BRITISH STANDARDS AND CODES OF PRACTICE FOR THE INSTALLATION OF WALL & FLOOR TILES

by William L. Walters and Roy Harrison (Great Britain)

- B.S.C. in physical chemistry from the University of Liverpool.
- Fellow of the Royal Society of Chemistry and Chartered Chemist.
- Fellow if the Institute of Ceramics.
- Senior Consultant, Tile Research Section, British Ceramic Research Ltd.
- Chairman of the British Standards Committee for codes of practice and all relevant BS, and ISO Committees dealing with tiles and tile adhesives.
- Vice - president of the Institute of Ceramics.

SYNOPSIS

The need for standardisation and the importance of adhering to recommended practice has been recognised as essential in the UK for many years. As new systems of fixing were proposed it was imperative that research and development was undertaken to assess and possibly modify the new system. As a result Ceram Research has been closely involved in the development of codes of practice and standards work from the outset and co-author Roy Harrison sat on and chaired many BS committees.

A comprehensive series of codes of practice is now established. Firstly in the form of BS5385 parts 1-5 and secondly as a series of site instructions for clerks of works as the BS8000 series.

The separate parts deal with internal wall tiling, external wall tiling, internal and external floor tiling, non-ceramic cladding eg. terrazzo, natural stone etc. and tiling in special conditions eg. swimming pools. This part is particularly important.

Selection of appropriate tiles is critical particularly in special conditions and Ceram Research suggest that some categories of tiles are suitable for walls and floors only.

Having been involved in the research of many aspects of tile fixing in the development of the standards and with a wealth of experience of tiling consultancies, Ceram Research is well placed to undertake research into new fixing systems.

INTRODUCTION

The UK implemented the European Standard for ceramic tiles as the parts achieved final acceptance in 1983 and 1984. Prior to that there were two standards, one for porous body glazed wall tiles, BS1281, and one for floor tiles BS1286. The latter included both single-extruded tiles, known as quarries, and dust-pressed tiles. There was not a BS for extruded split tiles. There has also traditionally been recognition of one other type of glazed tile, manufactured principally for tiled surrounds. For many years the latter were mainly for coal fires and they were made by placing tiles face down and at the sides of moulds into which dense concrete was poured. The tiled surrounds would typically weigh 150 kg and the tiles were required to be highly decoratively glazed but of higher strength than typical wall tiles. Nowadays a high proportion of tiled surrounds enclose radiant gas or electric fires and the strength requirement is not so critical. These are made of lightweight concrete or wooden boards. The casting and fixing techniques for tiled surrounds have never been incorporated in BS codes of practice but, after an extensive research programme, guidelines were established by Ceram Research.

The first Code of Practice for ceramic tiling was for floors and this was published in 1959. The demand for it arose from a number of pop-up failures; cases where tiles or tiles plus bedding mortar had popped-up as a result of the contraction of the base concrete. There had been a massive increase in the use of concrete bases and there was also pressure to achieve faster building completions. One of the main provisions of the flooring code therefore was to introduce the separating layer technique which enables base shrinkage to be isolated from the tiles and their bedding mortar.

Two other types of tiles, neither of which form part of the European Standard, have to be mentioned for completeness. These are architectural terracotta, which is usually red or buff coloured and unglazed. This material is usually vitrified with a water absorption below 3%. The other is architectural faience tiles, not to be confused with earthenware tiles. Faience tiles have porous, coarse textured bodies, but they are always glazed. Both architectural terracotta and architectural faience tiles are made to size or oversize and fitted to specific positions. They are adhered and also cramped, that is they have metal fixings. The main application is externally and they are therefore frost resistant. They are also usually large sized, typically up to 600 mm facial dimension.

1. OVERALL PLAN OF CODES OF PRACTICE

There are two series of codes. The main series is in five parts:

British Standard. Wall and floor tiling BS5385

Part 1. Code of practice for the design and installation of internal ceramic wall tiling and mosaics in normal conditions.

Part 2. Code of practice for the design and installation of external ceramic wall tiling and mosaics (including terracotta and faience tiles).

Part 3. Code of practice for the design and installation of ceramic floor tiles and mosaics.

Part 4. Code of practice for ceramic tiling and mosaics in specific conditions.

Part 5. Code of practice for the design and installation of terrazzo tile and slab, natural stone and composition block floorings.

Part 5 Deals with products which are designed and installed with many similarities to ceramic tiling. They are often treated as alternatives and the choice between them is frequently made aesthetically. There will however be no further discussion on them in this paper.

Whereas there are separate codes of practice for internal and external wall tiling there is only one code of practice (part 3) for flooring. The British winter climate is amongst the most severe in Europe and we have a very high rainfall. As a result particular care has to be taken with external tiling.

The second series consists of two parts only within a broad series on instruction which are based on the main series but reduced to sets of site instructions and with the minimum of explanations. They are intended for clerks of works, who direct day-to-day work on site, and the operatives. The two which deal with ceramic tiling and related products are:

Workmanship on building sites BS8000.

Part 11. Code of practice for wall and floor tiling

Section 11.1 Ceramic tiles, terrazzo tiles and mosaics.

Section 11.2 Natural stone tiles.

Thus the British codes of practice encompass general and detailed recommendations as well as site instructions and also deal with hard products other than ceramic tiles which are fixed in similar ways.

Revision of the main series, BS5385, has recently been completed but one minor addition has been proposed for part 1. This will add specific requirements for fixing natural stone tiles internally with adhesives.

Table 1.

Layout of BS5385, Parts 1, 2 and 3 which deal with ceramic tile fixing

Main Section	Examples of Type of information
1. General	Definitions Exchange of information Time schedules
2. Materials	Tiles Sand Fixing materials, including grouts, Reinforcement.

Table 1. cont'd.

Layout of BS5385, Parts 1, 2 and 3 which deal with ceramic tile fixing

Main Section	Examples of Type of information
3. Design	Alignment Bases and backgrounds Rendering and screeds Conditions of use. Movement joints.
4. Application of tiles: methods and materials.	Surface preparation Setting out Bedding methods Tile joint treatment Grouting procedure
5. Application of mosaics: methods and materials	Setting out Preparation of mosaics Bedding methods Application Grouting procedure Glass or natural stone mosaics

Table 1. cont'd.

Layout of BS5385, Parts 1, 2 and 3 which deal with ceramic tile fixing

Main Section	Examples of Type of information
6. Protection, cleaning and maintenance	Efflorescence Residual cement Cleaning agents Glazed tiles Unglazed tiles

2. LAYOUT

The overall layout, together with an indication of the type of information included in each section, for the three parts, 1, 2 and 3, which deal with ceramic tile fixing, are shown in Table 1.

3. FIXING BY ADHESIVESS

Attempts to use adhesives were made in the 1930s but the only adhesive that achieved substantial use in that period, Indasco, was bitumen-based and its use was largely confined to the manufacture of tile surrounds. In 1953 Ceram Research investigated test methods that had been published in the USA[1] the previous year.

When the first Code of Practice for wall tiling was published in 1963, with the number BSCP212: Part 1[2], a system of testing adhesives was included as an appendix. A separate standard BS5980[3], with a simplified system of testing was subsequently introduced and both systems of test were maintained for many years. The current BS5385 series does not contain adhesive test methods.

The British system has always identified thin-bed adhesives as being up to 3 mm-thick. Beyond that thickness the adhesives are described as thick-bed. Notched-trowel application is common with internal wall tile fixing but it is stipulated that all floor and all external fixing shall be by solid-bed, that is with no voids except for minor bubbles and imperfections. The recommended method for fixing tiles in swimming pools and tanks is also solid-bed.

The five categories of adhesives are cementitious (hydraulically - hardening mortars), dispersion, dispersion-cement, dissolved resin and reaction resin types. UK has been the principal user of ready-mixed dispersion adhesives, based on polyvinyl acetate emulsions, that are not water resistant. Their use has therefore been restricted to dry internal situations where they have been very successful. They have proved ideal for the do-it-yourself market which is important in UK. Current trends favour more water-resistant dispersions. Cementitious adhesives are used in all types of conditions. One common type of surface internally in UK is gypsum plaster and early in the history of adhesive fixing

many failures occurred with this background until a recommendation was introduced that no fixing should take place until the plaster had matured for at least four weeks. The dispersion and dispersion-cement adhesives are suitable for fixing on plaster but cementitious adhesives are not suitable because of the danger of formation of ettringite and the subsequent loss of adhesion.

Dispersion-cement adhesives with flexible fillers are used for special fixing in UK, especially on walls expected to show greater than normal size changes and in positions subject to vibration. These are true flexible adhesives unlike modified cementitious adhesives which deform as a result of plasticity.

Dissolved resin adhesives, containing solvents, are now rarely used. The commonest type of reaction resin adhesive is that based on epoxide resin. These are high-cost adhesives and their use is limited to special requirements. The high-cost arises not only from relatively expensive materials but also because the time required to fix tiles tends to be longer than with other categories.

Adhesive fixing is encouraged for all wall and special fixings. Adhesives are also increasingly used for floor although thick-bed systems with cement-sand mortar are preferred for most large institutional and work-place floors.

4. EXAMPLES OF INSTALLATION DETAILS

4.1. Compacted Semi-Dry Mortar Flooring

This is a method for applying floor tiles with a monolithic bedding layer without the necessity of applying a screed and having to allow this to mature before laying the tiles. A good bond is provided for the tiles but the semi-dry mortar mix does not adhere to the base and so it is a separating-layer technique, that is the base shrinkage is prevented from affecting the tiling. Another advantage is that depth variations can be accommodated and total depths over 100 mm are common in one application. The minimum thickness recommended is 40 mm.

After introduction into UK in the late 1970s there was a spate of failed floors laid by this method and Ceram Research undertook a research programme to determine the errors in the procedure and to correct them.

It was found that the semi-dry mortar as originally specified was too dry. The water:cement ratio now specified is 0.55 to 0.60 by weight (about 27.5 litres of water to 50 kg cement). A simple way of estimating the correct water content on site if a means of accurate gauging is not provided is:

(a) When a sample of mortar is squeezed in the hand, the sample should retain its shape and not crumble, the hand being left slightly moist.

(b) When a sample is compacted on the base, no film of water should form on the surface.

Another fault was poor mixing of cement, sand and water and this was corrected by banning the use of free-fall drum mixers for semi-dry mortars and insisting on a type of forced action mixer. Although only critical for semi-dry mortars the use of forced action mixers is now encouraged for wet mortar and concrete mixing too.

The semi-dry mortar is trowelled into place and a bond-layer slurry consisting of 1 part of cement to 1 part of sand, or a suitable adhesive with low plasticiser content, in a 2 mm thick layer is trowelled over this. The tiles are immediately place on the bond layer, ideally using a spacing grid and then they are tapped or vibrated in order to achieve a level surface with the tiles having complete bonding. This is checked, as with other fixing systems, by removing a recently-fixed tile occasionally to check that the technique is achieving the required adhesion contact.

If the tiles have deep grooves or panels on the reverse the hollows have to be filled in before placing the tiles.

4.2. Movement Joints

Perimeter joints are recommended for all areas of tiling. In some cases, as with floor tiles under sit-on skirting tiles, these can be hidden joints. Perimeter joints also include the joints around pillars and machinery plinths.

Structural joints always have to be followed through the layers to the tiled surface. Movement joints have also to be placed over junctions between unlikely backgrounds.

Intermediate joints in large wall areas are recommended to be placed at 3 m to 4.5 m centres horizontally and vertically. The positions should include horizontal joints at floor levels in external tiling.

The requirements are more demanding for floors and consideration has to be given to traffic and loading as well as the potential size changes of the installation. Thus ideally, flexible joints should be at right angles to main traffic flows and the minimum number inserted to prevent failure.

Different types of movement joints are illustrated in Figure 1 which is taken from BS5385: Part 3, the flooring code. For each type of joint the left hand side represents a section of floor with adhesive fixing and the right hand side has thick bed mortar fixing. Types A and B are used over structural joints. Smaller movements are accommodated by types C, D and E. Contraction joints which are non-compressible are type F. One particular type of installation where the choice of joints is critical is flooring suspended by beams or walls. Movement joints should be placed directly over the beams or walls and in line with them. These joints open out and do not compress and contraction joints (type F) may be chosen. At intermediate positions between the beams or walls the floor may sag as well as being subject to structural shrinkage and normal thermal size changes. Types C, D and E are suitable for such positions.

The minimum width of movement joints is 6 mm and the majority are made with flexible back-up material topped with a rectangular section of gunned sealant. There is increasing use of protected edges with flooring, advisable because of the vulnerability to impact damage of tile edges adjacent to flexible joints.

4.3. External Tiling

The high rainfall together with an average number of freeze-thaw cycles of 35 annually, with over 60 cycles occasionally in winters, inevitably means that special care has to be taken with external tiling. The fixing systems are the same internally and externally with flooring and it has therefore not been necessary to have two flooring codes. The main difference externally is the problem of drainage which is a major consideration at the design stage. The system has to be such that all waterproof layers have adequate drainage. So if tiles are fixed over a surface with an impermeable layer drainage has to be arranged at that level as well as at the surface.

Investigations of external wall failures and an extensive research programme at Ceram Research showed that the interface that was most likely to fail in adhesion was that between cement-sand mortar rendering and the structural wall. Unfortunately bedding mortars and adhesives have frequently been blamed for failure when the problem has been at this interface. If the rendering bulges away from the structure then the adhesive and tiles are also pushed off and it is these that are noticed first.

The solution has been to require all external rendering which is to take tiles to have austenitic stainless steel reinforcement anchored back into the structure.

Special care has to be taken to provide flashing at the top of walls which have no overhanging structure. This position has proved to be particularly vulnerable to rain when there have been strong winds. Window sills provide another position where precautions have to be taken to prevent ingress

of water. Once behind tiling, water may flow down to collect in cavities which in winter may become centres initiating frost damage. Parapet walls have to be sealed on both faces but provision has to be made below the capping for water vapour to evaporate, but these positions have to be overhung to prevent direct ingress of water.

Protection from rain is necessary during tile fixing and in the most severe wintry spells external work has to be suspended.

5. SPECIFIC CONDITIONS BS5385: PART 4

5.1. Scope

In the parts of BS5385 other than part 4 the conditions are either considered as normal internal conditions or British climatic conditions, even though both of these may be considerably varied. Part 4 on the other hand deals with tiles and mosaics in situations where there are specific functional or environmental requirements and/or conditions that are potentially detrimental to the installation or the background or both. It covers two groups of requirements:

Conditions to be resisted; movement, traffic, loads, wet and damp conditions, chemical attack, thermal effects, contamination from radioactivity.

Conditions to be achieved; sterile conditions, thermal insulation, sound insulation, antistatic conditions.

If there is a conflict between requirements either one overriding function has to be catered for or a satisfactory compromise has to be achieved. The specification has to meet the most exacting conditions even if these only occur infrequently.

Separate sections deal with problems associated with the specific conditions, choice of tiles and fixing methods and special maintenance requirements in the following subjects:

Movement
Traffic and load conditions
Damp and wet conditions (not continuously immersed)
Continuous wet immersion
Chemical attack
Sterile conditions
Climatic and environmental thermal effects
Thermal insulation
Sound insulation
Electrostatic conditions
Radioactivity

5.2. Damp and wet conditions

5.2.1.General

A distinction is made between installations that will be damp or wet in service and not continuously immersed as to whether they will have frequent or occasional wetting. Thus individual showers in domestic properties or hotels will have infrequent use. For most of each day the installations will be drying-out. These are considered to be normal conditions and BS5385 parts 1 and 3 are relevant. On the other hand showers in sports and leisure centres and in hospitals will have frequent use and these are dealt with by the specific requirements of part 4. In all cases major considerations have to be water resistance and the avoidance of seepage of water to lower parts in the building.

5.2.2. Swimming pools, tanks and reservoirs

Tanks are large containers used for the storage of liquids and the same basic provisions apply for them and reservoirs as for swimming pools. The primary requirement is that the structure or shell should be water-tight. No attempt is made to seal with tiles and waterproof fixing materials. Swimming pool shells are usually constructed in cast dense concrete but may be formed from metal sheets. The watertightness of the shell is checked. Internal surfaces are usually rendered and the tiles are fixed with solid beds of adhesive. Recommendations are made for the provision of flexible movement joints.

The recommended minimum time intervals between successive stages are:

(a) between completion of shell and rendering plus screeding: 6 weeks;

(b) between completion of rendering plus screeding and tile fixing: 3 weeks;

(c) between completion of tile fixing and grouting: 3 days;

(d) between completion of grouting plus movement joints and filling the pool or tank: 3 weeks.

The provisions of 6 and 3 weeks respectively for (a) and (b) are the same as for fixing floor tiles onto concrete slabs.

Instructions are given for the rendering and screeding and for the tile fixing operations. The special requirements of salt-water swimming pools and pools, tanks and reservoirs in external situations are also considered. Advice is also given on the rate of filling and emptying pools. The rate of heating should be 0.25°C/h.

6. CHOICE OF TILES

The choice of tiles is in accordance with the relevant parts of the European Standard for all normal conditions. For external tiling in UK it is recommended that all tiles are within the A1 and B1 classes, that is with water absorptions below 3%. One exception if for architectural faience tiles. Although they may be porous the coarse texture of these provides frost resistance. Kervit cast tiles, no longer manufactured, were also frost resistant although porous.

The code for specific conditions (part 4) gives additional information on choice. Thus in heavy traffic and heavy load situations thicker tiles and more vitrified tiles may be specified the greater the resistance required. The impact measurement method based on the coefficient of restitution is ideal as a means of quantifying the load requirements. In other situations such as swimming pool surrounds, but also for certain workplaces special surfaces may be specified to reduce the chance of slip. Thus textured surfaces and the possible incorporation of silicon carbide grains have to be considered as solutions. Nevertheless it has to be emphasized that slipping is principally a matter of cleanliness or treatment. Advice on cleaning floors is given in part 3 and further specific information is in part 4. Seals and polishes are not recommended. One source of problems with unglazed floor tiles is regular cleaning with alkaline detergents of greater than pH 9. These should only be used occasionally and then the residue should be thoroughly rinsed away with clean water, otherwise reaction can cause a glossy and potentially slippery surface.

The British Standards for wall tiles (BS1281) and floor tiles (BS1286) which existed prior to the introduction of the European Standard each had sections with illustrations of tile fittings. These are such special shapes as skirting tiles, internal and external angle pieces, stairtreads, worktop trims and channels. These were not included in the European Standard and the wall tile fittings are now included in BS5385: Part 1 and the floor tile fittings are in BS5385: Part 3.

Acknowledgement

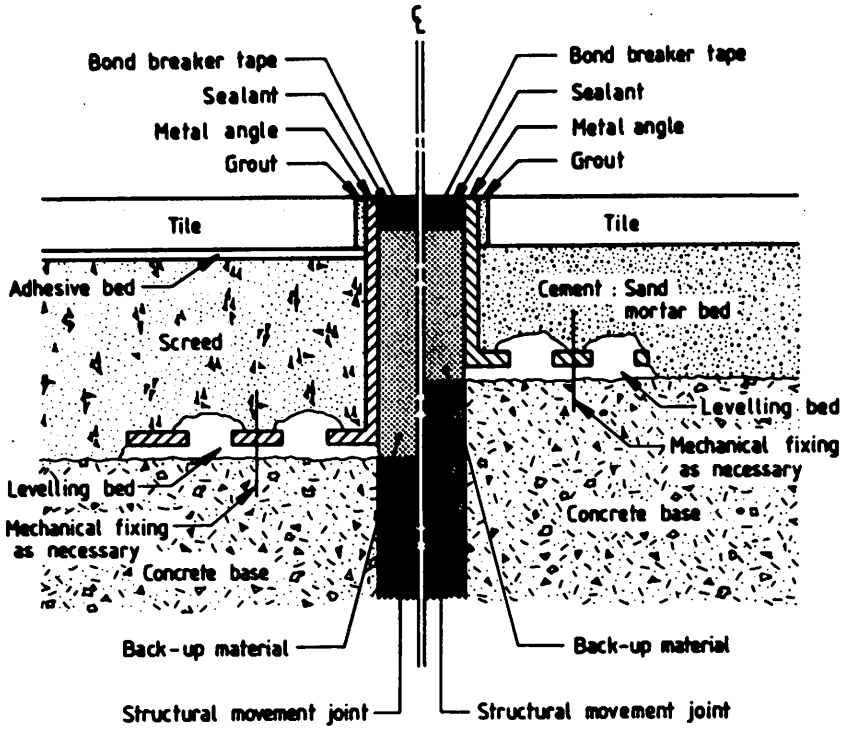
Permission to present this paper was given by Dr. N. E. Sanderson, Chief Executive of Ceram Research.

References

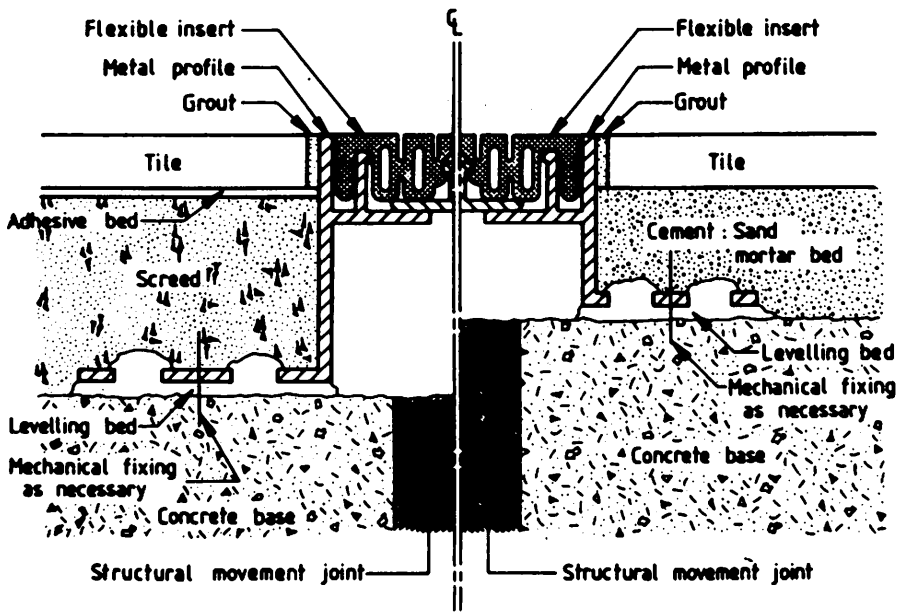
1. US Commodity Standard CS181-52

2. British Standard Code of Practice CP212: Part 1: 1963. Internal Ceramic Wall Tiling in normal conditions.

3. British Standard BS5980: 1980, Specification for adhesives for use with ceramic tiles and mosaics.



Type A. Joint aligned to structural movement joint

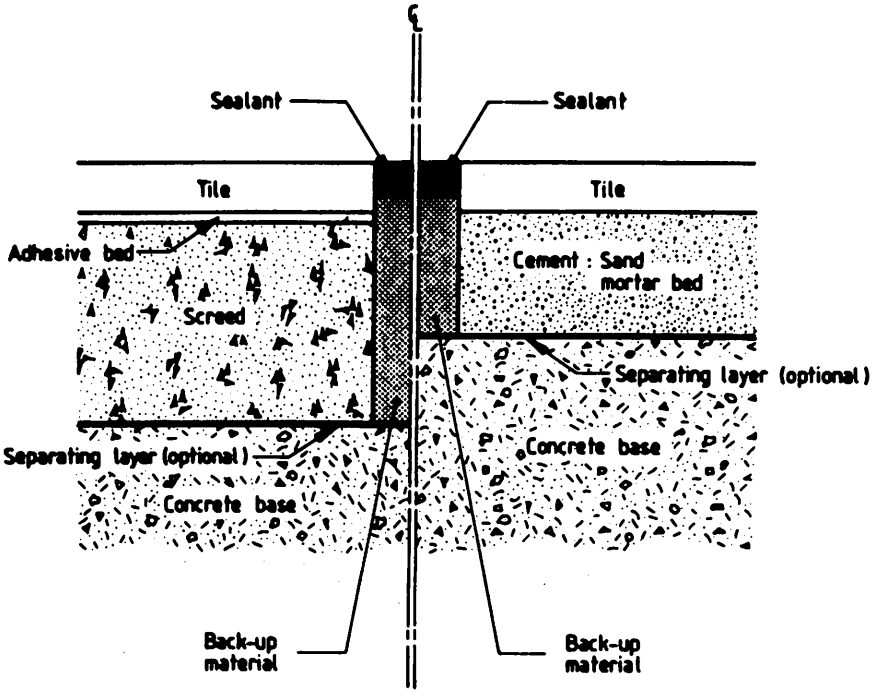


Type B. Prefabricated joint with reinforced edges and capping over structural movement joint

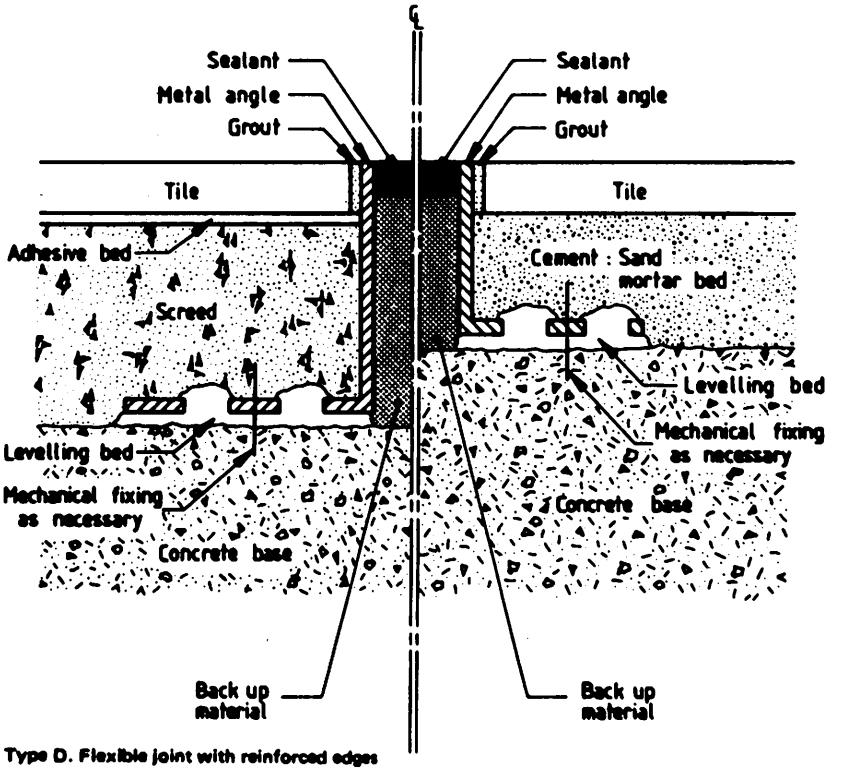
NOTE 1. All drawings in figure 2 illustrate principles only.

NOTE 2. Semi-dry mix beds have movement joints similar to those shown for screeds.

Figure 1 Some typical movement joints

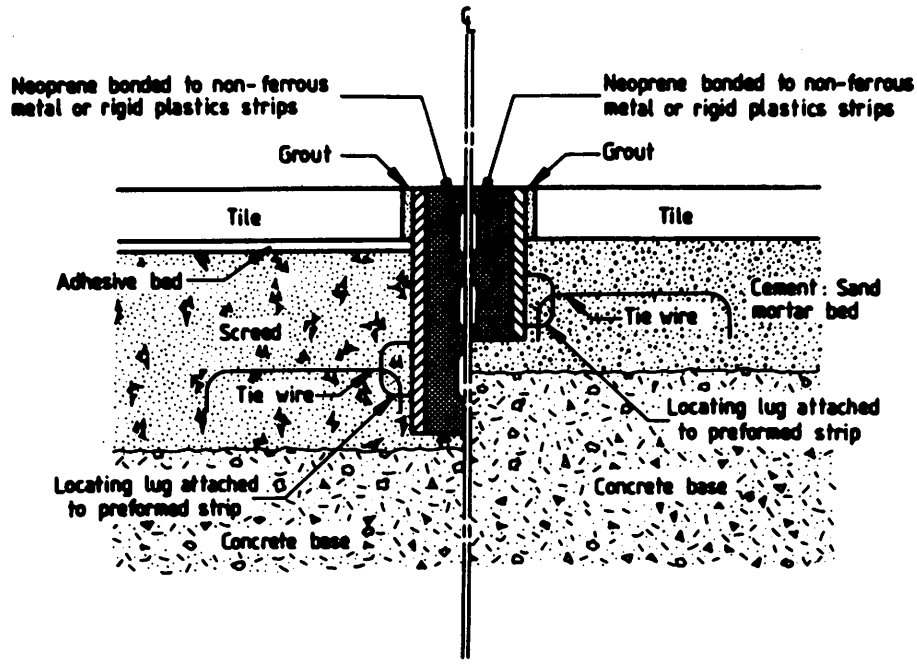


Type C. Flexible joint in bed, with or without separating layer

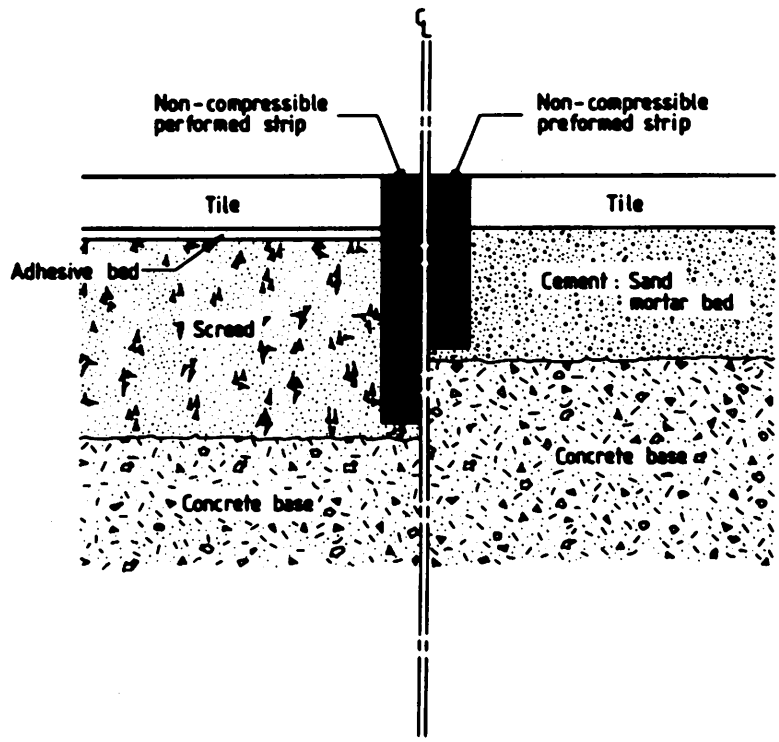


Type D. Flexible joint with reinforced edges

Figure 1 *(continued)*



Type E. Slightly flexible joint: preformed strip with reinforced edges



Type F. Contraction joint: preformed strip

Figure 1 *(continued)*