HOW TO PREVENT DAMAGES ON CERAMIC SURFACE ON BALCONIES AND TERRACES

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SUMMARY

1.) No tile covering can be permanently waterproof. None can guarantee that a covering will never crack, so that even liquid water can percolate. Further the laws of physics prove, that water vapour diffusion is very essential concerning the absolute quantity of condensed (liquid) water in the substrate. Therefore it is necessary that a sealing is laid underneath the screed.

2.) Waterproof membranes e.g. on balconies, terraces as well as in interior wet areas are sealings against non-pressure water.

3.) Following to physics' laws as well as to the international construction norms - most detailed are the German DINs - it is essential to protect the waterproofing membranes from environmental and weather influences and from water pressure.

4.) Environmental influences (e.g. mechanical stress) are prevented by screed and covering structure. Together they form the protective layer. In case ceramic tiles are being used, this protective layer doubles up as to a working surface.

5.) If there are no preventive measures taken to drain off permanently the water at the level of the waterproofing membrane, this screed will soon be saturated causing water pressure on the sealing and various forms of (frost-) damage and efflorencies.

6.) The conclusion is, that the effective drainage of the percolating water is of key importance for the long-term stability of the overall assembly. This requires the following construction features:

* sufficient incline from the sealing level to the drainage points;

* insertion of a drainage layer between the sealing and protection layers, to allow water to run off under its gravitational force. The market offers drainage systems which are functional and designed to meet requirements.

7.) The only possibility to hold or (in many countries) to win back terraces and balconies as potential markets for ceramics is to construct in accordance with laws of construction physics, norms and most advanced technologies.

BALCONIES AND TERRACES

Many thinkers have already focused on the question of water. Whether such reflections were prompted because there was too much or too little of it, water apparently is rarely a cause for satisfaction.

In the construction field, at any rate, water must be regarded as one of the primary causes of damage.

Damage-free construction therefore means waging a successful battle against water.

My topic today is "Using surface drainage systems under ceramic covering structures in order to improve their ability to carry off water".

No tile covering is permanently water-proof - none can guarantee that a covering will never crack.

First, I would like to tell you something about the way water is transported within ceramic covering structures, and the resultant necessity of draining this water in a controlled fashion, so as to prevent if from causing any damage.

This necessity holds for tile coverings in wet rooms, and especially for outdoor coverings.

Balconies and terraces are constructions which are directly exposed to the effects of the climate outdoors. **The task of a covering structure for such areas is to protect the construction from environmental and weathering influences, and to produce a surface which is usable for its intended purpose.**

To achieve this, certain necessary construction principles must be respected.

We refer in the following explanations to the German guidelines - not because they are German ones, as we are too, but because they seem to us to be the most detailed guidelines. And, more important: they are explaining in a logical way the tasks of every layer we find or use in these types of constructions.

But you also find it -however less detailed- in the French DTU's (Document technique unifié) 26.2, 43.1 and 52.1 or e.g. in the Belgian "Note d'information Technique" 161.

The German Practice Code "External tile and slab floor coverings" (July 1988 version), for example, offers directions for planning and execution. The last page of this Practice Code is one of the most important. There we find the standards and guidelines which are in effect and which are taken into account in the Practice Code. Especially worthy of mention in this connection is the reference to the flat roof guidelines, as well as (of course) the DIN 18 195, Part 5 (sealants against unpressured water) (DIN=Deutsche Industrienorm means German technical standard). While we cannot here explore the flat roof guidelines, Part 5 of DIN 18 195 should be examined in greater detail. Essentially, this DIN is concerned with offering construction principles.

Februar 1984

DK 699.82.002 : 691

Bauwerksabdichtungen
Abdichtungen gegen nichtdruckendes Wasser
Bemessung und Ausführung

DIN 18 195 Teil 5

Ersatz für Ausgabe 08 83

Water proofing of buildings, water proofing against non pressing water, dimensioning and execution

Etanchéité d'ouvrage; etanchéité contre d'eau non pressant, dimensionnement et exécution

Zu dieser Norm gehören:

DIN 18 195 Teil 1 Bauwerksabdichtungen, Allgemeines, Begriffe
DIN 18 195 Teil 2 Bauwerksabdichtungen, Stoffe
DIN 18 195 Teil 3 Bauwerksabdichtungen, Verarbeitung der Stoffe
DIN 18 195 Teil 4 Bauwerksabdichtungen, Abdichtungen gegen Bodenfeuchtigkeit, Bemessung und Ausführung
DIN 18 195 Teil 6 Bauwerksabdichtungen, Abdichtungen gegen von außen druckendes Wasser, Bemessung und Ausführung
DIN 18 195 Teil 8 Bauwerksabdichtungen; Abdichtungen über Bewegungsfugen
DIN 18 195 Teil 9 Bauwerksabdichtungen, Durchdringungen, Übergänge, Abschlüsse
DIN 18 195 Teil 10 Bauwerksabdichtungen, Schutzschichten und Schutzmaßnahmen

Ein weiterer Teil über die Abdichtungen gegen von innen druckendes Wasser befindet sich in Vorbereitung.

Inhalt

1 Anwendungsbereich und Zweck

1.1 Diese Norm gilt für die Abdichtung von Bauwerken und Bauteilen mit Bitumenwerkstoffen, Metallbändern und Kunststoff-Dichtungsbahnen gegen nichtdruckendes Wasser, d. h. gegen Wasser in tropfbar-flüssiger Form, z. B. Niederschlags-, Sicker- oder Brauchwasser, das auf die Abdichtung keinen oder nur vorübergehend einen geringfügigen hydrostatischen Druck ausübt.

1.2 Diese Norm gilt nicht für die Abdichtung der Fahrbahntafeln von Brücken, die zu öffentlichen Straßen gehören.

2 Begriffe

Für die Definition von Begriffen gilt DIN 18 195 Teil 1.

3 Stoffe

Für die Abdichtung gegen nichtdruckendes Wasser sind nach Maßgabe des Abschnittes 7 Stoffe nach DIN 18 195 Teil 2 zu verwenden.

Anmerkung: Sollen Kunststoff-Dichtungsbahnen vollflächig mit Bitumen verklebt werden, ist gegebenenfalls durch eine entsprechende Untersuchung die Verträglichkeit der verwendeten Stoffe untereinander zu überprüfen.

4 Anforderungen

4.1 Abdichtungen nach dieser Norm müssen Bauwerke oder Bauteile gegen nichtdruckendes Wasser schützen und gegen natürliche oder durch Lösungen aus Beton oder Mörtel entstandene Wasser unempfindlich sein.

Fortsetzung Seite 2 bis 5

Normenausschuß Bauwesen (NABau) im DIN Deutsches Institut für Normung e.V.

Fig. 1a

6 Hinweise auf Normen und Richtlinien

Allgemeine Technische Vorschriften VOB Teil C, insbesondere
DIN 18332 Naturwerksteinarbeiten
DIN 18333 Betonwerksteinarbeiten
DIN 18352 Fliesen- und Plattenarbeiten
DIN 18353 Estricharbeiten
DIN 488 Teil 4 Betonstahl; Betonstahlmatten, Aufbau
Verordnung über einen energiesparenden Wärmeschutz bei Gebäuden (Wärmeschutzverordnung - WSV) vom 24. Februar 1982
DIN 4108 Teil 1 bis 5 Wärmeschutz im Hochbau
DIN 4109* Schallschutz im Hochbau
DIN 18156 Teil 1 Stoffe für keramische Bekleidungen im Dünnbettverfahren; Begriffe und Grundlagen
Teil 2 –; Hydraulisch erhärtende Dünnbettmörtel
Teil 4 –; Epoxidharzklebstoffe
DIN 18157 Teil 1 Ausführung keramischer Bekleidungen im Dünnbettverfahren; Hydraulisch erhärtende Dünnbettmörtel
Teil 3 –; Reaktionsharzklebstoffe auf Epoxidharzbasis
DIN 18161 Teil 1 Korkerzeugnisse als Dämmstoffe für das Bauwesen; Dämmstoffe für die Wärmedämmung
DIN 18164 Teil 1 Schaumkunststoffe als Dämmstoffe für das Bauwesen; Dämmstoffe für die Wärmedämmung
Teil 2 –; Dämmstoffe für die Trittschalldämmung
DIN 18165 Teil 1 Faserdämmstoffe für das Bauwesen; Dämmstoffe für die Wärmedämmung
Teil 2 –; Dämmstoffe für die Trittschalldämmung
DIN 18174 Schaumglas als Dämmstoff für das Bauwesen; Dämmstoffe für die Wärmedämmung
DIN 18195 Teil 1 Bauwerksabdichtungen; Allgemeines, Begriffe
Teil 2 –; Stoffe
Teil 3 –; Verarbeitung der Stoffe
Teil 5 –; Abdichtungen gegen nichtdrückendes Wasser; Bemessung und Ausführung
DIN 18540 Abdichten von Außenwandfugen im Hochbau mit Fugendichtungsmassen
DIN 18560 Teil 1 Estriche im Bauwesen; Allgemeine Anforderungen, Prüfung
Teil 2 –; Estriche auf Dämmschichten (schwimmende Estriche)
Teil 4 –; Estriche auf Trennschicht
DIN 52104 Prüfung von Naturstein; Frost-Tau-Wechsel-Versuch; Verfahren A bis Q

Merkblatt „Bewegungsfugen in Bekleidungen und Belägen aus Fliesen und Platten"
Merkblatt „Hinweise für die Ausführung von Abdichtungen im Verbund mit Bekleidungen und Belägen aus Fliesen und Platten für Innenbereiche"
herausgegeben vom Fachverband des Deutschen Fliesengewerbes im Zentralverband des Deutschen Baugewerbes, Bonn
Bezug: Verlagsgesellschaft Rudolf Müller, Stolberger Str. 84, 5000 Köln 41

Flachdachrichtlinien
– Richtlinien für die Planung und Ausführung von Dächern mit Abdichtungen
herausgegeben vom Zentralverband des Deutschen Dachdeckerhandwerks, Köln

* DIN 4109 wird zur Zeit überarbeitet

Fig. 1b

For example, it states in **Part 5, Paragraph 4.2:**

"The sealant must surround or cover the structure to be protected and prevent the penetration of water."

In Part 5, Paragraph 5.1, DIN 18 195 requires: **"In the planning of the structure which is to be water-proofed. .. the prerequisites for a professional lay-out and execution of the sealant must be created. In doing this, the interaction between the sealant and the structure must be taken into account and, if applicable, the stresses imposed on the sealant layer must be kept within acceptable limits through appropriate construction measures."**

And finally, Paragraph **5.4 of DIN 18 195 states:**

A permanently effective drain-off of the water which affects the sealant must be assured through technical construction measures, e.g. by the lay-out of gradients. For the water-proofing of structures in the ground, if necessary, steps must be taken in accordance with DIN 4095.

DIN 4095 deals with **drainage systems.**

Protective layers are dealt with in **Part 10, Paragraph 3.2.1: "Protective layers must permanently protect structure sealants from damaging influences, whether these be of static, dynamic or thermal origin. They may, in individual cases, form use layers of the structure."**

Thus, according to DIN 18 195, Part 5, the tile covering, as a **protective layer designed for use, is actually a component of the sealant system.**

I would now like to focus on the water transport processes in screed and cement.

What water transport processes are possible in screeds and cement?

The transport of water or water migration in cement and in other porous, mineral-bound construction materials can in principle be triggered by the following transport processes:

a.) laminar percolating flow as described by Darcy's Law

b.) capillary water transport

c.) water vapour diffusion

These processes can occur individually, but most often they are found to occur in combination.

On a.) The water transport in accordance with Darcy's Law requires an extensive **water saturation** of the cement or the screed, and a **hydrostatic pressure difference** as the impelling force. Such transport can only take place in hollow spaces of a certain minimum size.

On b.) As its impelling force, capillary water transport requires **differential moisture levels in the construction material, which then attain an equilibrium via the capillaries.** A screed can never completely fill with water through capillary water transport alone. Hollow spaces and pores cannot suck up water in this way.

On c.) **Partial pressure** is equilibrated via water vapour diffusion. As a rule, the **moisture present in the form of vapour moves from warmer areas towards colder ones.**

Water vapour diffusion must be regarded as the essential transport process in such

construction materials.

I would like to present the three theoretical descriptions to you by using a number of diagrams.

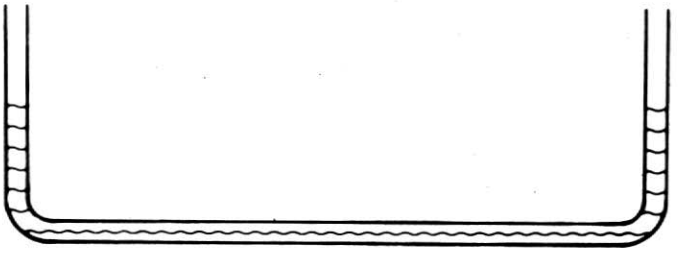


Fig. 6: Sketch of communicating tubes

First, let's go back to the laminar percolating flow.

This drawing makes clearer the principle of "communicating tubes".

If I take a tube and introduce water at one end, the water will rise at the other end to the same height. If I create additional branches, each of them will fill to the same level as the others. (Of course, the greater the number of branches, the lower this common level will be.)

Now, if I attach a **run-off drain** at a certain level (to any of the branches), the tube as a whole will empty down to the level of that outlet.

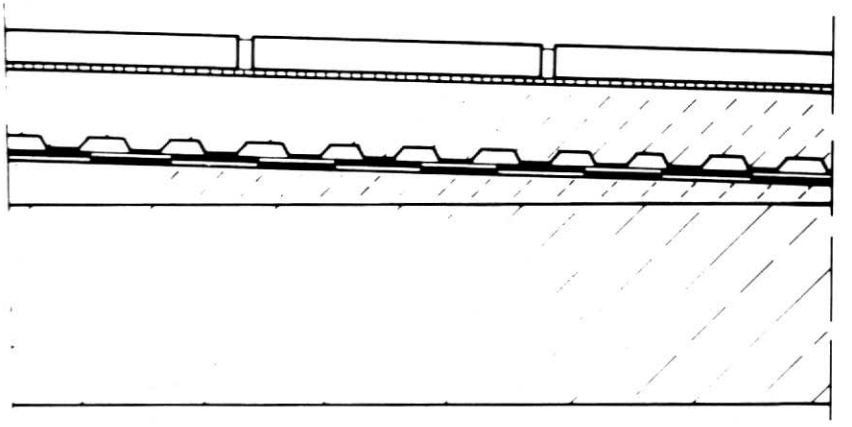


Fig. 7a: Covering cross-section

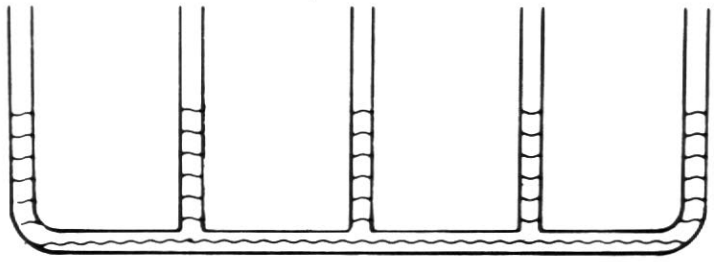


Fig. 7b: Tube sketch

If I now set on top of this covering cross-section the sketch with the tube, it becomes clear that all the pores of the mortar bed function like communicating tubes. Result: the mortar is completely saturated with water.

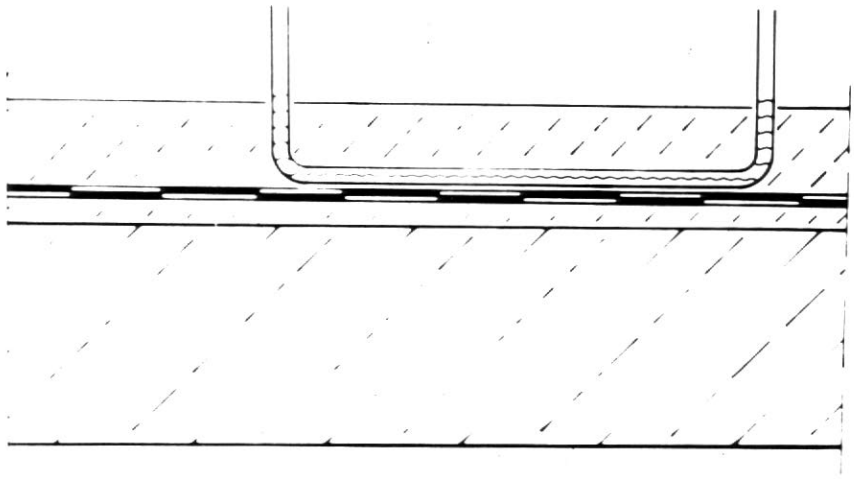


Fig. 7c: Mortar = like communicating tubes

Now, if under such a water-saturated covering the sealant is perforated at only one point, water will escape at that point. A **vacuum** develops which **automatically draws more water** after it - as long as the water lasts.

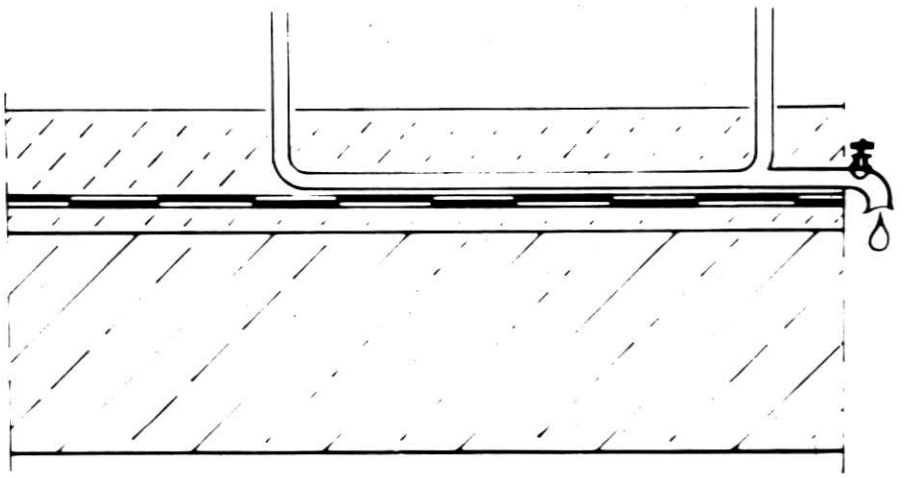


Fig. 7d: The way as functions a drainage-system between sealant and screed/mortar

If I lay a drainage system between the sealant layer and the covering structure, the water percolates in accordance with the hydrostatic pressure gradient down to the sealant and can then flow off there.

Yet what happens to the remaining water in the capillaries?

Capillary moisture can only escape from the covering structure via water vapour diffusion.

The following drawing will help clarify this.

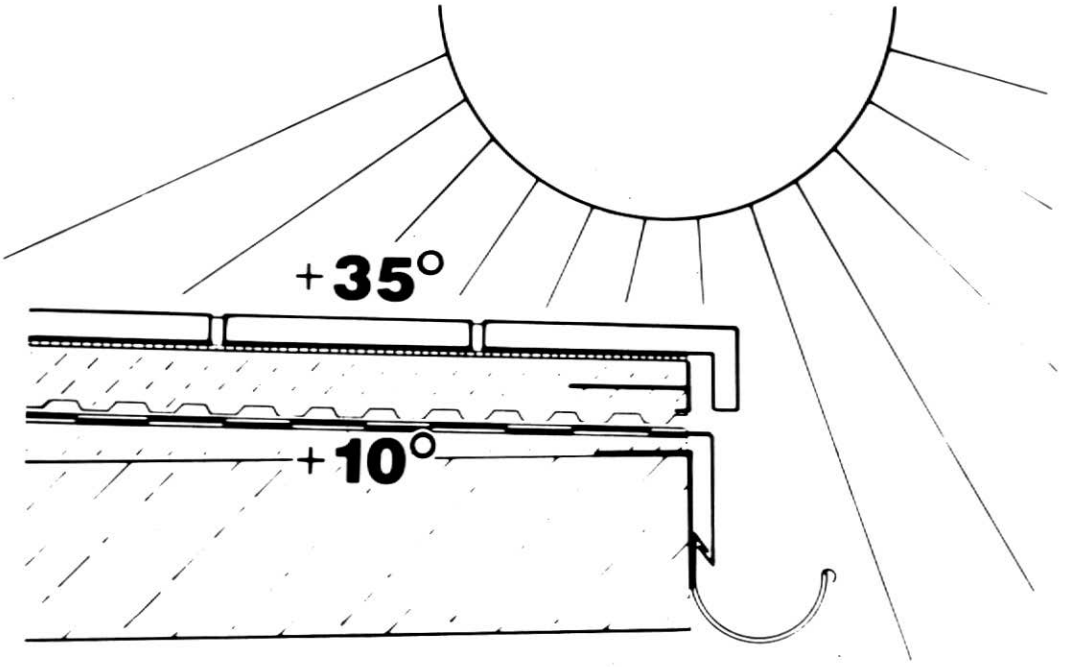


Fig. 7e: Normally vapour moves from the warmer part to the colder part

The source of warmth normally comes from the covering surface, e.g. through sunshine beating down on it. Thus, there is usually a temperature gradient running from the surface in the direction of the sealant. The water vapour diffusion therefore moves towards the sealant layer.

If a drainage system has been installed there, **the water can escape either in the form of vapour or in fluid liquid form.**

Since the ceramic tile surface is to a great extent vapour-proof, almost none of this moisture could escape upwards anyway.

Now, if there is no drainage system underneath, the water vapour condenses on the sealant layer and percolating water begins to develop, until the covering structure is completely saturated with water.

Let's return once again to the **DIN 18 195, Part 5, Paragraph 5.4.** It states: **A permanently effective drain-off of the percolating water which affects the sealant must be assured through technical construction measures.**

With respect to ceramic coverings, these requirements can only be fulfilled by installing a drainage system.

If we once again consider the various water transport possibilities, then it is a virtual certainty - the scientific community has until now done astonishingly little basic research in this area - that water vapour diffusion is the most important moisture penetration process. This is very often underestimated, even by specialists. Of course, this diffusion also has its positive sides and contributes - this cannot be ignored - together with capillary water transport to maintaining the moisture which the screed requires.

Thus the important thing is to limit the magnitude of these moisture values through the installation of a surface drainage system. Whoever fails to act in accordance with this working **contrary to the recognized technical rules.** This is clear, now that drainage systems over sealant layers have also been taken up in the new Practice Code concerning "Outdoor tile and slab floor coverings".

In light of the potential **warranty claims**, this is of decisive importance for companies carrying out this type of work. From this perspective, it may be that until now **the wrong people have been paying** for a lot of damage.

Many years ago, we were able to present for the first time - to the members of the German Säurefliesner Association, at the Säurefliesner Convention in Seefeld - a surface drainage system which was functional and designed to meet practical requirements.

Fig. 9: Working with a surface drainage system

The functional ability of this surface drainage system has also been demonstrated in a comprehensive series of research studies conducted in Großburgwedel.

The contents of this test certificate form a sort of standard for any drainage system.

"Under identical test conditions, when (the drainage system) was not used and the ceramic protective covering's bedding material was instead simply applied directly over the sealant layer, an 80-times longer period was required for the same quantity of released water to flow off."

And further: **"The research finding cited was also confirmed through test variations conducted with lime cement...**

The intended leaching out of easily soluble CaO components could thus be achieved during the test."

And: **"No impairment of the drainage capacity of the (drainage system) installed in the test coverings was determined at any point during the test period."**

The load imposed by a **whirling arm tester with 12,000 point loadings of 150 kg each had no negative impact on the sealant, the covering or the function of the (drainage system).**

The test results also correspond to 9 years of practical experience with balconies and terraces, parking surfaces, breweries, underground garages, pedestrian zones, etc.

I regard it as the task of all those involved with such ceramic surfaces -and particularly the specialists-, to work **towards structures which function** in accordance with the laws of construction physics and the most advanced technology, in order above all to hold onto - or win back - terraces and balconies as potential markets for ceramics.

Therefore specialists, architects, tile manufacturers as well as tile layers must themselves make the effort to understand the laws of construction physics.

We have presented our findings in a brochure entitled "Planning

Details for Balconies, Terraces and Flat Roofs".

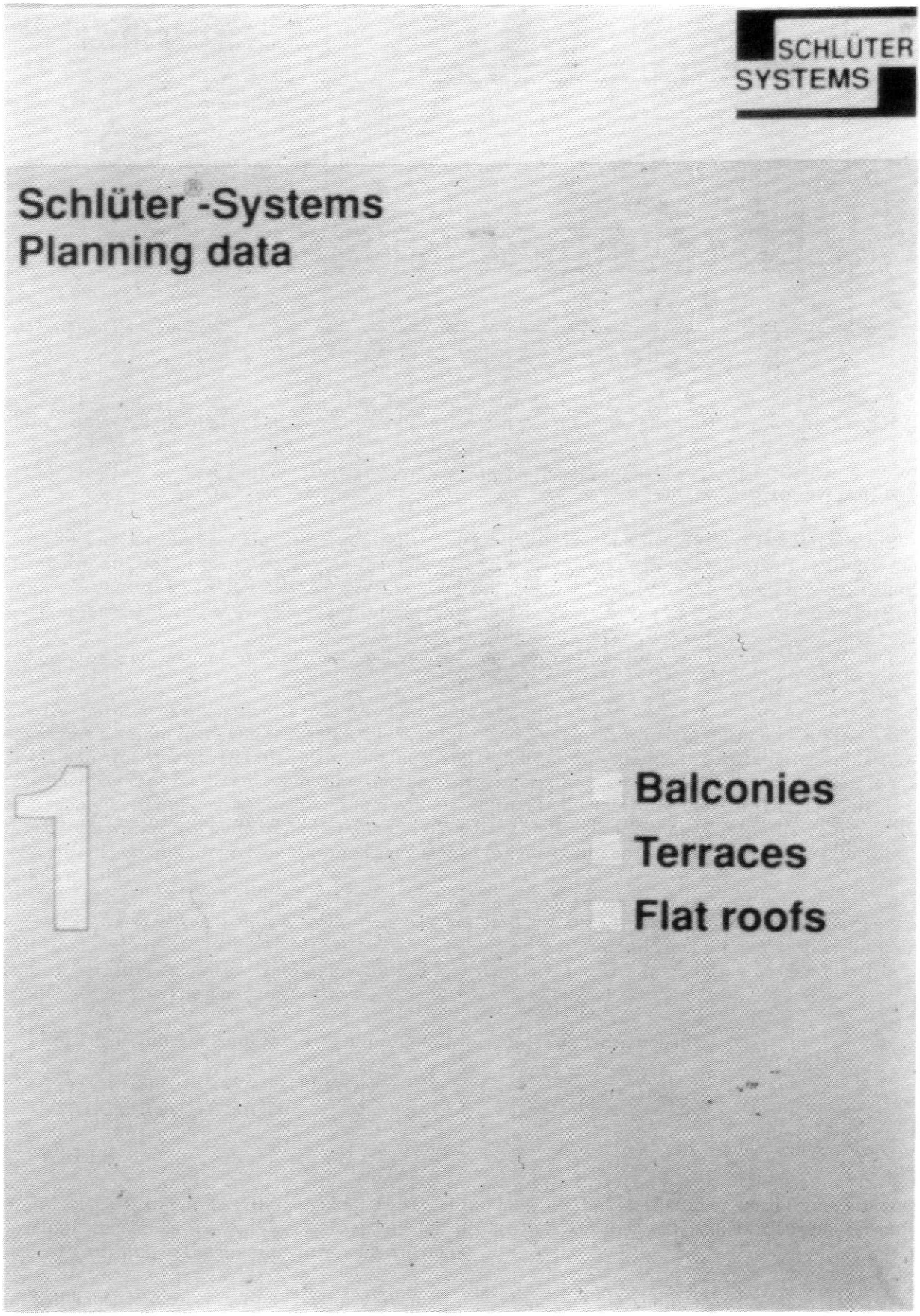
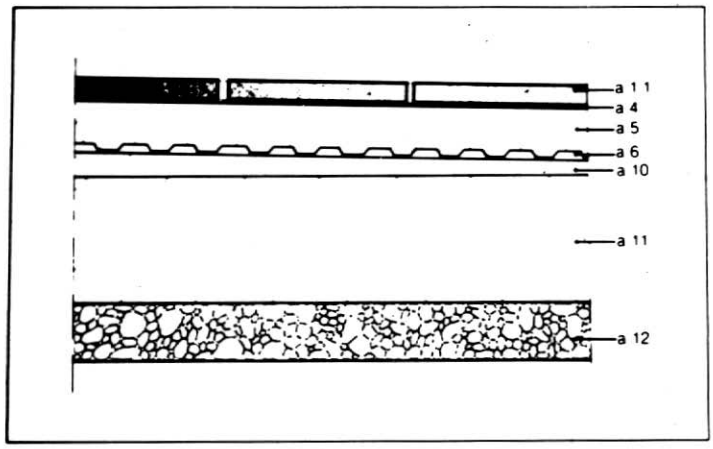


Fig. 11: The brochure "Planning Details for balconies, terraces and flat roofs", actually available in German, English, French, Dutch and Italian language; in preparation: The Spanish translation.



A 01 **Tiled or paved covering on concrete base at soil level without seal.**

a 1 1 Covering — tiles or paving
a 4 Contact layer (e g thin bed mortar)
a 5 Load distribution layer (composition flooring)
a 6 surface drainage and separation layer (Schluter-TROBA matting)
a 10 Incline layer
a 11 Concrete base
a 12 Clushed stone foundation

Fig. 12: Balcony-example taken from the brochure "Planning details for balconies, terraces and flat roofs".

A last remark:

Since August 27, 1991, we have the confirmation that our proposals for balcony and terrace constructions including the drainage system as key-element correspond also to the conditions of French laws of guarantees in construction sector by an "AVIS TECHNIQUE" of Bureau Veritas. Constructions recognized by this Avis technique must guarantee ten years without damages.