TECH SOLUTIONS 610.0

STYROFOAM™ Brand Extruded Polystyrene Insulation for Lightweight Fill Applications

Dow®

Introduction

Lightweight materials, such as foamed plastics, are often specified where weak foundation soils cannot support the weight of conventional backfill materials. STYROFOAM™ Brand Extruded Polystyrene Insulation can reduce the vertical compressive loads on poor, compressible underlying soils. This can reduce, or even eliminate, long-term soil settlements.

Stabilizing Foundation Soils

To stabilize foundation soils, designers can:

- consolidate the natural materials by using drains, surcharge fills or waiting for the materials to consolidate over time
- replace the unsatisfactory materials

Typically, the need for lightweight fills occurs at:

- bridge approaches
- landscaped fills on roof decks
- fills behind retaining walls

See Table 1 for the weights of various materials often considered as lightweight fill materials.

Compressive Modulus

Specifications for lightweight fill materials often ask for vertical compressive strength and density requirements. STYROFOAM™ Brand Extruded Polystyrene Insulation has vertical compressive strengths ranging from 16 psi to 100 psi (110 kPa to 690 kPa). However, the compressive modulus (or modulus of elasticity) of the lightweight fill materials must also be considered along with these specifications.

Compressive modulus is the ratio of stress over strain. The compressive modulus of STYROFOAM™ Brand Insulation ranges from E = 800 psi to 3,700 psi (E = 5,500 kPa to 25,500 kPa), depending on the product chosen. STYROFOAM™ Brand Insulation has a Poissons Ratio of 0.20. In contrast, the compressive modulus for 1.5 lb/ft^3 (24 kg/m^3) density beadboard is 300 psi (2,070 kPa)*, with a Poissons Ratio of 0.20.

If one uses a four-layer elastic plate computer solution to compare pavement surface deflection in three different embankment designs, it is easy to see the importance of compressive modulus. See Table 2 for the three embankment configurations studied.

If one assumes that the maximum allowable asphalt deflection under a design wheel load of 9,000 lbs (4,080 kg) is 0.035" (0.89 mm), the elastic plate computer solution predicts pavement deflection in the three modeled embankments (Table 3).

As a result of this comparison, the following comments may be made:

- 1.5 lb/ft^3 (24 kg/m^3) beadboard will produce up to 49 percent more pavement deflection than STYROFOAM™ Brand Insulation in similar lightweight fill embankment designs.
- An additional 13" to 14" (330 mm to 355 mm) of granular cover is required when using 1.5 lb/ft^3 (24 kg/m^3) beadboard to ensure pavement deflections similar to STYROFOAM™ Brand Insulation. Additional granular loads increase the weight on the weak subgrade and defeat the design objective.

*Value obtained from Manufacturers Technical Bulletin for 1.5 lb/ft^3 (24 kg/m^3) beadboard

- Products appearing similar in vertical compressive strength, density and even cost do not necessarily have similar stress/strain (modulus) characteristics.
- Design specifications for polystyrene lightweight fill foam materials must specify compressive modulus. Using CAN/ULC S701 alone is not sufficient – it is a standard designed specifically for thermal insulation, not lightweight fill.

Table 4 shows a sample of lightweight fill sites and applications in which extruded polystyrene insulation products from Dow were used between 1972 and 2002.

Table 5 gives properties of STYROFOAM™ Brand Extruded Polystyrene Insulation products recommended for lightweight fill applications.

Table 1: Lightweight Fill Materials and Weights

Material	Weight
Conventional backfill	120-140 lb/ft³ (1,922-2,243 kg/m³)
Cinders	90-100 lb/ft³ (1,442-1,602 kg/m³)
Blast furnace slag	80-100 lb/ft³ (1,281-1,602 kg/m³)
Fly ash	60-90 lb/ft³ (961-1,442 kg/m³)
Cedar logs	50-70 lb/ft³ (801-1,121 kg/m³)
STYROFOAM™ Brand Insulation	2-3 lb/ft³ (32-48 kg/m³)

Table 2: Modeled Embankments Using Four-Layer Elastic Plate Computer Solution

Embankment 1	Embankment 2	Embankment 3
5.5" (140 mm) Asphalt	5.5" (140 mm) Asphalt	5.5" (140 mm) Asphalt
24" (600 mm) Granular	24" (600 mm) Granular	37" (940 mm) Granular
39" (990 mm) STYROFOAM™ Brand Insulation E = 800 psi (5,500 kPa) Poissons Ratio = 0.20	39" (990 mm) Beadboard E = 300 psi (2,070 kPa) Poissons Ratio = 0.20	39" (990 mm) Beadboard E = 300 psi (2,070 kPa) Poissons Ratio = 0.20
Subgrade	Subgrade	Subgrade

Table 3: Predicted Asphalt Deflections Under 9,000 lb (4,080 kg) Wheel Load Using Four-Layer Elastic Plate Computer Solution

Embankment	Predicted Pavement Deflection, in. (mm)	Departure From Allowable Deflection of 0.035" (0.89 mm)
1	0.026 (0.66)	25% less
2	0.039 (0.99)	12% more
3	0.027 (0.69)	23% less

STYROFOAM™ Brand Extruded Polystyrene Insulation for Lightweight Fill Applications

Table 4: Job List of Lightweight Fill Sites			
Type of Job	**Location**	**Product**	**Year**
Bridge approach	Pickford, Michigan	STYROFOAM™ Brand HIGHLOAD 40[(1)]	1972
Bridge approach	St. Polycarpe, Québec	STYROFOAM™ Brand HIGHLOAD 40	1978
Bridge approach	Abitibi, Québec	STYROFOAM™ Brand HIGHLOAD 60	1978
Bridge approach	St. Sixte, Québec	STYROFOAM™ Brand HIGHLOAD 40	1979
Bridge approaches	Trois Rivières, Québec	STYROFOAM™ Brand HIGHLOAD 60	1979
Bridge approach	Embrun, Ontario	STYROFOAM™ Brand HIGHLOAD 40	1979
Bridge approach	Windsor, Ontario	STYROFOAM™ Brand HIGHLOAD 40	1979
Plaza deck fill	Kansas City, Missouri	STYROFOAM™ Brand SM	1983
Fill over sewer	Royal Oak, Michigan	STYROFOAM™ Brand SM	1984
Bridge approach	Cochrane, Ontario	STYROFOAM™ Brand HIGHLOAD 40	1984
Parking deck fill	Calgary, Alberta	STYROFOAM™ Brand SM	1985
Bridge approach	Sapporo, Japan	STYROFOAM™ Brand HIGHLOAD 40	1985
Bridge approaches	Annacis, British Columbia	STYROFOAM™ Brand Insulation STYROFOAM™ Brand HIGHLOAD 40	1986
Bridge approaches	Burnaby, British Columbia	STYROFOAM™ Brand Insulation STYROFOAM™ Brand HIGHLOAD 60	1987
Plaza deck fill	Indianapolis, Indiana	GRAYBOARD	1987
Bridge approaches	Richmond, British Columbia	NORD R-7	1988
Plaza deck fill	New York, New York	STYROFOAM™ Brand SM/PM	1988
Approach fill	Ottawa, Ontario	STYROFOAM™ Brand HIGHLOAD 100	1988
Bridge approach	Vernon, British Columbia	STYROFOAM™ Brand Insulation	1990
Type II, over utility line	Toronto, Ontario	STYROFOAM™ Brand Insulation	1999
Type III, bridge approach	Matheson, Ontario	STYROFOAM™ Brand Insulation	1999
Bridge approach and full road bed	Rainy River, Ontario	STYROFOAM™ Brand HIGHLOAD 40	2000
Fill over highway tunnel	Montréal, Québec	STYROFOAM™ Brand HIGHLOAD 40 STYROFOAM™ Brand HIGHLOAD 60 STYROFOAM™ Brand HIGHLOAD 100	2001
Building sidewall fill	Bathurst, New Brunswick	STYROFOAM™ Brand HIGHLOAD 40	2002
Bridge approach	Arnprior, Ontario	STYROFOAM™ Brand HIGHLOAD 47[(2)]	2002

(1) STYROFOAM™ Brand HIGHLOAD 40 Insulation was called STYROFOAM™ Brand HI-35 at the time of this installation.
(2) Specially produced product with 47 psi vertical compressive strength.

STYROFOAM™ Brand Extruded Polystyrene Insulation for Lightweight Fill Applications

Table 5: Physical Properties of STYROFOAM™ Brand SM Insulation and STYROFOAM™ Brand HIGHLOAD Insulation

Property and Test Method	Value			
	SM	HIGHLOAD 40	HIGHLOAD 60	HIGHLOAD 100
Thermal Resistance(1) per in. (25 mm), ASTM C518 @ 75°F (24°C) mean temp., ft²•h•°F/Btu (m²•°C/W) min., R-value (RSI)(2)	5.0 (.88)	5.0 (.88)	5.0 (.88)	5.0 (.88)
Compressive Strength(3), ASTM D1621, psi (kPa), min.	30 (210)	40 (275)	60 (415)	100 (690)
Water Absorption, ASTM D2842, % by volume, max.	<0.7	<0.7	<0.7	<0.7
Water Vapor Permeance(4), ASTM E96, perm (ng/Pa•s•m²), max.	0.9 (50)	0.6 (35)	0.6 (35)	0.6 (35)
Maximum Use Temperature, °F (°C)	165 (74)	165 (74)	165 (74)	165 (74)
Coefficient of Linear Thermal Expansion, ASTM D696, in/in•°F (mm/m•°C)	3.5×10^{-5} (6.3×10^{-2})	3.5×10^{-5} (6.3×10^{-2})	3.5×10^{-5} (6.3×10^{-2})	3.5×10^{-5} (6.3×10^{-2})
Flexural Strength, ASTM C203, min., psi (kPa)	50 (350)	70 (480)	85 (585)	85 (585)
Compressive Modulus (typical), ASTM D1621, psi (kPa)	1,000 (6,900)	1,400 (9,650)	2,200 (15,170)	3,700 (25,510)

(1) For 1" (25 mm) material.
(2) R means resistance to heat flow. The higher the R-value or RSI, the greater the insulating power. RSI (R-value Système Internationale) is the metric equivalent of R-value.
(3) For STYROFOAM™ Brand SM Insulation, vertical compressive strength is measured at 10% deformation or at yield, whichever occurs first. For STYROFOAM™ Brand HIGHLOAD 40, 60 and 100 Insulation vertical compressive strength is measured at 5% deformation or yield, whichever occurs first. Since STYROFOAM™ Brand Extruded Polystyrene Insulations are visco-elastic materials, adequate design safety factors should be used to prevent long-term creep. For static loads, 3:1 is suggested. For dynamic loads, 10:1 is suggested.
(4) Water vapor permeance varies with product type and thickness. Values are based on the desiccant method and they apply to insulation 1" (25 mm) or greater in thickness.

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CAUTION: This product is combustible. Protect from high heat sources. A protective barrier or thermal barrier may be required as specified in the appropriate building code. For more information, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400 in the U.S. or 1-519-339-3711 in Canada.

Building and/or construction practices unrelated to building materials could greatly affect moisture and the potential for mold formation. No material supplier including Dow can give assurance that mold will not develop in any specific system.

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