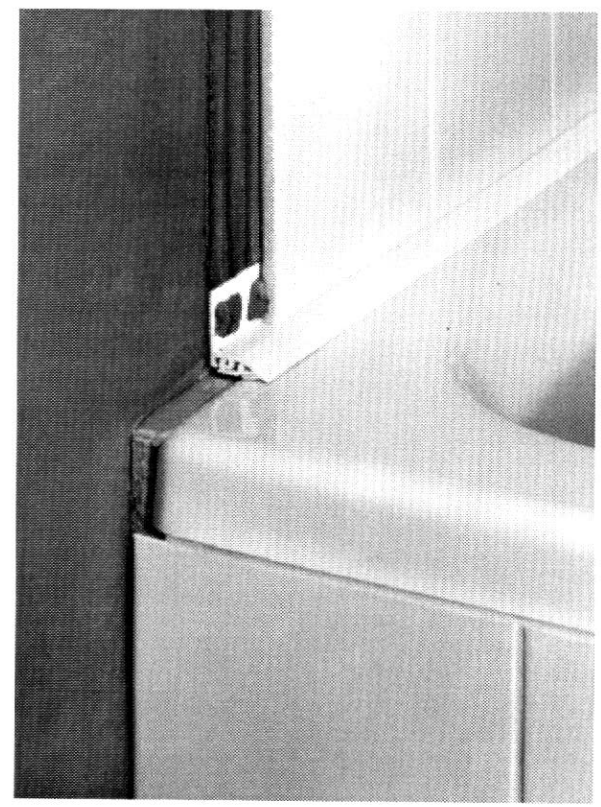
Pre-fabricated movement joint exposed to heavy mechanical stresses.

In addition, there are special junction profiles for permanently flexible joinings of tile coverings to construction elements and fixtures like bathtubs (Figures 11 and 11a), door frames or window elements. These profiles have already proven themselves to be UV resistant for years, and are therefore suitable for outdoor use. In addition, they are resistant against attack by mold and bacteria, as well as against the kinds of chemicals, cleaning agents and disinfectants that commonly come into contact with tiles.

As these remarks should have made clear, the industry offers a wide range of supports and innovative products for this complaint-prone area, products which will help keep complaints from arising in the first place. The manufacturers of these products also support the professional tile layers by guaranteeing a constant exchange of information. Clear informational material, talks held in the field as well as seminars on specific problem areas at the construction site all contribute to significantly reducing the frequency of complaints - prompted by the incorrect arrangement and structuring of movement joint.

Junction profile for use around bathtubs, etc.





Summary

A small cause with major effects : that's one way to summarize the topic of "movement joints". Thus, for the professional tile layer it is of great importance to fundamentally study this aspect of their daily activities, since (as already mentioned at the start of this presentation), practical experience shows that this is one area where many uncertainties still exist. Help is offered by the already-mentioned Codes of Practice, as well as the manufacturers of the relevant products. Once again, it should be pointed out that the designers are principally responsible for the arrangement of the movement joints. In the execution, the designers and the implementing craftsmen are equally responsible.