Ceramic Tile Installation Testing

Skills USA

March 12-13, 2020

Atlanta, GA

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♦ Personal Protective Equipment

Just like a football player needs shoulder pads and a helmet to play ball, a construction worker must have work boots and a hard hat to work. You will use several pieces of protective equipment in the course of your work depending on job conditions. On every job you will need a hard hat and regulation work boots.

Not only must you have safety equipment, you must wear it. It does you no good lying on the seat of your truck. Your safety glasses won't protect your eyes if they are balanced on the top of your hard hat or in your shirt pocket.

Personal Protection Equipment (PPE) is not optional. You are required by law to wear it on construction jobsites. The best way to think about protective equipment is as a part of your uniform. You don't go on a jobsite without it. Some people, however, continue to see the equipment as a nuisance. Making the equipment fit better and better suit your needs will help you to use it as a uniform.

For some, comfort is the reason they avoid wearing their safety equipment. Often comfort can be gained by getting a proper fit. On your hard hat, the headband and crown straps should fit your head snugly to keep it on your head. The space between the outer shell of the hat and your skull should absorb the shock from the impact of falling or flying objects or a bump against a fixed object. Hard hat chin straps may help you to keep your hat on, as well. Hard hat liners will insulate your head from cold in the winter.

Attaching straps to safety glasses will better hold them in place. On humid days a defogger will keep the lenses clear. Make sure your work boots are the right size. Wool socks and sock liners can help to cushion your feet.

There is really only one reason to wear personal protective equipment--**YOUR LONG-TERM HEALTH**. When considering whether or not it is worth the effort to wear safety equipment, also consider what it would be like to live without your vision, a foot or a finger. Every workplace has dangers. You can wear equipment that will protect you from the dangers in yours. Don't Blow It!

♦ Protective Equipment You Need

Hard Hat

Protects your head against falling or flying objects or low hanging objects you could bump into.

Regulation Work Boots

Protect your feet and toes from nails and other sharp objects lying on the ground of the jobsite as well as objects falling to the ground

Safety Glasses

Protect your eyes from chemical splashes, chips of tile or pieces of other material in the air including dust.

Latex Gloves

Protect your hands from chemicals that may cause burn or allergies.

Ear Protection

Protect your hearing from loud and high-pitched sounds.

♦ Lifting Basics

As a tile setter, one of your main duties will involve squatting and lifting. Because lifting heavy loads is a part of your job, you must know how to lift and carry material safely.

Lifting and carrying a heavy load requires thinking the task out before you pick up the material. Judge the weight and size of the box to make sure you can carry it alone. Be sure you have a clear path to the place you are taking the material and check to make sure you have steady footing before you lift.

Standard Lifting Procedure

1. Tuck your pelvis. Tighten stomach muscles and pull your pelvis forward to keep your back in balance as you lift.

2. Bend your knees and keep your back straight. This will keep your center of balance steady so your leg muscles can do the work. NEVER bend at the waist to pick up a load.

3. Hold the load close to your body. Straighten your legs until you are standing straight.

4. Do not twist your body. Point your feet, knees and torso the same direction.

5. Use the same four steps to put the load down.

♦ Lifting Awkward Objects

Sometimes using the standard lifting procedure is not possible because of the shape or location of the load. Use the following tips if the standard lifting procedure will not work.

Oddly shaped object

Long objects may be lighter weight but harder to carry. Place long objects on your shoulder and carry the front end higher than the back. Do not carry anything that blocks your vision. If your vision is blocked, you may need some mechanical help or a co-worker's help.

Above shoulder level

If you must move something that is stored above shoulder level, use a ladder to avoid reaching. Test the weight of the object before you pull it down. If the weight will allow you to get the object down without falling, slide it toward you, hug it close to your body and step down. If possible, lower it to a co-worker before you move down the ladder.

In a stack or inside a container

Moving items that are in bins, containers or stacked on a pallet using the standard lifting procedure is practically impossible. When you need to make this kind of lift, stand with your feet the same distance apart as your shoulders, bend your knees slightly and bend your hips like you are about to sit down in a chair. Pull the load as close to your body as possible, tighten your stomach muscles and straighten hips and legs.

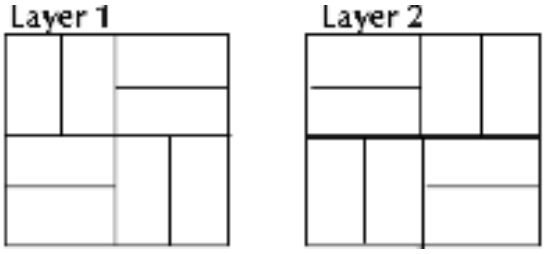
♦ Material Handling

I. The handling of material is an important factor in determining the profitability of a project. Damaged or lost material can turn a good job into a bad job. Follow the rules below when loading, unloading or moving material on a jobsite.

A. Never drop or toss tile when unloading or moving tile.

B. When stacking material, always be sure that the description and numbers on the front of the carton are facing out, where they can be read, and that the cartons are stacked right-side-up.

C. Do not stack tile cartons too high. In most cases, six cartons high is the limit. Use a tie system. The diagram below illustrates the arrangement of the alternating layers of boxes of tile stacked using a tie system, which creates a more stable cube or stack.



D. When placing loose tile in a carton, be sure to place the tile its on edge. Never place tile in a carton flat, as it is more vulnerable to breakage. Use cardboard or crumpled paper to hold the stack upright if it does not completely fill the carton.

E. Be aware of small cartons. Smaller cartons often contain corners, which are expensive. The loss of these items will add to cost in both material and labor, in terms of callback or punch list items to replace missing pieces.

F. Some tiles have a softer finish and will scratch. When placing this type of material in a carton, place tiles face-to-face and back-to-back to avoid having a rough surface adjacent to a soft glazed finish.

♦ Product Identification and Application

I. The major types of **CERAMIC TILE**, their characteristics and uses are described below.

A. **Glazed Wall:** Tile with a body that is suitable for interior use, and which is usually non-vitreous, and is not required or expected to withstand excessive impact or freeze/thaw conditions.
1. **Characteristics:** Good surface hardness, easy to clean and maintain, fire-resistant, chemically resistant to household acids.
2. **Uses:** Interior walls, ceilings and counter tops

B. **Mosaic:** Tile formed by either dust-pressed or plastic method; usually 1/4" to 3/8" thick and having a facial area of less than six square inches; may be of either porcelain or natural clay composition, and may be either plain or with an abrasive mixture throughout.
1. **Characteristics**: Nonstaining, excellent wearing qualities.
2. **Uses:** Floors, walls, ceilings, and counter tops; interior or exterior.

C. **Quarry:** Glazed or unglazed tile made by extrusion process from natural clay or shale; usually has six square inches or more of facial area.
1. **Characteristics**: Excellent wear under hard service conditions
2. **Uses:** Floors, walls, ceilings, and counter tops; interior or exterior.

D. **Porcelain:** Glazed or unglazed tile formed by the dust-pressed or extruding method having a water absoption on 0.5% or less per ASTM C373 test
1. **Characteristics**: Excellent wear under hard service conditions.
2. **Uses**: Floors, walls, ceilings, and counter tops, interior or exterior.

E. **Pressed Floor:** Glazed ceramic tiles made by pressing, having a facial area equal to or greater than 9 square inches.
1. **Characteristcs:** Good wea characteristics in residential and light commercial applications.
2. **Uses:** Floors and walls, normally interior use.

II. Setting materials used in thin-set installation methods, usually referred to as **"THINSET,"** are described below.

A. **Dry-set mortar** Mixture of portland cement with sand and additives giving water retentivity; used as a bond coat for setting tile.

B. **Latex-portland cement mortar** Mixture of portland cement, sand, and special latex additive; used as a bond coat for setting tile.

C. E**poxy mortar** Mortar system employing epoxy resin and epoxy hardener portions.

D. **Organic adhesive** Prepared organic material ready to use with no further addition of liquid or powder; cures or sets by evaporation. Organic adhesives require 24 hours to cure before grouting.

Tilesetter's Rule of Thumb

Organic adhesive should NOT be used for wet or exterior installations.

E. **Epoxy adhesive** Adhesive system employing resin and epoxy hardener portions.

III. **GROUTS** used in the installation of tile are described below.

A. **Sand-portland cement:** On-the-job mixture of one part portland cement to one part finely graded sand used for joints up to 1/8" wide; 1:2 for joints up to 1/2" wide; 1:3 for joints over 1/2" wide - up to 1/5 part lime may be added.

B. **Standard Unsanded Cement:** A factory-prepared mixture of cement, fine aggregate, and other ingredients to produce a water-resistant, dense, uniformaly-colored material meant for joints 1/8” in width or less.

C. **Standard Sanded Cement:** A factory-prepared mixture of cement, fine aggregate, and other ingredients to produce a water-resistant, dense, uniformaly-colored material meant for joints 1/8” in width or greater.

D. **High Performance Unsanded Cement:** A factory-prepared mixure of cement and other ingredients, including a redispersible latex/polymer powder, to which only water is added at the jobsite, or a liquid latex admixture. When added in a latex form, it is added as a replacement for part or all of the mixing water. These grouts are designed for installation in joints 1/8” in width or less.

D. **High Performance Sanded Cement:** A factory-prepared mixure of cement and other ingredients, including a redispersible latex/polymer powder, to which only water is added at the jobsite, or a liquid latex admixture. When added in a latex form, it is added as a replacement for part or all of the mixing water. These grouts are designed for installation in joints 1/8” in width or greater. The maximum allowable joint width is deignated by the grout manufacturer.

E**.** **Epoxy** Systems employing epoxy resin and epoxy hardener portions. Emulsified versions will also include a portland cement and sand portion.

IV. Additional products are described below. When using any of the products in this section, it is advisable to read thoroughly and understand the accompanying literature or directions for use printed on the packaging material. As with any material, refer to the Material Safety Data Sheet for safe use and hazard information.

A. **Acid** Opposite of "base," or alkali; an acid has a low ph factor, which is raised, or neutralized, by dilution with water.

B. **Acrylic latex additive** An acrylic latex liquid which is added to commercial (preblended) mortars and grouts in lieu of water. The acrylic base enhances the grout's appearance through better color retention and less fading caused by ultra-violet rays. Helps retain water required for hydration of portland cement, especially when used with tiles with high absorptive levels, 7% or more.

C. **Cement backer board** (also called CBU) A nailable or screwable underlayment, produced by different manufacturers normally in 3'x 5' sheets, with thicknesses of 1/4" or 1/2"..

D. **Latex-fortified mortar (or grout**) Thinset or grout which has been mixed with a latex additive in lieu of water.

E. **Latex additive** Also called "latex admixture." A blend of latex emulsions and chemical modifiers which is added to commercial preblended mortars and grouts in lieu of water to improve bond strength and flexibility of mortar systems. Will increase internal adhesion, frost resistance, and inhibit the penetration of water and other liquids.

F. **Organic Adhesive** (commonly called "Mastic") Typically packaged in plastic pails, with the texture of a creamy, heavy-bodied paste, requires no additives or mixing to use.

G. **Muriatic acid** Chemical name: Hydrochloric Acid (HCL Aqueous Solution). An inorganic acid, colorless to very light yellow liquid, with a pungent, suffocating odor. Used in very dilute solutions to clean some installations. Vapors, caused by the evaporation of hydrogen chloride gas, are corrosive to metal surfaces. Follow MSDS precautions when using this product.

I. **Portland cement** A mixture of certain minerals which, when mixed with water, forms a gray paste and cures into a very hard mass. The hardening process is called hydration, and is a chemical reaction between the water and the cement. To produce portland cement, lime, silica, alumina, and iron components are pulverized, mixed together in certain proportions, fired in a kiln to about 2700º F and formed into clinkers. The clinkers are then mixed with a small amount of gypsum (which controls the rate of hydration) and ground into a fine powder known commonly as "portland cement."

J. **Sand** A sedimentary material with grains between 0.06 and 2.0 millimeters in diameter. Often composed of silica, a white or colorless crystalline compound, SiO_2, occurring abundantly in nature in many minerals. Sand should be clean and without organic material such as salts or alkalis.

K. **Sealant** Also silicone or elastomeric joint sealant.One-part or two-part, usually silicone rubber, packaged in a tube which is loaded into a caulk gun. The material is extruded to fill the prepared joint and allowed to cure. Most sealants are waterproof, weather extreme temperature changes, and provide the flexibility needed for expansion and control joints which absorb movement. Most sealants adhere to ceramic tile, metals, plastics, woods, glass, rubber, paints, and most porous substrates. Also used for joints in precast concrete panels, curtain walls, metal walls, perimeters of door and window frames. Also, refer to the sealant listing under Materials on page 30.

L. **Backer rod** Also called "backing rope" Round, flexible lengths of closed-cell polyethylene foam or open-cell polyurethane foam, chemically inert, usually waterproof, dust-free, resistant to gas, oil, solvents. Backer rope does not adhere to sealant materials, acting as a "bond breaker" or backing for elastomeric and other cold-applied sealants. It helps to control the amount of sealant applied for a proper seal and produce the proper joint shape. Typically packaged continuously wound on reels, in diameters from 3/16" to 7/8". Also refer to the backer rod listing under Materials on page 30.

M. **Grout releases** Any temporary protective coating applied before grouting, which aids in cleaning porcelain, ceramic, quarry, slate, or prssed floor tile. Releases are designed to provide for easy removal of grout, mortar, or other construction dirt.

♦ Ceramic Tile Finishes, Sizes, and Shapes

I. Most ceramic tile can be categorized according to the following finishes:

A. **Bright (or Brite) glaze:** Gloss finish used for walls, countertops, and other areas not requiring foot traffic.

B. **Matt (or Matte) glaze:** Low gloss finish used for walls, countertops, and other areas not requiring foot traffic.

C. **Unglazed:** Porcelain tile used primarily for floors and walls, most commonly in commercial installations.

D. **Glazed** wall tile finishes are manufactured in wide range of surface textures. Two finishes frequently used in residential and commercial installations are:

1. **Crystal Glaze** A low gloss finish, with a pebbled, finely textured crystalline surface, used for interior floors, walls, countertops, and ceilings, in residential and light commercial installations. Each manufacturer may have its own name for this finish.
2. **Roma Gloss** A high or low gloss finish with a wavy surface, giving the tile a hand-made look. Each manufacturer gives its own name to this surface and style; "Roma Gloss" is specific to Dal-Tile (see p. 9, Dal-Tile product catalog). This glaze is used for interior walls and countertops, but is not recommended for floors, exteriors, or surfaces subject to abrasive wear.

II. Typical sizes of ceramic tiles, with some of the most common uses, are:

A. **4 1/4" x 4 1/4"** Wall tile, residential and commercial

B. **6" x 6"** Quarry tile, mostly commercial floors

C. **1" x 1", 2" x 2"** Unglazed and glazed mosaics

D. **12" x 12" and larger** Unglazed porcelain and glazed floor tile.

♦ Reference Guides for the Installation of Ceramic Tile

Three standard reference guides for the installation of ceramic tile are in use today: The *Handbook* for Ceramic, Glass, and Stone Tile Installation produced by the Tile Council of North America; the American National Standard Specifications for the Installation of Ceramic Tile (ANSI) produced by the American National Standards Institute in conjunction with the Tile Council of North America and an appointed committee; and the NTCA Reference Manual produced by the National Tile Contractor's Association.

Handbook for Ceramic Tile Installation

Published by the Tile Council of North America, this collection of industry information is printed annually. The stated purpose of this publication is to assist in clarifying and standardizing specifications for ceramic, glass, and stone tile. Inside the *Handbook* you will find information regarding:

- Product SelectionGuides
- Field and Installation Requirements
- Floor Tiling Installation Guide
- Environmental Wxposure Classifications
- Using the TCNA *Handbook* for Specification Writing
- Installer and Contractor Qualifications Guide
- Ceramic and Glass Tile Installation Methods
- Natural Stone Tile Installation Methods
- EJ171 Movement Joint Guidelines for Ceramic, Glass, and Stone

While it provides guidelines for installation, the *Handbook* is not a specification book. Architects and installers may use the guidelines in this book as a communication tool and reference for technical material usage, but the standard specification reference book is the American National Standard Specifications for the Installation of Ceramic Tile.

American National Standard Specifications for the Installation of Ceramic Tile

Also known as ANSI Specifications, this book is available for most crafts and is used by architects, installers, builders, OSHA and other organizations for setting and communicating construction industry standards.

ANSI specification reference numbers for ceramic tile include:

A108 Installation Standards
A118 Material Specifications
A136.1 Organic Adhesive

NTCA Reference Manual

Produced to recognize and address potential problems occurring during installation of ceramic tile, the NTCA Reference Manual provides written documentation to assist tile contractors in preventing and curing problems associated with installation methods.

This manual is divided into sections including, Grouts, Thin-Bed Methods, Underlayments, Substrates, Installation Procedures, Marble and Granite Tiles,

The manual provides general information about installing tile on various substrates. It also gives detailed instruction on some common installation problems based on a cause, cure, and prevention format..

♦ Basic Layout: Square Layout for Floor

SECTION 1: SQUARE LAYOUT FOR FLOOR

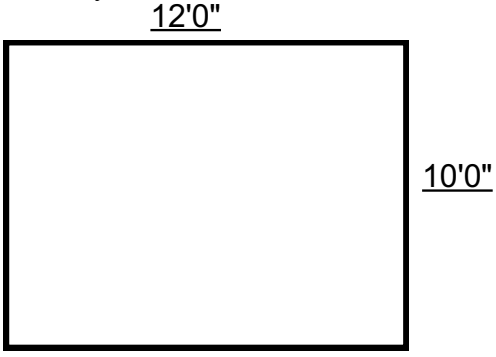
One of the most basic layout patterns is a **square layout** on a floor. Other patterns, such as herringbone or broken joint, are used for floors, but the apprentice tile setter should master the square layout before attempting more complex patterns.

1. Assemble the tools required:

Steel measuring tape	Steel square	Tile as specified
Chalk line	Pencil	

2. Verify that the floor is ready for installation: clean, flat, and free of debris.

3. Assume that you are going to tile a room that is 10' 0" x 12' 0", using 8" square tiles. A tile that is said to be 8" square may in actuality measure anywhere from 7 1/2" to 7 3/4". We will assume that the tile is 7 3/4" square, and that we will use a joint of 1/4". Therefore, our tile size is 7 3/4"+1/4" or 8". The room will look approximately like this:

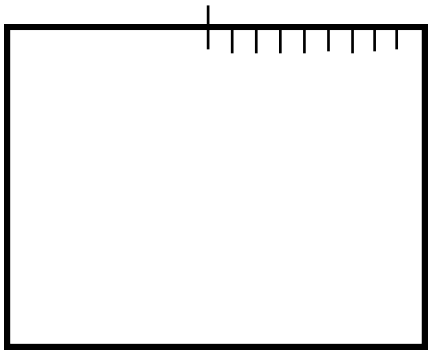


4. Check the exact dimension of the longest wall; determine the center point of the longest wall by dividing length by two, and mark the center point. Check your measurement again. Given the dimensions of the room above, and assuming that the walls are perfectly square, the wall will divide into two 6' 0" sections...

 Tilesetter's Rule of Thumb

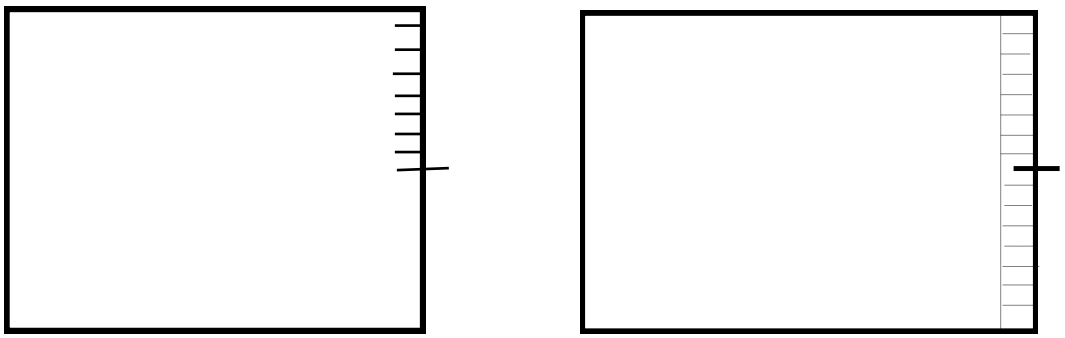
Measure twice--Cut Once.

5. Beginning at the center mark, measure to the end wall in 8" increments to determine how many tiles will be required for the floor section and what size cut will be required. If a cut is required, the cut piece must be larger than 1/2 the size of the full piece of tile. The section of wall that you are laying out is 6'0" long - or 72" long (12 inches per foot). The dimension of the wall (72") divided by the size of the tile (8") will tell you the number of tiles that will be needed for that section. In this case, the section works out to 9 tiles.



6. If your layout requires a cut that is less than one-half tile, center the tile you began with over the center line of the layout. Then determine the cut size by adding together your previous cut measurement and one-half the width of the tile being installed. This dimension will be the cut size. It is always preferable to have the same size cut tile at each wall. The architect's specifications typically require that the courses are centered, which gives a more aesthetically pleasing effect than uneven cuts, or a cut against one edge only.

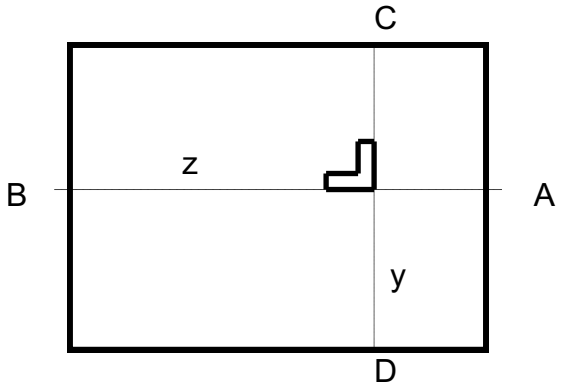
7. Check the exact dimension of the end wall. Assuming that the dimension of 10' 0" is correct, the center point of the wall will create two 5' 0" sections. Beginning at the center mark, measure to the end wall in 8" increments to determine the cut to be made. This section is 60" long; this dimension divided by 8" yields 7.5, or 7 whole tiles and a cut of approximately one half of an 8" tile, or a 4" cut. In this layout, the cut can be eliminated by centering one whole tile on the center mark of the layout. This can be determined by dividing the length of the entire wall, 120", by the tile width plus joint width, 8 ". The result is 15 whole tiles.



8. Measure the distance from the long wall to the starting line (center point) of the end wall **(A)**. Measure and mark an equal distance from the long wall on the opposite end wall **(B)**. Then chalk a line the length of the room between the starting points of the two end walls **(z)**. This line is parallel to the long wall.

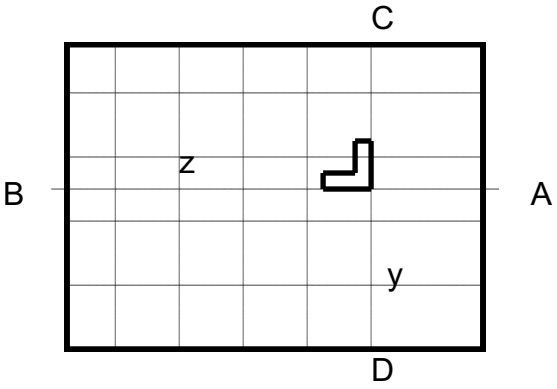
9. Measure from the end wall to a joint about two feet from the end wall in the course laid out along the

long wall **(C).** Measure the same distance along the opposite end wall **(D)** and chalk a second line parallel to the end wall **(y).**



10. Using the square, check that the line chalked the width of the room is perpendicular (at a 90° angle, or a right angle) to the line parallel to the long wall. If the room is in square, the intersection will have perpendicular corners. If the room is out of square, adjustments will need to be made in the cuts along the wall so that an even, straight line is maintained against the wall.

11. Continue to measure and mark lines parallel to the long wall at joints approximately two feet apart across the width of the room.



12. Measure and mark lines perpendicular to the long wall at joints approximately two feet apart the length of the room. This will create a grid squared to the long wall.

13. The layout is now complete, and the tilesetter is ready to begin installation. Note that the door is not shown on the above drawing. The installation should begin at the point farthest from the door (or exit from the room), working toward the door.

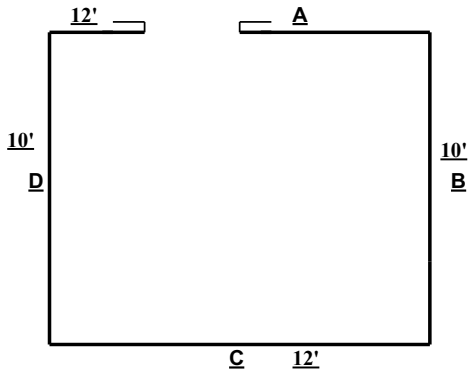
Note: Measurement of both walls yielded a course of full tiles. The long wall, with the joint centered at the midpoint, and the end wall with a tile centered at the midpoint of the wall.

♦ Basic Layout: Centering a Wall

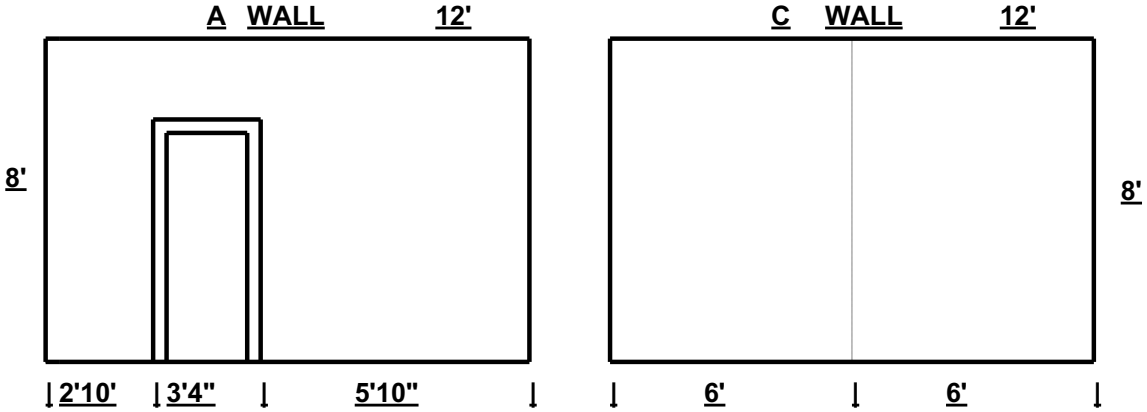
SECTION 2: CENTERING A WALL

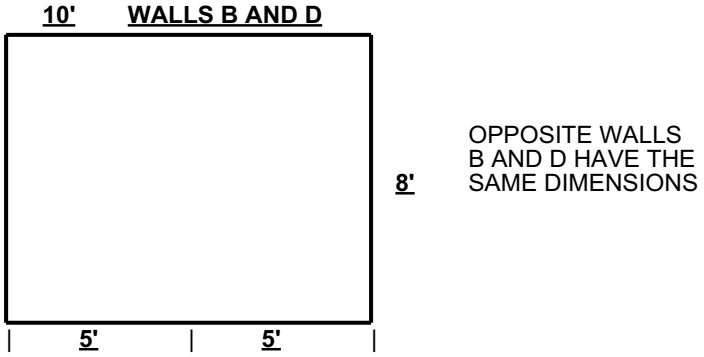
One of the basic layouts for a wall is to center the installation on each wall. This section continues the installation of a room measuring 10' 0" by 12' 0", with a door on one 12' wall. The wall tile to be used measures 4 1/4" x 4 1/4".

The sketch below names the four walls **A, B, C,** and **D**, and notes the dimensions and door location.

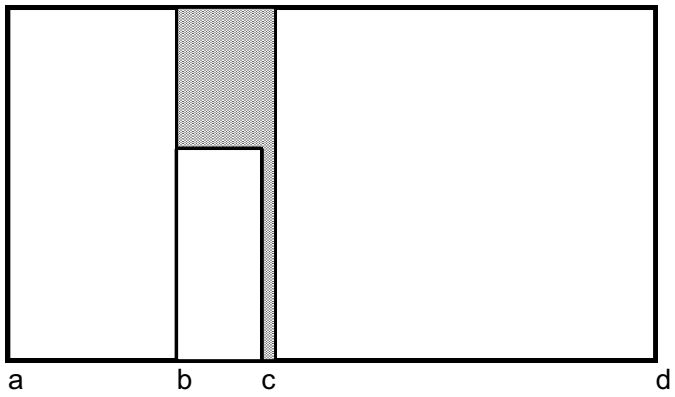


Elevation views of the four walls are below. An elevation shows the wall as a vertical view - as if you were looking at it face-on.





1. **Review the elevation of Wall A on the previous page. Since the door frame naturally divides the wall into sections, the measurements of each section will determine where the cuts fall. Below is an expanded, not to scale sketch of Wall A.**



Step 1: Convert the dimension from (a) to (b) into inches: 2'10" = 34"
34" divided by the width of the tile, 4 1/4" = 8 full tiles.

Note that the dimension (a) to (b) is measured to the **outside** of the door frame. The section to the left of the door will lay out to courses of 8 whole tiles.

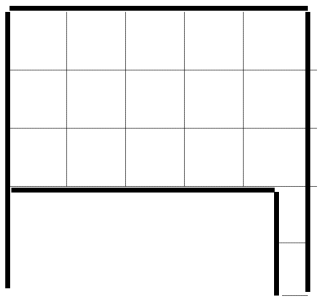
Step 2: Convert the dimension from (b) to (c) into inches: 3'4" = 40", to the outside of the door frame.

40" divided by the width of the tile, 4 1/4" = 9 tiles with a 2 1/2" cut.

A common-sense way to determine this is to determine the closest whole-tile measurement and then subtract the actual measurement:

For example:
10 tiles x 4.25" (4 1/4") = 42 1/2"
42 1/2" - 40" = 2 1/2", the size of the cut against the right side of the door frame.

The sketch below details the section at the corner of the door, illustrating the whole tile extension into the cut along the door frame.



Step 3: Convert the dimension from (c) to (d) into inches: 5'10" = 70". The 2 1/2" cut at the door frame must be subtracted from this dimension, leaving 67 1/2" as the dimension remaining to finish the wall.

67 1/2" divided by the width of the tile, 4 1/4" is 15 whole tiles
with a 3 3/4" cut at the wall.

Determine the cut size by using the above common sense method. Determine the closest whole-tile measurement and subtract this from the full measurement:

15 tiles x 4.25" (4 1/4") = 63 3/4"
67 1/2" (full measurement of the section) - 63 3/4" = 3 3/4", the cut size.

2. Review the elevation of Walls B and D on the previous page. The center of this 10' 0" wall is 5' 0", or 60".

Step 1: The center, as noted above, divides the wall into two 5' 0", or 60", sections.

60" divided by the width of the tile, 4 1/4" is 14 whole tiles, with 1/2" left over.

Determine the cut size by using the above common sense method. Determine the closest whole-tile measurement and subtract this from the full measurement:

14 tiles x 4.25" (4 1/4") = 59 1/2"
60" (full measurement of the section) - 59 1/2" = 1/2"

Step 2: As noted in the beginning of this section, the cut size should never be less than one-half of a tile. Here we have a possible cut size of 1/2", or a measurement that we must account for in some other way. In this situation, the correct procedure is to install Walls **A** and **C** first.

The distance from center to each side wall is reduced to 59 5/8" (60" minus the thickness of the tile at the wall, 3/8" = 59 5/8").

With 14 tiles measuring 59 1/2", we have reduced the "left-over" measurement to 1/8" (wall measurement, 59 5/8", minus tile measurement, 59 1/2" = 1/8"). This small joint in the corner can easily be adjusted out, or eliminated, by spreading each joint slightly.

3. Review the elevation of Wall C. The center of this 12' 0" wall is 6' 0", or 72".

Step 1: The center, as noted above, divides the wall into two 6' 0", or 72", sections.

72" divided by the width of the tile, 4.25" (4 1/4") is 16 whole tiles with 4" left.

Determine the cut size by using the above common sense method. Determine the closest whole-tile measurement and subtract this from the full measurement:

16 tiles x 4.25" (4 1/4") = 68"
72" (full measurement of the section) - 68" = 4", the size of the cut.

4. The layout pattern is typically determined by the field measurements. In our exercise in centering a wall, we were able to lay a joint as the center line, with a cut larger than one-half tile at each wall.

As we noted in the floor layout, occasionally it is necessary to center a tile over the center line, in order

to create appropriate cut sizes at the walls.

Assume the measurement of Wall C is 12'2". The center is now changed to 6'1", or 73".

17 tiles x 4.25" (4 1/4") = 72 1/4".
73" (wall measurement) - 72 1/4" (tile measurement) = 3/4"

These numbers indicate that the cut size, with a joint on center, would be 3/4", which is not an acceptable cut.

If, however, a tile is centered over the center line, the cut size changes to 2 7/8" at the corner:

1 tile, 4 1/4" / 2 = 2 1/8"
2 1/8" (one-half tile) + 3/4" = 2 7/8"

This step yields a cut size larger than one-half tile, which is acceptable

Tile setter's Rule of Thumb:

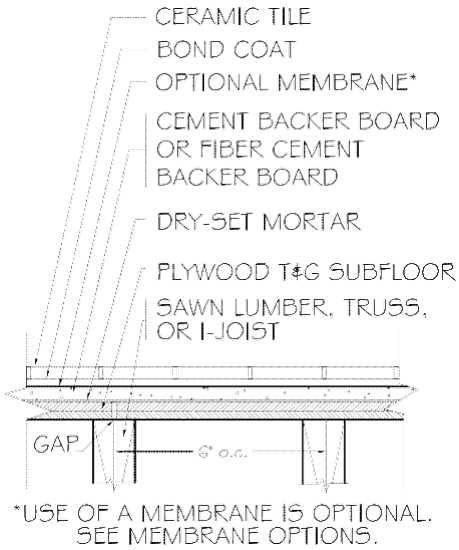
If the cut, from center point, measures less than one-half tile:

1. Measure the tile and divide by two
2. Add this measurement to the measurement that was less than one-half tile.
3. The result is the cut size when a tile is centered over the center line.

♦ **Floor Detail F144**

F144

Joists 16” o.c./Plywood Subfloor
Cement Backer Board or Fiber-Cement Backer Board
Ceramic Tile



Recommended Uses
- For wood substrates where water-resistance is desired.

Service Rating
- Residential with minimum 19/32”-thick subfloor and minimum 1/4”-thick cement backer board.
- Light commercial with minimum 19/32”-thick subfloor and minimum 7/16”-thick cement backer board or 1/4”-thick fiber cement backer board.
- Light commercial with minimum 23/32”-thick subfloor and minimum 1/4”-thick cement backer board.
- When glass tile is used, service rating may be lower.

Environmental Classifications
- Res1, 2; Com1, 2.
- May be suitable for increased water exposure. See Membrane Options.
- May be suitable for exterior applications in areas not subject to freeze/thaw cycling when appropriate precautions are taken, including expansion joint placement, proper slope, waterproofing, and material selection.
- For installations that may be exposed to staining, specify tile and grout suitable for exposure. Consult product manufacturers; see also Product Selection Guides.
- For installations that may be exposed to mild chemical attack, specify epoxy grout and tile suitable for exposure.
  For greater resistance to chemical exposure, also specify an epoxy bonding material. Consult product manufacturers; see also Product Selection Guides.

Typical Weight of Tile Installation
- 8 pounds/square foot if 1/4” cement backer board or 1/4” fiber-cement backer board used.
- 9 pounds/square foot if 7/16” fiber-cement backer board used.
- 10 pounds/square foot if 1/2” cement backer board used.
- Does not include weight of substrate. See Appendix B for assumptions, included materials, and their individual weights.

Limitations
- Maximum joist spacing 16” on center.

Membrane Options

- A waterproof membrane (A118.10) may be specified to prevent moisture intrusion and protect adjacent walls and building materials. Base flashing should be used for maximum effectiveness.
- Specifier shall indicate if complete waterproofing is required, including if/how membrane connects to drain assembly, if base flashing is required, and treatment at other termination points.
- Check with membrane manufacturers for suitability for applicable conditions, as not all membranes are suitable for steam, high temperature, and/or chemical exposure, exterior use, use over above-ground structural slabs, use over pourable underlayments, use with radiant heat, or use over concrete with excessive moisture vapor transmission and/or alkalinity. Membrane may also affect service rating.
- When glass tile is used, consult glass tile manufacturer for membrane options and recommendations.

Requirements
- Surface of units—clean and free of dirt, dust, paint, and oily film.

Preparation by Backer Board Installers
- Use a sufficient amount of Portland cement mortar under the backer board to establish a supporting plane and eliminate voids.
- Fasten backer units with corrosion-resistant fasteners per manufacturer's directions.
- Leave 1/8" perimeter movement gap and 1/8" gap between sheets. Fill joints between sheets solid and tape with Portland cement mortar and 2" alkali-resistant glass fiber mesh tape. Do not fill perimeter joint.
- Maximum allowable variation in the tile substrate—for tiles with all edges shorter than 15", maximum allowable variation is 1/4" in 10' from the required plane, with no more than 1/16" variation in 12" when measured from the high points in the surface. For tiles with at least one edge 15" in length, maximum allowable variation is 1/8" in 10' from the required plane, with no more than 1/16" variation in 24" when measured from the high points in the surface.
- Stagger backer board end and edge joints so as not to coincide with joints in subfloor. Stagger joints in adjacent rows so four corners do not come together within the same plane. Space panel ends and edges in accordance with manufacturer's recommendations.

Materials
- **Multiple options exist for membranes, mortars, grouts, and other materials and MUST BE CLEARLY SPECIFIED to be included. If not specifically indicated, optional materials are not included**
  and mortar/grout choice defaults to minimum performance specification indicated. Consider each system component and intended use to determine minimum requirements and to specify options.
- Ceramic tile—ANSI A137.1.
- Glass tile, when used—ANSI A137.2; see also Glass Tile Selection and Installation Guide, and consult tile manufacturer for service rating and environmental classification recommendations. Not all glass tiles are suitable.
- Cementitious grout—ANSI A118.6 or better or ISO CG1 or better. When glass tile is used, specify grout designated by tile and grout manufacturers.
- Epoxy grout, when used—ANSI A118.3 or ISO RG.
- Cementitious bond coat:
  - When a waterproof membrane is not used—ANSI A118.1 or better or ISO C1 or better.
  - When a waterproof membrane is used—ANSI A118.4 or better or ISO C2S1 or better unless ANSI A118.1 or ISO C1 is recommended by membrane manufacturer.
  - When porcelain tile is used—ANSI A118.4 or better or ISO C2 or better.
  - When glass tile is used, specify mortar designated by tile and mortar manufacturers. For translucent glass, use white mortar.
- Epoxy bond coat, when used—ANSI A118.3 or ISO R1 or better.
- Cement backer board, when used—ANSI A118.9 or ASTM C1325. See Service Rating for minimum thickness.
- Fiber cement backer board, when used—ASTM C1288. See Service Rating for minimum thickness.
- Mortar under backer board—ANSI A118.1 or better or ISO C1 or better.
- Waterproof membrane, when used—ANSI A118.10.

Materials for Green/Sustainable Design
- See Green Building Standards and Green Product Selection Guide and consult manufacturers and suppliers for product sustainability and contribution to green building design.

- Consider specifying tile and installation materials that meet ANSI A138.1, the *American National Standard Specifications for Sustainable Ceramic Tiles, Glass Tiles, and Tile Installation Materials*.

Preparation by Other Trades
- Floor systems, including the framing system and subfloor panels, over which tile will be installed shall be in conformance with the IRC for residential applications, the IBC for commercial applications, or applicable building codes. Maximum allowable deflection under live load not to exceed l/360. See also Substrate Requirements.
- When concentrated loads (scissor lifts, pallet jacks, automobiles, forklifts, etc.) will be used on an above- ground tiled floor, the engineer and/or specifier shall specify a substrate to accommodate the concentrated loads. Owner/specifier is responsible for protecting the tilework from damage, including allowing sufficient time for installed materials to cure properly.
- Face grain of plywood shall run perpendicular to joists.
- Subfloor—minimum 19/32" exterior-glue tongue and groove plywood with 1/8" gap between sheets. See also Service Rating.
- Maximum variation in the plywood surface—1/4" in 10' and 1/16" in 1' from the required plane. Adjacent edges of plywood sheets—maximum 1/32" above or below each other.

Movement Joint (architect must specify type of joint and show location and details on drawings)
- Movement joints—mandatory in accordance with EJ171.
- When glass tile is used, adhere to more frequent placement recommendations within the ranges listed in EJ171.

Installation Specifications
- Tile—ANSIA108.5.
- Glass tile—ANSI A108.15, .16, or manufacturer's directions.
- Cementitious grout—ANSI A108.10.
- Epoxy mortar/grout—ANSI A108.6.
- Backer board—ANSI A108.11 or manufacturer's directions.
- Waterproof membrane—ANSI A108.13.
- Movement Joints—EJ171 and ASTM C1193.

Notes
- When glass tile is used, see Glass Tile Selection and Installation Guide, and consult manufacturer for recommendations and requirements.

♦ **Wall Detail W244**

INSTALLATION OF CERAMIC TILE PER TCNA METHOD W244, CEMENTITIOUS BACKER UNITS OVER WOOD OR METAL STUDS, INTERIOR WALLS.

1. Study *Handbook* for Ceramic, Glass, and Stone Tile Installation, Specification **W244**, which describes the recommended requirements, products, and preparation for the application of ceramic tile over cementitious backer units on wood or metal studs on interior walls.

   Recommended uses for this method are wet areas over dry, well-braced wood studs, furring, or metal studs.

2. Identify the tools which will be required:

nippers	tile cutter	steel square
rub stone	tile saw	sponges
chalk line	rubber mallet	grout float
beating block	margin trowel	towels
claw hammer	gauging trowel	hole saw
steel measuring tape	notched trowel	joint spacers
straightedge	pencil	screwdriver

3. Identify the materials which will be required.
   A. tiles, trim, accessories and grout as specified
   B. potable water
   C. dry-set mortar (ANSI A118.1) **or** latex-Portland cement mortar (ANSI A118.4)
   D. cementitious backer units, corrosion-resistant nails or screws, fiber mesh tape (ANSI A118.9)
   E. Vapor retarding membrane (when required) – asphalt impregnated paper, 15 lb. roofing felt or 4 mil polyethylene film

4. Verify that the substrate is properly prepared for installation, as specified by ANSI AN 3. See also ANSI A108.11 for detailed framing requirements for wood or metal framing.

   A. Check stud spacing.
   1. Studs must be spaced a maximum of 16" on center.
   2. Metal studs should be a minimum depth of 3 5/8", 20 gauge or heavier.
   B. All corners, door jambs, etc. must be square and plumb within 1/8" in 10' 0".
   C. Studs should be furred out flush with face of receptors and anchor plates;
   D. Install blocking or headers to support accessories and fixtures.
   E. Verify that expansion joints will be installed per architect's plans and specifications.

5. Lay out area for installation according to architect's plans and specifications.
6. Install cementitious backer units according to ANSI A108.11:

   A. Install membrane if required by local building codes.
   B. Membrane is required in wet areas.

      1. Apply CBU with long dimension across framing, centering end and edge joints on framing,

staggering joints in adjacent rows. Space horizontal and vertical joints and corners 1/8" apart; spaces will be filled solid with dry-set or latex-Portland cement mortar, then taped and embedded with skim coat of mortar.

2. Fasten CBU to wood or metal studs with selected fasteners a maximum of 8" on center. Over steel framing, begin fastening at the bottom or edge nearest the runner or track. Blocking may be added where needed to permit proper attachment. Provide continuous support for ends and edges of CBU parallel to framing. Drill holes in CBU around protruding items; fill holes with setting material.
3. Take care to leave all specified expansion joints open.

7. Install tile by following the steps listed below.

A. Verify that the proper size notched trowel is available for the installation. Notch size depends on the backing of the tile. Bond coat required is a minimum of 3/32". This indicates that after beat-in, finished bonding material thickness must be 3/32".
B. Spread the bonding material:
   1. Verify open time. Apply only what can be covered with tile within this time.
   2. The surface of the combed bonding material must remain wet to the touch in order to obtain the proper bond to tile. Remove any material that films over and apply a fresh coat
   3. Leaving chalk lines visible as a guide, spread the adhesive with the flat side of the square-notched trowel to get a good mechanical bond. Cover enough area for about two rows of tile. Then comb in one direction with the notched side of the trowel, without scraping the surface of the backer unit. Cover the surface uniformly, with no bare spots. A sufficient quantity of bonding material should be spread at the chalk line so that the edge of the tile is supported by the bonding material; 1/8" is the maximum void permitted at the edge of the tile.
C. Beginning with the first course of tile, press tiles into freshly combed bonding material. Maintain even spacing between each tile within the grid lines. If using spacers, remove them from each section of the grid as completed. Keep a minimum of 2/3 of joint depth open for grouting. Smooth cut edges with a rub stone; place toward an end wall or toward an accessory.
D. Press and twist each tile into place. Then, using a beating block and hammer, beat tiles into the adhesive bed. Minimum coverage on the back of each tile is 80% (interior) or 95% (wet areas) - work to maintain this as closely as possible. Remove at least 3 tiles to inspect coverage achieved. There should be uniform contact between tile, mortar, and substrate.
E. Complete the installation, making cuts in each grid as required. Cut and install trim as needed to complete the installation. Leave open expansion and control joints; cut tiles if necessary. Cut holes in tiles for water pipes and fixtures; never split tiles to fit around pipes and controls.
F. Use a damp sponge to clean each section as it is installed.

G. Check the job thoroughly after the installed area is finished. Verify that:
   1. All joint lines are straight; realign any tiles which have become misaligned before initial mortar set has taken place.
   2. No tiles have been broken or chipped during beat-in.
   3. No excess adhesive remains in any grout joints or in the joint between tile and tub.
   4. No adhesive has been left on the face of the tile.
   5. Spacers, strings, ropes, pegs, and other material have been removed.

6. If tile is face-mounted, remove paper before the adhesive is firmly set and realign any tiles which have shifted.

8. Grout the installation as specified.

♦ **EJ171**

EJ171 MOVEMENT JOINT GUIDELINES FOR CERAMIC, GLASS, AND STONE

Perimeter and field movement joints within a tile installation are essential and required. This section provides general recommendations and guidelines, including the means by which movement joints in concrete are carried through and incorporated into tile installations.

Because of the limitless conditions and structural systems on which tile can be installed, the architect or designer shall show the specific locations and details of movement joints on project drawings. Preparation of openings left by the tile contractor and installation of backup strip and sealant should be specified in the Caulking and Sealant section of the job specification.

Location and Frequency of Joints

Interior—Maximum 25'each direction.

Exterior—8' to 12' in each direction.

Interior-exposed to sunlight or moisture-Max 12'in each direction.

Above-ground concrete slab substrate—Max 12' in each direction.

Perimeter Joints—movement joints are required where tilework abuts restraining surfaces such as perimeter walls, dissimilar floors, curbs, columns, pipes, ceilings, and where changes occur in backing materials, but not at drain strainers.

All expansion, control, construction, cold, saw-cut, isolation, contraction, and seismic joints in the structure should continue through the tilework, including such joints at vertical surfaces. If proprietary crack isolation membrane is specified over saw cut joints to relocate a movement joint, contrary to EJ-171, the tile contractor is not responsible for cracking in grout joints or tile where tile has been installed over any such relocated movement joints, provided the tile, membrane, and other materials are installed correctly; this includes curling and/or deformation of the concrete occurring after installation of the membrane. Where tile pattern falls diagonally across a saw-cut joint, relocation of the movement joint is specifically not recommended because of the reduced performance of the sealant when used in a saw tooth or other non-linear fashion.

Joint Width

Exterior (all tile)—minimum 3/8" for joints 8' on center, minimum 1/2" for joints 12' on center. Minimum widths must be increased 1/16" for each 15°F tile surface temperature change greater than 100°F between summer high and winter low. (Decks exposed to the sky in northern U.S.A. usually require 3/4"-wide joints on 12' centers.)

Interior for quarry tile and paver tile—same as grout joint, but not less than 1/4".

Interior for ceramic mosaic tile and glazed wall tile—preferred not less than 1/4", but never

less than 1/8". Joints in tile and setting materials shall never be less than the width of the

saw-cut control joint width.

Joints through tilework directly over structural joints must never be narrower than the structural joint.

Materials

Backup strip (commonly known as backer rod) 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, as shown in details, and as recommended by sealant manufacturers. It must fit neatly into the joint without compacting and to such a height to allow a sealant depth of 1/2 the width of the joint. Sealant must bond to the tile edges only and not bond to joint sidewalls or bottom.

Suitable sealants include silicone, urethane, and polysulfide. Sealants are available in both single- and multicomponent formulations. Either formulation is generally suitable for movement joints in tilework. Single-component sealants are furnished in prepacked cartridges or other forms requiring no jobsite mixing. Multicomponent sealants require jobsite mixing, but cure faster than single-component counterparts, making them advantageous for traffic areas.

Urethane sealants are recommended for exterior vertical tile surfaces and both exterior and interior horizontal tile surfaces, including tiled traffic areas. Because of their abrasion and penetration resistance, urethane sealants are recommended for movement joints in tiled traffic areas.

Silicone sealants may be used on both exterior and interior vertical tile surfaces. Single-component, mildew-resistant silicone sealants are formulated with fungicide for sealing interior joints in ceramic tile showers and around tubs, sinks and plumbing fixtures.

Sealants in traffic areas require a Shore A hardness of 35 or greater.

Use sealants complying with ASTM C920, which designates sealants according to Type, Grade, Class, and Uses. The following are suitable for use in tilework:

- Type S—single component sealant.
- Type M—multicomponent sealant.
- Grade P—sealants for joints on horizontal surfaces.

- Grade NS—non-sagging sealants for joints in vertical surfaces.
- Class 25 and 12-1/2—identifies sealants which can withstand an increase and decrease of +/- 25% or +/-12-1/2% of joint width.
- Use T—use in joints subjected to pedestrian and vehicle traffic.
- Use NT—sealants for non-traffic exposures.
- Uses M and G—sealants that will remain adhered to mortar (M) and glass (G) are suitable for use with tilework.

The performance requirements of some applications such as exterior swimming pools, dairies, food plants, etc., may exceed the minimum requirements of these sealant specifications. Therefore, follow recommendations of experienced manufacturers as to specific sealants suitable in the job environment. In some severe environments, a program for regular maintenance of sealant in joints may be required.

Silicone sealants contain plasticizers that may stain some natural stones. See Natural Stone Tile Selection and Installation Guide.

Manufactured/preformed joint profiles are available. Consult manufacturer.

Materials for Green/Sustainable Design

See Green Building Standards and Green Product Selection Guide and consult manufacturers and suppliers for product sustainability and contribution to green building design.

Consider specifying tile and installation materials that meet ANSI A138.1, the *American National Standard Specifications for Sustainable Ceramic Tiles, Glass Tiles, and Tile Installation Materials*.

Installation

Install movement joints per ASTM C1193 Standard Guide for Use of Joint Sealants.

Tile edges to which the sealant will bond must be clean and dry. Sanding or grinding of these edges is recommended to obtain optimum sealant bond.

Some sealants require edge priming. Consult manufacturer's specifications. If required, care must be taken to keep primer off tile faces.

To insure that location of joints in tilework align with existing joints in substrate, joints in tilework should be constructed during installation of mortar beds and/or tile, rather than saw-cutting joints after installation.

Keep movement joint cavities open and free of dirt, debris, grout, mortar, and setting materials.

Set compressible backup strip when mortar is placed or utilize removable wood strip to provide space for backup after mortar has cured.

Install sealant after tilework and grout are dry. Follow sealant manufacturer's recommendations.

Joints in Concrete

Construction/cold joint—The surface where two successive placements of concrete meet, across which it may be desirable to achieve bond and through which reinforcement may be continuous. A cold joint becomes a weakened joint that, upon movement, will crack, permitting leakage or buckling and cracking of a tile floor set over the slab. Such joints should be shown on architectural drawings

Contraction/control joint—Formed, sawed, or tooled groove in a concrete structure to create a weakened plane and regulate the location of cracking resulting from the dimensional change of different parts of the structure. Also referred to as "saw-cut joint."

Expansion joint—(1) A separation provided between adjoining parts of a structure to allow movement where expansion is likely to exceed contraction; (2) a separation between pavement slabs on grade, filled with a compressible filler material; (3) an isolation joint intended to allow independent movement between adjoining parts.

Isolation joint—A separation between adjoining parts of a concrete structure, usually a vertical plane, at a designated location such as to interfere least with performance of the structure, yet such as to allow relative movement in three directions and avoid formation of cracks elsewhere in the concrete and through which all or part of the bonded reinforcement is interrupted.

Some large slabs on-grade are poured monolithically, then later saw-cut at intervals, providing control/contraction joints to allow for cracking at these weakened points.

Other Type of Joints

Acoustical Joint—A non-drying, non-hardening, rubber-like seal at the perimeter and at all penetrations and retaining surfaces of a floor installation in which a bonded sound reduction membrane is used for sound reduction. The primary function of an acoustical joint is to minimize flanking, the transmission of sound through joints, penetrations, or structural components in the assembly.