Failure of Tiling System

(Extracted from "Guide to the deterioration and failure of building materials" By R. O. Heckroodt pp.76-84, published by Thomas Telford)

One of the major causes of the failure of tiling system is poor workmanship particularly incomplete bedding the tiles in the adhesive, which allows puncturing and other kinds of impact damage to occurs, laying tiles on area of adhesive where the open time has been exceeded, resulting in poor adhesive of the tiles, is another common.

Causes of failure

For an adhesive to perform successfully it must: achieve good contact with both adherends; set to a solid material; distribute and dissipate stresses; and continue to function for a given life time i.e. has good ageing properties in its working environment (e. g in different weathering conditions).

There are several agents which can cause or contribute to failure, the chief ones being :

(i) Environment stress(fatigue) caused by different thermal or moisture movement by mechanical shock;

(ii) Weathering of the bond line in exposed situations, e.g. embrittlement by oxidation of rubbery components;

(iii) Hydrolysis-water might enter the joint by diffusion, by wicking at interfaces and/or by penetration through cracks and holes;

(iv) Solvents-leaching of plasticizers or other components;

(v) Biological attack by agents such as fungi and bacteria.

There are three basic ways in which an adhesive joint can fail :

(a) Fissure in one of the substrates (adherend)-Cohesive failure in adherend;

(b) Fissure in the body of the adhesive-Cohesive failure in the adhesive;

(c) Separation at the interface between the adhesive and one of the adherends-adhesive failure

Some tiling failures manifest themselves quite soon after the tiles have been fixed, while other failures may take many months or even years to become apparent. Two types of failure of tiled areas that were initially sound can be distinguished like material failure and system failure.

Material failure

Tile adhesive failure

The first aspects to establish when tiles de-bond from the substrate are whether or not-there were opposing dimensional changes in the different elements of the tiling system. This kind of system failure is characterized by droning, bulging or ridging of the tile layer. The different types of adhesive failures during testing between adhesive and substrate (Fig: B.1), between adhesive and tile (Fig: B.2) and between tile and pull head plate (Fig: B.3) are shown by sketches below.

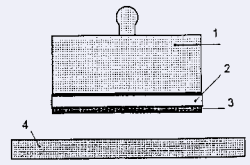

Figure B.1

Adhesive failure between adhesive and substrate (AF-S)

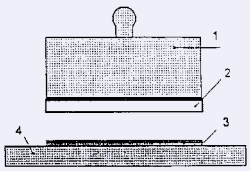

Figure B.2

Adhesive failure between tile and adhesive (AF-T)

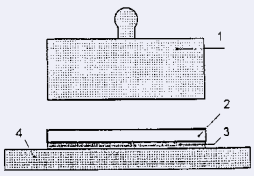

Figure B.3

Adhesive failure between tile & pull head plate (BT)

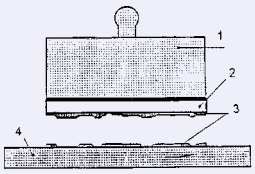

Figure B.4

Cohesive failure within the adhesive (CF-A)

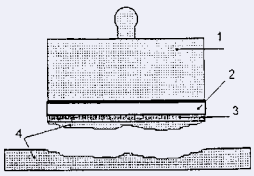

Figure B.5

Cohesive failure within the substrate (CF-S)

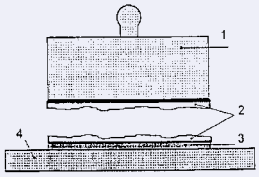

Figure B.6

Cohesive failure within the tile (CF-T)

1. Pullhead plate 2. Tile 3. Adhesive 4. Substrate

The adhesive can fail because an inappropriate type was used for the specific application or as a result of the ingress of aggressive chemical.

Inappropriate adhesive

Adhesive of specific type and class are required for adverse conditions, such as room walls, floors subjected to heavy traffic, external facades and flexible substrates. The development of modern adhesive has resulted in a degree of overlapping of the types, depending on the performance characteristics required. The adhesive

could thus also be classed according to the application conditions, and specifications. Adhesive and cohesive failure may attribute to errors in specification.The failure due to inappropriate adhesive is shown in fig. 1

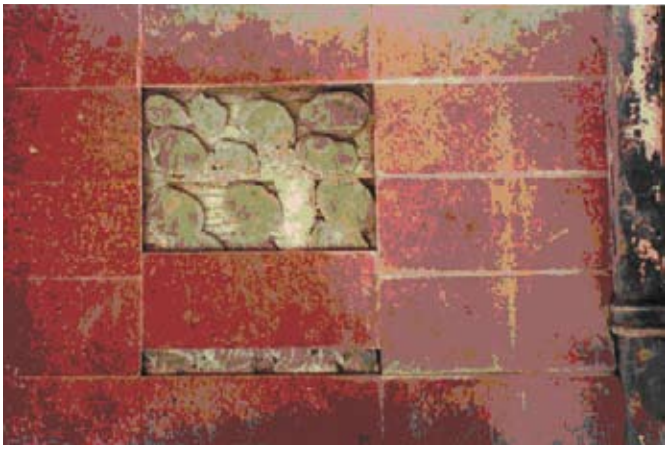

Fig 1 : Adhesion failure due to use of cement as adhesive

Cohesive failure

Cohesive failure tends to be associated with faults in specification such as the choice of an adhesive not flexible enough to withstand movement stress or the failure to provide movement joints.

The other type of failure of the material may be due to cohesive within the adhesive (Fig: B.4), within the substrate (fig: B: 5) and within the tile (Fig: B.6) may take place as per the given sketches.

Attack by Aggressive Chemical

Cement based adhesive are attacked by sulphate (leached from the substrate or adjoining soil) as well as fertilizers, sewage effluent, industrial chemical etc. Note that a sulphate resisting Portland cement will only be effective against sulphate but not against acids that may be part of industrial and sewage effluent.

Poor Workmanship

Factors involving poor site workmanship, such as inadequate surface preparation, uneven or frugal application of adhesive and insufficient pressure applied when making the bond, tend to give rise to adhesive failure. This does necessarily mean that an observed adhesive failure can automatically be attributed to errors in workmanship.

Tiles may de-bond at the adhesive interface because one or more of the application characteristics of the adhesive have been exceed, usually by exceeding the pot life or open time. This type of failure is the result of ignorance, poor workmanship or inadequate supervision.

Preventive and remedial action

Crazing of the glaze surface, lime blowing or disintegration caused by frost action and salt. Crystallizations are processes that cannot be stopped by any subsequent treatment or action; they are inherent defect of the tiles. The remedy if the defect becomes unacceptable is to re-tile the area with sound tiles and by using appropriate adhesive.

- Careful attention should be given to the choice of materials, correct work procedures and good workmanship.
- Be aware that the application of surface sealant or impregnates to porous, unglazed tiles could exacerbate to their spalling due to salt action.
- It is of utmost important that the correct type of tile adhesive be selected and that all materials and installation procedures should.

System failure of tiled floor and wall

A tiled floor or wall is a complex multi component layered system. It consists of various elements.

- The visible parts, namely the tiles, grouting and movement joints.
- The invisible parts, which could include some or all the following adhesive, screed or plaster, membrane and slab or wall.

Each element makes a specific functional contribution to the unit as a whole. All the elements have different properties and frequently slow incompatible behaviour. As far as the failure of a tiling system is concerned, the dimensional stability of the entire component is the determining factor. If all the component of an integrated floor checking dimensionally by exactly the same amount in the same direction than the floor as an unit will expand without any internal stresses being developed.

Different movement

The reason for dimensional change of the tiling elements are temperature change irreversible moisture expansion of the ceramic tiles, as well as drying shrinkage and creep of the floor or wall.

Thermal movement

The variation in thermal expansion of clay bricks and tiles is small and changes in ambient temperature do not cause signification stresses in a tiled bricks wall system.

The different in thermal expansion of cement products and clay tiles can be significant and, coupled with the decimal temperature gradient could be enough to cause stress damage to such tiled systems. Special precautions are required in particular with the tiling of cold storage spaces.

The failure due to thermal movemnet is shown in Fig 2

Fig 2 : Failure due to thermal movement

Irreversible moisture expansion of tiles

The moisture expansion of some ceramic tile can be considerable physically restraining the tile will not prevent from expanding. If the floor system is unable to accommodate the stresses caused by the strain, the tiles will either crushed or the adhesive will fail and the tiles will lift from the floor or detach the wall.

Some tiles have an expansion as wish as 0.1% (1.0 mm / m) after 5 years of exposure, which is of the same magnitude as their crushing or critical strain. Table 1 lists the categories in which tiles are placed according to their total expected moisture expansion (as measured after 96 hours of steaming.)

Table 1 : Thermal expansion of materials in tiling systems

Materials	Thermal expansion (mm/m per 20°C)
Dense concrete	0.22 – 0.26
Calcium Silicate bricks	0.16 – 0.28
Fixed Clay bricks and tiles	0.14 – 0.18

Movement Joint

It is a fallacy to think that movement joint will prevent tiles and the base. These joint are there to accommodate shrinkage, settling, and dynamic movement between different parts of the structure. They cannot be used as a cure for poor design, or to avoid the effect of unbridled fast tracking.

Failure of adhesive bonds in flooring

Due to specification:

- Wet screed (construction water or faulty dpm
- Wrong adhesive used
- Insufficient movement accommodation
- Plasticizer migration of leaching by washing

Workmanship:

- Inadequate adhesive cover and/or insufficient pressure applied
- Incorrect use of open time (i.e. flooring laid too soon or too late
- Inadequate surface preparation

Failure of adhesive bonds in internal walls

Due to specification:

- No allowance for initial movement (shrinkage of background/expansion of tiles)
- Wrong adhesive chosen (wet conditions, service movement or incompatible with background)

Workmanship:

- Inadequate adhesive cover and/or insufficient pressure applied

Failure of adhesive bonds in internal walls

- Non-allowance for thermal movement between facing and background,
- Frugal application of adhesive and insufficient pressure used in installing the facing.

Failure of adhesive bonds in Swimming pools

- Incorrect choice of materials
- Inadequate application of adhesive

By taking care of the above facts the failure of the tiling system can be effectively minimized.

The various other International standards may be referred for tile adhesives and grouts as given below.

ISO 13007 : Ceramic tiles-Grouts and adhesives Part 1: Terms, definitions and specifications for adhesives, Part 2: Test methods for adhesives, Part 3:Terms, definitions and specifications for grouts, Part 4: Test methods for grouts

BS 5980(1991) : Specification for Adhesives for use with ceramic tiles and mosaics

EN 12004 (2007) : Adhesives for tiles-Requirements, evaluation of conformity, classification and designation

EN 1308 : Adhesives for tiles-Determination of slip

EN1324(2007) : Adhesives for tiles-Determination of shear adhesion strength of dispersion adhesives

EN1346 : Adhesives for tiles-Determination of open time

EN1347 : Adhesives for tiles-Determination of wetting capacity

EN 1348(2007) : Adhesives for tiles-Determination of tensile adhesion strength for cementitious adhesives

EN12002 : Adhesives for tiles-Determination of transverse deformation for cementitious adhesives and grouts

EN 12003(1997) : Adhesives for tiles-Determination of shear adhesion strength of reaction resin adhesives

EN 12808-1 : Adhsives and grouts for tiles-Part 1: Determination of chemical resistance of reaction resin mortars

ANSI A118.7(99) : American National Standard Specifications for Polymer Modified Cement Grouts for Tile Installation (N-3.3, N-3.4, N-3.5, N-3.6 and N-3.7)