Roof Expansion And Control Joints

By Kris Zielonka, P. Eng.

Introduction

Roof expansion and control joints frequently pose a set of difficult if not unusual problems to the roof designer and installer. By their very nature, an expansion or control joint on a roof has to have the ability to meet and accommodate movement (horizontal, vertical and in shear) while remaining waterproof for the life of the roof. Traditionally, the approach has been to raise the expansion joint above the plane of the roof and then install flashing roof membrane around it, with the objective of moving the actual waterproofing of the joint above the water line. This approach, while having some advantages, can also introduce problems to the roof's performance over its service life.

This article will examine the various methods and approaches of designing and detailing expansion and control joints in roof assemblies. Design parameters considered include the amount of movement required in a joint and the detailing and installation procedures involved, while taking into consideration the impact on the performance of the roof. Presented also will be leading edge technology in roof joints that use a flat type of expansion joint which accommodates tri-dimensional movements of the roof and roof membrane while remaining waterproof. An actual case study of an installation with a flat expansion joint will be examined. The advantages and disadvantages of this type of expansion and control joint will be reviewed.

Building Expansion Joints

Buildings readily move by contraction and expansion of components resulting from changes in temperature. The degree of this movement is dependent upon the type of material from which they are constructed. The extent of movement is dependent upon building dimensions and the ambient temperature (variation) change.

In order for a building and its components to accommodate these movements, the extent of this contraction/expansion is usually limited to a maximum of 2″ (50 mm). Any movement that is greater than 2″ (50 mm) within a building can result in damage to the building and its external finishes (cracking, dislodgement of exterior panels). In order to limit the expansion and contraction of the building, the building's designer (architect or structural engineer) incorporates a periodic and intentional break in the building structure. These breaks or gaps are usually referred to as expansion joints. An expansion joint is in essence a joint that passes through the entire building's cross section as if slicing through it. The idea is to provide a gap or space for the building to move. To further clarify this terminology, when reference is made to an expansion joint, this refers to the actual gap in the building structure. This paper is concerned with waterproofing the expansion joint gap.

The presence of an expansion joint poses some very unique problems in the building envelope design as such joints are not always straight and yet must keep out the elements, air, water, moisture, dust, etc., while allowing for the building's movement. The primary concern is water and moisture, as this causes the most damage to a building's interior and roof components. Water can enter the building's interior through the expansion joint at either below or above grade. Many remedies to this problem have been sought. Each method has had it drawbacks or problems. A properly designed expansion joint ideally should remain waterproof and weather tight.

Location of Expansion Joints

Expansion joints are usually found in the following places: on a roof, within a building's wall, above and below grade. Reasons for their requirement at these locations can include the following:

- Changes in deck direction.
- Changes in deck type, e.g., a concrete deck abutting

a steel deck.

- Re-entrant building corners.
- Long buildings exceeding 200 feet (61 m) or more in length.
- Additions built next to existing structures.
- Areas requiring isolation from vibration.
- Buildings that experience extreme thermal movement, i.e., freezer buildings.

Roof Control Joints

Expansion joints are considered to be the main type of joint in a building and they are deliberately installed to accommodate movement. Another type of joint that is introduced to provide room for movement is a roof control joint. These roof control joints can be thought of as expansion joints within the roof assembly. Their function is to provide room for the movement of the roof membrane material and relieve stress that may build up. This is especially critical on very large roofs.

The reasoning behind this is that roof membranes are materials that have the physical ability to contract and expand just like any other material (a fundamental law of natural physics). The degree of expansion and contraction is measured through what is known as the coefficient of thermal contraction or expansion. The coefficient of thermal contraction or expansion is described as unit change in length per degree change in temperature. For example, concrete has a coefficient of thermal expansion of 5.5 x 10^{-5} in/in°F (10 x 10^{-5} m/m°C). For the purposes of this discussion, material contraction and expansion are synonymous as they describe movement due to temperature change.

Another need for roof control joints in a roof assembly may also be as a result of the roof membrane being laid down on a substrate that has a different coefficient of expansion than that of the roof membrane itself, i.e. insulation boards. As the air temperature changes, these two materials, which are in direct contact, undergo a dimensional change which is not uniform. The membrane may dimensionally change more than the substrate to which it is attached or adhered.

It should also be noted that a surface area of a roof will change dimensionally in the two principal plane directions. The roof surface movement can be established through a thermal coefficient known as the coefficient of thermal surface expansion. The coefficient is approximately twice that of the coefficient of linear expansion. To accommodate surface movements on large roofs it is common to introduce roof control joints in the roof membrane, in both directions. The joints are usually perpendicular to each other.

Design Methodology of Expansion and Control Joints

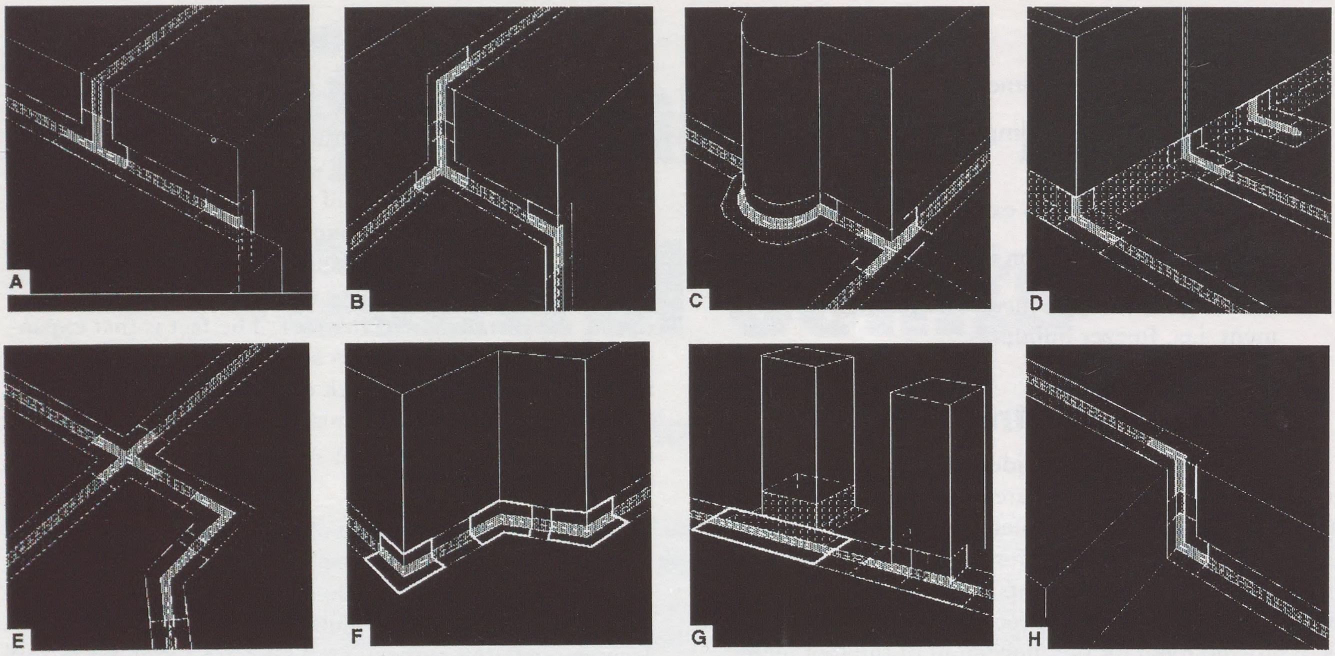
Expansion joints, as mentioned, by their own very nature interrupt the building's envelope and compromise the waterproofing integrity of the roof. Frequently, expansion joints are overlooked in the design process and are considered to be an appendage listed in specifications as "to suit site conditions" or at worst, an afterthought during the installation of the roof. The fact is that expansion joints in roof assemblies are a leading cause of water infiltration and leakage. Lack of proper consideration and detail will result in compromising the roof's waterproofing integrity, either immediately after installation or during the service life of the roof.

Approaches to the design of expansion joints are many, ranging from the crude to the sophisticated. The most simple approach is to provide additional roof membrane material at the expansion joint location specifically to accommodate the movement. There are a number of "off the shelf" expansion joint solutions. These usually comprise a variety of rigid plastic membrane sheets preformed into a bellows type shape (the bellows allowing for material movement). The more sophisticated systems in place are also bellows types manufactured to site specific conditions to accommodate predetermined movements. The various solutions require that these expandable materials be raised above the roof level on a curb. Once the expansion joint is elevated above the roof level. the roof membrane is then flashed around the base of the curb and the waterproofing expansion joint material spans the gap. The entire expansion joint detail is usually capped with metal flashing as a protection from the elements and mechanical damage.

The approach described above has been used in roofing for a long time; in fact, if one were to look back at a building roofed in the 1940s, this was the "modus operandi." This approach, although elevating the expansion joint assembly above the roof membrane, has a number of disadvantages which can be detrimental to the roof membrane and the roof assembly. Outlined are some of the factors that may be considered to have a negative impact on the roof itself.

Primarily, the elevated curb obstructs water flow across the roof, and, in fact, has a damming effect. Water cannot flow to a drain, which may be located on the other side of the expansion joint. The roof owner is then left to make modifications to the expansion joint by installing scuppers through the expansion joint to allow water flow.

Ponded water on a roof, as conventional wisdom dictates, is not a good thing and every effort has to be made to remove standing water from the roof. In addition, a raised expansion joint on a curb is exposed to roof traffic and damage. This is an important consideration, especially when there is no metal coping or cap on the expansion joint curb. Another problem associated with expansion



Typical conditions encountered with expansion joints:

The above diagrams describe some very typical expansion joint conditions. Fig. A: Two expansion joints coming from two different elevations joined together at a point. Fig. B: Three expansion joints, from three different elevations, coming together to a point. Fig. C: An expansion joint going around a circular column. Fig. D: An expansion joint condition at the base of a parapet wall. Fig. E: A four-way expansion joint junction. Fig. F: An expansion joint following the contours of an irregular exterior wall. Fig. G: An expansion joint bordering with square columns. This is a fairly typical condition when an expansion joint abuts a roof curb or column. Fig. H: Changes in elevation of a continuous expansion joint, a common condition found on multilevel roofs or in transition of plane surfaces from the horizontal to the vertical

joints that is even more fundamental to their function is that of expansion and contraction. The materials used to waterproof expansion joints today are rigid or allow very little material elongation. The movement of these materials is accomplished through the provision of extra material (e.g. bellows, folds). This in itself has disadvantages. The material does not always return to its original shape and position, and the material can also suffer physical damage during the movement. An even more critical aspect is the material's ability to be joined or seamed together. Even straight expansion joint runs cannot be manufactured from one piece of material; two or more pieces have to be joined together to make up the length required. The two most common methods used for joining material pieces are adhesives or hot air welding/fusing. Though initially providing a watertight connection, the material at the actual joint does not always exhibit the same mechanical properties (elongation, tensile) as the rest of the expansion joint material. These issues can be of critical significance as to the performance of an expansion joint, especially when a complex shape or configuration is required, examples of which are shown below.

A Different Approach to Expansion Joints

As described above, traditional expansion joints rely on the advantage of being raised above the roof level. Though this is a logical precaution, there are other approaches. In other countries, the philosophy is to protect and make integral any roof protrusions or projections on a roof by not exposing them to the elements or roof traffic. This is to prevent unnecessary damage. This thinking has found its way to roof expansion joint design, too. The approach to designing such waterproofed expansion joints is to make them as level as possible with the roof membranes. This has evolved a new concept of the flat waterproofed expansion joint — an idea that has found application in parking garages and blind-side waterproofing for the last three decades.

A Case Study

In September of 1996, a unique problem was encountered on a reroofing project. The owner of an eight floor building decided to reroof. The existing roof was an inverted BUR Protected Membrane Roof Assembly. On the roof were eight skylights which allowed light into the building's central atrium. An expansion joint ran across the building adjacent to the skylights (see Figure 1). The expansion joint had been repaired at least three times and was a source of continual water leakage and aggravation to the building's occupants. (see Figure 2).

Particular areas of failure were at the corners of the

Fig.: 1 View of roof with skylights and expansion joint.

skylight curb where the expansion joint butted the skylight curb (see Figure 3). In addition, the roof was drained at the perimeter, thus water flow was being obstructed by the raised existing expansion joint detail. The roof consultant and roofing contractor were faced with a significant dilemma—how to provide an expansion joint that did two things: 1) reliably waterproof the corner of the skylight curb; and, 2) allow the flow of water across the roof. This all had to be accomplished in an economical and cost effective manner.

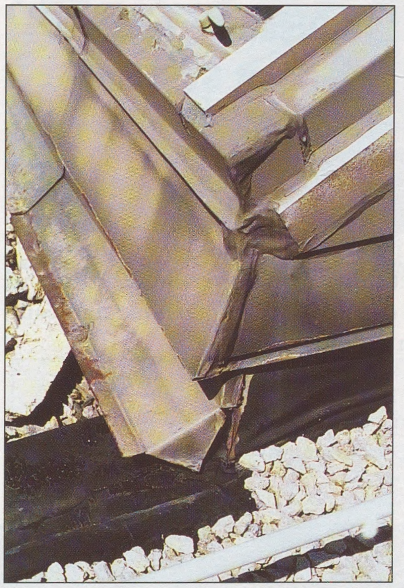


Fig.: 3 Close up of existing expansion joint at skylight curb corner.

The determination was made to try a flat "zero profile" expansion joint waterproof material. Although this may be thought of as an unorthodox approach to the problem, it seemed to fit the bill. The total length of the expansion joint was 210 feet (61 m), terminating at a vertical expansion joint down the building's side elevation.

Product Description

The system is comprised of 10″ (250 mm) or 13″ (325 mm) wide material strips which are compounded out of a specially formulated EPDM elastomer with polyester fleece embedded in flaps on either side. The expansion

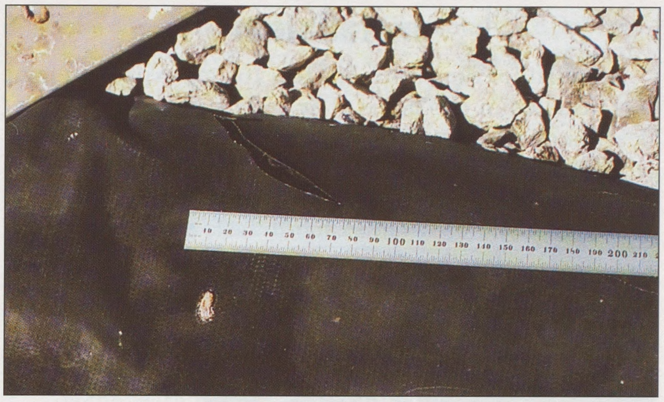


Fig.: 2 Close up of existing expansion joint.

joint material is manufactured by an extrusion process from an EPDM elastomer. During the manufacturing process, the polyester fleece is embedded into the gelling EPDM matrix on both sides, top and bottom, of the material. The intent is for the fleece to engage the plies of the bitumen roof membrane. The joint material has no fleece material attached over the actual expanding joint part. The EPDM elastomer used in the formulation is very unique, as it has a number of specific chemical properties suited to this application. The EPDM elastomer used is an Ethylene-Propylene-Diene-Methylene with a saturated polymethylene chain. The saturated polymethylene chain in the elastomer renders it inert by not allowing for chemical reactions to occur. The material is resistant to the effects of UV, ozone, high temperatures, chemicals such as alkalis. acids, saline solutions, alcohol and ketones. The high quality and purity of the EPDM elastomer also make vulcanization of expansion joint pieces possible. This makes the construction of details around unique shapes possible and watertight without the use of glues or tapes.

Technical Data as Manufactured

Appearance:

Color: Orange red with white fleece on the side flaps

Physical Properties:

Bonding Medium:	1.20 oz/ft^2 (400 g/m^2) polyester fleece
Elongation:	> 500 % at -40°F (-40°C)
Tensile Strength:	725 psi (5 N/mm^2)
Hardness:	45 ± 5 Shore A
Long term Operating Temperature:	-40°F (-40°C) to +194°F (+90°C)

Geometry

Width	Thickness	A	B	C
13 1/4″ (340 mm)	87 mils (2.2 mm)	±1 3/4″ (±40 mm)	±13/16″ (±20 mm)	±1 3/16″ (±30 mm)

Installation

Material for the entire 210-feet (61 m) expansion joint was installed in two hours. The installation procedure is described in brief as follows. The expansion joint material is shipped to the job site in a roll. Installation takes place as roofing progresses (see Figure 5). The material is laid down in a flood coat of asphalt/bitumen (see Figure 6). The asphalt/bitumen should be at its EVT when being applied to the fleece. Both the fleece and the roof ply surface must be covered in asphalt/bitumen. The asphalt/bitumen must totally encapsulate and impregnate the fleece with a bleed out visible along the ply's edge. The next step is to strip in the top ply of the roof membrane over the expansion joint material (see Fig-ure 7).

Fig. 5: The building expansion joint being prepared for roof expansion joint installation.

The top ply should be installed in a flood coat of asphalt/bitumen as well. It is important that the asphalt/bitumen be at the correct temperature at the point of application. The asphalt/bitumen flood coat must impregnate the entire polyester fleece material; only the top fleece surface needs to be flood coated. It does not matter if the entire joint is covered in asphalt/bitumen. Particular attention is paid to the skylight corner curb detail (see Figure 8). It should be noted that the asphalt/bitumen will not stick to the material that has no fleece. The installation is finally complete once the parapet flashings are installed (see Fig-ure 9). The Protected Roof Membrane is then given a glaze coat of asphalt and insulation, slip sheet and ballast are installed and placed on the roof (see Figure 10).

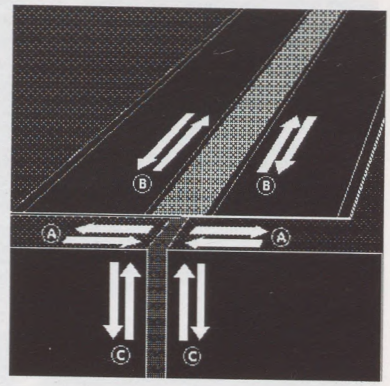
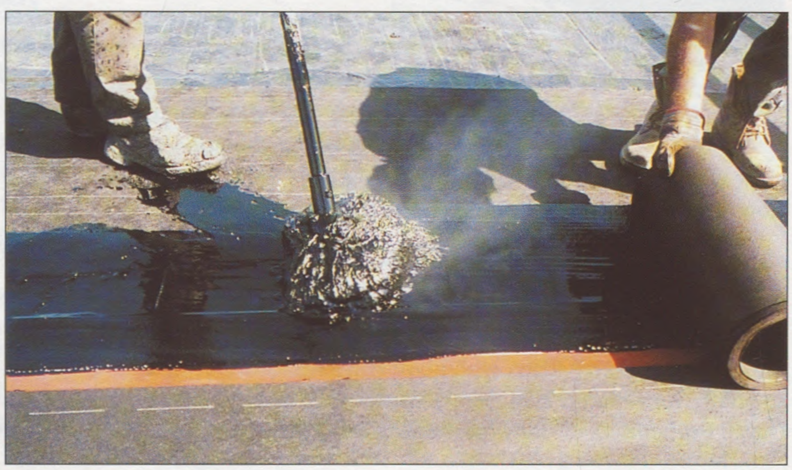


Fig. 4: An illustration showing the three principal movement directions with a flat expansion joint. Direction A is horizontal, Direction B is transverse (shear) and Direction C is vertical.

Advantages and Disadvantages of Flat Expansion Joint Systems

One of the key advantages of the flat waterproof expansion joint systems is that it can be tailored to specific site conditions. This makes the waterproofing of difficult joint details easy, (i.e., curved joints, inside/outside corners, changes in joint elevations and planes.) The case study project described above showed that the installation of the flat expansion joint is simple and can provide a solution to a specific situation.

The flat expansion joint system has a number of advantages. These can be grouped broadly into two categories, technical and economic advantages. These are as follows:



(Left): Fig 6: The roof expansion joint being installed in a flood coat of asphalt.
(Above): Fig. 7: The roof expansion joint being stripped in with flashing plies.

Fig. 8: The roof expansion joint detail at the skylight curb corner.

Fig. 9: The completed installation of the flat roof expansion joint. Note the vertical flashings.

Fig. 10: The completed roof with roof expansion joint installed.

Technical

1. Provides a flat, "zero profile" waterproofed joint without obstructing the flow of water.
2. The system is tailored to specific site conditions. This includes such difficult roof areas to detail and waterproof as inside and outside corners, "T" joints, joint intersections, curved joints, multilevel joints, etc.
3. The flat expansion joint system has the capacity to move in all three planes simultaneously, i.e. horizontally (side ways), vertically (up and down) and transversely (shear), while remaining flat.
4. There are no complicated calculations or "guesstimates" to be done, since the joint is flat and in the plane of the expansion joint. The only measurements required are clear distances between fixed points.
5. The flat expansion joint material is installed between the roofing plies of BUR and Modified Bitumen in a flood coat of asphalt. The result is that the waterproofed joint is an extension of the actual roof membrane, with no flashing plies or special detailing required.
6. The flat expansion joint system forms a continuous, uninterrupted waterproofing solution from the start of the expansion joint to its termination, which can be in a different part of a building — for example, underground. The "zero profile" of the tape allows it to traverse any building surface, from inside to outside, above or below ground.
7. The expansion joint can be made continuous with the same expansion capability along its entire length. Any seams that are in the tape are as flexible and have the same elongation as the expansion joint material itself.
8. The seams found in the expansion joint system are all vulcanized under factory-controlled conditions (although site seaming is possible through the use of a special portable vulcanizing press system). Since there is no site seaming, this prevents any weak seams that can result from being done in adverse weather or poor site conditions.
9. Being flat, the expansion joint end termination can accommodate movement in all three directions. There is no warping or wrinkling at the joint termination.
10. The flat expansion joint is laid down at the roof membrane level over insulation, leaving no void space where condensation can form.
11. There are no metal fasteners used in the installation of the flat expansion joint; thus, there is no possibility of thermal bridging or additional thermal heat loss.
12. The expansion joint's "zero profile" forms no trip hazard on the roof, nor is it affected by normal roof traffic.

Economic

1. Eliminates the need for expensive wood curbs and roof membrane and metal flashings.
2. The expansion joint system can be laid down and installed in minutes, with minimum preparation time and skill required, resulting in significant labor savings to the contractor.
3. The expansion joint is supplied in one piece for the

entire project; it is rolled and ready to be installed immediately.

Conclusion

The case study project offered an insight into a different way of tackling an old problem. At last report, the flat expansion joint is performing well. The roof now has proper drainage and ponding water has been eliminated. The difficult skylight corners which seemed to defy flashing and waterproofing have remained watertight. An added benefit is that the expansion joint is hidden from roof traffic and does not require any maintenance. The opinion of the author is that, though every application has its own solution, it would appear that flat expansion joints demonstrate a place in roofing and provide a fresh and innovative approach to an old problem.

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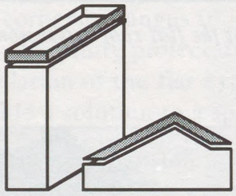
About The Author

Kris Zielonka is a professional engineer who has been involved in roofing and building since 1986. He is a specialist in waterproofing of above- and below-grade structures. Zielonka is a director of CRCA and an active member of its National Technical Committee, as well as a member of both the Canadian and American Association(s) of Civil Engineers. This paper was presented at RCI's 12th Annual Convention and Trade Show in Anaheim.



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