TECHNICAL BULLETIN

DIFFERENTIAL MOVEMENT & TILE FINISHES

INTRODUCTION & SCOPE

What is Differential Movement?

Differential movement is that expansion/contraction and or deformation movement that occurs at different rates, and often in different directions, between materials in a structurally sound building. Typical differential movement may be due to:

- Shrinkage of substrates, e.g. concrete or wood shrinkage due to drying.
- Thermal and moisture related expansion/contraction of tiles and substrates, e.g. timber swelling in very humid and/or damp and/or wet conditions, or natural stone tiles experiencing dimensional change when in contact with fresh adhesive.
- Reversible movements of substrates, e.g. vibrations and deflections.

Evidence of differential movement between substrates and tile finishes may include the following;

- Peaking of tiles.
- Loose and/or drummy tiles.
- Cracking and spalling of grout in joints between tiles.
- Compression of sealant in movement joints.
- Opening or Closing of movement joints.

Differential movement between the tile finish and the substrate may result in failure. When failure occurs, the typical modes of debonding can be;

- Between the tile and the adhesive, (described as Adhesion failure).
- Within the adhesive layer, (described as Cohesion failure).
- Between the adhesive and the substrate, (described as Adhesion failure).
- Within the substrate, (described as Cohesion or Cohesive failure).

Failure can occur in whichever is the weakest link in the tiling system. The adhesive is generally weaker than the tiles or concrete substrates hence failures are commonly observed in the adhesive layer. However, where the substrate is weaker than the tiles or the adhesive, failure may occur in the substrate and some of the substrate remains adhered to the adhesive when these loose tiles are removed.

ADHESIVE PROPERTIES

The value of the adhesion strength of the tiling system is therefore critical. The tile adhesive performance standard ISO13007 (which has now replaced Australian Standard 4992.1-2006) requires minimum tensile bond strength of 0.5 MPa to be achieved under wet and dry test conditions, for cement based C class adhesive. However when the tile finish is exposed to service and climatic conditions and subjected to differential movements, deformability (often referred to as flexibility) of the adhesive is required to “accommodate” the stresses generated due to differential movements. (Note: the substrate is assumed to be structurally sound).

Cement based adhesives are relatively rigid even though they may have high tensile bond strength (resistance to pull apart forces acting at right angles to the plane of the adhesive layer), and high shear bond strength (resistance to forces acting parallel to the plane of the adhesive layer).

The performance of cement based adhesives may be improved by the addition of polymer additives. These additives provide increased adhesion and limited flexibility as determined by the degree of deformation observed before failure occurs. Failure of

the tile system occurs when differential movement is greater than the capacity of the tiling system to absorb this movement.

Note: Movement within the ground supporting any structure is not discussed in this bulletin although the effects on a tile finish within the structure may appear similar.

The classification of adhesives according to ISO 13007 is based on the principal binder used in each adhesive. Thus adhesives may be classified as Cement based (powder) adhesives —C Class, Dispersion (premixed emulsion paste) adhesives -D Class and Reaction (generally 2 part systems that must be, mixed together such as epoxies) adhesives –R Class.

Cement based adhesives are by far the most used (economical and versatile) category and includes formulations containing rubber crumb fillers. Additional deformation characteristics may be provided by mixing the cement based adhesive powders with liquid polymer emulsions. (note: rubber crumb added to the adhesive is considered as a filler only with negligible contribution to the deformation performance). However, the benefits of increased deformation in the adhesive layer to accommodate any differential movement between the tile finish and the substrate may be overcome by the lack of suitable stress relieving mechanisms, called movement joints, in the tile finish. The more deformable the adhesive, the greater the requirement for correctly placed and installed movement joints in the tile finish.

How to Lessen the Effects of Differential Movement

The effects of differential movement may be reduced by following the recommendations set out in Australian Standard 3958.1. These recommendations may be summarised as follows;

i. Reduce large areas of a tile finish into several smaller sections bounded by movement joints. These joints may also be located to provide symmetry to the joint layout and/or tile pattern as an additional feature in the tile finish.

ii. Ensure movement joints are placed at all perimeters where the tile finish abuts restraints such as walls, columns, penetrations (such as pipes, brackets and waste fittings) and the like through the tile finish.

iii. Ensure movement joints around perimeters are continued across doorways to complete a continuous joint around each tile section. Each panel or section of tiles must be bounded by a movement joint or otherwise unrestrained.

iv. Ensure the adhesive used has sufficient thickness under the tiles so that it may deform to its' designed movement capability.

v. Ensure the movement joints are to full depth of the tile finish and adhesive layer. Each movement joint is to be raked free of adhesive and/or grout residues down to the substrate.

vi. Deep movement joints shall include a suitable compressible backing rod so that the flexible sealant is able to achieve the manufacturers recommended sealant thickness to joint width ratio.

vii. Ensure movement joints are provided at all changes in direction of the substrate.

viii. Ensure movement joints are placed at all changes in the plane of the substrate.

ix. Ensure movement joints are located over existing joints in the substrate even if this means cutting the tiles to provide these joints.

The above summary of the recommendations of AS3958 indicates the requirement to reduce to very small amounts, any differential movement that may occur in each section of the tile finish bounded by the movement joints. Any small movement that does occur may then be within the adhesive deformation capability and the stresses generated can be relieved by compressing the flexible sealant in the movement joints.

Notes

Always refer to the product data sheets for specific usage details.

The information contained herein is to the best of our knowledge true and accurate.

No warranty is implied or given as to its completeness or accuracy in describing the performance or suitability of the product application.

Users are asked to check that the literature in their possession is the latest issue.

ARDEX AUSTRALIA PTY LTD,

ABN 82 000 550 005

7/20 Powers Road, Seven Hills, NSW. 2147.

GLOSSARY

AS3958.1-2007 Part 1: Guide to the installation of ceramic tiles.

AS4992.1-2006 Ceramic tiles—Grouts and adhesives.

Binder– The basic material that holds the adhesive together.

Brittle-A material that is hard and rigid, and even if strong, does not deform much under applied force before catastrophically failing. For example, neat cement adhesives without any polymer additives.

Deformation-The dimensional changes that occur in a material when it is subjected to either stress or strain. Deformation can be;

- reversible when the force is removed (called elastic deformation). In other words the material has accommodated the forces and not 'failed,

-or permanent (called plastic deformation) when the material no longer can go back to its original shape. Further, if the deformation is sufficient and the plastic limit is exceeded, catastrophic failure can occur (called the ultimate limit or failure) when the material physically breaks.

Elastic-Easily deforms without suffering catastrophic failures. For example, silicone sealants are highly elastic, whilst polymer modified adhesives are described as more elastic or resilient.

ISO13007.1-2014 Ceramic tiles -- Grouts and adhesives -- Part 1: Terms, definitions and specifications for adhesives.

Moisture expansion and contraction-Materials expand and contract by absorbing or releasing water from their matrix. Natural materials such as timber change dimensions rapidly with changes in moisture content.

MPa-This is an SI short hand for the pressure unit Megapascal or millions of pascals. 1MPa is the same as ~140psi or 10 atmospheres of pressure.

Stress-The strict definition of stress is compression or squashing along one or more of the three principle axes of a material.

Strain-There are two usages of strain. One usage refers to tensile or pull apart forces applied to an object applied along or more principle axes of the material.

The other usage refers to the amount of dimensional change in an object when it is either compressed or stretched. This can be in units such mm or percent.

Thermal expansion/contraction-Materials expand of contract with changes in temperature. The amount can be quantified by knowing the Co-Efficient of Thermal Expansion for each item.