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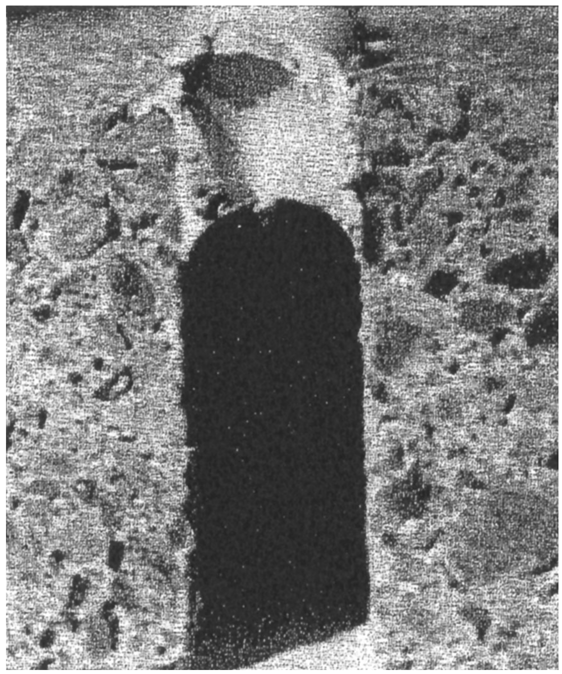
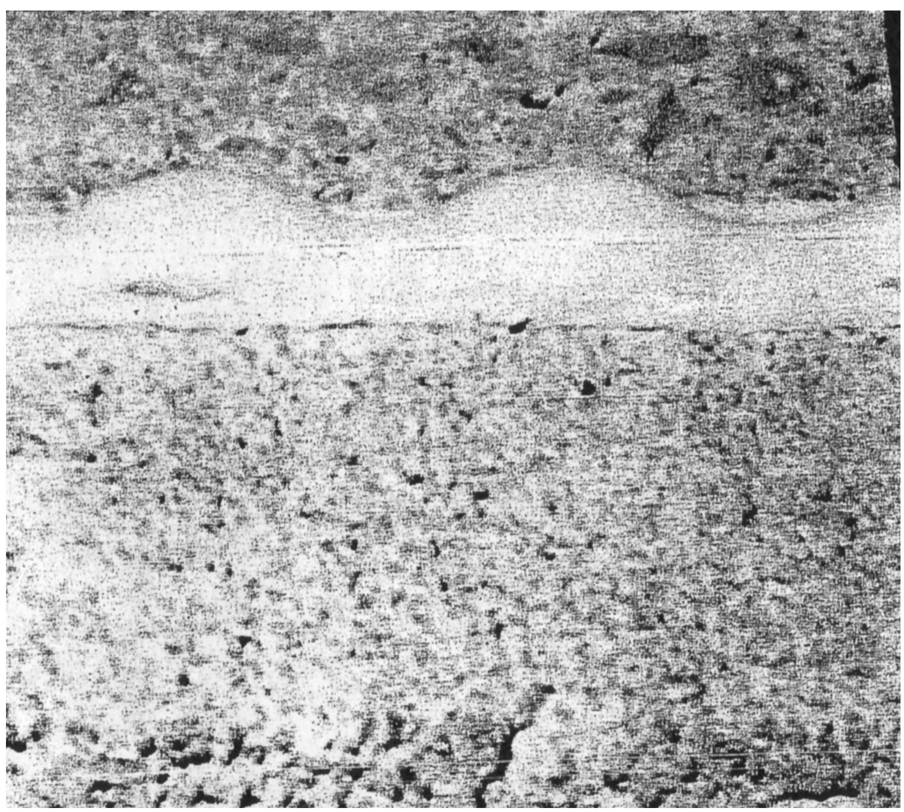
Hidden, but essential

A technical review of backer rods

by J.F. Gibb



At left, the result of outgassing by a closed cell backer rod. The rod has been removed, and the panels and sealant bead sawed in cross-section to show cavities caused by the bubbles. This is an unsatisfactory seal. Below, the sample at left seen from the side. A cured sealant bead applied above a closed cell backer rod was ruptured when trapped gases escaped from the rod.



The majority of construction in commercial building today is done by use of large building panels of various types, connected by a high performance elastometric sealant material to form a waterproof seal. These panels consist of either precast concrete, prestressed concrete, or curtain wall which is predominately glass and metal. Any combination of these three types also is commonplace in modern construction.

It is vitally important that the connecting link, the sealant, joining all these panels be of top quality, capable of performing satisfactorily for a great many years. without this performance, water tightness soon is lost, resulting in long, costly modifications and repairs.

Many factors must be considered in designing a commercial building which will give many years of trouble free service. These include joint design, selection of sealant, surface preparation of joints just prior to caulking and, finally, selection of the proper backer rod (against which sealant is placed). The right decisions in these important areas, plus proper installation of the products, ensures desired results.

The backer rod evolves

Evolution of the backer rod from the first use of caulking to the present

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state of the art covers use of many different types of materials. They range from sand in horizontal joints, through wood, fiber board, jute, rope, and twisted paper. About 17 years ago, a product evolved which consisted of an extruded plastic rod.

This new backer rod was a closed cell, flexible foam material. At first, it was made from polyethylene plastic. Now it consists of polyethylene and polypropylene, both nearly identical in appearance and performance. This new rod is manufactured by plastic extrusion: A gas is injected into the material, creating plastic foam. The result might be described best as being somewhat similar to a tube inflated under slight pressure as gas is trapped within its cellular structure. This rod proved to be far superior to what had been used previously in the trade, but was not without its problems.

Problems — and solutions

One of the more serious problems was outgassing. When these closed cells and their outer skin somehow become ruptured, trapped gases slowly escape to the atmosphere. If a high proportion of these cells become ruptured or deflated (so to speak), much of the rigidity of the rod is lost. The rod also loses much of its ability to regain its original round shape once it has been deformed.

The problem of outgassing associated with these new flexible foam backer rods resulted in sealant manufacturers insisting on further research, in the attempt to find a suitable material that would eliminate this problem — without creating even more serious ones.

For many years, in limited applications only, polyurethane foam materials had been used successfully. This promoted further development of this material, to determine its suitability for use in backer rods in the caulking business.

Most early applications employed a backing material cut into short strips (square or rectangular in cross-section). The material exhibited a wide range of physical properties, because much of it had been cut from scrap material used by the furniture business. The type of polyurethane used in that industry is required to have a very high degree of resiliency, and to retain this property through severe usage. This same property is necessary in expansion joint backer rod. Therefore, it proved to be an ideal material for backer rod use.

About six years ago, a round, open cell, flexible polyurethane backer rod was introduced. The product was made from special formulations of these flexible foams, producing a more uniform material. (As noted, uniformity was lacking in previous urethane backer rod produced from scrap.)

Open vs. closed cell

There are some interseting (and important) differences between open and closed cell backer rods.

Both open cell and closed cell are inert to all common and more predominately used sealant materials on the market today. Both have excellent chemical resistance.

Both, too, are classified as non-staining. This means they contain no materials that would bleed out slowly and seep into the sidewalls (substrate), later to reappear as discoloration on the surface (some distance away). This is a particularly important point, if marble or other masonry materials are used.

The open cell rod is more flexible than its counterpart closed cell. The open cell must depend on its chemical and physical make up to attain rigidity, while closed cell rigidity is the result of gases trapped in its interior (as explained earlier).

Rarely in commercial building construction do expansion joint widths conform exactly to design. For instance, a one-half inch joint frequently will vary from as little as one-quarter inch or less to as much as three-quarter inch (or more). It is virtually impossible to manufacture or to erect large building panels economically to such precise dimensions that joints between such panels stay within close tolerances. A backer rod to be packed between these panels must be flexible enough for easy insertion.

Manufacturers of closed cell backer rods recommend that the product not be compressed more than 25 percent of its diameter. Consequently, the applicator must change sizes frequently, using closed cell in commonplace, varying width joints, and open cell rod if he is to exceed the 25 percent maximum compression limit.

Open cell backer rod must be compressed at least 25 percent; it does not hurt these rods to be compressed as much as 75 percent of their diameter. This allows the applicator to use fewer sizes in varying width joints. Many times, one size will work the full length of the joint (which might not be the case when using closed cell rod).

Three primary purposes

A backer rod has three primary purposes. First, it forms a base against which sealant is applied. (It therefore determines the thickness of the sealant bead.) Also, it forces uncured sealant out laterally under tooling pressure, resulting in 100 percent contact of sealant to sidewall (substrate). These are the bond lines. Finally, backer rods dictate the cross-sectional configuration of the sealant bead.

Flexibility of the two backer rod materials plays an important part in tooling the newly applied sealant beads. A backer rod, although important in an expansion joint, is secondary to the primary product—the sealant. The desired end result is a satisfactory seal that meets or exceeds specifications.

The more rigid closed cell backer rod is able to withstand a heavier pressure. The greater flexibility of the open cell rod requires the caulker to use lighter tooling pressure, to minimize spring back. (It is not a difficult technique to master, for open cell backer rod has been used successfully for 20 years or more.)

Tooling the hour glass

Tooling is done with a variety of instruments. Most incorporate a semi-flexible blade, like a spatula. It is the tooling operation that gives the cross-sectional shape to the newly applied sealant bead. This shape is referred to as an "hour glass" configuration.

The hour glass shape is important. It results in a maximum bonding surface on the sidewalls, and a thinner section midway between. This means the adhesive bond to the sidewalls will be of sufficient strength to eliminate failure caused by repeated elongations and contractions of the sealant material. In simple terms, the strength of the bond to the sidewalls forces elastic movement of the sealant. Elasticity of the sealant comes into play by allowing stretching and contraction at the thinnest point, avoiding excessive stress at the bonds to the sidewall. Choosing the correct backer rod obviously plays an important part.

If a backer rod is placed incorrectly (too deeply) or so it doesn't force an hour glass cross section, cohesive or adhesive failure becomes a distinct possibility.

Proper cross sections

Figures 1 and 2 show the differences between the proper cross section of a newly applied sealant bead, and an incorrect one. Figure 2 is incorrect because the ratio of thickness of the sealant bead at the bond line to that at the midway point is too small. Movement of the joint sidewalls will put undue stress on the bond lines. The high cohesive strength of the overly thick sealant bead will make it very difficult or impossible for the sealant to elongate. The bonds may fail eventually because of this; they will not if they have the correct ratio depicted in Figure 1.

This problem can be compounded if an incorrect back-up is used in cases where three-sided adhesion occurs. In these cases, a sealant cures while adhered to both sidewalls, and to the backer rod. When the back-up rod is composed of a rigid, unyielding material, problems can arise.

Closed cell backer rods, being an olefin-type plastic material, are well known for their anti-stick properties. Usually, any inital adhesion to these back-ups break down quickly, and the sealant comes free.

This was thought to be the case with open cell rods as well, since the weak open cell surface structure also shears away from the sealant bead. In cases where it does not, however, the flexibility of the open cell rod allows it to move with the sealant bead (with absolutely no ill effects) for the life of the sealant.

This has been demonstrated both

FIGURE 1

Correct placement of backer rod sealant

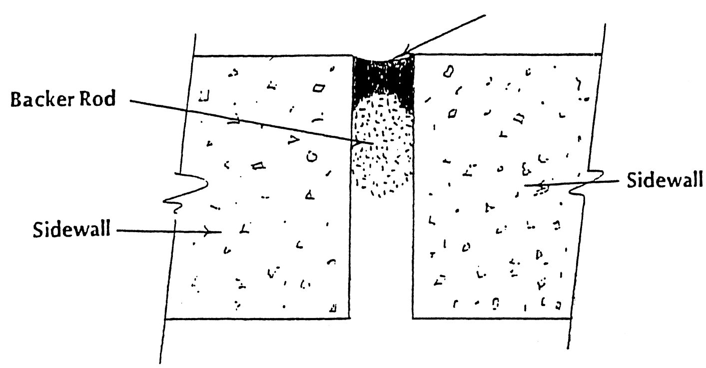


FIGURE 2

Incorrect placement of backer rod sealant

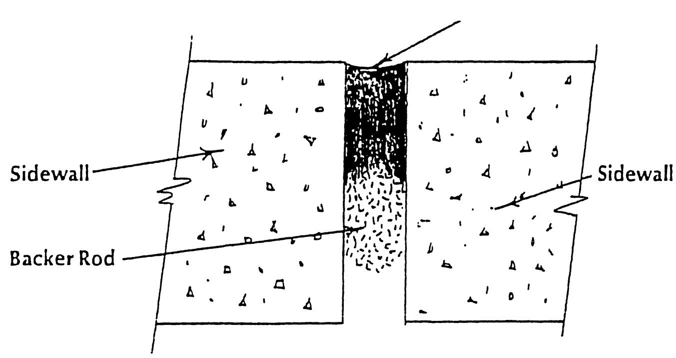


FIGURE 3
Trapped moisture, open cell backer rod

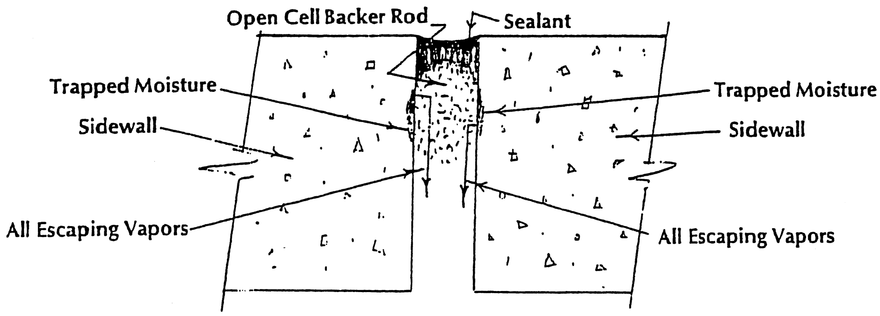
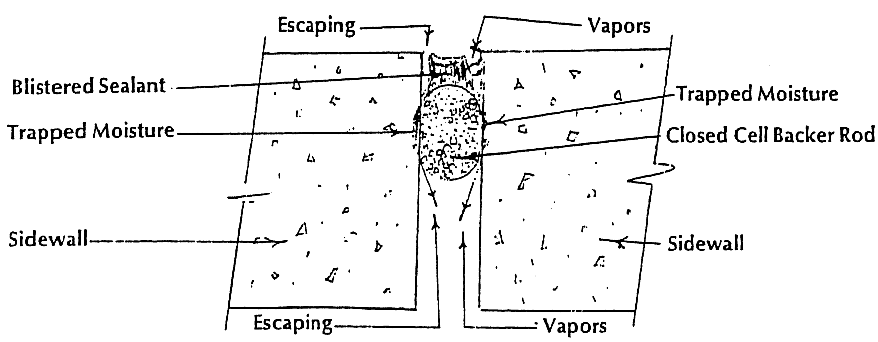


FIGURE 4
Trapped moisture, closed cell backer rod



in laboratory tests of 10,000 cycles (excess of 25 years) and in over 20 years of actual use in the field. Problems do arise when a rigid back-up is used: the sealant bonds to it tenaciously. When the joint moves, the sealant doesn't—and failure likely will occur.

Closed cell rods tend to take a set when compressed for extended periods of time. This is not the case for open cell rods. It is a basic requirement of these open cell foams in the furniture and padding industry that they not take a set. On occasion, closed cell rods have been known to move back into a joint under gunning pressure, if the rod first was placed in the joint too far. (This permits too thick a sealant bead, risking bond failure.)

Open cell rods have a high coefficient of friction, and do not slide easily over most surfaces. This results in a good grip to sidewalls, and a resistance to movement under gunning presuure. Open cell rod can move, however, if it is not compressed the recommended 25 percent in joint packing.

Moisture Absorption

One of the myths that existed for years about open cell backer rod was its alleged moisture absorption. Many felt its open cell structure made it perform as a sponge. Open cell foam will absorb some water, but under most situations it does not retain it for long. Twenty-four hour total submersion tests indicate 50 percent absorption is about average. (This, of course, is not encountered in the field, but whatever water might be absorbed in actual practice still is not retained long.) Closed cell rod, on the other hand, is virtually non-absorbent; therefore, no problem.

This open cell feature has proven to be an important asset, because an escape route for gases always is readily available. Should some moisture become trapped between the sidewalls and the backer rod, the area usually is much slower to dry out than is that part of the joint not covered by the backer rod—and exposed to the air. (See **Figure 3** and **Figure 4**.) The portion to be caulked, however, is dry enough to be sealed.

When this moisture problem occurs and the wetness begins to evaporate, vapor pressure is built up between the backer rod and the sidewalls. In the case of the open cell rod, when these vapors take the course of least resistance they go through the backer rod to escape. As for closed cell, being impervious, the only escape route is through the newly applied sealant bead. When this occurs, the sealant bead blisters. Channels can develop throughout it; at times, the bond line fails or is seriously weakened.

Another important plus for open cell rod which became obvious in the application of air cured sealants (silicones) was the fact that a cure is initiated from both sides. This speeds up the cure substantially (highly desirable with slow-curing sealants). This faster cure to a large extent eliminates precure adhesive or cohesive failure problems.

Two-sided curing is impossible with closed cell rod material, therefore air curing sealants remain in an uncured or semi-cured state for a longer period of time. (See **Figure 5** and **Figure 6**.)

Outgassing

Bubbling of newly applied or semi-cured sealant beads is referred to as outgassing. The results are similar to those caused by trapped moisture. This is a common problem when using closed cell rod. For many years, it was suspected this bubbling in newly applied sealant beads was caused by the sealant. However, more precise observation showed it to be from closed cell backer rod.

It was explained earlier that closed cell backer rod contains trapped gases within its surface skin and inside its closed cells. Also, it was pointed out that if this skin and/or some of these cells become ruptured, the gas begins to seep out. The impervious nature of the closed cell backer rod prevents escaping

FIGURE 5
Two-sided air cure with open cell backer rod

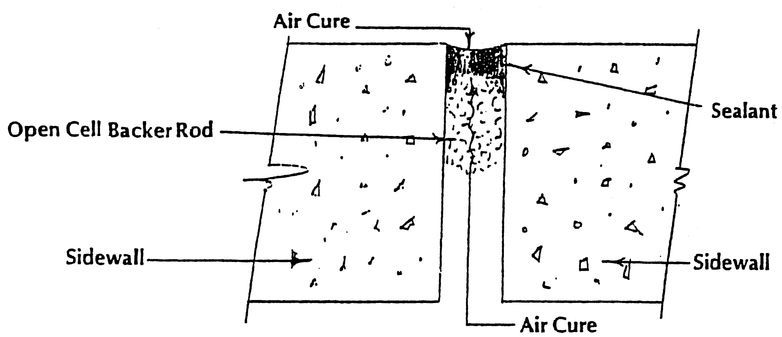
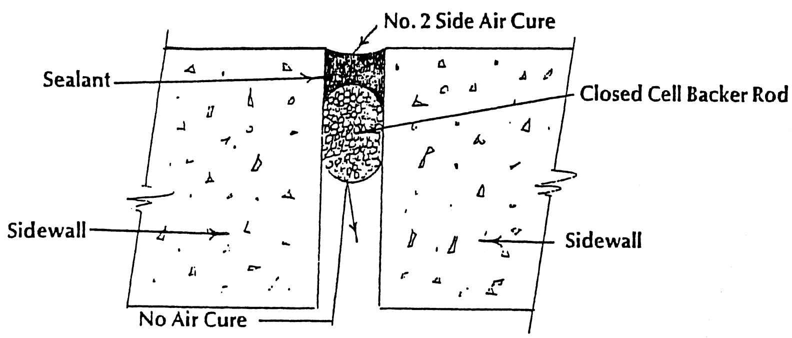


FIGURE 6
Absence of two-sided air cure with closed cell backer rod



gases from going any place other than through the newly applied sealant beads.

This seepage bubbles in the sealant, that, at times, can extend from the vent hole in the backer rod completely through the sealant bead, to its outer surface. This causes a leak in the seal. Most outgassing and bubbling isn't quite this severe. Usually, these gas bubbles stay within the sealant bead, though they do detract from appearance, and weaken the sealant bead. (See **Figure** 7.)

Backer rod rupture

Rupture of closed cell backer rod can occur in several ways. Rough masonry surfaces often (and easily) cut open the surface skin and underlying cells, allowing enclosed gases to escape. Rupture also can be caused by equipment used to pack the backer rod into the joints. As mentioned earlier, closed cell rod should not be compressed over 25 percent of its diameter. Variation in joint width is so predominant that over-compression occurs often; this too can cause rupture of the skin and underlying cells.

Over-compression in packing the joint requires heavier pressure in use of the packing tool, which introduces more chance of rupture of the skin and underlying cells, at the point of contact of the tool. The more over-compression, the more points of contact, therefore the more chance of rupture. Should the joint be in a rough masonry wall, the problem is compounded. The rough surfaces also will tear open the backer rod when it is subjected to such over-compression.

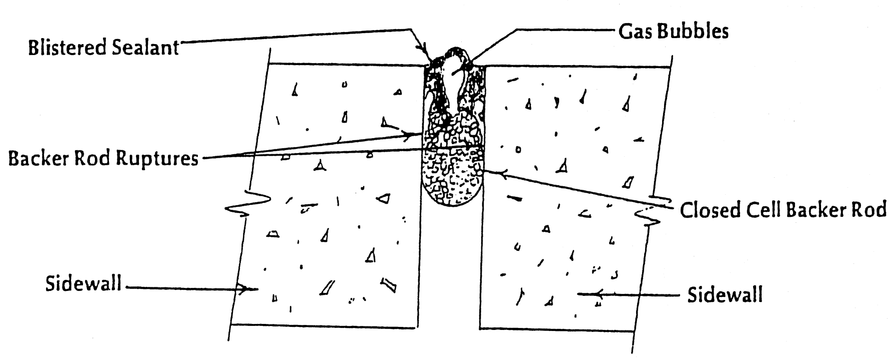
This problem can be compounded further if heat is involved, and rapid expansion of the building panels occurs. The more rapid closure of the joints (and expansion of the gases) due to heat forces gases into the uncured sealant faster, only adding to the troubles.

Another cause of outgassing with closed cell rod is sharp bends. Again, the surface skin and underlying cells can be ruptured. It is better to break closed cell backer rod at sharp turns than to bend it. The break provides an avenue of escape for these gases, away from the sealant bead.

One proposed partial solution to this outgassing problem was to pack the joint well in advance of (days before) the caulking operation. However, this would increase labor costs substantially. The closed cell rod would take a permanant set, partially releasing its grip to the sidewalls. This would risk movement during caulking (what's more, it was found closed cell rod still gassed, even after a year in a joint).

Outgassing is one problem that does not exist with open cell rod. The lack of an outer skin (or closed cells) totally eliminates any possibility of this occurring. In fact, prevention of outgassing was the primary reason open cell backer rod was developed.

FIGURE 7
Outgassing with closed cell backer rod



Other consequences of heat

Closed cell backer rod is a thermoplastic olefin material. This characteristic limits its usage if higher temperatures are encountered. (The maximum allowable temperature recommended by manufacturers is 160°F.) Open cell backer rod is a thermosetting plastic material with much higher heat resistance. It has been used successfully for limited periods under hot-applied sealant material (up to 500°F), with no ill effects.

The effects of elevated temperatures on successful application of a satisfactory sealant bead are of vital importance. New construction in hot climates reportedly will encounter temperatures of nearly 300°F for some materials. A backer rod material installed under such conditions must be able to withstand these temperatures without having a detrimental effect on applied sealants. The possibility of backer rod outgassing or shrinking brought about by contact with hot surfaces should be considered carefully.

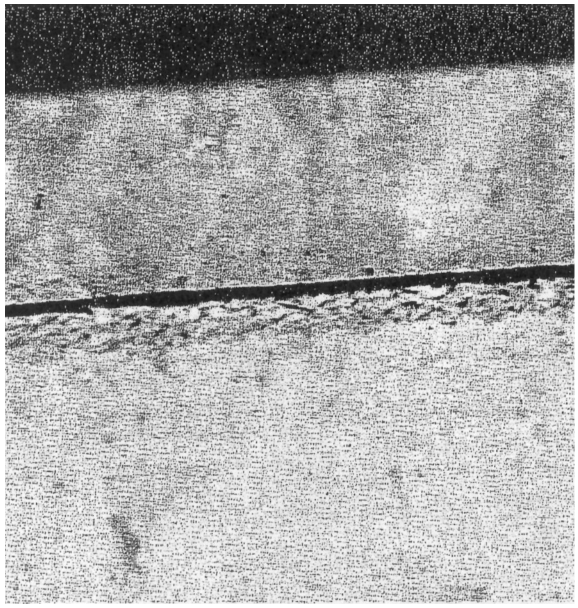
Both closed cell and open cell materials have good cold temperature characteristics under normal caulking environments. However, in extremely cold temperatures the open cell has a definite edge, remaining flexible at minus 60°F.

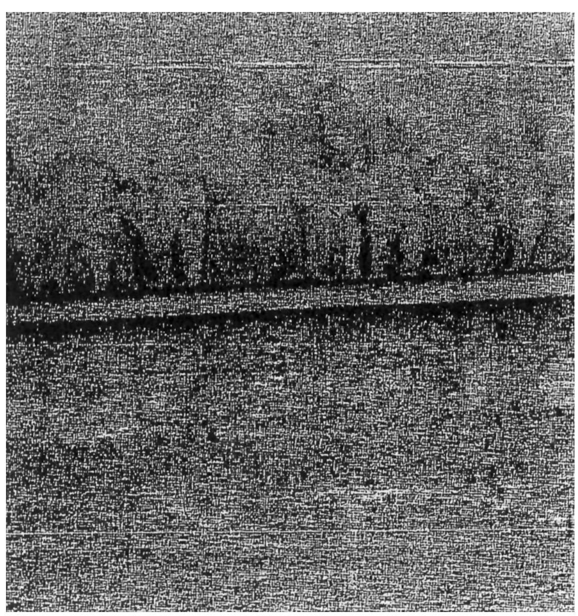
A minor role?

The backer rod in an expansion joint appears to play somewhat of a minor role. After the sealant has attained a full cure, the rod serves no further purpose other than, perhaps, offering some insulating properties in the expansion joints.

Although the role backer rods play may seem minor, it is important that architects, specification writers, caulking contractors and building owners ensure that seals in expansion joints perform well, and do not become the prematurely weak link in the structure.

It is in making possible that important seal that the backer rod performs its hidden, but essential task. □





From top to bottom: (1) A typical rough masonry joint which will be sealed with a caulking material, after a backer rod has been packed between the panels. (2) An open cell backer rod being packed into an expansion joint prior to caulking. (3) A properly caulked joint in rough masonry, using an open cell backer rod (note the absence of bubbles in the cured sealant bed).