Designation: E 1643 – 98

Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs[1]

This standard is issued under the fixed designation E 1643; 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 practice covers procedures for installing flexible, prefabricated sheet membranes in contact with earth or granular fill used as vapor retarders under concrete slabs.

1.2 Conditions subject to frost, heave or hydrostatic pressure, or both, are beyond the scope of this practice.

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.*

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

D 224 Specification for Smooth-Surfaced Asphalt Roll Roofing (Organic Felt)[3]

E 631 Terminology of Building Constructions[4]

2.2 *Other Standard:*

ACI 302.1R Guide for Concrete Floor and Slab Construction[5]

3. Significance and Use

3.1 Vapor retarders provide a method of limiting water vapor transmission upward through concrete slabs on grade, which can adversely affect moisture-impermeable or moisture-sensitive floor finishes.

3.2 Adverse impacts include adhesion loss, warping, peeling, and unacceptable appearance of resilient flooring; deterioration of adhesives, ripping or separation of seams, air bubbles or efflorescence beneath seamed, continuous flooring; damage to flat electrical cable systems, buckling of carpet and carpet tiles, offensive odors, and growth of fungi.

4. Manufacturer's Recommendations

4.1 Where inconsistencies occur between this practice and the manufacturer's instructions, conform to the manufacturer's instructions for installation of vapor retarder.

5. Placement

5.1 Level and tamp or roll granular base.

5.2 Place vapor retarder sheeting with the longest dimension parallel with the direction of concrete pour.

5.3 Lap vapor retarder over footings or seal to foundation wall, or both, and seal around penetrations such as utilities and columns in order to create a monolithic membrane between the surface of the slab and moisture sources below the slab and at the slab perimeter (see Figs. 1-3).

5.4 Lap joints 6 in. (150 mm), or as instructed by the manufacturer, and seal with the manufacturer's recommended adhesive or pressure sensitive tape or both.

6. Protection

6.1 Take precautions to protect vapor retarder from damage during installation of reinforcing steel and utilities and during placement of concrete.

6.2 Use only concrete brick type reinforcing bar supports, or provide 6 by 6 in. (150 by 150 mm) protective pads of asphaltic hardboard or other material recommended by the vapor retarder manufacturer to protect the vapor retarder from puncture.

6.3 Avoid use of stakes driven through vapor retarder.

6.4 Refer to X2.2 and X2.3 for discussion of aggregate for protection of vapor retarder.

7. Repair

7.1 Repair vapor retarder damaged during placement of reinforcing or concrete with vapor barrier material or as instructed by manufacturer.

7.2 Lap beyond damaged areas a minimum of 6 in. and seal as prescribed for sheet joints.

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[1] This practice is under the jurisdiction of ASTM Committee E-6 on Performance of Buildings and is the direct responsibility of Subcommittee E06.21 on Serviceability.

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

[3] *Annual Book of ASTM Standards*, Vol 04.04.

[4] *Annual Book of ASTM Standards*, Vol 04.11.

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

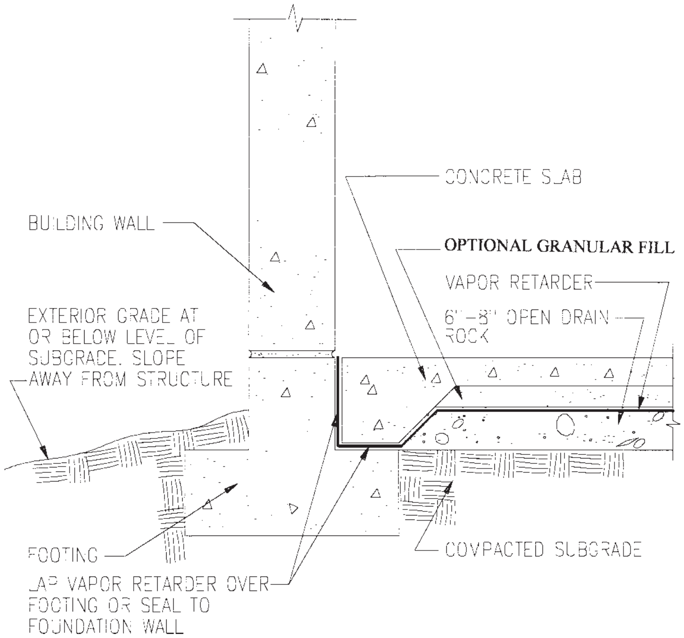

FIG. 1 Concrete Slab on Grade: Optimum Relationship of Vapor Retarder Components

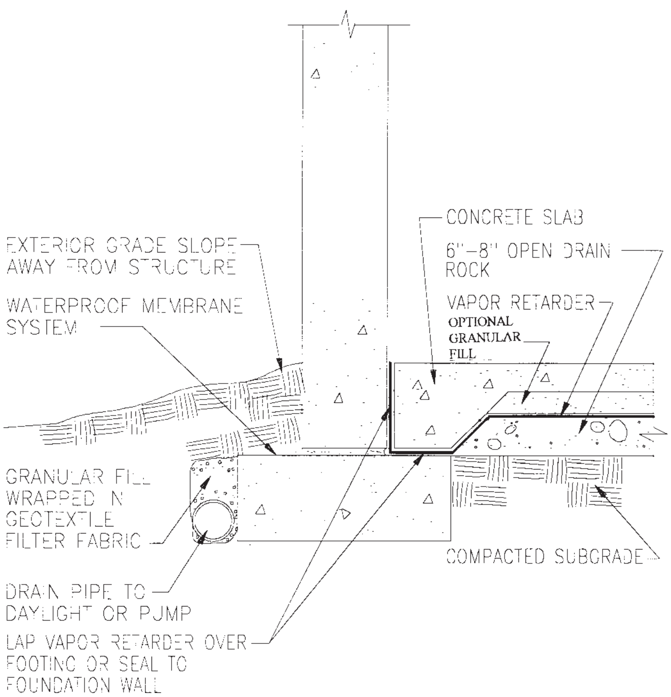

FIG. 2 Concrete Slab on Grade: Solution for Subgrade Slightly Below Exterior Grade

8. Suggested Field Check List

8.1 *Moisture Entrapment Due to Rainfall or Ground Water Intrusion*—Moisture entrapment can occur with tilt-up construction or other construction methods where exterior walls are erected before the concrete slab and underlying subgrade, base, or sand/small aggregate layer or combination thereof, are protected from precipitation. This can be avoided by appropriate construction scheduling and sealing of any entry points in uncompleted slabs[6] (see Fig. 4).

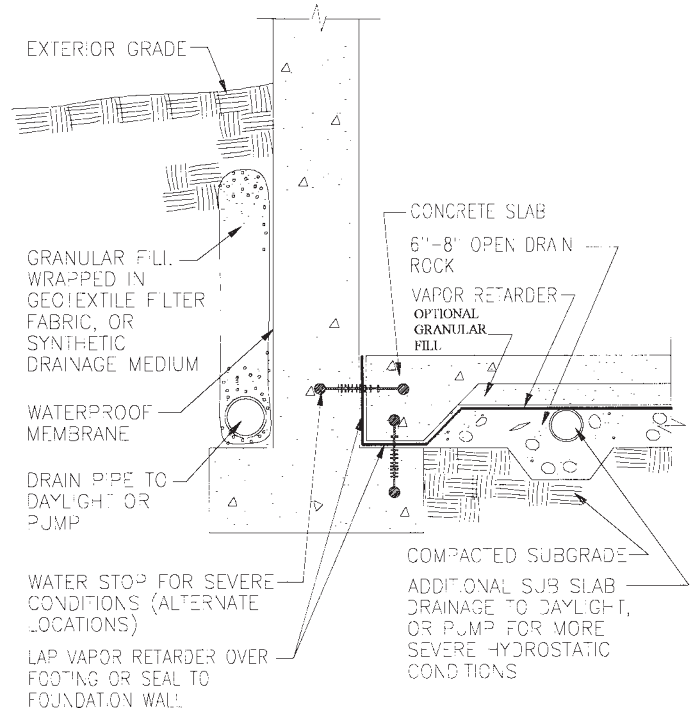

FIG. 3 Concrete Slab on Grade: Solution for Subgrade Up to One Story below Grade with No Hydrostatic Pressure on Vapor Retarder

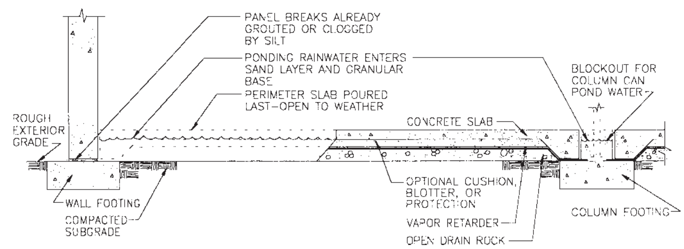

FIG. 4 How Moisture Can Be Retained in Base or Cushion, Blotter, or Protection Course During Construction

8.2 *Integrity of Vapor Retarder*—Check seams and penetrations at columns and utilities to look for discontinuities in the vapor retarder.

8.3 *Damage and Repair*—After installation of reinforcement (if used) but before pouring concrete, check for damage. Do not pour concrete until repairs are made, if required, in vapor retarder. This is particularly difficult if covered with sand or granular fill.

8.4 *Moisture Conditions of Slab*—Following placement of concrete and climatization of building, check to see that any specified tests for moisture emission have been made and a written report submitted prior to floor covering or coating installation.

[6] Collins, F. Thomas, *Manual of Tilt-Up Construction*, Berkeley, Know-How Publications, 1965, pp 78–81.

9. Keywords

9.1 concrete slabs; vapor; vapor retarder

APPENDIXES

(Nonmandatory Information)

X1. PRE-DESIGN CONSIDERATIONS

X1.1 Architectural

X1.1.1 *Planning and Organization of Construction Documents*—To avoid ambiguities, redundancies, conflicts, and omissions, plan the organization and coordination of drawings and specifications so that graphic, dimensional, and descriptive information on subgrade, granular base, vapor retarder, and protection course, if any, appears in only one place. Since the relationship of the subgrade (pad) elevation (usually shown on grading plans) to the rest of the building finish floor elevations and finished site grades is a function of the depth of the granular base and protection course, these dimensions should be shown in only one place. For graphic depictions and dimensions of the granular base and the protection course, the architectural drawings are preferred, but structural drawings are sometimes used. Specifications for sub-base conditions should be in the grading section. Specifications for base, vapor retarder, and protection course should be in the section on concrete, but there are advocates of a separate section in Division 7 for the vapor retarder system. Examination and testing of surface conditions should be in appropriate finish sections.

X1.1.2 *Scheduling*—Determine if slab drying will be on the critical path for schedule occupancy. If so, plan measures to reduce drying times, mitigate moisture, or select floor finish materials not subject to damage by moisture.

X1.1.3 *Geotechnical*—Ensure that the geotechnical survey includes comprehensive and reliable information on subsurface water table levels and the hydrology of geological strata as well as historical data on surface flooding and hydrology. The geotechnical study should consider not only the past but also the projected change from ongoing or anticipated development patterns. Soils with comparably higher clay contents are particularly troublesome because the relatively high capillary action within the clay allows moisture to rise under the slab.

X1.1.4 *Civil*—Ensure that site topographic surveys and grading plans accurately and comprehensively establish surface drainage characteristics for the site and surrounding areas.

X1.1.5 *Landscape and Irrigation*—Most traditional geotechnical studies do not take into account the post-construction change in ground moisture conditions due to introduced planting and irrigation which is a major problem. For example, in California coastal areas, the average annual rainfall is about 18 in. (457 mm). Turf irrigation amounting to 1.3 in. (33 mm) of water per week over the normal 7-month dry season will increase this to nearly 60 in. (1524 mm) with almost no runoff. It is not enough to assume that irrigation will simply duplicate natural conditions encountered during the wet season. The landscape architect, geotechnical engineer, and civil engineer should closely coordinate design recommendations to avoid moisture problems introduced or exacerbated by landscape planting and irrigation. Once a project is completed, effective irrigation management is instrumental not only in water conservation but also in avoiding potential building-related moisture problems.

X2. DESIGN PHASE CONSIDERATIONS

X2.1 Subgrade Design and Specification

X2.1.1 Specify preparation and configuration of sub-base material as directed by the geotechnical engineer. Design sub-grade topography and drainage to ensure positive relief of hydrostatic pressure. Incorporate design of mechanical drainage system if gravity outflow is not possible, or design sub-grade waterproofing to resist expected hydrostatic pressures.

X2.1.2 The grading specifications must require the contractor to keep any below grade excavations free of water. It is important to avoid potential reservoirs of moisture that migrate upward through slabs, but it is also important to prevent structural degradation of soil bearing strength and to avoid swelling and subsequent shrinkage in soils containing excessive silt/clay with expansive characteristics. If any subgrade moisture-induced swelling is anticipated, the construction sequence should be planned so that it occurs prior to slab construction rather than after.

X2.1.3 ACI 302.1R-89 warns that the subgrade must be well drained and of adequate and uniform load-bearing nature. The "in-place density" of the subgrade soils should be at least the minimum required in the specifications. The bottom of an undrained granular base course must not be lower than the adjacent finished grade; otherwise, the base course becomes a reservoir for water.

X2.1.4 Details of site preparation are given by ACI Committee 330 and the Building Research Advisory Board. When expansive soils are encountered, the recommendations of a soils engineer should be followed.

X2.1.5 The subgrade must be free of frost before concrete placing begins. If the temperature inside a building in which concrete is to be placed is below freezing it must be raised and maintained above 50°F (10°C) long enough to remove all frost from the subgrade. The subgrade should be moist at the time of concreting. If necessary it should be dampened with water in advance of concreting, but there must be no free water standing on the subgrade, nor should there be any muddy or soft spots when the concrete is placed (see ACI 301.2 R89, 3.1).

X2.2 *Open Drain Rock Base/Capillary Break Design and Specification:*

X2.2.1 A base using a minimum of 3 in. (76 mm) of clean, compacted, crushed rock provides adequate bearing strength while at the same time incorporates sufficient air pockets to reduce the potential of ground water migrating upward through capillary action. While a vapor retarder used in conjunction with the base may obviate the need for capillary break, the break provides a margin of safety in case of punctures and lap seam failures.

X2.2.2 To be an effective capillary break, the base should be open (mostly single) graded, clean coarse rock of ¾ in. (19 mm) maximum size.

X2.2.3 Both crushed and river run rock are used, but one or the other may not be readily available in certain areas. Crushed rock is much more likely to cause puncture damage to the vapor retarder but is more easily compactable. If crushed rock is used, special attention must be given to selecting and protecting the vapor retarder. A ½-in. (13-mm) (approximately) layer of fine grade, compactible fill may be rolled or compacted over the base to protect against crushed rock base.

X2.3 *Cushions, Blotters, and Protection Courses:*

X2.3.1 *Background*—The use of a cushion, blotter, or protection course has often been considered an integral part of the vapor retarder installation because one of its perceived functions is to protect the vapor retarder from damage. A consensus of vapor retarder product producers is that the protection role is either unnecessary or overrated and should not be a component of an application standard practice for vapor retarders. The principal role of the cushion, blotter, or protection course, according to its proponents, is its function in the placement, finishing, and curing of concrete. Its use, if any, should be related to the concrete mix design and curing specifications, not the use of a vapor retarder. Nevertheless, the following considerations are provided to guide the specifier.

X2.3.2 *Arguments in Favor of Cushions, Blotters, and Protection Courses:*

X2.3.2.1 *Blotter Theory*—A common practice in many parts of the United States is to place a layer of sand or granular fill on top of the vapor retarder prior to the placement of concrete. The theory is that the fill serves as a blotter to help equalize moisture content and reduce plastic shrinkage cracking. In the 1980 version of ACI 302.1, the fill is described as "sand." In ACI 302.1R-96, *Guide for Concrete Floor and Slab Construction* (4.1.4 and 4.1.5), and is no longer recommended. Instead a "fine graded" material is described as follows:

X2.3.2.2 *Base Material*—Use of the proper material is essential in order to achieve the tolerances suggested in Section 4.1.3 of ACI 302.1R-96. The base material should be compactible, easy-to-trim, granular fill that will remain stable and support construction traffic. The tire of a loaded concrete truck mixer should not penetrate the surface more than ½ in. (13 mm) when driven across the base. The use of so-called cushion sand or clean sand with uniform particle size, such as concrete sand meeting Specification C 33 will not be adequate. This type of sand will be difficult, if not impossible, to compact and maintain until concrete placement is complete. A clean, fine-graded material with at least 10 to 30 % of particles passing a No. 100 (150 µm) sieve but not contaminated with clay, silt, or organic material is recommended. Manufactured sand from a rock-crushing operation works well; the jagged slivers tend to interlock and stabilize the material when compacted. It is important that the material have a uniform distribution of particle sizes ranging from No. 4 (4.75 mm) through the No. 200 (80 µm) sieve. See Specification C 33, Table 1, for limitation of deleterious material finer than No. 200 (80 µm) sieve. Unwashed size No. 10 per Specification D 224 works well.

X2.3.2.3 *Vapor Barrier/Vapor Retarder*—If a vapor barrier or vapor retarder is required due to local conditions, these products should be placed under a minimum of 4 in. (100 mm) of trimable, compactible, granular fill (not sand). A so-called "crusher-run" material, usually graded from 1-½ to 2 in. (38 to 50 mm) down to rock dust, is suitable. Following compaction, the surface can be choked off with a fine-grade material (see Section 4.1.1 of ACI 302.1R-96) to reduce friction between the base material and the slab. If it is not practical to install a crusher-run material, the vapor barrier/retarder should be covered with at least 3 in. (75 mm) of fine-graded material, such as crusher fines or manufactured sand (see Section 4.1.4 of ACI 302.1R-96). The granular fill, as well as the fine-graded material, should have sufficient moisture content to be compactible, but still be dry enough at the time of concrete placement to act as a "blotter" (see Section 4.1 of ACI 302.1R-96). If a vapor barrier/retarder is to be placed over a rough granular fill, a thin layer of approximately ½ in. (13 mm) of fine-graded material should be rolled or compacted over the fill prior to installation of the vapor barrier/retarder to reduce the possibility of puncture (see Section 4.1.4 of ACI 302.1R-96).

X2.3.2.4 *Protection Theory*—Polyethylene films and reinforced polyethylene films are seldom capable of surviving normal jobsite traffic and abuse and must be protected with a sand cushion.

X2.3.3 *Arguments Against Cushions, Blotters, and Protection Courses:*

X2.3.3.1 Polyethylene and polyethylene reinforced products are frequently damaged during installation. Even with a cushion of sand or granular fill, these products can still be easily damaged.[7]

X2.3.3.2 The concept of permitting excess moisture loss from the surface and draining water from the bottom of concrete slabs is to facilitate the early and effective finishing operation of concrete mixes with a high ratio of water to cement. Contractors will frequently favor high slump (soupy) mixes, as they are easy to place and program over the site.

[7] "Cast-in-Place Concrete-Division 3, San Scenario," *Tech Tips,* Elgin IL: W.R. Meadows, Inc., 1993, p 2.

However, they then have to get rid of this "water of convenience" before the mix will stiffen, and they can complete the finishing operation.[7]

X2.3.3.3 Proper applications would be the use of a low slump concrete with an effective cure or seal material or both to treat the top surface.[6]

X2.3.3.4 With a proper concrete mix, the specifier can obtain high performance concrete at no additional cost. The contractor's desire for workability can be readily satisfied with a number of high-range water reducers (super plasticizers), currently recommended by ACI (see ACI 302.1-80).

X2.3.3.5 Sand is easily displaced by walking or by impact from pumped or chuted concrete mix (see ACI 302.1-80).

X2.3.3.6 Sand or granular fill as "blotters" is not used in above grade slabs, but concrete is routinely installed and finished successfully (see ACI 302.1-80).

X2.3.3.7 The large aggregate described in the draft of the proposed revision of ACI 302.1 would puncture a membrane vapor retarder.

X2.3.3.8 Geotextile fabric can be used to provide protection to vapor retarders without affecting the quality of the concrete.