NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

CONSTRUCTION DETAILS FOR AIR TIGHTNESS

Record of the DBR Seminar/Workshop
October, November 1977 and January 1978

Proceedings No. 3
of the
Division of Building Research

Ottawa, April 1980

PREFACE

For many years DBR/NRC has held seminars dealing with various aspects of building design, construction and materials as a means of providing information to the building industry. The seminars have taken the form of presentations made by DBR members, and frequently also by experts from the industry, followed by a discussion or "workshop" of particular aspects of the presentations.

The seminar on "Construction Details for Air Tightness" was presented in ten cities, and sometimes more than once in some locations. Even so, the total number of persons who could be reached by this means amounted to just over a thousand. These Proceedings have been compiled, therefore, to make this information available to a wider audience.

These Proceedings present the texts of the talks given in the DBR Seminar/Workshop entitled "Construction Details for Air Tightness," presented in October and November, 1977, and in January, 1978.

Ottawa
April 1980

C.B. Crawford
Director DBR/NRC

TABLE OF CONTENTS

The following people assisted in the preparation of material for the seminar and in its presentation: D.C. Tibbetts, DBR Halifax; C.P. Hedlin and H.W. Orr, DBR Saskatoon; W.H. Ball, DBR Vancouver; and R.G. Brand, Carleton University, Ottawa.

* PCL Construction Ltd., Edmonton, Alberta

DESIGN PRINCIPLES

by G.O. Handegord

Although the importance of air tightness has been stressed for the past 25 years in the technical literature dealing with the design of building enclosures, we still construct buildings that provide their owners with excessive energy costs, that make the occupants uncomfortable because of drafts and the infiltration of contaminated air, and that suffer from problems of condensation and the deterioration of their components and materials, which require high costs for repair and maintenance. Air tightness, accordingly, should be the primary objective in the design and construction of walls, windows, floors and roofs of buildings.

The following reasons for the lack of achievement of air tightness in practice may be cited: (1) a lack of appreciation by designers, builders and materials manufacturers of its importance; (2) the assumption that by simply specifying an air vapour barrier the problem is solved; (3) a resignation to the belief that in the practical case air tightness cannot be achieved; and (4) the traditional attitude that some air leakage is necessary in order to provide adequate ventilation.

The notion that air leakage is necessary for ventilation must be dispelled. Instead, air leakage through the building enclosure must be regarded as undesirable, unnecessary and uneconomical, because air leaking into a building cannot be treated or conditioned, nor can its rate of supply or distribution throughout the building be controlled. Similarly, air leaking out of a building not only constitutes a waste of energy but results in condensation and deterioration of the building fabric. Any openings in the building envelope and even those in floors and partitions disrupt the intended operation of heating, ventilating and air-conditioning systems, make it difficult to control noise, and increase the danger of the spread of fire and smoke. In addition, a wall that suffers from air leakage may also suffer from rain leakage if it is exposed to wetting by rain.

In a Canadian Building Digest dealing with fundamental considerations in the design of exterior walls for buildings,[1] Dr. N.B. Hutcheon provided a list of requirements, the first seven of which, termed the "barrier requirements," related to the control of the flow of mass and energy through the enclosure. All of these flows, except for those involving light and solar or other radiation, are influenced by the size, location and distribution of cracks and openings in the building enclosure.

It has been demonstrated that substantial amounts of heat can flow through small cracks and openings. These also provide the primary means for the transport of water vapour into the cold regions of walls, which takes place mainly by the mass flow of air rather than by vapour diffusion

If an exhaust system is employed, the decreased pressure within the building results in the raising of the neutral pressure plane. Accordingly, air movement will be inward over most of the wall area, with exfiltration through the exhaust fan and through those portions of the building that are at a higher pressure than outside. This will also increase the air exchange rate and energy loss, with possible discomfort due to drafts on lower floors.

The effect of wind is to create different conditions on the windward and leeward sides of a building. On the windward side, the outside pressure increases with respect to that inside and the neutral pressure plane is raised; accordingly, air infiltration will occur over more of the windward face, while exfiltration occurs only through the area where the interior pressure exceeds that outside. In contrast, on the leeward side, suction is produced, the neutral pressure plane is lowered, and exfiltration occurs over most of the leeward face of the building.

The maximum pressure resulting from stack effect depends on the building height and the temperature difference between the inside and outside. For a 20-storey building maintained at 70°F (21°C) inside, surrounded by air at -20°F (-29°C), a pressure difference equivalent to that produced by a wind of 25 mph (40 km/h) is generated as a result of stack action. Since average wind velocities are usually in the order of 10 - 15 mph (16 - 24 km/h) it can be readily appreciated that stack effect usually overrides wind pressure for high buildings under winter conditions.

Because the pressure differences created by mechanical systems are required for air distribution within the building, and because nothing can be done to change the pressure differences resulting from wind and stack effect, the only solution to minimizing their effects is to reduce the size and number of openings through the enclosure. The objective, therefore, should be to provide as airtight an enclosure as possible. The requirements for fresh air and for exhaust must be met by a separate ventilation system capable of adjustment and control to meet the specific needs of the occupancy.

It has been generally assumed that leakage through the building enclosure occurs primarily at the doors and windows where recognizable joints occur. The Handbook of Fundamentals of the American Society of Heating, Refrigerating and Air-Conditioning Engineers[3] provides information on leakage through doors and windows as well as that occurring between their frames and the wall in which they are installed. Values of air leakage are also provided for masonry construction and wood-frame walls. A masonry wall, for example, will allow substantial air leakage because of the numerous small fissures and openings between the units and mortar; by simply plastering such a wall, however, its air tightness is improved, in some cases by a factor of 100.

Improved air tightness also assists in the control of ventilation and air distribution, including the control of smoke movement in the case of fire. In addition, it enables a more equitable apportioning of energy charges to be made between the individual units in apartment buildings.

Improving the air tightness of walls, windows, floors and roofs must be regarded as an essential step toward energy conservation in building. Air leakage should never be relied upon for ventilation but should be recognized as an impediment to the proper operation and control of a ventilating system. Such a system, having a specific means of air supply and exhaust, should be required in all buildings to provide an adjustable fresh air supply and used-air exhaust, and should incorporate energy recovery devices. Under such conditions it will be easier to evaluate the actual air leakage characteristics of the completed building, easier to monitor the energy needs associated with ventilation, and easier to predict the performance of the building under the anticipated climatic conditions.

References

[1] Hutcheon, N.B. Requirements for exterior walls. National Research Council of Canada, Division of Building Research, CBD 48, 1963.

[2] Underwriters' Laboratories of Canada. Standard method of small scale fire tests of walls and partitions penetrated by small pipes. ULC-S115-1977.

[3] American Society of Heating, Refrigerating and Air-conditioning Engineers. Handbook of Fundamentals. Issued every four years.

APPLICATION OF DESIGN PRINCIPLES IN PRACTICE

by J.C. Perreault

Webster defines the word "detail" as a "small or unimportant part," but a construction detail is not unimportant. Rather it is of extreme importance. It should not be small. On the contrary, it should be big, easy to read and easy to understand.

A good or bad detail will often make the difference between a good or bad installation. Building designers should bear in mind that those who actually build the buildings usually have no design background. They should not be forced to guess the designer's intention, or to play the role of designer, but should only be expected to build carefully, as detailed. That is why a detail must be precise, easy to understand and practicable. There should be no guess-work; if a problem arises in understanding the function or purpose of any item or specification or if a detail does not appear to be good practice, it should be queried. If a detail appears to be impossible to build, no attempt should be made to build it.

Attention to detail in design and construction is of prime importance if air tightness is to be achieved. In this regard one single thing will make a detail a success or a failure. This is the presence of holes. Indeed, in the investigation of many building problems an appropriate saying would be "cherchez le trou" (look for the hole). In practically all cases it will work.

Many examples of building problems directly resulting from openings or holes can be documented. In a certain hotel, for example, water appeared at the ceiling line of many bathroom walls, badly staining them. As usual, the first call went to the roofer, but because the problem occurred in mid-winter it could not be blamed on a roof leak. Because there were no windows in the bathrooms the window installer could not be blamed either. The leakage was eventually traced (by putting dye in the toilet water) to holes in the soil pipes. The pipes had inadvertently been placed in the wall directly behind the location chosen for the installation of the towel racks. In drilling holes in the walls to install the racks, the workman in many instances also drilled holes into the soil pipes, providing the paths for leakage.

Another example of "cherchez le trou" involved a shopping centre that had an outside pedestrian area beneath a large roof overhang (Figure 1*). Water dripping out of openings, intended originally to serve as air vents for the soffit space, did not concern the management except that the water froze on the sidewalk, forming patches of ice that were hazardous to the customers. The first proposed solution to the problem was simply

---

*Figures are presented at the end of these Proceedings.

is the wall above a suspended ceiling, from which the vapour barrier and insulation are frequently omitted, thus allowing air leakage to take place through this part of the wall.

Insulation and vapour barriers are the two most misunderstood items in construction today. Many builders and designers apparently do not know exactly what these two things are supposed to do. Sometimes designers get carried away and provide two vapour barriers on the same element, but they never seem to be able to connect the vapour barrier of one element with that of another element.

In the choice and application of material for building, care must be taken to ensure that one specified material or installation does not destroy or interfere with other specified items. Sometimes two materials, seemingly good in themselves, when combined together can harm the other. In a certain building, for example, foil-covered insulation was specified to be glued to the back of precast wall cladding, a difficult installation job because of all the precast anchors, sway braces and furring channels that the insulation had to be cut around and sealed to. But in addition, the specification called for wet concrete to be poured against the aluminum foil, to cover precast anchors and provide fire separation between floors. The product data sheet for the insulation, however, clearly indicated that: (1) the material backing the foil contains water soluble salts, and if it becomes wet these salts have a corrosive action on the foil; (2) the foil, when placed in contact with wet plaster or mortar, will corrode. In spite of these warnings, however, both specification and drawing for the foil's application in this instance called for wet cement to be poured against it.

An interesting case of problems arising from air leakage involved one of the first high-rise buildings built on the rain-screen principle in Alberta. An account of this building and its performance, prepared by G.O. Handegord for a DBR Building Science Seminar,† referred to the construction and the problem as follows:

> "The wall consists of an inner wythe of 8-in. (200 mm) thick common brick together with cast-in-place reinforced concrete spandrel beams. Expanded polystyrene insulation, 1 in. (25 mm) thick, was installed on the exterior with spot applied asphalt adhesive."
>
> "The outer rain screen is a 4-in. (100 mm) thick precast concrete panel 18 in. (460 mm) long and approximately 5 ft (1.5 m) wide suspended to create an air space 1 in. (25 mm) wide between its inner face and the outer face of the insulation. The space is open to the outside at the bottom above

---

† DBR Audio-Visual Presentations No. 12A and 12B, Feburary 1972. Presented at the Building Science Seminar "Walls, Windows, and Roofs," October 1971.

adviser, decorating consultant, and guardian of culture and aesthetics. His job is not made easier by the proliferation of new and inadequately understood methods and materials, and a quickened pace of construction. The successful performance of the building depends on his ability to choose the right material or system.

Just as builders must try to understand the designer's job, so must the designer realize that putting up a modern structure is also a formidable task. The construction superintendent spends a third of his time pushing papers and answering the phone. If he has to spend half of his remaining time figuring out how to build a particular detail and once it is done, he has to spend the other half of his time around a conference table trying to explain why he did it that way or why it doesn't work then he will not be able to do what he is good at doing, which is putting up the building.

The problems resulting from the faulty design and construction of buildings, and the need for joint action by designers and builders to overcome them, have been well summarized in the following words prepared by M.C. Baker for a DBR Building Science Seminar¶ which are worth repeating as a summary of this account of the application of design principles in practice:

> "In this age of unprecedented technological expertise, it should be possible to predict performance. The construction industry, however, appears to be plagued by an ever increasing amount of extremely poor performance, including buildings that leak, stream with condensation, overheat in summer or whose appearance is marred by streaking, discoloration, and material break-down on the exterior. It is obviously necessary to get back to scientific principles in the design and construction of enclosures for building. All details must be examined to ensure the continuity of air and vapour barriers, and the construction must be carried out in a manner that achieves this continuity. There is no doubt that the present unsatisfactory performance of many buildings, and building elements, can be overcome by a concerted team effort on the part of designers and builders."

¶ DBR Audio-Visual Presentation No. 11, February 1972. Presented at the Building Science Seminar "Walls, Windows, and Roofs," October 1971.

MASONRY WALLS

by K.N. Burn

In the following discussion of masonry walls in relation to the air tightness of buildings, panel walls constructed of concrete blocks will mainly be considered. The primary function of such a wall is to close the space between the floors of a building in such a way that the desired and controlled environment on the inside is isolated from the natural environment on the outside by means of a barrier that will prevent the movement of air and whatever it contains. This can only be achieved if the panel wall is constructed of some material that is not permeable to air and if it is fitted into the space between the floors without leaving cracks or holes around the perimeter.

Most common building materials, including cast-in-place and precast concrete, gypsum board, plywood, sheet metal and glass are relatively impermeable to air. When joints between components made of these materials are adequately sealed an effective air stop or air barrier can be formed. In contrast, however, masonry walls, constructed of concrete blocks held together with mortar, are quite permeable to air for a number of reasons. Mortar shrinks about 10 times as much as concrete block and the differential movement produces numerous fine tension cracks in the mortar. In addition, when a block is laid in mortar there may be areas where bond does not develop between the bottom surface of the block and the top surface of the mortar. Another cause of the permeability of block walls is the incomplete filling of mortar joints, particularly the vertical ones.

Shrinkage of concrete blocks also plays a part in the problem of the permeability of such walls. Concrete blocks made with dense aggregate may shrink as much as 0.04 per cent after being placed, while lightweight blocks generally shrink twice as much. Autoclaved blocks shrink less than those cured at low pressure, but even so, their shrinkage is not generally less than 50 per cent of that of blocks not autoclaved. This amount of shrinkage means that for a 10-ft (3 m) high panel wall the vertical shrinkage amounts to between 1/20 and 1/10 in. (1.3 - 2.5 mm). Horizontal shrinkage also occurs but is usually somewhat less than the vertical because of the restraint caused by frictional resistance to movement along the base of the wall under its own dead weight.

It can be seen, therefore, that panel walls of concrete blocks placed within a rigid structural frame providing 20 ft (6 m) bays and 10 ft (3 m) spacing between floors, could produce, because of shrinkage, a continuous opening between each panel and the frame, at both sides and across the top, of 1/20 in. (1.3 mm) or more. The quantity of air flowing through this crack, at 1/10 in. (2.5 mm) water pressure difference,*

---

* The pressure difference of 0.1 in. (2.5 mm) of water was selected for these examples because it is frequently encountered in all types of buildings. Pressure differences in high-rise buildings may be several times greater and the air leakage volumes would increase accordingly.

Steel, unlike concrete, does not develop creep strains. It is a more nearly elastic material in the range of stresses normally imposed on it in building construction. Therefore, its deformations are proportional to the load and are more predictable than for concrete.

For the development of the details used in this and the following discussions, the general approach was adopted that the insulation be placed outward of the structure and its panel walls to take advantage of the increased dimensional stability that results when the temperature variations they experience are minimized. The insulation, placed immediately to the cold side of the air barrier, is protected by a rainscreen on the outside, which shields it from the weathering effects of sun, wind and rain.

A design approach to the foundation wall/ground floor junction is illustrated in Figure 2. The outer face of the concrete block panel wall, placed flush with the foundation wall, supports the air barrier that is formed by the application of a suitably textured mastic. Besides sealing the cracks in the block faces and mortar joints, the mastic may also serve as an adhesive for fixing semi-rigid glass-fibre insulation to the wall. This configuration places the wall and foundation insulation in the same plane, making it easy to form an unbroken cover and thus avoid a thermal bridge at the edge of the floor slab. It also allows the cutting of service chases in the inner face of the block without interrupting the air barrier.

The insulation over the basement wall may be foam plastic or a rigid glass-fibre insulation; the latter would serve the added purpose of providing adequate drainage through the soil to the perimeter tile thus avoiding the cost of hauling in granular material for backfill. If foam plastic insulation is used, it needs to be protected against the effects of ultraviolet radiation and both types of insulation would need protection against mechanical damage at this level, which may be provided by an asbestos-concrete board, or by parging.

The brick rainscreen is supported by a normal-size shelf angle from a wedge insert in the edge of the floor slab, and a spacer fabricated from a hollow rectangular structural section. Adjustment in three directions of the position of the shelf-angle is permitted by a horizontal slot in the shelf angle, a vertical slot in the wedge insert and a selection of sizes of sections for the spacer. This type of support was chosen in preference to an angle with longer legs fastened directly to the edge of the slab mainly because the heavier section required would be much more difficult for the masons to handle. Where steel reinforcement of the masonry wall is required to resist earthquake loads the block and brick wythes must be reinforced and tied together and to the structure.

Windows usually account for large heat losses, because of air leakage through both the window sash and frame and through the space between the frame and the opening in the wall into which it is fitted. Good window design takes care of the first; the second is a construction problem that arises from the common practice of fixing windows by wedging the frame into the opening and securing it to the wall with

The joint beneath the edge of the floor slab at the top of the wall will experience a reversal of movements. With drying shrinkage of the panel-wall, the joint will first of all open fairly uniformly, followed by a closing which will be greatest at mid-span as the panel wall above is being constructed. A further closing, again greatest at mid-span, will occur as creep-shortening of the columns and creep deflections of the edges of the slab continue. Because the combined elastic and creep deflections of the edge of the slab will normally be greater than that due to drying shrinkage of the wall, the total effect of these movements will be to close the joint. Consequently, unless sufficient space is provided, the slab will eventually rest on the top of the wall and begin to transfer loads to it, which could lead to buckling and collapse.

In a high-rise building with identical floor layouts above the first floor or two, the floors and beams are usually of the same structural design because they carry similar loads. Under these conditions the edges of the slabs deflect about the same amount with the result that the vertical distance between floors is likely to be fairly uniform across the span. Only the creep shortening of the columns will be significantly different from storey to storey because the actual amount varies with the level of stress and with the ratio of the area of steel reinforcing to that of the concrete.

Nevertheless there will be some variations in the movements of the slabs and infill walls, therefore the materials used to block these potential air-leakage paths must be sufficiently flexible to accommodate the opening and closing of the joints. In addition, the differential movements between the edge of the slab and top of the panel wall have implications for the details of the brick veneer. Sufficient space, filled with a suitably flexible sealant to exclude the rain, must be provided beneath the structurally supported shelf-angle to avoid transferring compression stresses from the structure to the brick cladding.

Design details in the horizontal section of a column and window jamb are shown in Figure 6. The wall insulation is brought as close to the window frame as the construction will allow, but finishing the window surround with brick means that the wall insulation stops some 5 or 6 in. (128 - 153 mm) away from the jamb. The resultant thermal bridging means that the window jambs will be colder than the head and sill. At the columns, the outer surface of the wall is in the same plane as the column face, simplifying the application of the mastic and insulation blanket. The two joints between the panel walls and the column may be left without mortar, but at the outer face the space should be bridged by a sealant bead of the proper geometry to permit extension of the joints as the wall shrinks, without excessive strain in the sealant material.

In summary, because of the differential movements of the various materials and components of a panel wall structure the joints between them must be sealed to prevent air and moisture leakage through the wall. It is critical to the continued satisfactory and economical performance of a building that such seals and air stops be properly designed, properly installed, and of suitable materials.

METAL STUD WALLS

by R.L. Quirouette

Exterior walls of metal studs and gypsum board are gaining popularity for use as infill walls in frame construction of industrial, commercial and high-rise residential buildings. While many of the practices followed in this type of construction are based on the traditional wood-frame construction, the metal wall as an infill panel for frame structures must be designed and built to resist the lateral loads imposed by wind, must resist rain penetration, and must serve as a member to which thermal insulation is applied.

One of several constructions of this type, introduced in western Canada several years ago, consists of nominal 4 in. (100 mm) metal studs faced on both sides with gypsum board, with an additional covering of light metal on the outside to provide protection from the weather. A polyethylene vapour barrier incorporated in the wall serves as an air barrier, and special attention is given to the sealing of joints at the floor, ceiling and interior partition wall intersections to produce a relatively airtight assembly. This construction, however, suffers from poor thermal performance because of the high conductivity of the metal studs and the horizontal channel sections supporting them. The result, in addition to heat loss, is dust marking and the possibility of condensation on the interior surface of the wall.

Measurements[1] of the surface temperature of metal stud walls have confirmed that the temperature over the framing members is substantially lower than elsewhere on the interior surface under cold outside conditions. Low surface temperature was also noted in the vicinity of electrical outlet boxes. Open joints between the concrete panels that clad this particular stud wall appeared to affect its thermal performance by allowing the air to circulate in the cavity between the panels and the stud wall.

The problem of high heat loss through the concrete floor slabs that are projected through walls to serve as balconies is not solved by metal stud construction, but in the absence of balconies the construction can permit the thermal protection of the edge of floor slabs. This may be done by cantilevering outward the metal framework beyond the edge of the slab to allow the insertion of rigid insulation between the frame and the slab's edge.

Thermal bridging at the slab edge is a major problem when precast concrete cladding is used with a metal-stud wall infill panel because the heavy weight of the cladding requires substantial support, which is usually obtained by using the floor slab as a direct shoulder. Accordingly there is no means to reduce the heat transfer through this portion of the wall, although detailing for air tightness is relatively easy.

In the detail shown in Figure 15 a hollow structural section is used to frame the window opening, while the remainder of the infill wall is built with metal studs and channel sections. A flexible flashing installed over the lintel supporting the masonry serves as a soffit closure to screen the insulation.

A plan section at a column and window is shown in Figure 16, in which the line of air resistance is brought inward to the inner face of the window where a suitable gasket and sealant is applied.

A means of applying exterior sheathing at the roof/wall junction of a steel frame building is shown in Figure 17. Short studs with sliding joints are used to handle deflection of the spandrel beam, while a flexible membrane secured at the exterior sheathing accommodates any differential movements, thus maintaining the joint airtight at the location.

In conclusion, the detailing of exterior steel-stud wall design must be closely coordinated with the structural design. Where possible and practicable steel-stud exterior walls should be insulated on the outside surface. The air barrier should be applied on the outside of the steel stud but on the warm side of the insulation to provide a service space for electrical and other mechanical services that will not break the air barrier. As with any other assembly, air barriers require control joints of good quality to ensure that they will work properly and have a long service life.

Reference

[1] Sasaki, J.R. Thermal performance of steel-stud exterior walls. National Research Council of Canada, Division of Building Research, BR Note No. 77, Ottawa, August 1971.

WALL/ROOF JUNCTIONS AND SOFFITS

by R.G. Turenne

Efflorescence on masonry walls at roof level and damage to brick parapets from freeze-thaw action, due to excessive dampness, may result from moisture-laden air escaping from buildings because of chimney effect and wind action. Such air leakage results from a failure to make the walls and wall/roof junction airtight. Although these problems generally appear when the air is highly humid, any air leakage contributes to the total energy cost of operating a building.

While stack effect is a dominating force behind air leakage in high-rise buildings, wind action, which creates relatively high suction forces along the windward eaves, can be a major source of air leakage in low buildings. In both cases large quantities of air are drawn from inside the building unless the wall/roof junction is made airtight. Suction forces created by the wind vary with its speed, and they affect different areas of the building depending on the wind's direction.

A wind speed of 20 mph (32 km/h) exerts a velocity pressure of 0.20 in. (5 mm) of water, but the stagnant pressure acting on the walls of a building is usually less than the velocity pressure. Along the eave on the windward side, however, local suctions are created that are two to three times greater than the velocity pressure of the wind. This means that a crack 1/16 in. (1.6 mm) in width at the wall/roof junction can allow air to exfiltrate at a rate from 5.5 to 8.0 cfm (0.15 to 0.23 m^3/min) per foot (0.3 m) of crack from a 20 mph (32 km/h) wind, depending on its direction, the height of parapet, etc.

It is often said that up to 85 per cent of all roofing problems originate along the roof edges and other discontinuities of the membrane where water infiltration can saturate the insulation and find its way into the building. The lack of success in making buildings both air and watertight in these locations suggests that the quality of building enclosures should be improved by modifying the design of the wall/roof junction and other problem areas.

In the design of a building enclosure, a water vapour retardant is usually called for in the wall, but as shown in Figure 18, it may or may not extend to the roof deck, and it or some other component may perform the role of air barrier. A roofing membrane, whether conventional or inverted, is mandatory but seldom extends to the edge of the roof. Instead it is turned up a cant strip and bituminous flashings are installed on the inside face of the parapet wall. The result is that a hole is left in the building envelope which allows moist air to escape, and water vapour to condense within the wall and parapet.

A solution to this problem might consist of extending the roofing membrane to the edge of the roof where it is turned downward to overlap the air and vapour stop of the wall (as shown in Figure 19). This

The details shown in Figure 20 have been modified in Figure 11 to improve air tightness and structural performance. The changes involve

(1) leaving a gap between the top of the concrete block wall and the spandrel so that the beam can deflect freely under its superimposed load and not transfer the load to the wall. The top of the wall is supported laterally if required by clip angles welded or bolted to the bottom flange of the beam.

(2) the steel beam is faced with drywall;

(3) a continuous strip of flexible membrane is installed along the edge of the steel deck, overlapping the drywall on one side and the roofing vapor retardant on the other;

(4) a continuous strip of flexible membrane is installed so as to seal the gap between the drywall and the block wall;

(5) the vapor retardant of the conventional roof is turned up the inside face of the insulation stop to act as a water stop and the membrane can be nailed along its edge to the insulation stop prior to the installation of the cant strips;

(6) the roofing is completed with the installation of bituminous flashings and metal counterflashings.

Placing the steel frame inside the masonry wall line, as shown in Figure 21, does not necessarily guarantee a successful design since the detail as shown does not attempt to incorporate an effective air seal at the wall/roof junction nor does it concern itself with the differential movement that is likely to occur between the steel structure and the masonry wall. Some of the deficiencies of the design shown in Figure 21 can be overcome by the arrangement shown in Figure 22 where

(1) steel joists are kept clear of the masonry wall so that the beam can deflect freely;

(2) the insulation and air barrier are moved outside the concrete blocks;

(3) the roof's vapor retardant is joined to the wall air stop by means of a strip of flexible membrane material which is supported by a sheet metal closure supplied and installed by the steel deck contractor.

The masonry bearing wall shown in Figure 23 provides an easy solution to the problem of achieving air tightness at the wall/roof junction, obtained by installing a strip of flexible material at that location. In this design, too, differential movements between structure and wall are not a matter of concern.

It may be preferable to build the canopy as a separate structure, but this may create problems of its own, such as drainage and the need to provide an independent supporting structure, but the benefits may well offset the disadvantages. If, however, the canopy is attached to the main structure, although the deck itself is not continuous, a large number of holes may have to be cut through the wall for the support of the canopy, in which case every hole must be sealed to restore the air barrier, as installing a soffit may conceal the holes but will do little more.

Insulated soffits can be a source of air infiltration in buildings unless a proper air stop is installed. An insulated metal soffit extending over an entrance is shown in Figure 27. The wall at ground level, built of steel studs faced both sides with drywall, has its inside sheet of drywall extended to the suspended ceiling, while the exterior sheet stops at the soffit. The wall is insulated with batts, which are extended over the inside face of the horizontal metal siding, and are covered by a sheet of polyethylene. It is obviously difficult to assemble an airtight barrier under such conditions since the polyethylene sheet has to be perforated by the metal braces supporting the soffit framing. Thus outside air is capable of flowing freely through the insulation and polyethylene film under stack or wind effect, reducing the thermal efficiency of the insulation.

A better solution to the soffit problem from the point of view of air tightness might consist in extending the exterior sheet of drywall along the outside face of the canopy framing (metal studs in this case); the friction fit insulation and polyethylene vapour retardant could be installed as before. Air movement between the exterior and interior of the building is prevented by the drywall, improving the efficiency of the insulation. This solution, however, raises the possibility of warm moist air, transported by convection through openings in the polyethylene vapour retardant, coming in contact with cold drywall; condensation may then form on the inside face of the drywall and be absorbed by the gypsum, causing it to deteriorate.

A superior solution to the above canopy problem is shown in Figure 28 where the vapour retardant and the insulation are placed on the outside of the drywall, thus properly controlling air, vapour and heat flows through the assembly.

In conclusion, air tightness is difficult to achieve at a wall/roof junction unless it is carefully considered in the design of the wall, the structure and the roof deck or slab. It is at the wall/roof junction that cracks and openings frequently form as a result of the differential movements of materials and components, thus requiring the use of adequately flexible air and vapour barriers. An additional problem in achieving air tightness arises because the wall/roof construction usually proceeds in stages and involves various trades, each of which contributes to its success or failure. The potential for air movement through stack effect and wind action is always present in buildings; only good design can hold in check the driving force for air leakage.

LEGEND

1 Asbestos-Cement Board
2 Brick
3 Concrete Block
4 Concrete Block Lintel
5 Concrete Column
6 Concrete Curb
7 Concrete Foundation Wall
8 Concrete Slab
9 Aluminum Sill
10 Dovetail Anchor
11 Flashing
12 Furring Channel
13 Hollow Metal Frame
14 Metal Anchor
15 Steel Deck
16 Metal Counter Flashing
17 Metal Siding
18 Metal Sheet
19 Sheet Steel Closure
20 Metal Stud
21 Metal Tie
22 Metal Up-Stand
23 Metal Z Bar
24 Nesting Channels
25 Shelf Angle
26 Sill
27 Soffit Closure
28 Spacer
29 Spandrel Beam
30 Steel Column
31 Open-Web Steel Joist
32 Wedge Insert
33 Batt Insulation
34 Rigid Insulation
35 Semi-Rigid Insulation
36 Bituminous Flashing
37 Flexible Membrane Flashing
38 Window Frame
39 Caulking
40 Compressible Mastic
41 Foam Plastic Rope
42 Built-Up Roofing Membrane
43 Air-Vapour Barrier
44 Gypsum Board
45 Plywood
46 Gravel
47 Wood Frame or Brick
48 Wall Cladding
49 Sealed Double-Glazed Window
50 Clip Angle

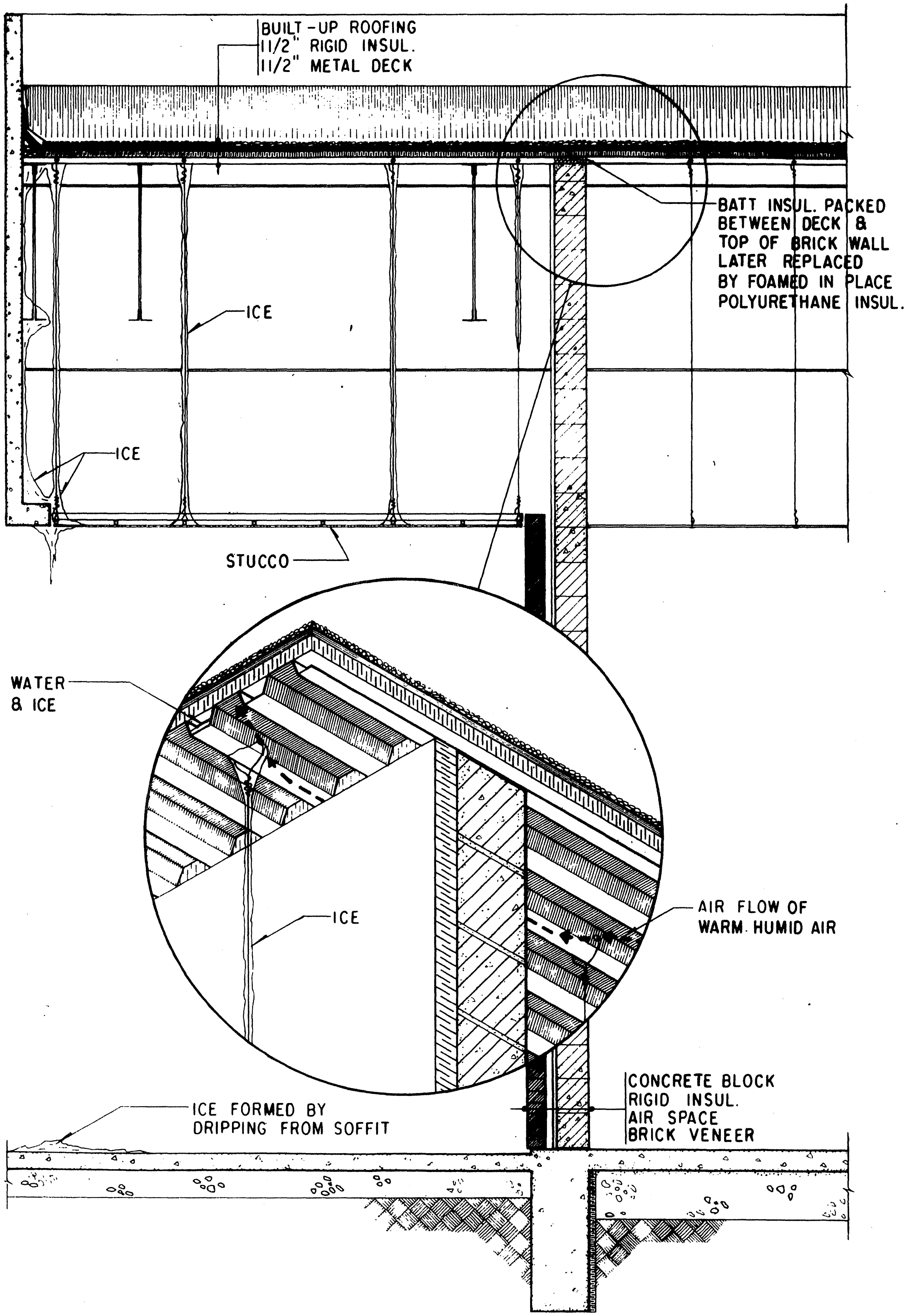
BUILT-UP ROOFING
11/2" RIGID INSUL.
11/2" METAL DECK
BATT INSUL. PACKED BETWEEN DECK & TOP OF BRICK WALL LATER REPLACED BY FOAMED IN PLACE POLYURETHANE INSUL.
ICE
ICE
STUCCO
WATER & ICE
ICE
AIR FLOW OF WARM HUMID AIR
CONCRETE BLOCK
RIGID INSUL.
AIR SPACE
BRICK VENEER
ICE FORMED BY DRIPPING FROM SOFFIT

FIGURE 1

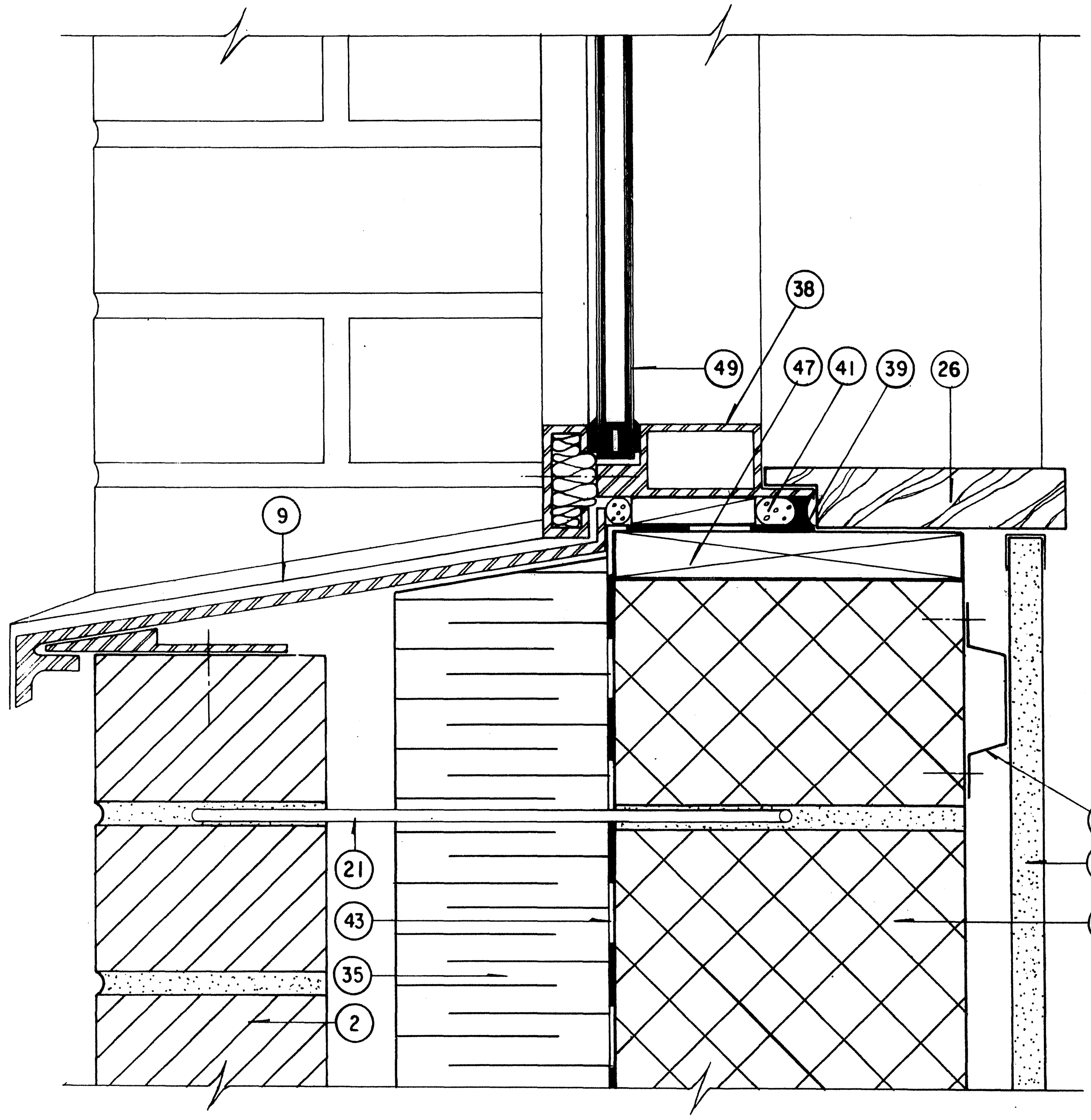

FIGURE 3

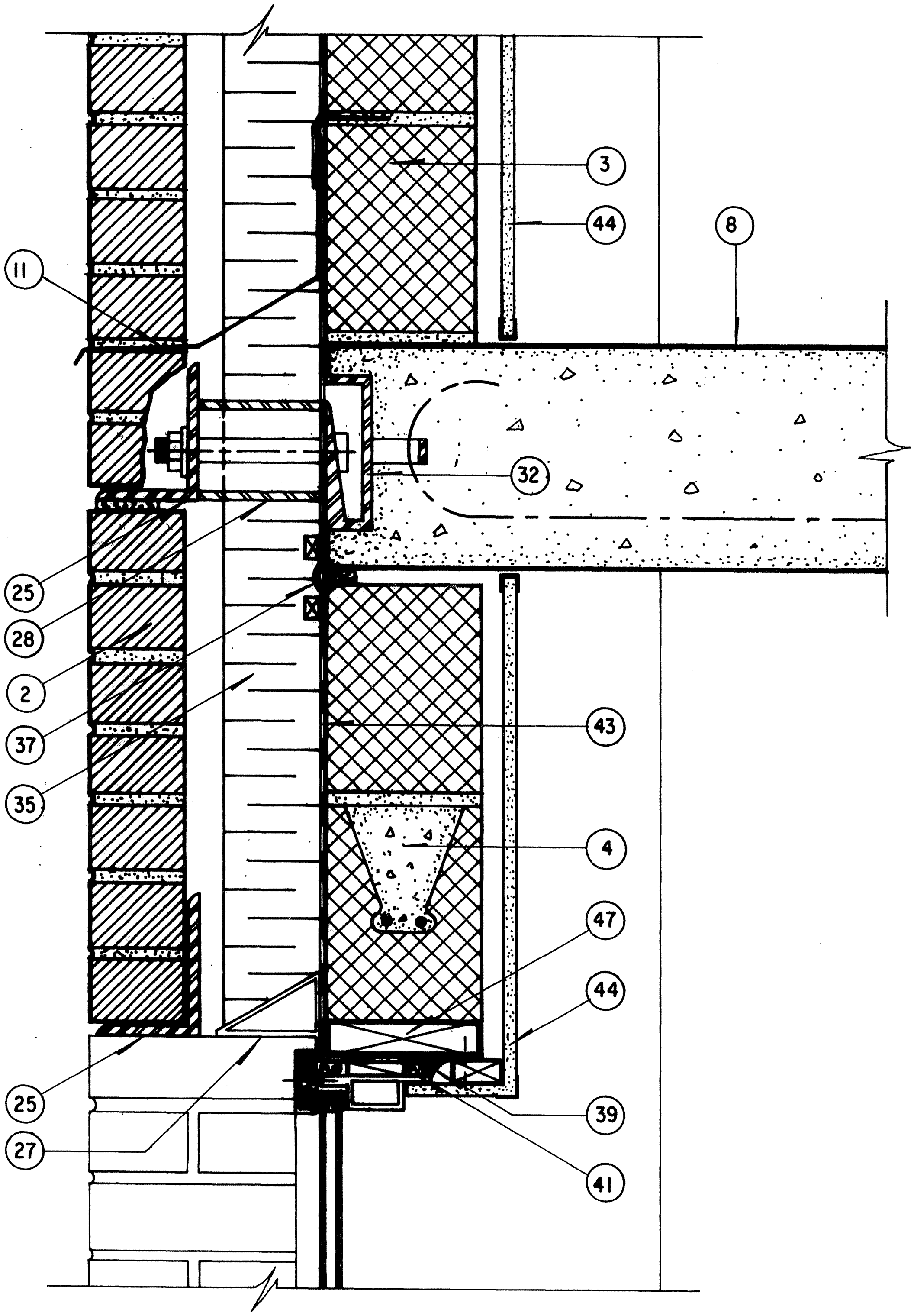

FIGURE 5

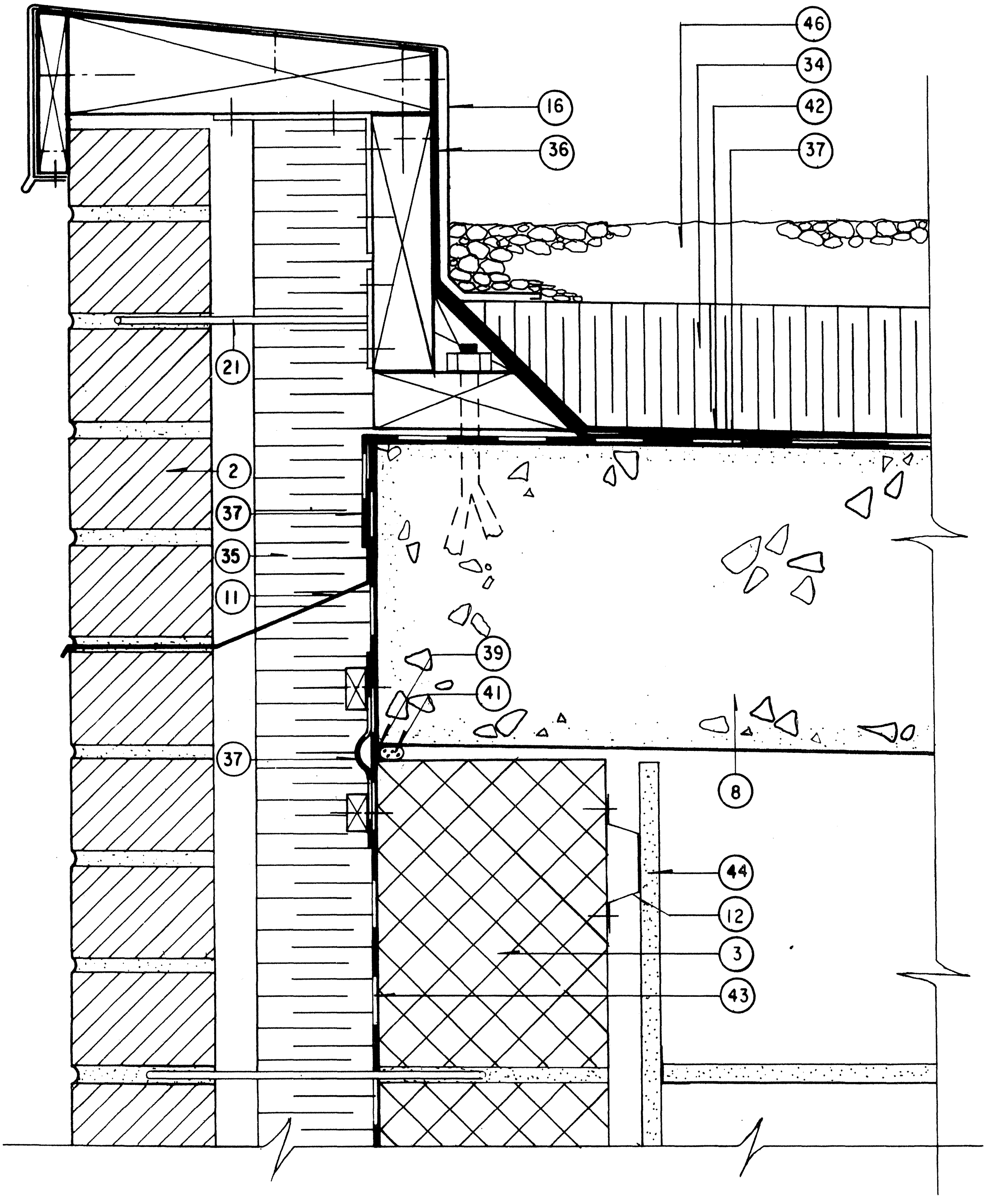

FIGURE 7

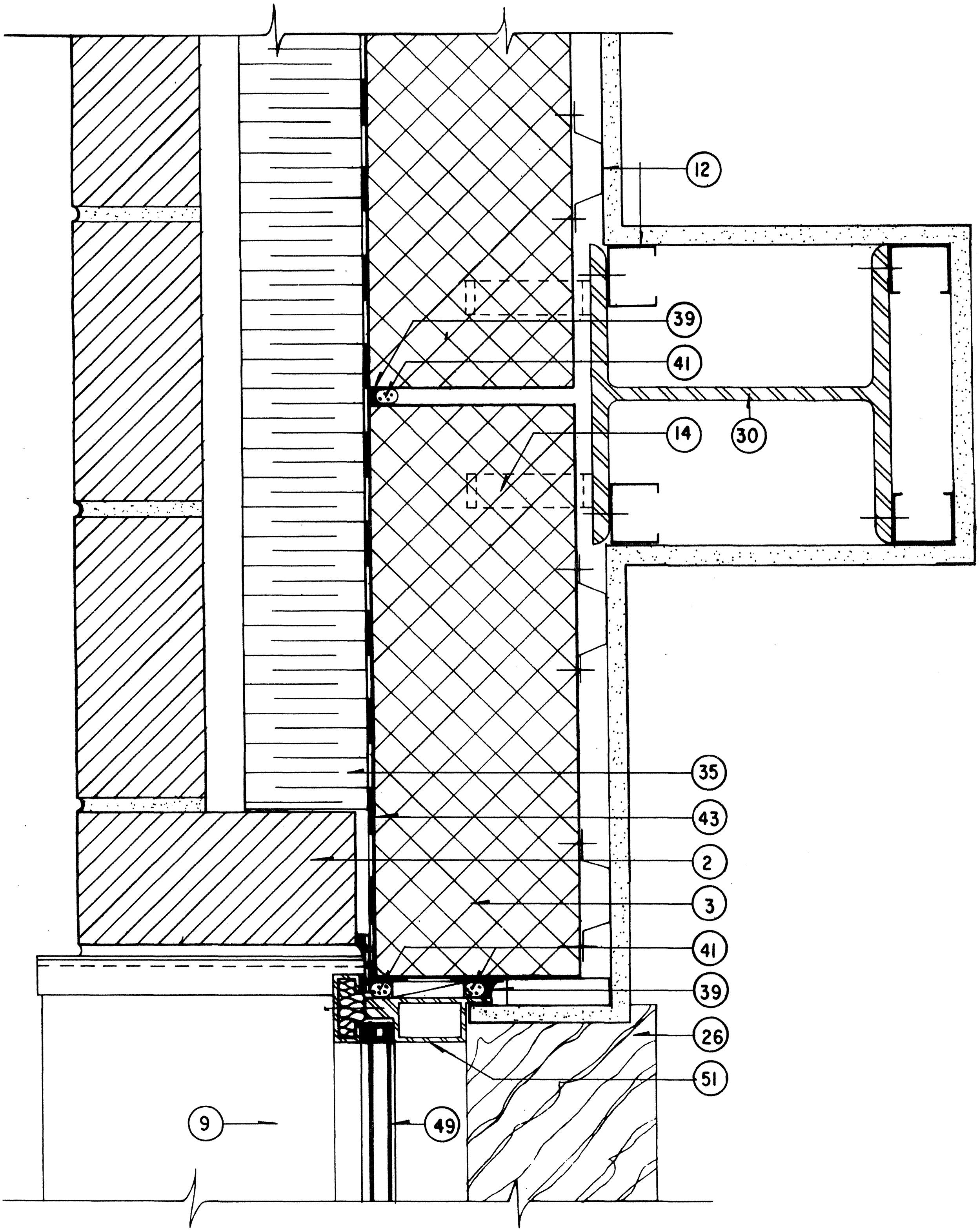

FIGURE 9

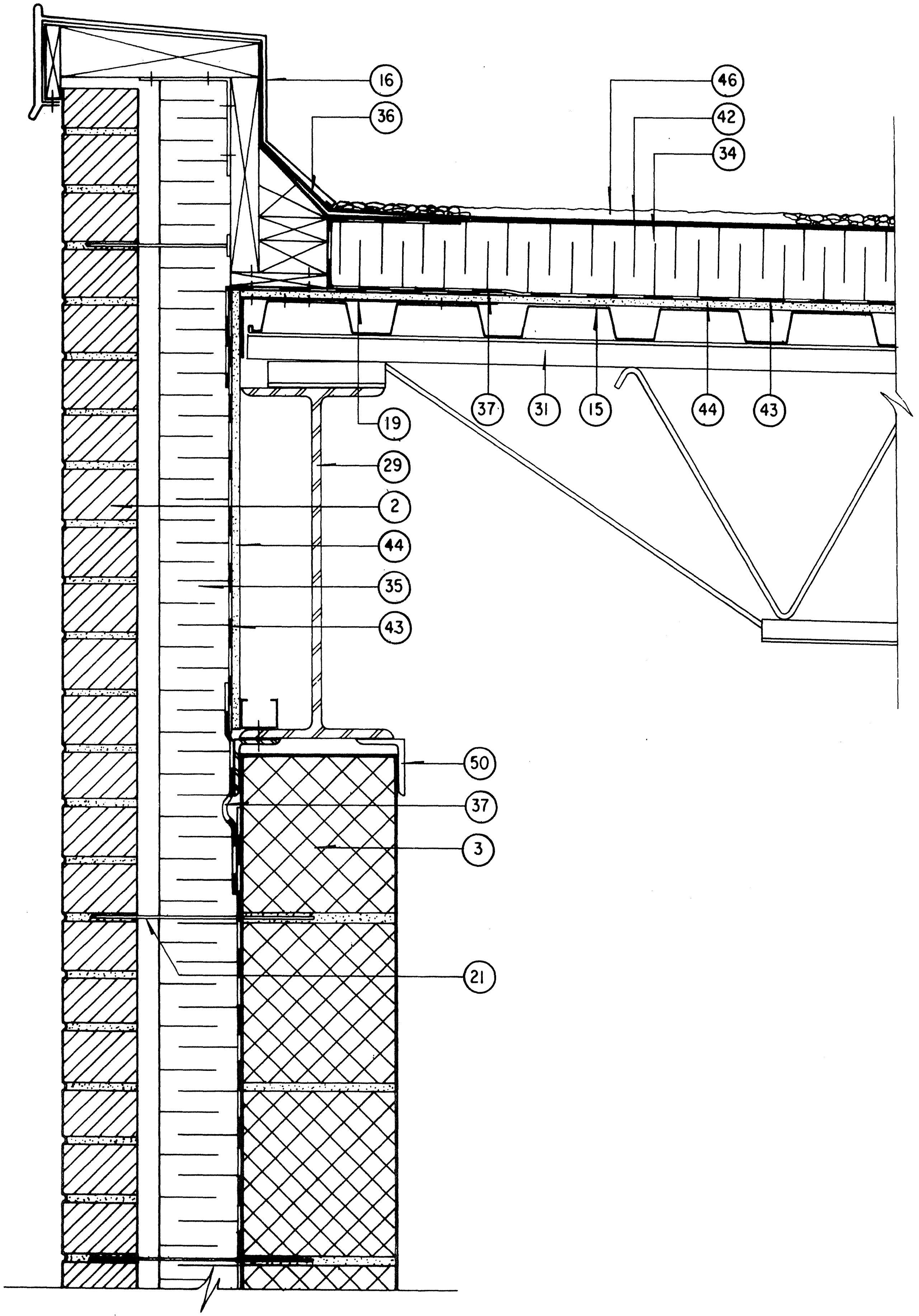

FIGURE 11

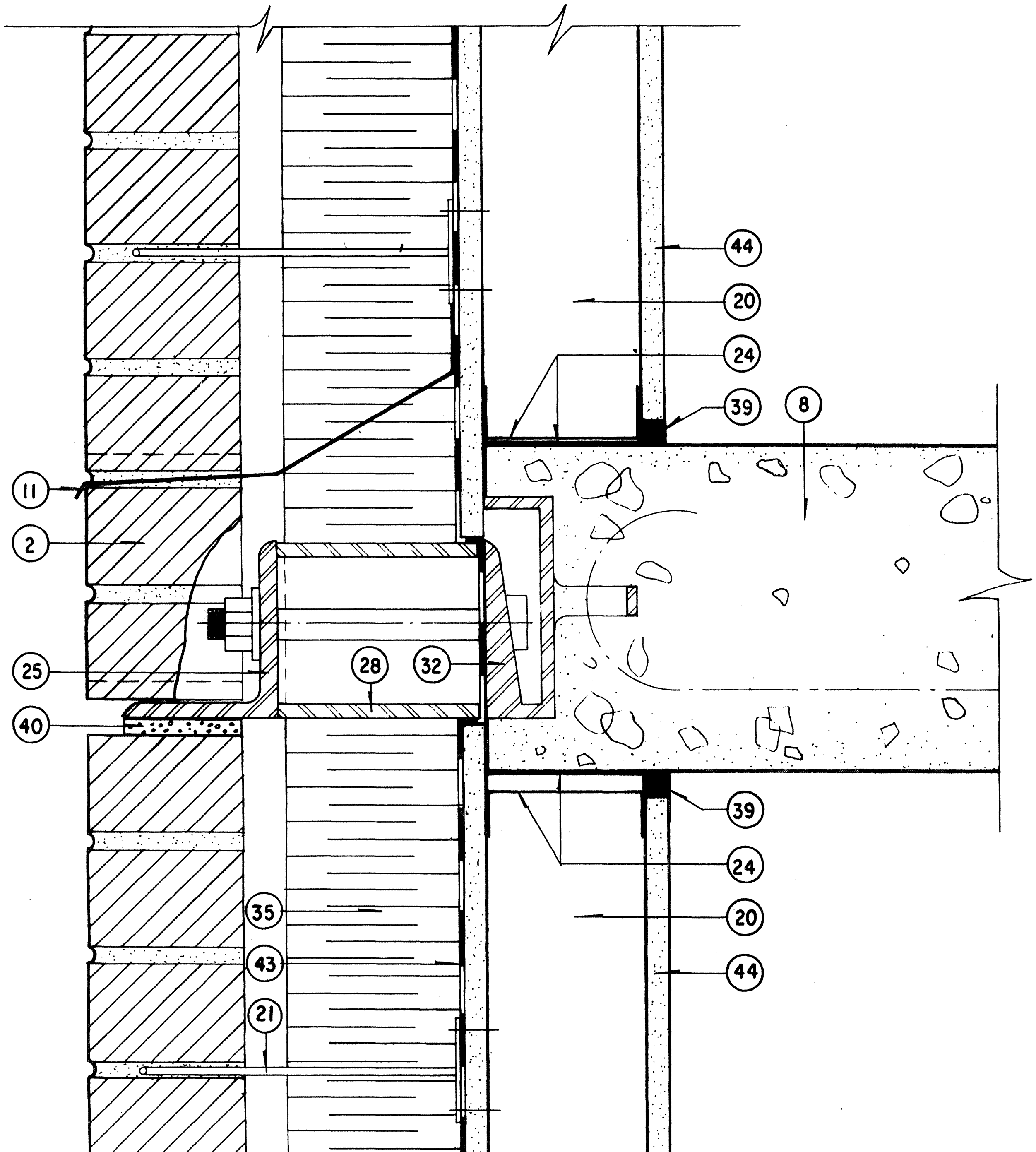

FIGURE 13

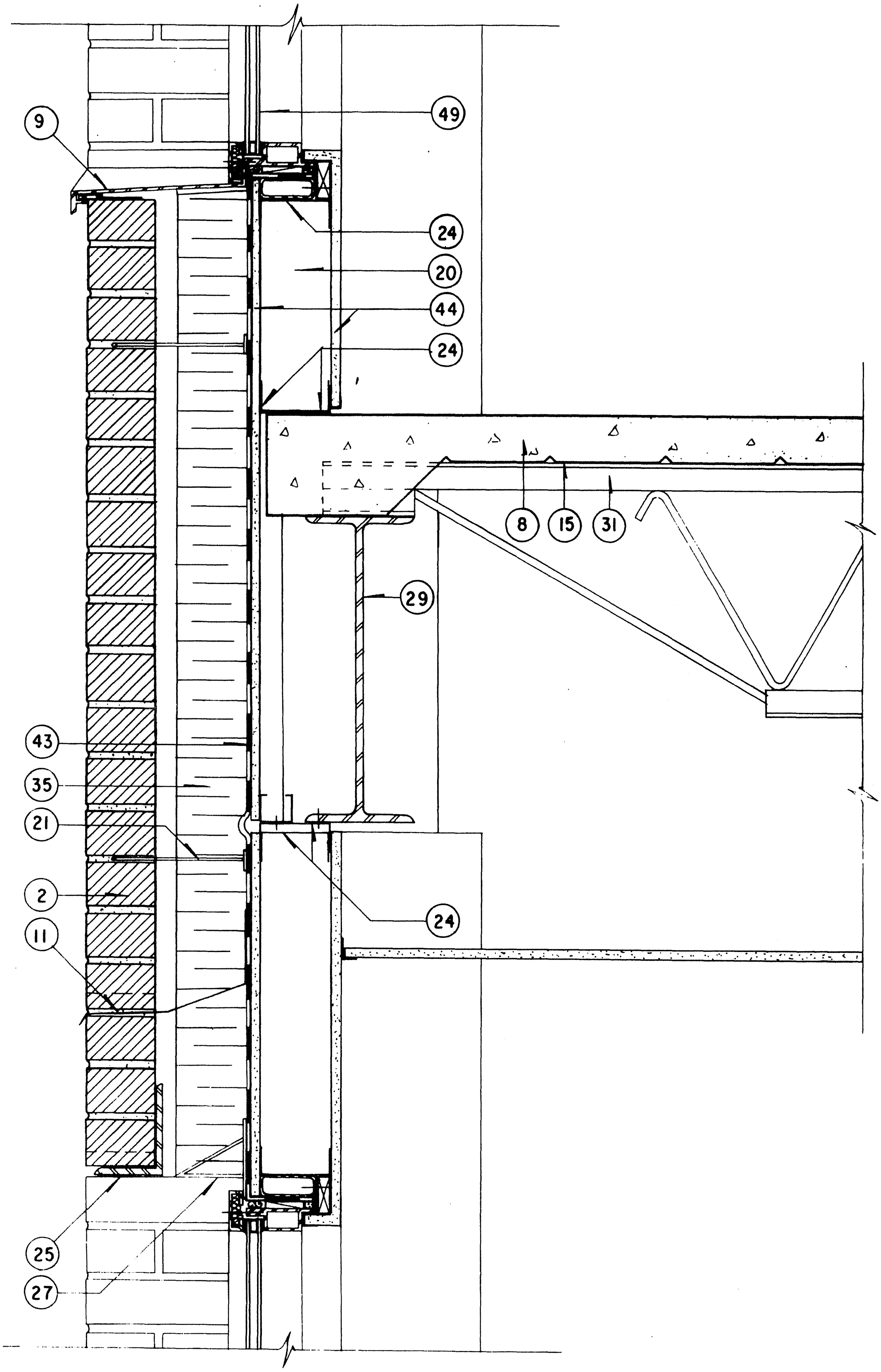

FIGURE 15

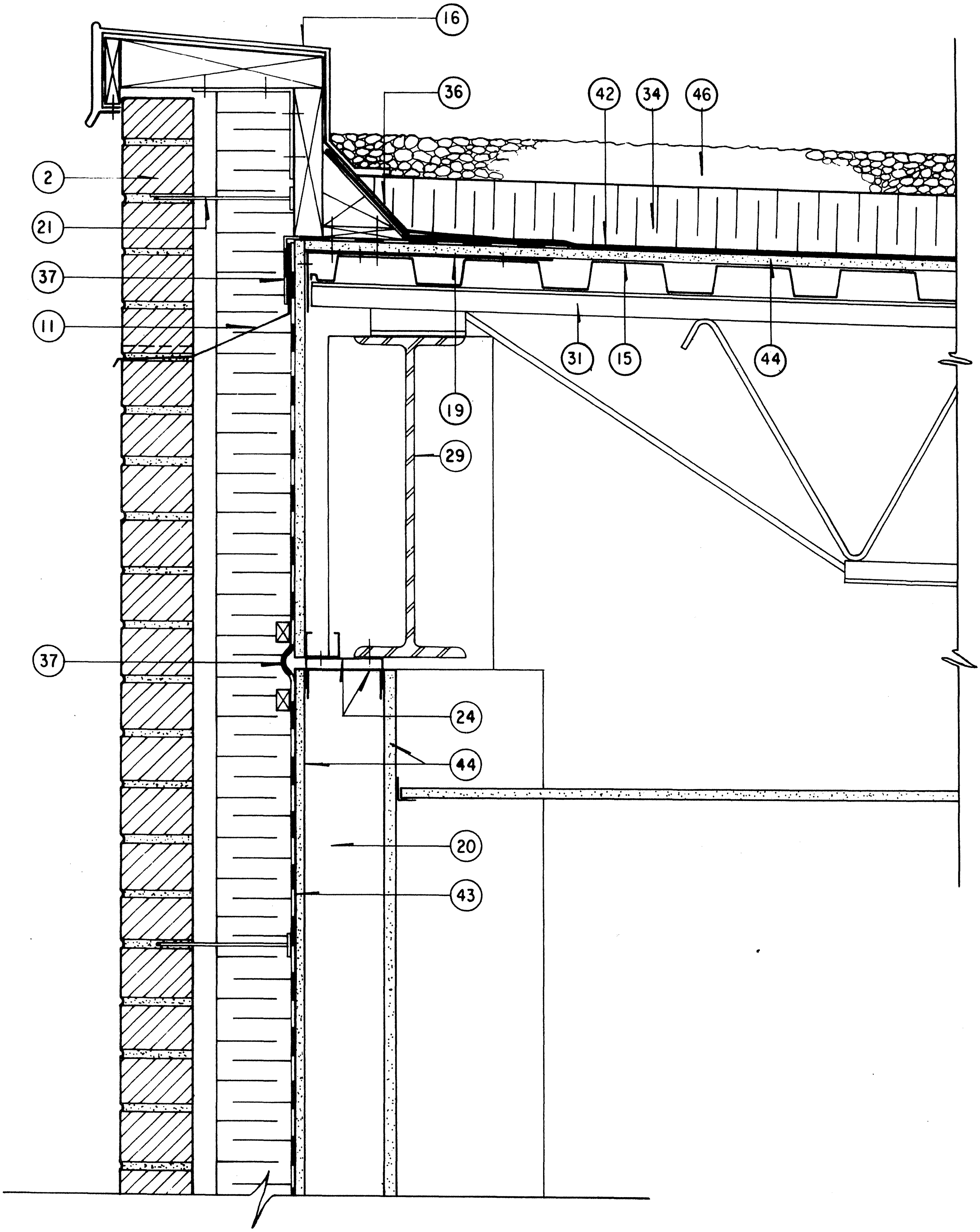

FIGURE 17

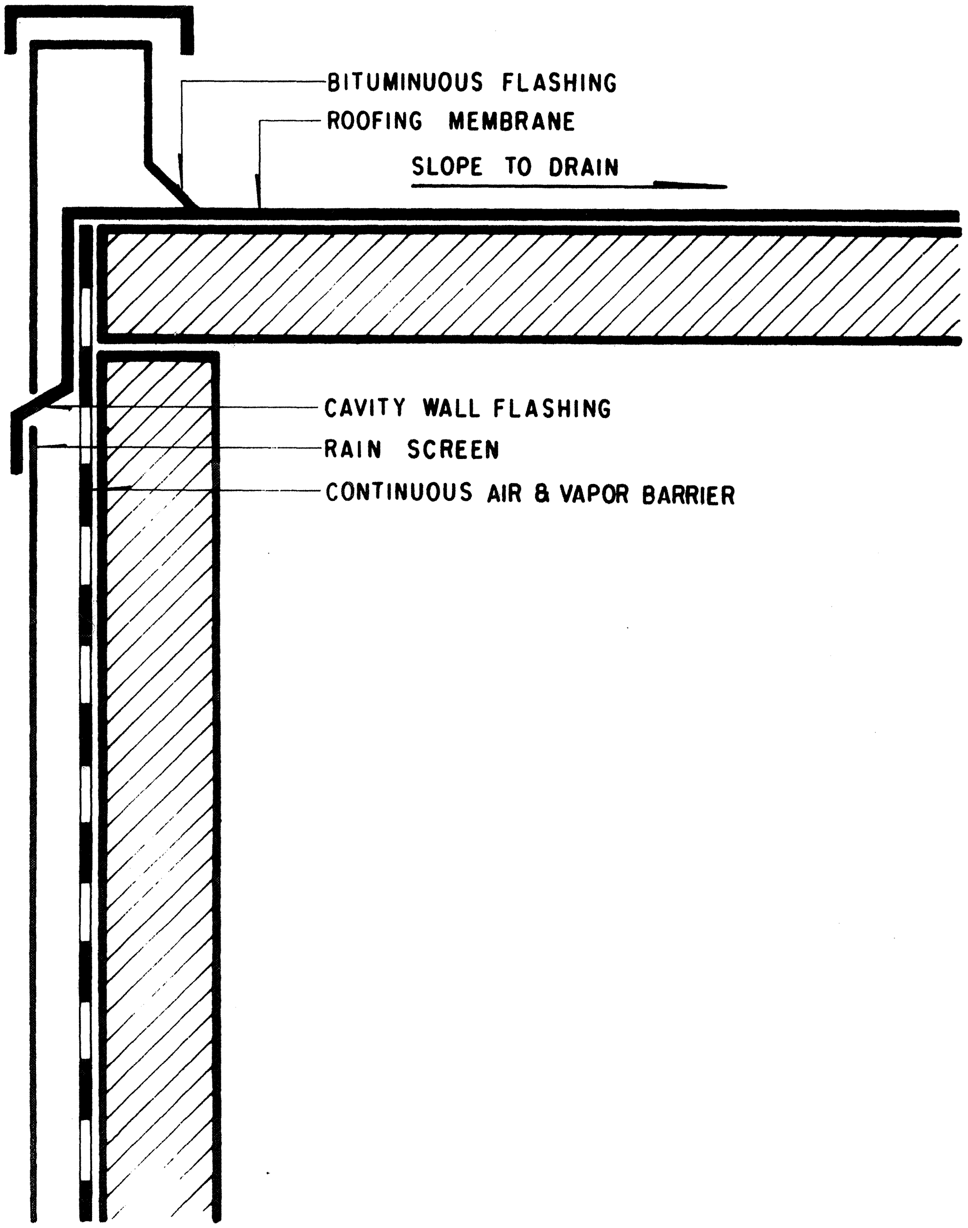
BITUMINUOUS FLASHING
ROOFING MEMBRANE
SLOPE TO DRAIN
CAVITY WALL FLASHING
RAIN SCREEN
CONTINUOUS AIR & VAPOR BARRIER

FIGURE 19

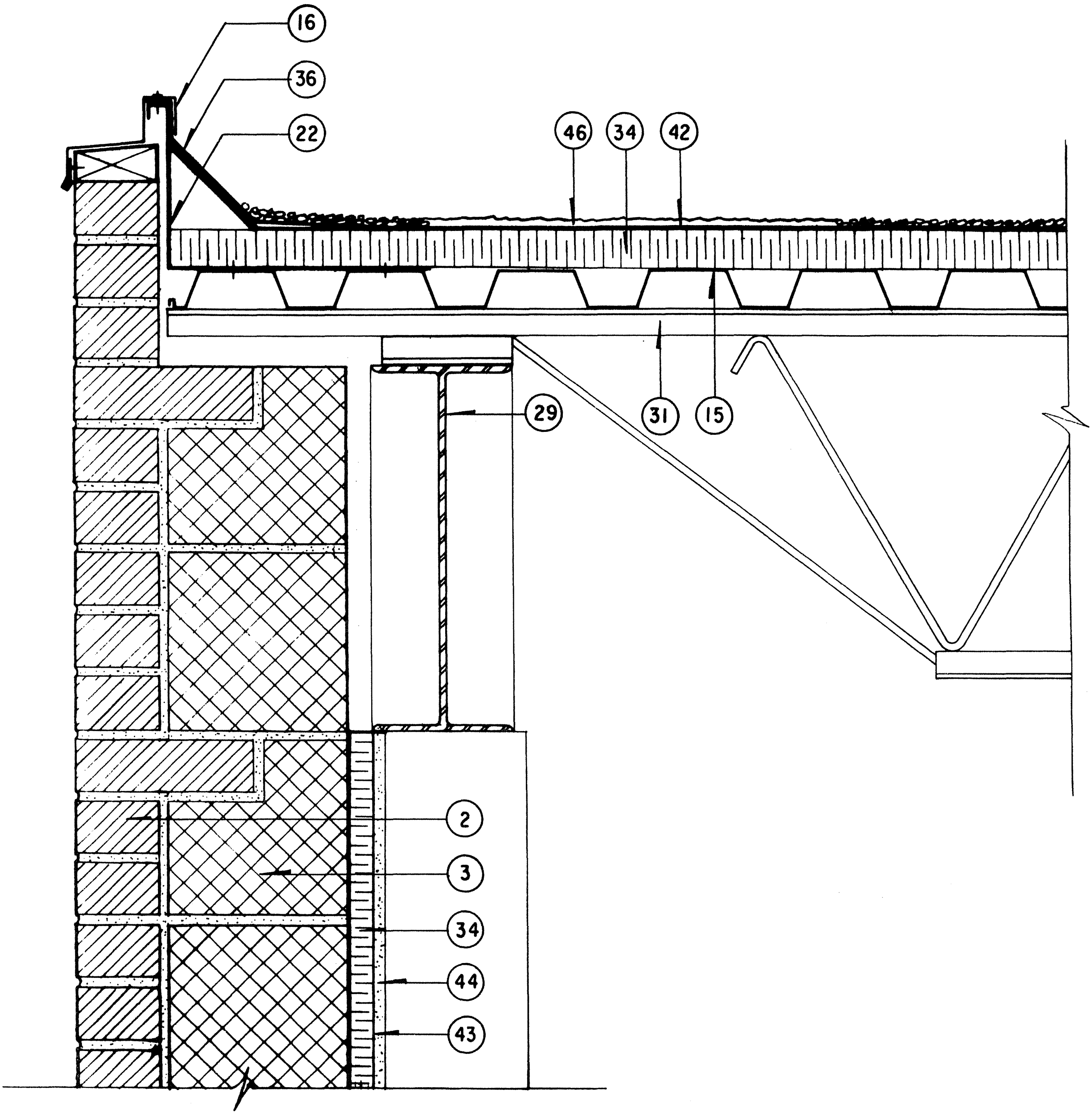

FIGURE 21

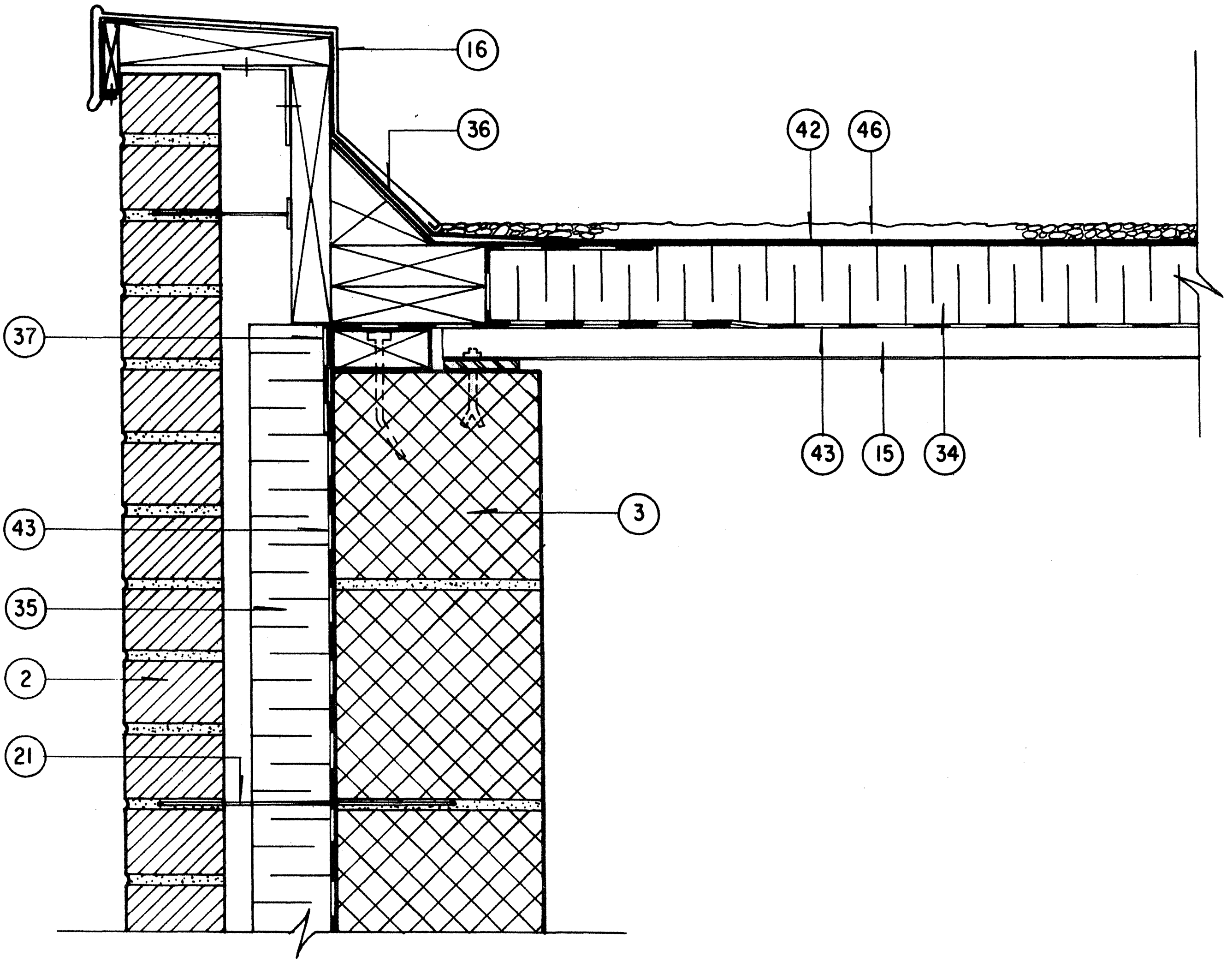

FIGURE 23

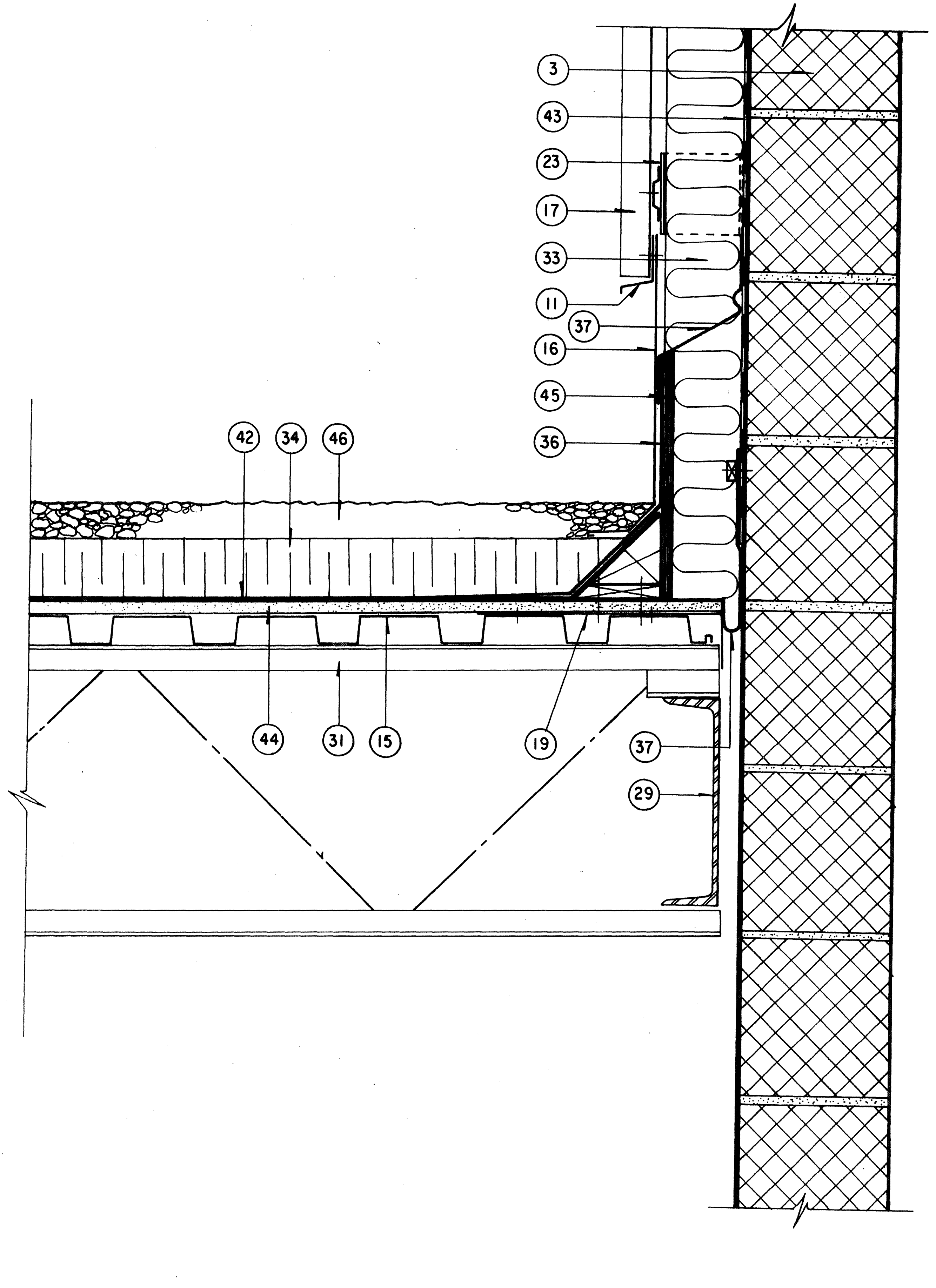

FIGURE 25

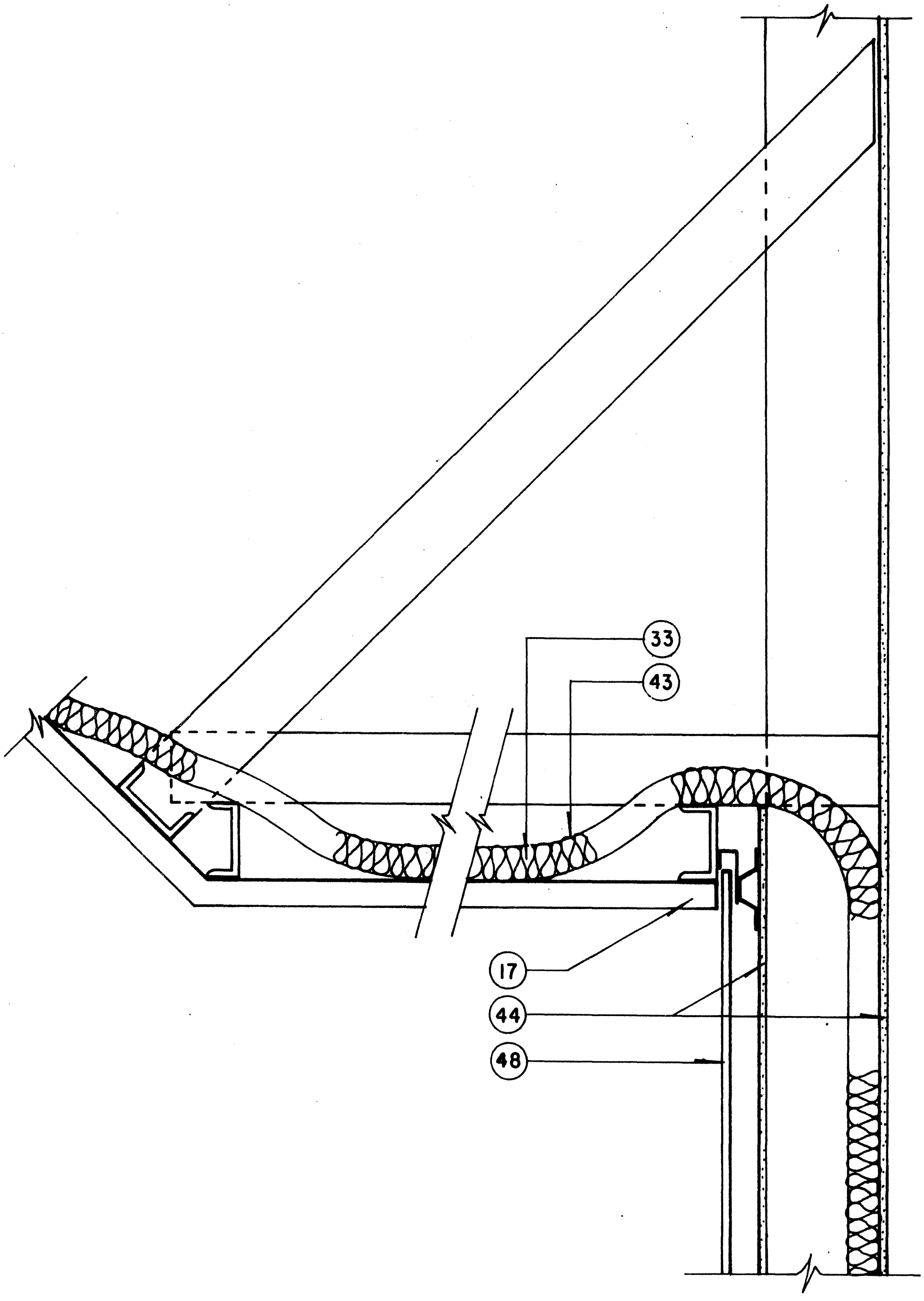

FIGURE 27