Designation: C 898 – 95

# Standard Guide for Use of High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Separate Wearing Course[1]

This standard is issued under the fixed designation C 898; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide describes the use of a high solids content, cold liquid-applied elastomeric waterproofing membrane in a waterproofing system subject to hydrostatic pressure for building decks over occupied space where the membrane is covered with a separate protective wearing course.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[2]

C 717 Terminology of Building Seals and Sealants[3]

C 755 Practice for Selection of Vapor Retarders for Thermal Insulations[4]

C 836 Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course[3]

C 920 Specification for Elastomeric Joint Sealants[3]

C 962 Guide for Use of Elastomeric Joint Sealants[5]

D 1056 Specification for Flexible Cellular Materialsù-Sponge or Expanded Rubber[6]

D 1751 Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)[7]

D 1752 Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction[7]

D 3253 Specification for Vulcanized Rubber Sheeting for Pond, Canal, and Reservoir Lining[8]

2.2 *American Concrete Institute Standard:*

301-72 (1975) Specifications for Structural Concrete for Buildings[9]

## 3. Terminology

3.1 Refer to Terminology C 717 for definitions of the following terms used in this guide: bond breaker; cellular; cold joint; compatibility; compound; construction joint; control joint; creep; dry film thickness; elastomer; expansion joint; gasket; isolation joint; joint; laitance; primer; reglet; reinforced joint; sealant; spalling; waterproofing.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cold-applied*—capable of being applied without heating as contrasted to hot-applied. Cold-applied products are furnished in a liquid state, whereas hot-applied products are furnished as solids that must be heated to liquefy them.

3.2.2 *curing time*—the period between application and the time when the material reaches its design physical properties.

3.2.3 *deflection*—the deviation of a structural element from its original shape or plane due to physical loading, temperature gradients, or rotation of its supports.

3.2.4 *drainage board—see prefabricated drainage composite*, the preferred term.

3.2.5 *drainage course*—see *percolation layer* and Fig. 1.

3.2.6 *finish wearing surface*—see *traffic surface*.

3.2.7 *flashing*—a generic term describing the transitional area between the waterproofing membrane and surfaces above the wearing surface of the building deck; a terminal closure or barrier to prevent ingress of water into the system.

3.2.8 *floated finish*—a concrete finish provided by consolidating and leveling the concrete with only a power driver or hand float, or both. A floated finish is coarser than a troweled finish. For specifications, see ACI 301-72 (1975).

3.2.9 *freeze-thaw cycle*—the freezing and subsequent thawing of a material.

[1] This guide is under the jurisdiction of ASTM Committee C-24 on Building Seals and Sealants and is the direct responsibility of Subcommittee C24.80 on Building Deck Waterproofing Systems.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.07.

[4] *Annual Book of ASTM Standards*, Vol 04.06.

[5] Discontinued. See 1992 *Annual Book of ASTM Standards*, Vol 04.07. Replaced by C 1193.

[6] *Annual Book of ASTM Standards*, Vol 08.01.

[7] *Annual Book of ASTM Standards*, Vol 04.03.

[8] Discontinued. See 1988 *Annual Book of ASTM Standards*, Vol 04.09.

[9] Available from American Concrete Institute, P.O. Box 19150 Redford Station, Detroit, MI 48219.

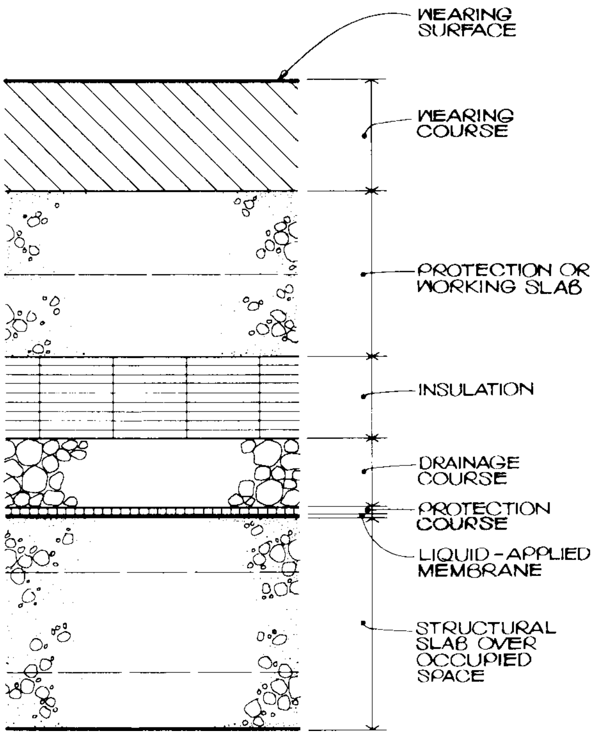


**FIG. 1 Basic Components of Cold Liquid-Applied Elastomeric Membrane Waterproofing System with Separate Wearing Course**

3.2.10 *grout*—concrete containing no coarse aggregates; a thin mortar.

3.2.11 *percolation layer (drainage course)*—a layer of washed gravel or of a manufactured drainage media that allows water to filter through to the drain (see Fig. 1).

3.2.12 *prefabricated drainage composite*—proprietary devices to facilitate drainage, usually a composite laminate of more than one material including filter fabric.

3.2.13 *protection board*—see *protection course*.

3.2.14 *protection course*—semi-rigid sheet material placed on top of the waterproofing membrane to protect it against damage during subsequent construction and to provide a protective barrier against compressive and shearing forces induced by materials placed above it (see Fig. 1).

3.2.15 *structural slab*—a horizontal, supporting, cast-in-place, concrete building deck. See Fig. 1.

3.2.16 *traffic surface*—a surface exposed to traffic, either pedestrian or vehicular, also described as finish wearing surface.

3.2.17 *troweled finish*—a concrete finish provided by smoothing the surface with power driven or hand trowels or both, after the float finishing operation. A troweled finish is smoother than the floated finish. For specifications, see ACI 301-72 (1975).

3.2.18 *wearing surface*—see *traffic surface*.

3.2.19 *wet-film thickness*—the thickness of a liquid coating as it is applied.

3.2.20 *wet-film gage*—a gage for measuring the thickness of a wet film.

## 4. Significance and Use

4.1 This guide provides design considerations for the design of the waterproofing system as well as guide specifications. The intent of Sections 5-14 is to provide information and guidelines for consideration of the designer of the waterproofing system. The intent of the remaining sections is to provide minimum guide specifications for the use of purchaser and seller in contract documents. Where the state of the art is such that criteria for a particular condition is not as yet firmly established or has numerous variables that require consideration, reference is made to the applicable portion of Sections 5-14 that covers the particular area of concern.

## DESIGN CONSIDERATIONS

## 5. General

5.1 *Major Components, Subsystems, and Features*—The major components to be considered for a building deck waterproofing system are the structural building deck or substrate to be waterproofed, waterproofing membrane, protection of the membrane, drainage, insulation, and wearing course (see Fig. 1). Additional features to be considered are membrane terminal conditions and expansion joints.

5.2 *Compatibility*—It is essential that all components and contiguous elements be compatible and coordinated to form a totally integrated waterproofing system.

## 6. Substrate

6.1 *General*—The building deck or substrate referred to in this guide is reinforced cast-in-place structural concrete. Precast concrete slabs pose more technical problems than cast-in-place concrete, and the probability of lasting watertightness is greatly diminished and difficult to achieve because of the multitude of joints which have the capability of movement and must be treated accordingly. Moving joints are critical features of waterproofing systems and are more critical when sealed at the membrane level than at a higher level with the use of integral concrete curbs. Such curbs are impractical with precast concrete slabs and necessitate an even more impractical drain in each slab. Other disadvantages of precast concrete slabs are their inflexibility in achieving contoured slope to drains and the difficulty of coordinating the placement of such drains.

6.2 *Strength*—The strength of concrete is a factor to be considered with respect to the liquid-applied membrane insofar as it relates to finish, bond strength, and continuing integrity (absence of cracks and other defects that could affect the integrity of the membrane after installation).

6.3 *Density and Moisture Content*—Density of concrete and moisture content when cured are interrelated and can affect adhesion of the membrane to the substrate with an excessively high moisture content, moisture may condense at the membrane and concrete interface and cause membrane delamination. This is particularly so if the top surface is cooler than the concrete below. Lower moisture contents are achieved with the use of hard, dense, stone aggregate. This type of coarse aggregate will generally provide structural concrete with a moisture content from 3 to 5 % when cured. Lightweight aggregate, such as expanded shale, will generally provide lightweight structural concrete with a moisture content from 5 to 20 % when cured. Lightweight insulating concrete made with a weaker expanded aggregate, such as perlite, has a relatively low compressive strength and can contain over 20 % moisture when cured. The concrete used for the substrate should have a minimum density of 1762 kg/$m^3$ (110 lb/$ft^3$) and have a maximum moisture content of 8 % when cured. From this it can be seen that only certain lightweight aggregates can be considered for use and no lightweight insulating aggregates can be used.

6.4 *Admixtures, Additives, and Cement/Concrete Modifiers*—Admixtures, additives, and modifiers serve many functions in mixing, forming, and curing concrete, such as to retard or accelerate the cure rate; reduce the water content required; entrain air; increase strength; create or improve the ability of the concrete to bond to existing, cured concrete; permit thin topping overlayers; and improve workability. Some admixtures and modifiers (particularly polymeric, latex, or other organic chemical based materials) may coat the concrete particles and reduce the ability of the waterproofing membrane to bond to the concrete. The membrane manufacturer should be consulted if the concrete used for the deck will contain any admixtures, additives, or modifiers in order to determine the compatibility of the membrane with the concrete.

6.5 *Underside Liner and Coating*—The underside of the concrete deck should not have an impermeable barrier. A metal liner or coating that forms a vapor barrier on the underside can trap moisture in the concrete and destroy or prevent the adhesive bond of the membrane to the upper surface of the concrete. Uniformly spaced perforations in metal liners may provide a solution to the vapor barrier problem but as yet there are no definitive data on the requirements for the size and spacing of the perforations. It should also be recognized that this method would preclude any painting of the metal liner after the concrete is poured on it.

6.6 *Slope for Drainage*—Drainage at the membrane level is important. When the waterproofing membrane is placed directly on the concrete slab a monolithic concrete substrate slope of a minimum 11 mm/m (1⁄8 in./ft) should be maintained. Slope is best achieved with a monolithic structural slab and not with a separate concrete fill layer. The fill presents the potential of additional cracks and provides a cleavage plane between the fill and structural slab. This cleavage plane complicates the detection of leakage in the event that water should penetrate the membrane at a crack in the fill and travel along the separation until reaching a crack in the structural slab.

6.7 *Finish*—The structural slab should have a finish that facilitates proper application of the liquid-applied membrane. The surface should be of sufficiently rough texture to provide a mechanical bond for the membrane but not so rough as to preclude achieving continuity of the membrane of the specified thickness across the surface. As a minimum, ACI 301-72 (1975) floated finish is required with ACI 301-72 (1975) troweled finish preferred, deleting the final troweling.

6.8 *Curing*—Curing of the structural slab is necessary to provide a sound concrete surface and to obtain the quality of concrete required. The concrete should be cured a minimum of 7 days and aged a minimum of 28 days including curing time, before application of the liquid-applied membrane. Curing is accomplished chemically with moisture and should not be construed as drying.

6.8.1 *Moist Curing*—Moist curing is achieved by keeping the surfaces continuously wet by covering them with burlap saturated with water and kept wet by spraying or hosing. The covering material should be placed to provide complete surface coverage with joints lapped a minimum of 75 mm (3 in.).

6.8.2 *Sheet Curing*—Sheet curing is accomplished with a sheet vapor retarder that reduces the loss of water from the concrete and moistens the surface of concrete by condensation, preventing the surface from drying while curing. Laps of sheets covering the slab should not be less than 50 mm (2 in.) and should be sealed or weighted (see Practice C 755).

6.8.3 *Chemical Curing*—Liquid or chemical curing compounds should not be used unless approved by the manufacturer of the liquid-applied membrane as the material may interfere with the bond of the membrane to the structural slab.

6.9 *Dryness*—Membrane manufacturer's requirements for substrate dryness vary from being visibly dry to passing a 4-h glass test with no condensate, or having a specific maximum moisture content as measured by a moisture meter. Since there is a lack of unanimity in this regard, it is necessary to meet the manufacturer's requirements for the particular membrane being applied.

6.10 *Joints*—Joints in a structural concrete slab in this guide are referred to as reinforced joints, nonreinforced joints, and expansion joints.

6.10.1 *Reinforced Joints*—Reinforced joints consist of hairline cracks, cold joints, construction joints, isolation joints, and control joints held together with steel reinforcing bars or wire fabric. These are considered static joints with little or no anticipated movement because the slab reinforcement is continuous across the joint.

6.10.2 *Nonreinforced Joints*—Nonreinforced joints consist of butted construction joints and isolation joints not held together with steel reinforcing bars or wire fabric. These joints are generally considered by the designer of the structural system as nonmoving or static joints. However, they should be considered as capable of having some movement, the magnitude of which is difficult to predict.

6.10.3 *Expansion Joints*—Expansion joints are designed to accommodate a predetermined amount of movement. Such movement could be due to thermal change, shrinkage, creep, deflection, or other factors and combinations of factors. In the detailing of expansion joints to achieve watertightness, the amount of movement anticipated should be carefully determined using a reasonable factor of safety. The opening size and configuration should then be related to the capability of the joint seal materials to accommodate the anticipated movement. Expansion joints are best located at the high points of a contoured slab to permit water to flow away from the joint.

## 7. Membrane

7.1 *Adherence to Substrate*—A liquid-applied waterproofing membrane has the capability of adhering to the structural slab and should be applied to take optimum advantage of this inherent characteristic. The detection of leakage in a building deck waterproofing system that is covered over with a separate wearing course could be a significant problem when the waterproofing membrane is not bonded to the structural slab or when additional layers of material separate the membrane from the structural slab. Water penetrating an unbonded membrane could migrate laterally under the membrane until reaching a crack or defect in the structural slab and then leak through to the space below. Leakage through the slab, therefore, would not necessarily indicate the location of the water entry in the membrane above. That point could be at a considerable distance away, and the costly removal of large areas of the wearing course might be required before it is located.

7.2 *Placement Protection*—The membrane should be applied under dry, frost-free conditions on the surface as well as throughout the depth of the concrete slab. Excessive moisture in the substrate (see 6.3) or moisture on the surface (see ) as from frost or rain will result in a defective membrane with such deficiencies as an improper cure with formation of excessive gas pockets and little or no adhesion to the substrate. Should rain or snow interrupt the application after at least one coat of material has been applied, the instructions of the membrane manufacturer should be followed pertaining to any necessary treatment of the cured, already applied material prior to continuation.

7.3 *Terminal Conditions*—Four locations where a liquid-applied membrane is normally terminated or interrupted are on walls, at drains, at penetrations, and at expansion joints having relatively large movement. The important consideration at terminal conditions is to prevent water from penetrating into the substrate or behind the membrane at its edge.

7.3.1 *Termination on Walls*—When the membrane is turned up on a wall, it is preferable to terminate it above the wearing surface to eliminate the possibility of ponded surface water penetrating the wall above the membrane and running down behind it into the building. The minimum safe height of such a termination is dictated by the opportunity for conditions such as ponding and drifted snow presented by the building's geometry and environment. A liquid-applied membrane, because of its inherent adhesive properties, may be terminated flush on the wall without the use of a reglet. However, the use of a reglet in a concrete wall has the advantage of providing greater depth protection at the terminal. The reglet should be a minimum of 6.3 mm (¼ in.) deep and 6.3 mm (¼ in.) wide. Termination on a masonry wall will require counterflashing (see Figs. 2-4).

7.3.2 *Termination at Drains*—Drains should be designed with a wide flange or base as an integral part. The drain base should be set flush with the structural slab. The wide flange provides a termination point for the liquid-applied membrane without endangering the function of the membrane or the drain (see Fig. 5).

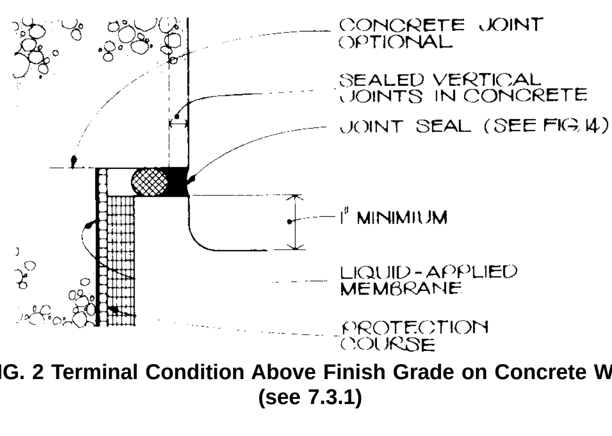


**FIG. 2 Terminal Condition Above Finish Grade on Concrete Wall (see 7.3.1)**

7.3.3 *Termination at Penetrations*—Penetrations or protrusions through the slab by such items as conduits and service pipes create critical problems and should be avoided wherever possible. For protection at such critical locations, pipe sleeves should be cast into the structural slab against which the membrane can be terminated (see Fig. 6). Core drilling to provide openings for penetrations is not recommended.

7.4 *Treatment at Joints*—Joints in the structural slab should be treated as follows, depending upon whether they are reinforced joints, nonreinforced joints or expansion joints:

7.4.1 *Treatment at Reinforced Joints*—Fig. 7 indicates one recommended treatment of reinforced concrete joints in the structural slab. The designer should realize that the elongation capacity of this type of detail is quite limited and implicitly relies on the membrane's crack-bridging ability to withstand the strains imposed by the opening of cracks and reinforced joints. An alternative approach that may be considered is to prevent the membrane from adhering to the substrate for a finite width centered on the joint or crack by means of a properly designed compatible bond-breaker tape.

7.4.2 *Treatment at Nonreinforced Joints*—Nonreinforced joints that are in reality nonmoving could be treated in the same manner as reinforced joints. However, since the joints are not held together with reinforcing steel, some movement, however slight, should be anticipated and provided for, since the liquid-applied membrane has limited ability to take movement. Nonreinforced joints could open due to such factors as shrinkage, creep, and thermal contraction. Fig. 8 shows a nonreinforced butted joint that is capable of expanding 3.2 mm (⅛ in.), the minimum that should be provided for when using a sealant capable of $\pm$ 25 % movement. The minimum sealant width should be correspondingly wider with a sealant having lesser movement capability. If the designer of the structural system feels that greater movement than 3.2 mm (⅛ in.) could occur in such joints, they should be treated as expansion joints.

7.4.3 *Treatment at Expansion Joints*—There are basically two concepts that could be considered in the detailing of expansion joints at the membrane level of membrane waterproofing systems. These are the *positive seal concept* directly at the membrane level and the *water shed concept* with the seal at a higher level than the membrane. Where additional safeguards are desired, a drainage gutter under the joint could be considered (see Fig. 9). Note that flexible support of the membrane is required in each case. Expansion joint details should also be considered and used in accordance with their movement capability.

7.4.3.1 *Positive Seal Concept*—The positive seal concept entails a greater risk than the water shed concept since it relies fully on positive seal joinery of materials at the membrane level, where the membrane is most vulnerable to water penetration. The materials used, and their joinery, must be carefuly engineered by the manufacturer of the liquid-applied waterproofing system, and subsequent field installation requires the best of workmanship with no margin for error for potential success. Since the precision required is not always attainable, this concept is best avoided.

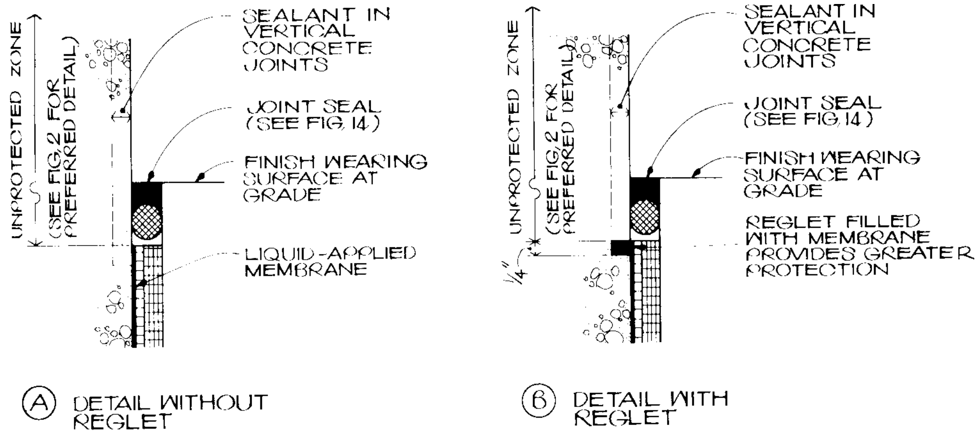


FIG. 3 Terminal Conditions on Concrete Wall Below Finish Wearing Surface at Grade (see 7.3.1)

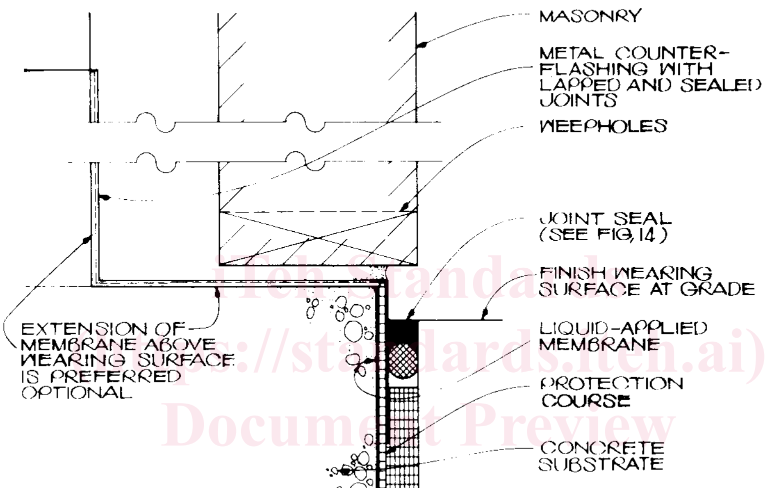




FIG. 4 Terminal Condition with Masonry Above Finish Wearing Surface at Grade (see 7.3.1)

7.4.3.2 *Water Shed Concept*—The water shed concept, although requiring a greater height and more costly concrete forming, is superior in safeguarding against leakage, having the advantage of providing a water dam at the membrane level. The joinery of differing materials can then be placed at a higher level and treated somewhat in the manner of counterflashing, hence the term "water shed concept." However, if a head of water rises to the height of the material joinery, this concept becomes almost as vulnerable as the positive seal concept. Therefore, drainage is recommended at the membrane level and is further analyzed in Section 9.

7.4.3.3 *Provision for Movement*—Generally, expansion joints in a structural slab are seldom less than 30.5 m (100 ft) apart and may be as much as 91.4 m (300 ft) or more apart. Therefore, relatively large amounts of total movement are to be dealt with, generally in the range from 13 mm (½ in.) up to 38 mm (1½ in.). Maximum movement generally occurs during the construction phase before insulation and wearing course are installed over the membrane. However, the joint should be detailed for maximum movement at any time. Since it is unpredictable when the membrane will be installed, taking opening and thermal conditions into consideration, an expansion joint detail that cannot take ± 9 mm (⅜ in.) of movement is hardly worth considering. Such movement, when treated as a sealant joint and using the positive seal approach, requires a joint width of 75 mm (3 in.), and this is considered impractical. Gaskets and flexible preformed sheets lend themselves better to absorbing such amounts of movement. Since such materials, when used at an expansion joint, must be joined to the liquid-applied membrane, the water shed concept should be used. Figs. 10-12 indicate expansion joints using the water shed concept that have a movement capability of ± 9 mm (⅜ in.) when installed in a designed concrete opening of the width indicated. These details could be increased in movement capability with a larger gasket and concrete opening if so desired.

## 8. Protection Course

8.1 *General*—The liquid-applied membrane should be protected from damage prior to and during the remainder of deck construction. A protection course should be applied after the membrane is installed. The protection course, which is most commonly a protection board, also serves to protect the membrane from damage due to movement and penetration of materials above after the deck construction is complete. The proper timing of the application of the protection course after

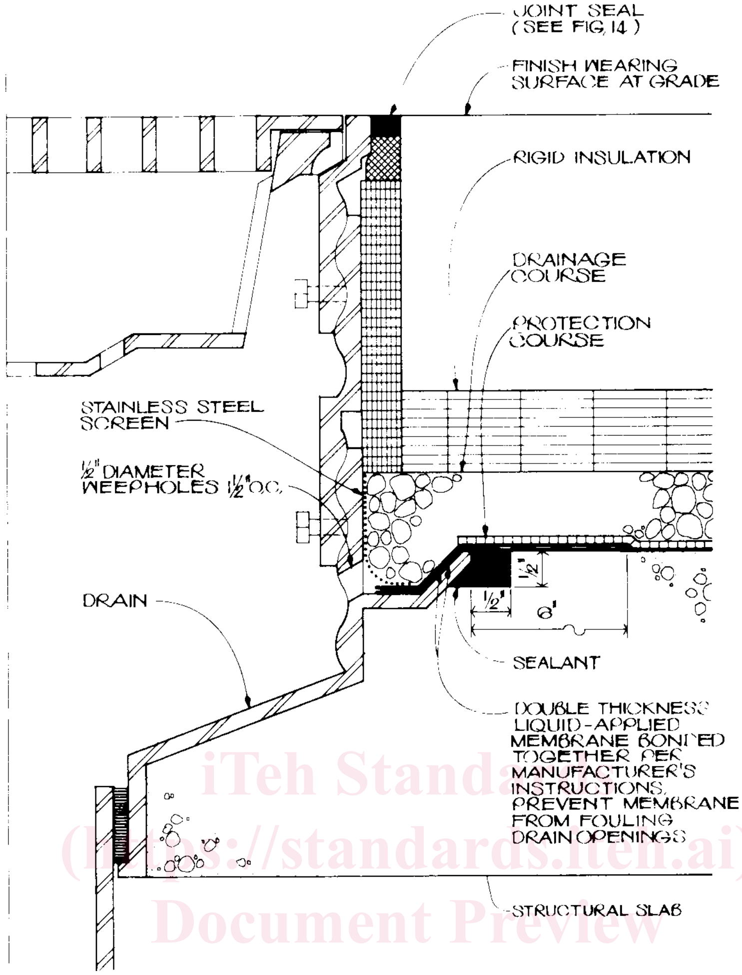


**FIG. 5 Termination at Drain**



placement of the membrane is important and could vary with the proprietary type of membrane used. The manufacturer's printed instructions should be followed.

## 9. Drainage System

9.1 *General*—When the membrane waterproofing is covered over with a wearing surface, it is necessarily assumed that water can and will reach the membrane; otherwise, the membrane below the wearing surface would not be needed. Drainage should then be considered as a total system from the wearing surface down to the membrane. Since it would be undesirable to permit water to build up below the wearing surface, multilevel drains should be used, with particular emphasis on rate of flow into the drain at the membrane level. Basically, the drainage system is analyzed as to how it functions both at the membrane level and at the wearing surface.

9.2 *Requirements for Drainage at Membrane Level*—It is essential that water be removed from the membrane level for the following reasons:

9.2.1 To avoid building up a pressure head against the membrane and particularly against the more vulnerable splices and joints in the system.

9.2.2 To avoid freeze-thaw cycling of trapped water which could heave and disrupt the wearing course.

9.2.3 To minimize the deleterious effect prolonged undrained water could have on wearing course materials.

9.2.4 To minimize thermal inefficiency of wet insulation and of water under the insulation.

9.3 *Recommendations for Drainage at Membrane Level*:

9.3.1 Slope the monololithic concrete substrate under the membrane a minimum of 11 mm/m (⅛ in./ft).

9.3.2 Slope the monolithic concrete substrate under the membrane so as to drain away from expansion joints and walls.

9.3.3 Use a drainage course to increase the rate of flow to drains.

9.3.4 Avoid undrained pockets such as downward loops of flashing into expansion joints.

9.3.5 Use multilevel drains capable of draining all layers of the building deck. The drain should have an integral flange at least 50 mm (2 in.) for adherence and bonding with the concrete slab and to provide for termination of the liquid-applied membrane with sufficient room for an adhesive bond. The flange should be set level with the structural slab surface.

9.4 *Drainage Concepts at Wearing Surface*—Drainage at the wearing surface is generally accomplished in one of two ways: (*1*) by an open-joint system permitting most of the rainwater to penetrate rapidly down to the membrane level and subsurface drainage system, or (*2*) by a closed-joint system