INTRODUCTION

There is an ever increasing need for information on the construction of expansion joints and the proper sealant and backer material to use.

There are several fine technical articles available through the Ceramic Tile Institute of America, Inc. on the subject of expansion joints and sealants. The purpose of this document is to synthesize the important information of the existing literature with a more complete discussion of the key elements of expansion joint design.

Expansion joint design must be considered in two phases: Those in the structure and those in the tile surfacing placed over the structure. Expansion joints must be placed in the tile directly over those in the structure and also, as recommended, in the tile.

PURPOSE

The focus of this report is to fully describe the various backer rod materials and sealant compounds for expansion joints. Information is also supplied on where to use them in tile installations and how to properly form them and fill them.

DISCUSSION

Proper backer material.

a. In what is a complex world of sealants, there is one area which is relatively simple. The backer material for most all sealants must be one that possesses several properties. One, it must be capable of being compressed into the joint, as the backing material must be wider than the joint to provide a firm water tight base upon which to put the sealant. Two, the material must be capable of weathering with no loss of performance qualities. Third, the material must not be affected in terms of a chemical reaction with the sealant. Fourth, the sealant must not be bonded to the backer rod or the sealant will not perform adequately.

b. There are basically two types of backer material. The open cell polyurethane meets all the above requirements with the exception of an ability to resist water penetration. This characteristic eliminates
this material from most horizontal application. It can be used in vertical applications but only if it is called for by the sealant manufacturer. The backer material which is most versatile is the closed cell polyethylene foam. This material is suitable for use with virtually all sealants including polysulfides, polyurethanes, butyl rubbers and silicones.

c. As mentioned earlier, the backer rod must be larger than the joint width. The following table is a recommended joint to rod diameter guide. Cut stock polyethylene foam strips may be used also and the same sizing procedure is applicable.

<table>
<thead>
<tr>
<th>Joint Width, in.</th>
<th>Backer Rod Diameter, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/16 or less</td>
<td>3/8</td>
</tr>
<tr>
<td>3/8</td>
<td>5/8</td>
</tr>
<tr>
<td>7/8</td>
<td>1</td>
</tr>
</tbody>
</table>

2. Polysulfides

a. This joint compound has the lowest performance characteristics of the materials discussed in this paper.

b. Polysulfides are subject to deterioration from ultra violet and ozone attack. Consequently, polysulfides are not recommended for exterior installations.

c. Polysulfides should not be used in floating slabs which have asphaltic or tar membranes.

d. The Shore-A-Hardness is generally 22 which would preclude its use in traffic areas.

e. Polysulfides can be used effectively in interior vertical applications. Joint primers are usually not necessary unless the joint will be subject to severe moisture exposure or the surface it is to bond to is exceptionally porous.

f. Setting time is approximately that of the polyurethanes. The cure time is between 7 and 14 days depending on type of formulation used and weather variables.

3. Polyurethanes are formulated to be multi-part and single part compounds. The multi-part material consists of a base, curing agent and an additive. This type of material is the most durable of the three types of sealants which are discussed here. For that reason, where the joint comes in contact with foot or vehicular traffic, the multi-part polyurethane would be the best choice. Shore-A-Hardness of 35 is required.

a. The urethanes take considerably longer to cure than do the silicones. For instance, multi-part compounds require three days to fully cure. The single component compound requires seven days at an ambient temperature of 70 degrees and 50% relative humidity.
Consequently, the joints would have to be protected.

Either of the compounds would be acceptable for use in both vertical and horizontal joints. Heavy or non-sag formulations are available. The multi-part compounds are more durable and have greater extensibility. This material has greater abrasion resistance and would be recommended in traffic areas where the joint sealant will come in contact with foot or vehicular traffic.

c. The expected life cycle for polyurethane sealant is 15 to 20 years. These figures vary, of course, due to climatic conditions and other variables.

4. Silicone

a. Silicone sealants have the longest effective life span. They are virtually impervious to discoloration and breakdown due to weathering. They have excellent movement capability and cure to their maximum hardness in hours rather than days.

Silicones do not have the good resistance to wear as polyurethanes do,

If silicone sealant is to be used in a traffic area, it must be tooled to a depth that would preclude its being abraded away.

c. A Shore-A-Hardness of 35 is beyond the reach of most silicones, however, Shore-A-Hardness of 25 is not. A value of 35 should be specified and used if a sealant is required in a traffic area.

d. As is the case with all sealants, a closed cell polyethylene backer rod is the appropriate filler material unless another type is specifically called for by the sealant manufacturer.

e. Do NOT use an ACID cure silicone as it is not compatible with ceramic tile, cement, limestone or marble.

Sealant Adhesion

a. There are several ways to test the structural qualities of sealants. The two test methods we should be concerned with are peel test strength (PLI - pounds per lineal inch) and adhesion strength in regard to the sealant expansion and contraction characteristics.

b. ASTM requirements set 5 PLI as the minimum acceptable value for sealant peel tests. Industry experts feel, however, that 10 PLI is required so that a margin of safety could be incorporated into the specification and installation.

c. Adhesion values would vary with regard to the amount of movement the sealant is designed to withstand.

d. The following is a test which can be performed at the job site to test adhesion of the sealant:

FIELD ADHESION TEST - FOR HIGH MODULUS SILICONES, URETHANES & POLYSULFIDES.

As a check for adhesion, a hand pull test may be run on the job site after the sealant is fully cured (usually within 14 to 21 days.)
The hand pull test procedure is as follows:
I. Make a knife cut horizontally from one side of the joint to the other.

II. Make two verticular cuts approximately two inches long, at the sides of the joint, meeting the horizontal cut at the top of the two inch cuts.

III. Grasp the two inch piece of sealant firmly between the fingers and pull up at a 90 degree angle or more, and try to pull the uncut sealant out of the joint.

IV. If adhesion is proper, the sealant should tear cohesively in itself before releasing adhesively from the substrate.

NOTE: Adhesion may be adversely affected by:

- Moisture in or on the substrate during sealant application and cure.
- Contaminated or weak surfaces. Poor application technique.

IF PART APPLICATION - REPAIR OF SEALANT IN ADHESION TEST AREA

Sealant may be replaced in test area easily, by merely applying more sealant in the same manner it was originally installed (assuming good adhesion was obtained.) Care should be taken to assure that the new sealant is in contact with the original, and that the original sealant surfaces are clean, so that good bond between the new and old sealant will be obtained.
<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient of Thermal Expansion In./in./F (x 10^-6)</th>
<th>Change of Inches in 10-ft. for temperature 150 F 180 F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic tile</td>
<td>1.4</td>
<td>.0244</td>
</tr>
<tr>
<td>Wood: Perpendicular to Grain</td>
<td>1.9 to 3.2</td>
<td>.034 to .039</td>
</tr>
<tr>
<td>Parallel to Grain</td>
<td>2.1 to 3.6</td>
<td>.036 to .065</td>
</tr>
<tr>
<td>Brick Masonry</td>
<td>3.1</td>
<td>.056</td>
</tr>
<tr>
<td>Limestone Masonry</td>
<td>3.5</td>
<td>.063</td>
</tr>
<tr>
<td>Plate Glass</td>
<td>5.1</td>
<td>.092</td>
</tr>
<tr>
<td>Stainless Steel, Type 430</td>
<td>5.8</td>
<td>.126</td>
</tr>
<tr>
<td>Concrete</td>
<td>6.5</td>
<td>.117</td>
</tr>
<tr>
<td>Structural Steel</td>
<td>6.7</td>
<td>.144</td>
</tr>
</tbody>
</table>

a. This chart details the thermal coefficient of expansion of various materials. It is commonly held that concrete will expand approximately one inch in one hundred feet. This is a considerable amount of movement. It must be expected and adequate provisions made to receive it. Other factors which must be considered in the design phase are structural movement and moisture expansion.

b. Tile installations should be isolated from all rigid surfaces. This includes walls, columns, concrete curbing or walkways and all other surfaces that would restrict the movement of the installation. Expansion joints should be detailed at all of these areas especially exterior installations. Perimeter isolation in above grade installations is highly recommended. This, because structural movement is more dramatic and thereby potentially more destructive to the tile.

c. Moisture expansion in tile is a characteristic that is often overlooked. Some types of tile are subject to significant moisture expansion. This phenomenon is unlike thermal expansion in that once the tile unit has undergone moisture expansion, it does not return to its original size. One can easily see the potentially disastrous consequences which could arise if this expansion was not anticipated. Although there is no industry standard level for acceptable moisture expansion, the CTIOA recommends that tile should not have moisture expansion coefficient in excess of 0.04%. The ASTM test to determine the moisture expansion of ceramic tile is ASTM C370-88. In the Handbook For Tile Installation, it calls for expansion joints to be mandatory in quarry the installations. This is an example of anticipating moisture expansion and providing for it.

Tile Edge Preparation for Sealants

a. For maximum adhesion of sealant to tile edge, it is recommended that the edge be ground or sand-blasted.

b. Most all of the sealant types do not call for primers unless they will be exposed to severe moisture conditions, however, primers will increase sealant adhesion.

c. Especially porous substances may also require priming prior to placing the sealant. Consult manufacturer recommendations for proper primer if one is needed.
d. Generally, common sense rules can be followed when preparing a joint to receive sealant. All surfaces to receive sealants shall be clean, dry, free of loose materials, dirt, dust, rust, oil, frost and bitumines. Concrete or masonry surfaces shall be cured then cleaned by manual or power brushing or grinding, blast cleaning with oil free air or vacuumed to remove dust of cleaning. All non-porous surfaces can be cleaned with oil free solvent such as Methyl Ethyl Keytone (MEK), Toluol (toluene) or Xyol (xylene). Care should be taken when using the afore mentioned solvents as they are flammable.

Joint Design (Horizontal)

a. Joints must extend through all strata of the installation and sever any reinforcing wire. All control or expansion joints in a concrete subfloor must be carried through to the surface of the tile.

b. Requirements for exterior joints are that the joint width be a minimum of 3/8" and joints be placed 12' on center. For joints designed to be 16' on center, 1/2" joints are recommended.

c. For interior joints, the 3/8" minimum joint width is required at 24' to 36' on center. However interior timework subject to moisture or direct sunlight require spacing as for exteriors.

d. Expansion joints for quarry tile and paver tile are mandatory.

e. In most cases a closed cell polyethylene backer rod is used as backer material. However, consult with sealant manufacturer as some are recommending open cell polyurethane as backer material. Sealant depth is generally ½ the width of the joint to a minimum of 1/4".

f. Most sealant manufacturers recommend that where a sealant will be subjected to intermittent or total water emersion, that the edge be primed with their suggested primer solution.

The Ceramic Tile Institute recommends that when expansion joints are to be subjected to abrasive traffic wear, that the sealant have a Durometer Shore-A Hardness of 35 and no more than 45.

g. 9. Joint Design (Vertical)

a. The same design requirements as those listed in section 8 are true for vertical expansion joint installations as well.

b. American National Standard Specifications for the Installation of Ceramic Tile (ANSI 108.1) states:

AN-3.7.4.1.1 "Unless otherwise specified, use sealants complying with ASTM C920, which designates sealants according to Type, Grade, Class and Uses. The following are suitable for use in tile work.

- Type S---single-component sealant. - Type M---Multi-component sealant
- Grade P---pourable or self-leveling sealants for joints on horizontal surfaces
- Grade NS---non-sagging sealants for joints in vertical surfaces - Class 25 or 12 1/2---identifies sealants which can withstand an increase and decrease of f 25% or ± 12 1/2% of joint width - Use T--use in joints subjected to pedestrian and vehicle traffic - Use NT---sealants for nontraffic exposures
- Uses M and G---sealants that will remain adhered to mortar (M) and glass (G) are suitable for use with tilework
Suitable sealants include silicone, urethane, and polysulfide. Generally, urethane sealants are recommended for exterior vertical tile surfaces and both exterior and interior horizontal tile surfaces, including tiled traffic areas. Cured sealants in traffic areas require a Shore-A-Hardness of 35 or greater.

Back-up strip shall be a flexible and compressible type of closed-cell foam polyethylene, butyl rubber, or open cell and closed cell polyurethane, rounded at surface to contact sealant, and as recommended by sealant manufacturers.

AN-3.7.4.1.2 "Tile edges to which the sealant will bond shall be clean and dry. Sand or grind these edges to obtain optimum sealant bond. Primer on tile edges is mandatory when recommended by sealant manufacturer. Keep primer off tile faces."

AN-3.7.4.1.3 "Install sealant after tilework and grout are dry. Follow sealant manufacturer's recommendations."

c. By way of a warning, CTI has found through field experience that "U" shaped, "M" shaped or "V" shaped one piece expansion joint strips are ineffective for use in ceramic tile installations. these types of joints are improperly designed for the amount of movement that takes place in tile and mortar.

d. All vertical exterior expansion joints should be designed as shown in detail a in section 11.

Expansion Joint Design for Ceramic Tile Set in the Thin-Set Method Over Dimentionally Stable, Properly Prepared Concrete Slab-On-Grade.

In terms of placement, we would recommend that these joints be spaced with the same frequency as called for in the ANSI Standards. In this case, however, the deviation is in the formation of the joint. The CTI recommendation is to make a saw cut 3/4" in depth into the concrete slab directly under the joint in the tile. The purpose of this is to create a weakened plane joint in the concrete slab. If the concrete cracks, it hopefully will crack where these weakened plane joints are made. The joint would be left open and free of mortar and grout and an appropriate sealant would be used to seal the joint.

11. Typical Expansion Joint Details (Vertical). Note: Wood strips are used to fabricate joints but are removed when joints are completed.

b. WORKING BUTT JOINTS  c. PERIPHERY BUTT JOINTS

CONCRETE COLUMN SEALANT
12. Points to Remember - Vertical Surfaces

   a. Whenever butting tile surface to metal structures such as door jambs, provide for expansion joint to allow for differences in coefficients of expansion and contraction.

   b. Periphery butt joints within rigid structures such as concrete columns must have provisions for expansion and contraction movements.

   c. Joints in field of tile on vertical surfaces must extend in depth to last substrate - through metal lath and scratch coat down to but not through the waterproofing paper.

13. Typical Expansion Joint Details (Horizontal)

   a. Exterior Periphery joint

14. Points to Remember - Horizontal Surfaces

   a. Whenever terminating the tile surface on exterior peripheries against or up to concrete curbs, retaining walls, etc., expansion joints must be provided.

   b. Frequency of joints in the exterior fields of tile should be provided every 12 to 16 feet.

   c. Size of sealant (cross section) should not be less than 1/4" x 1/4" or larger than 1" x 1/2".

   d. Use backup filler whenever possible as a means of economy and to prevent sealant from bonding to substrate.
CONCLUSION

Expansion joints are an often overlooked and under-designed component of ceramic tile installations. Expansion joint design must be considered in two phases: One, those in the structure and two, those in the tile surfacing, placed over the structure.

Expansion joints are an important if not critical element to a successful tile installation on exterior and interior vertical and horizontal surfaces. They must be placed directly over those expansion joints in the structure and in additional places in the tile installation as outlined on previous page.

When designing expansion joints, be sure to take into consideration all of the critical movement factors, i.e., an anticipated amount of thermal expansion and contraction, structural movement, special considerations such as increased heat from reflective glass faces on buildings, isolation from rigid surfaces which will impose pressure on the tile installation and moisture expansion of ceramic tile.

The expansion joint material must also be considered. Qualities such as abrasion resistance, non-sag, adhesion, resistance to weathering and more must be evaluated so the proper sealant is used.

Expansion joints are not as durable as the tile installation. They must be inspected and repaired if necessary on a regular basis. If the joint is allowed to deteriorate and become packed with debris, its effectiveness in allowing for...
expansion and contraction will be greatly reduced if not eliminated.

Expansion joints can conform aesthetically to tile installations. They need not be straight and may be colored to match the grout joints.

It is important to gauge the requirements of the sealant. No one sealant is appropriate for every condition. If questions arise, consult the manufacturers of sealants for their recommendations.