Fig. 4.7.5 Typical architectural panel joints.

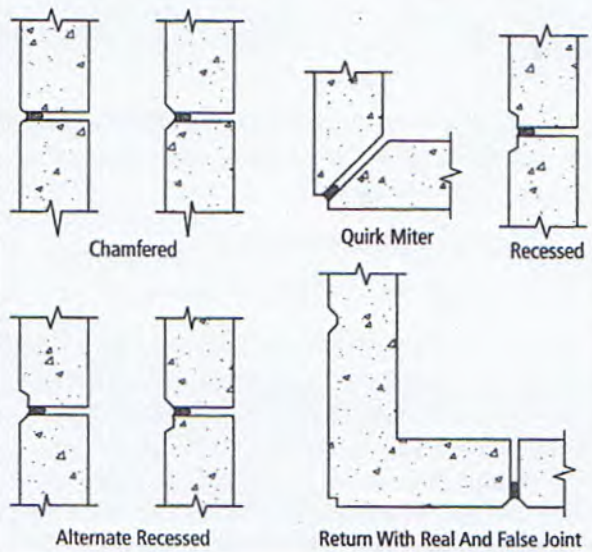


Fig. 4.7.6 Proper channeling of water.

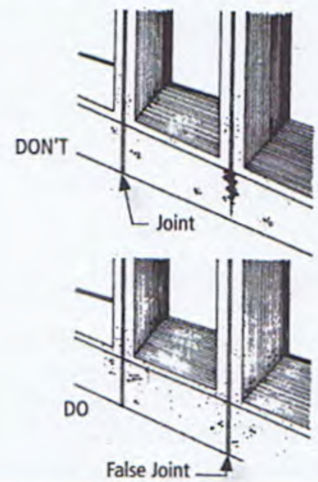
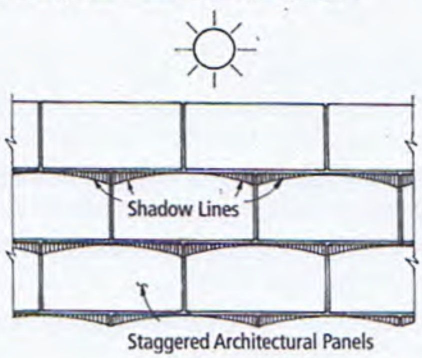


Fig. 4.7.7 Staggered architectural wall panels.



vulnerable joints in the wall system to reduce the magnitude and frequency of water exposure.

Figure 4.7.6 shows an elevation where some of the false vertical joints, into which water is channeled, discharge this water over a vertical concrete surface with fewer joints than at higher levels. This causes a marked washing effect at termination of the joint; the water should be directed until it reaches the ground or a drainage system.

Joints in forward-sloping surfaces are difficult to weatherproof, especially if they collect snow or ice. This type of joint should be avoided, whenever possible. When forward sloping joints are used, the architect should take special precautions against water penetration.

All joints should be aligned, rather than staggered, throughout their length (Fig. 4.7.7). Non-aligned joints subject sealants to shear forces in addition to the expected compression or elongation forces. The additional stress may cause sealants to fail. In addition, non-aligned joints force panels to move laterally relative to each other, inducing high tensile forces.

4.7.6 Width and Depth of Joints

Joint width must not only accommodate variations in the panel dimensions and the erection tolerances for the panel, but must also provide a good visual line and sufficient width to allow for effective sealing.

The performance characteristics of the joint sealant should be taken into account when selecting a joint size. Joints between precast concrete units must be wide enough to accommodate anticipated thermal expansion, as well as other building movements and proper sealant installation. Joint tolerances must be carefully evaluated and controlled if the joint sealant system is to perform within its design capabilities. When joints are too narrow, bond or tensile failure of the joint sealant may occur and/or adjacent units may come in contact and be subjected to unanticipated loading, distortion, cracking, and local crushing (spalling).

Joint widths should not be chosen for reason of appearance alone, but must relate to panel size, building tolerances, joint sealant materials, and adjacent surfaces. The required width of the joint is determined by the temperature extremes anticipated at the project location, the movement capability of the sealant to be used, the temperature at which the sealant is initially applied, panel size, fabrication tolerances of the precast concrete units and panel installation methods. The following factors take precedence over appearance requirements:

1. **Temperature extremes and gradients.** The temperature range used when selecting a sealant must reflect the differential between seasonal extremes of temperature and temperature at the time of sealant application. Concrete temperatures can and normally will vary considerably from ambient air temperatures because of thermal lag. Although affected by ambient air temperatures, anticipated joint movement must be determined from anticipated concrete panel temperature extremes rather than ambient air temperature extremes.
2. **Sealant movement capability.** A sealant's performance within joints is rated as the allowable movement expressed as a percentage of the effective joint width. The minimum design width of a panel joint must take into account the total anticipated expansion and contraction movement of the joint and the movement capability of the sealant. This evaluation should include volume changes from creep, shrinkage, and temperature variations.

PCI Design Handbook supplies figures for estimating volume changes directly related to the size of the panel. Most drying shrinkage occurs in the first weeks following casting, and creep normally levels out after a period of months. For these reasons, movements caused by ambient air temperature variations are more important than those caused by shrinkage. For loadbearing panels, the effect of creep may be cumulative, thus may be more important.

Many factors may be involved in actual building joint movement. These include, but are not limited to, mass of material, color, insulation, building load, building settlement, method of fastening and location of fasteners, differential heating due to variable shading, thermal conductivity, differential thermal stress (bowing), building sway, and seismic effects. Material and construction tolerances that produce smaller joints than anticipated are of particular concern.

Tolerances in overall building width or length are normally accommodated in panel joints, making the overall building size tolerance an important joint consideration. Where a joint must match an architectural feature (such as a false joint), a large variation from the theoretical joint width may not be acceptable and tolerances for building lengths may need to be accommodated at the corner units.

A practical calculation of panel joint size can be made as follows, as shown in ASTM C1193 and C1472:

$$J = \frac{100A}{X} + B + C$$

where:

J = minimum joint width, in.

X = stated movement capability of the sealant, in percent

A = calculated movement of panel from thermal changes = (coefficient of thermal expansion) (change in temperature) (panel length)

B = material construction tolerances

C = seismic or other considerations as appropriate

Example: Concrete panels of 30 ft (9.1 m) in length, expecting a temperature change in the concrete of 60 °F (33 °C) from sealant installation temperature, with a material or construction tolerance of 0.25 in. (6 mm), are to be sealed with a sealant having ±50% movement capability (as determined by ASTM C719). The coefficient of thermal expansion of the concrete is 6×10^{-6} in./in./°F. The calculated movement of the panel from thermal change is as follows:

$$A = (6 \times 10^{-6} \text{ in./in./°F})(60 \text{ °F})(360 \text{ in.}) = 0.130 \text{ in.} \ (3 \text{ mm})$$

X = 50%

B = 0.25 in. (6 mm)

No seismic considerations, (C = 0).

The calculated minimum joint width is as follows:

$$J = \frac{(100)(0.130 \text{ in.})}{50} + 0.25 \text{ in.} = 0.51 \text{ in.} \ (13 \text{ mm})$$

To provide optimum quality for the installation and performance of sealants, the architect should specify a minimum panel joint width of not less than $^3/_4$ in. (19 mm). This is the minimum nominal joint width needed to adequately account for production and erection tolerances and still maintain an effective minimum joint width that can be caulked. The use of larger joints at reentrant corners and mitered panels at outside corners helps to relieve the possibility of impact between panels under large drifts in high seismic areas. It is also important that the joint between precast concrete panels and window frames also maintains the same nominal joint width. Corner joints may be $1^1/_4$ in. (30 mm) wide to accommodate the extra movement and bowing often experienced at this location. A minimum joint width of $^3/_4$ in. (19 mm) also is recommended for two stage joints to allow sufficient space for insertion of the interior seal with a 1 in. (25 mm) joint width recommended for insulated panels.

The required sealant depth is dependent on the sealant width at the time of application. The optimum sealant width/depth relationships are best determined by the sealant manufacturer, however, generally accepted guidelines are:

1. For joints designed for $^3/_4$ to 1 in. (19 to 25 mm) width: The sealant depth should be equal to one half the width. The sealant should have a concave shape providing greater thickness at the panel faces. The sealant should have a minimum $^1/_4$ in. (6 mm) contact with all bonding surfaces to ensure adequate surface adhesion.
2. For joints greater than 1 in. (25 mm) wide: Sealant depth should be limited to $^1/_2$ in. (13 mm) maximum, preferably $^3/_8$ in. (10 mm). For sealant widths exceeding 2 in. (50 mm), the depth should be determined by consultation with the sealant manufacturer.

The depth of the sealant should be controlled by using a suitable sealant backing material. To obtain the full benefit of a well-designed shape factor, the backing material must also function as a bondbreaker (Fig. 4.7.1). When it comes to sealant depth, more is not better. If too much sealant is applied, the stresses on the sealant bead are magnified and the chance of premature debonding at the precast concrete interface is increased. If the bead is too shallow, there may be insufficient material to accommodate the joint movement and the sealant will split.

4.7.7 Sealant Materials and Installation

The most common joint materials are sealants meeting ASTM C920. These sealants are used in both one-stage and two-stage joints. If used as an air seal, they may be applied from the front provided joint width and depth permit, or from the interior if access to the joint is not blocked by edge beams or columns.

Designers should consult with the various sealant suppliers to ensure they are specifying an appropriate sealant for the specific needs of the project, as well as the sealant's proper installation. For a comprehensive discussion of joint sealants used between wall panels, refer to ASTM C1193, *Standard Guide for Use of Building Sealants*. Table 4.7.1 provides a list of common sealants and their qualities. Non-staining joint sealants should be selected to prevent the possibility of bleeding and heavy dirt accumulation, which are common problems with sealants having high plasticizer contents. Also, care should be taken to avoid sealants that collect dirt as a result of very slow cure or long tack-free time. Dirt accumulation is more a function of specific product formulation rather than generic sealant type.

When specifying a sealant, a current sample warranty should be obtained from the manufacturer and the contents studied to avoid uncalculated risks. The warranty period for a polyurethane material can be up to 10 years, and up to 20 years for a silicone. This doesn't imply that the sealant will deteriorate during that time. Some polyurethane-based products maintain their appearance and integrity for more than 15 years. Warranties can be written to cover either the material or the material and the labor needed to replace them. The specifier should be familiar with the available sealants and associated warranties prior to selecting a sealant for the building.

The following characteristics should be considered when making the final selection of sealants from those with suitable physical (durability) and mechanical (movement capability) properties:

1. Adhesion to different surfaces—concrete, glass, or aluminum.
2. Surface preparation necessary to ensure satisfactory performance—priming, cleaning, and drying.
3. Serviceable temperature range.
4. Drying characteristics—dirt accumulation, susceptibility to damage due to movement of joint while sealant is curing.
5. Puncture, tear, and abrasion resistance.
6. Color and color retention.
7. Effect of weathering—water and ultraviolet (UV) light—on properties such as adhesion, cohesion, elasticity.
8. Staining of adjacent surfaces caused by sealant or primer.
9. Ease of application.
10. Environment in which the sealant is applied.
11. Compatibility with other sealants to be used on the job.
12. Long term durability.
13. Life expectancy.

The sealants used for specific purposes are often installed by different subcontractors. For example, the window subcontractor normally installs sealants around windows, whereas a different subcontractor typically installs sealants between panels. The designer must select and coordinate all of the sealants used on a project for chemical compatibility and adhesion to each other. In general, contact between different sealant types should be avoided by having