GRAYCO

P.O. Box 143 Eureka, MO 63025

Roofing Design and Practice

Roof Systems
and
Components

Roof Types Based on Roof Slopes

- Steep Roofs
- Low-Slope Roofs
- Other Roof Types

- Steep Roofs = *Water-Shedding Roof*
- Low-Slope roofs= *Water –Resisting Roof*

- Steep Roof Shingle Systems =
  - asphalt shingles, slate shingles, concrete and clay tile, wood shingles/shakes and metal shingles.

Substrates and Underlayments

- Substrates
  - Structural roof component
  - Plywood or OSB (oriented strand board)
  - Boards and planks
  - Lath or Spaced Boards

- Underlayment
  - Second line of protection
  - Cushions roofing materials
  - Ice-dam protection
  - Critical in valleys and on eaves

Steep-Sloped Materials

"Water Shedding"

- Steep Roof Shingle Systems
  - Asphalt shingles
  - Slate shingles, concrete and clay tile
  - Wood shingles/shakes
  - Standing seam metal

Asphaltic Composition Shingles

Standard 3-tab

Standard to Premium Grades: 215lb. to 265lb. per square

20, 25, 30, 40 year warranties offered – ***Class A Fire-Rated***

Asphaltic Composition Shingles

Architectural Laminates

Heavy Weight Premium Grade Shingles

250lb. to 465lb. per square, ***Higher Wind Resistance***

30 year to 50 year to Lifetime warranties - ***Class A Fire-Rated***

Natural Slate

100 % Fire-Proof and High Wind Resistance

- **Standard Smooth Texture:** 700 to 850 lbs. per Sqr.**1/4" to 3/8“ thickness**
- **Rough Texture:** 1000 lbs. per Sq. **3/8" to 1/2" thickness**
- **Rough Texture:** 1500 lbs. per Sq. **1/2" to 3/4" thickness**
- **Rough Texture:** 2300 lbs. per Sq. **3/4" to 1" thickness**
- **Rough Texture:** 3200 lbs. per Sq**. 1”+ thickness**

Clay Tile

Fire-Resistant

500lb. To 1500lb. per square = *Greater Wind Resistance with available attachment methods*

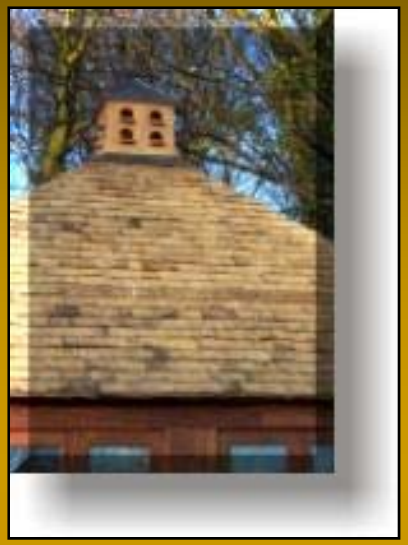
- Interlocking Tiles
- French Tile
- Rustic-Style Flat Slab Shingle Tiles
- Crude-Style Flat Slab Shingle Tiles
- Spanish Tile
- Mission Tile
- Greek, Italian and Roman Pans and Covers
- Tower Tile
- Standard Fittings
- Custom Fittings

Spanish

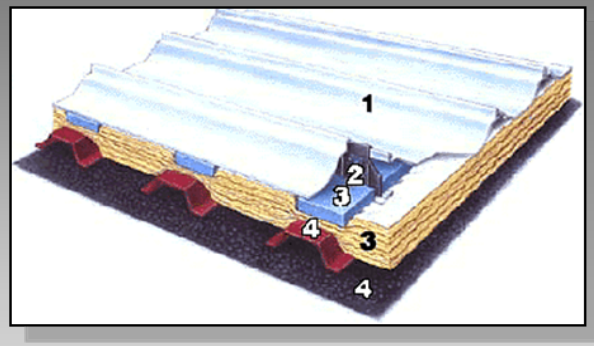
French

Wood Shingles/Shakes

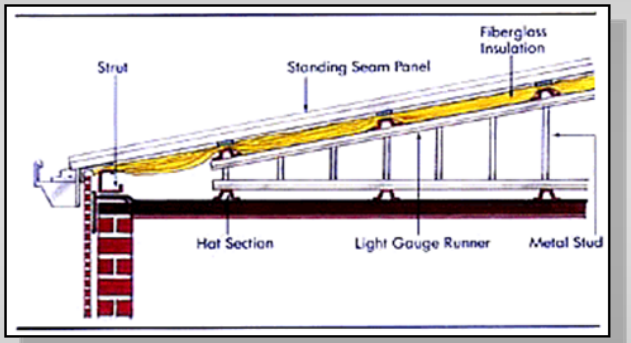
- Natural Cedar “Typical”, hand split and sawn
- Very attractive natural beauty early on in life cycle
- Fire Ratings: Class “C”, “B” and “A” ratings depending on retardants.
- Wind resistance depends on exposures and fastening procedures
- Short Life Span in fluctuating climates



Standing Seam Metal



- 1) Weather-tight when seam sealants are utilized and slopes are sufficient
- 2) Durable: Hail will dent, but factures are rare
- 3) Energy Efficient: When insulation is utilized in system
- 4) Low-Slope Solution to Flat Built-Up Roof when structural water-resisting panels are utilized
- Cost affective option
- Wind resistance varies depending on system and fastening specifications



Low-Sloped Materials

"Water Resisting"

Components of Low-sloped Roof Systems

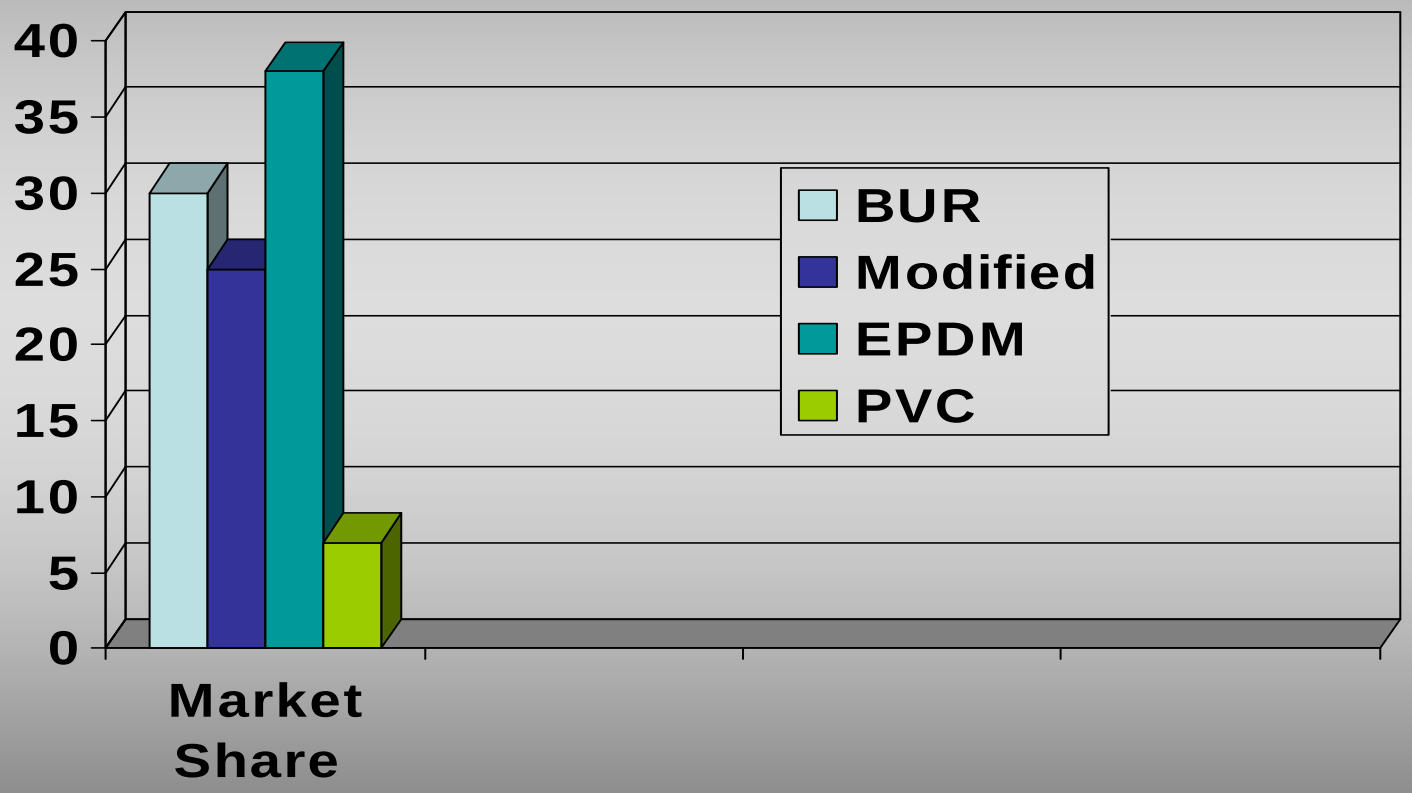
- **Roof membrane, including optional protective coating, cap sheet or ballast**
- **Insulations (optional) on nailable substrates and structural concrete**
- **Insulations required on fluted steel substrates**
- **Flashings, including membrane and sheet metal**

Commonly Used Low-sloped Roof Membranes

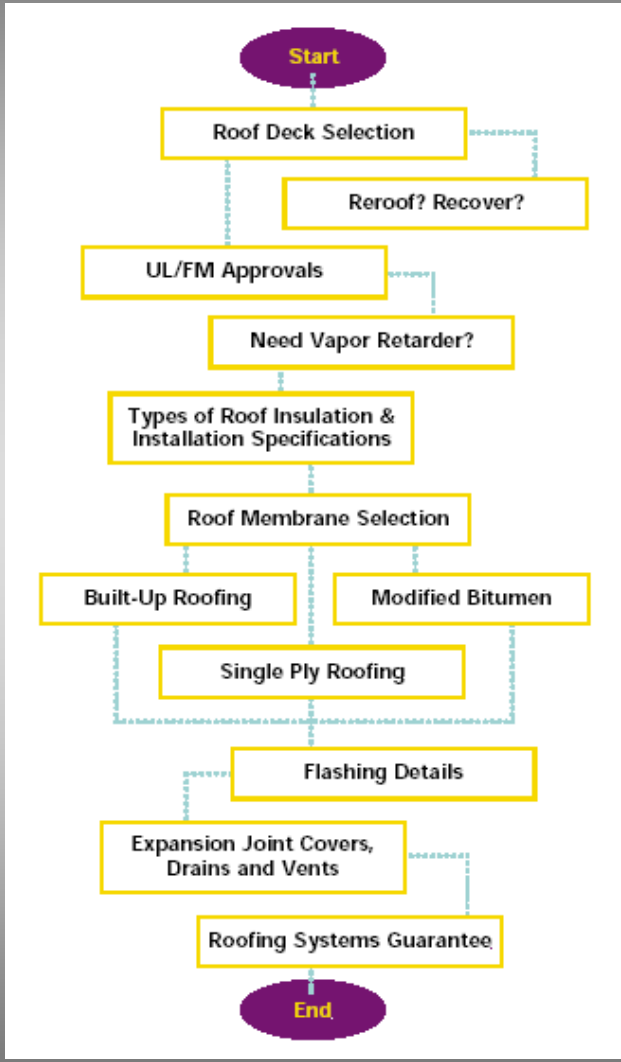
- **Built-Up Roofing (BUR): Asphalt and coal tar pitch with fiberglass ply sheets**
- **Modified bitumen membranes: SBS and APP, smooth or granulated**
- **Single-Ply membranes: EPDM, PVC, and TPO**

Market Shares

Low-sloped Roof Systems



System Selection



BUR – Built-Up Roofing

- Consist of several layers of roofing felts adhered together by bitumen (asphalt or coal tar).
- Typically consist of 3 to 5 felt plies separated by inter-ply moppings of bitumen.
- The top ply is typically covered with a protective coating, aggregate or cap sheet to protect from the affects of weather and/or fire.
- The felt plies are the reinforcing elements and the bitumen is the waterproofing element.
- Together they are necessary to “build” a built-up roof membrane, hence, the name “Built-Up Roof” system (BUR).

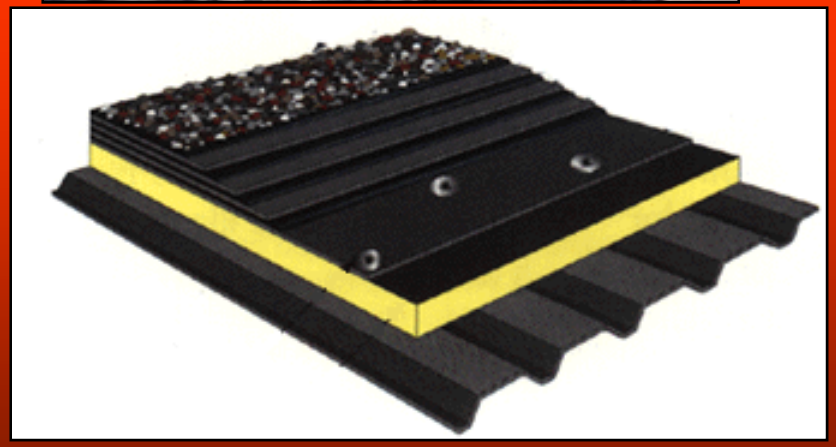
BUR – Built-Up Roofing

Advantages

- **Low front-end cost**
- **Redundancy of many layers**
- **Graveled surface resistant to hail and ultraviolet exposure.**

Disadvantages

- Degrades faster from ponding water and ultraviolet exposure
- Higher life-cycle cost
- Labor intensive and dangerous to install



Modified Bitumen Systems

2 Types

- **SBS** = **S**tyrene **B**utadiene **S**tyrene
  - Installed with hot asphalt or adhesive
- **APP** = **A**ttactic **P**oly**P**ropylene
  - Installed and heat welded with propane torch

Modified Bitumen Systems

Advantages

- Durable, more puncture and impact resistant
- Greater resistance to ultraviolet radiation
- More flexible
- Redunacy of layers
- Greater weatherability
- Compatible with older BUR roof systems

EPDM and Single-Ply Systems

Heat Welded and Non Heat Welded Seams

Heat Welded

- PVC (polyvinyl chloride)
- CPE (chlorinated polyethylene)
- CSPE (chlorosulfonated polyethylene)
- TPO (thermoplastic olefin)

Non-Heat Welded (most common)

- EPDM (ethylene propylene diene monomer)

Advantages

- Highly flexible even when very cold
- Large sheets with fewer lap seams

Disadvantages

- Lack of redundant layers
- Prone to puncture and mechanical damages

EPDM and Single-Ply Systems

Advantages

- Highly flexible even when very cold
- Large sheets with fewer lap seams

Disadvantages

- Single layer, lack of redundant layers
- Prone to puncture and mechanical damages
- Although flexible when cold should be installed at or above 40 degrees

Roof Insulations

Uses

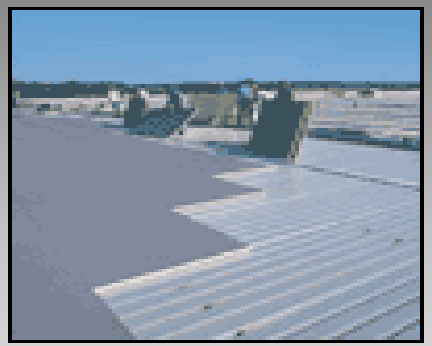
- Building thermal protection
- Roofing substrate

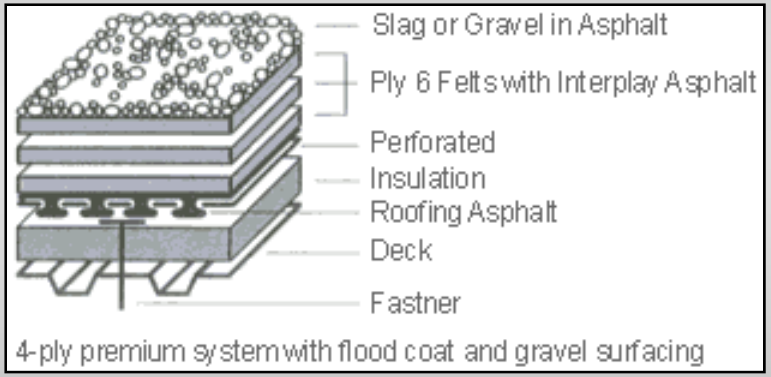
Types

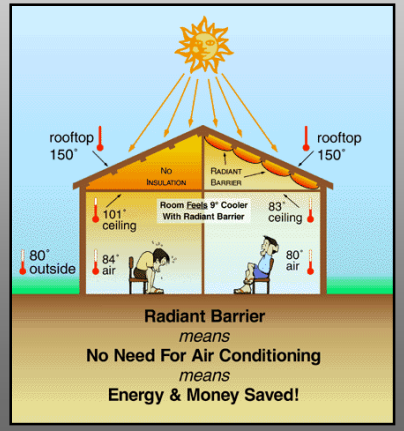
- Foam Plastics (Polyurethane and Polyisocyanurate
- Wood fiberboard
- Perlite board
- Foam Glass and Fiberglass Boards

Property	Perolite	Wood fiber	EPS	XEPS	ISO	Glass
Compressive Strength	High	High	Low	High	High	High
Comp. with hot bitumen	Good	Good	Poor	Poor	Fair	Good
Blister resistance with hot bitumen	Good	Good	Poor	Poor	Poor	Poor
Moisture resistance	Fair	Fair	Fair	Good	Good	Good
Thermal expansion	Low	Low	High	High	High	Low
R-Value per inch	2.8	2.8	3.9	5.0	5.6	2.0

Roof Substrate and Thermal Protection







Polyisocyanurate

- High thermal resistance
- Less water permeable
- Must use cover-board with hot applied roof systems

LTTR values of Firestone Building Products' polyisocyanurate insulation	
Insulation thickness	**LTTR**
1.0 inch (25 mm)	6.0
1.5 inches (38 mm)	9.0
1.7 inches (43 mm)	10.3
1.8 inches (46 mm)	10.9
2.0 inches (51 mm)	12.1
2.5 inches (64 mm)	15.3
2.7 inches (69 mm)	16.6
3.0 inches (76 mm)	18.5
3.3 inches (84 mm)	20.4
3.5 inches (89 mm)	21.7
4.0 inches (102 mm)	25.0

E'NRG'Y 2 and ISO 1 Thermal Values

Thickness (nom.)*		C-Value (Conductance)		R-Value (Resistance)	
in	mm	BTU/(hr•ft²•°F)	W/m²•°C	(hr•ft²•°F)/BTU	m²•°C/W
1.0	25	0.167	0.95	6.0	1.05
1.5	38	0.10	0.57	10.0	1.76
1.8	46	0.08	0.45	12.5	2.20
2.0	51	0.07	0.40	14.3	2.52
2.3	58	0.06	0.34	16.7	2.94
2.5	64	0.054	0.31	18.6	3.27
2.7	69	0.05	0.28	20.0	3.52
3.0	76	0.046	0.26	22.0	3.83
3.4	86	0.04	0.23	25.0	4.40
4.0	102	0.033	0.19	30.0	5.34

Fiberglass

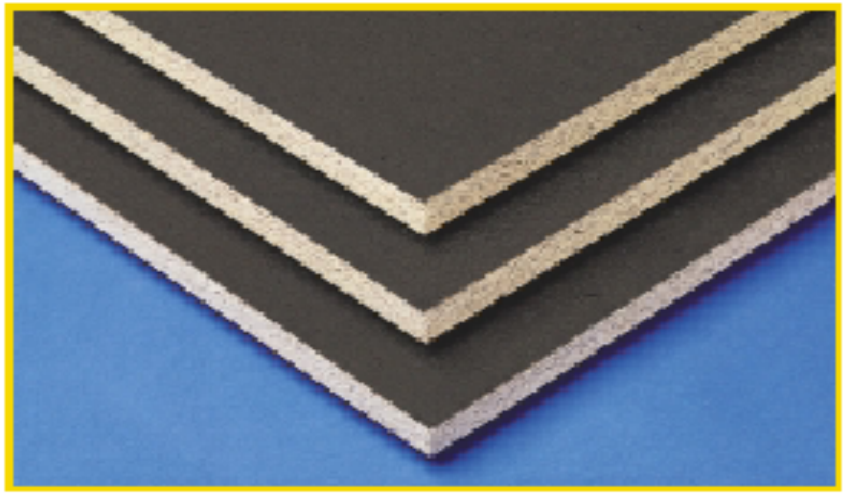
- Midrange thermal resistance
- Excellent surface for hot applied roof systems
- Permeable, will hold water

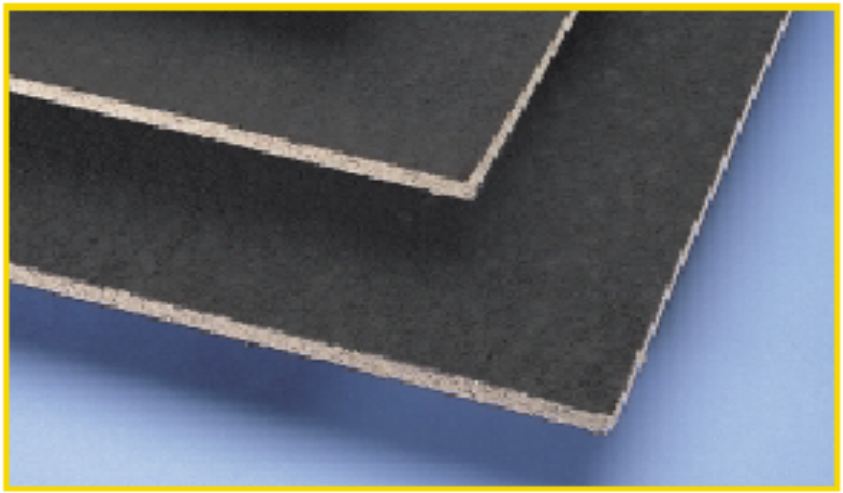
Fiber Glass Roof Insulation Thermal Values

Thickness (nom.)		C-Value (Conductance)		R-Value (Resistance)	
in	mm	BTU/(hr•ft²•°F)	W/m²•°C	(hr•ft²•°F)/BTU	m²•°C/W
3/4	19	0.36	2.04	2.78	0.49
15/16	24	0.27	1.53	3.70	0.65
1 1/16	27	0.24	1.36	4.17	0.74
1 5/8	41	0.15	0.85	6.67	1.18
2	51	0.125	0.71	8.00	1.41
2 1/4	57	0.11	0.62	9.09	1.61
3	76	0.08	0.45	12.50	2.22

Fesco and Dura Boards

Low Thermal Products





Fesco® Board is a high-density board, composed of expanded perlite, blended with selected binders and fibers. It is intended for use as a low thermal insulation board and general purpose cover board over closed-cell foam insulation boards in BUR, modified bitumen and some single ply roofing systems. Because its special TopLoc® coating prevents excessive absorption of asphalt during installation, and its expanded perlite contains air cells which provide superior insulating efficiency, Fesco Board is the best board for low thermal applications. It meets the physical requirements of ASTM C 728. Fesco Board is also available in tapered panels.

Fesco Board Thermal Values

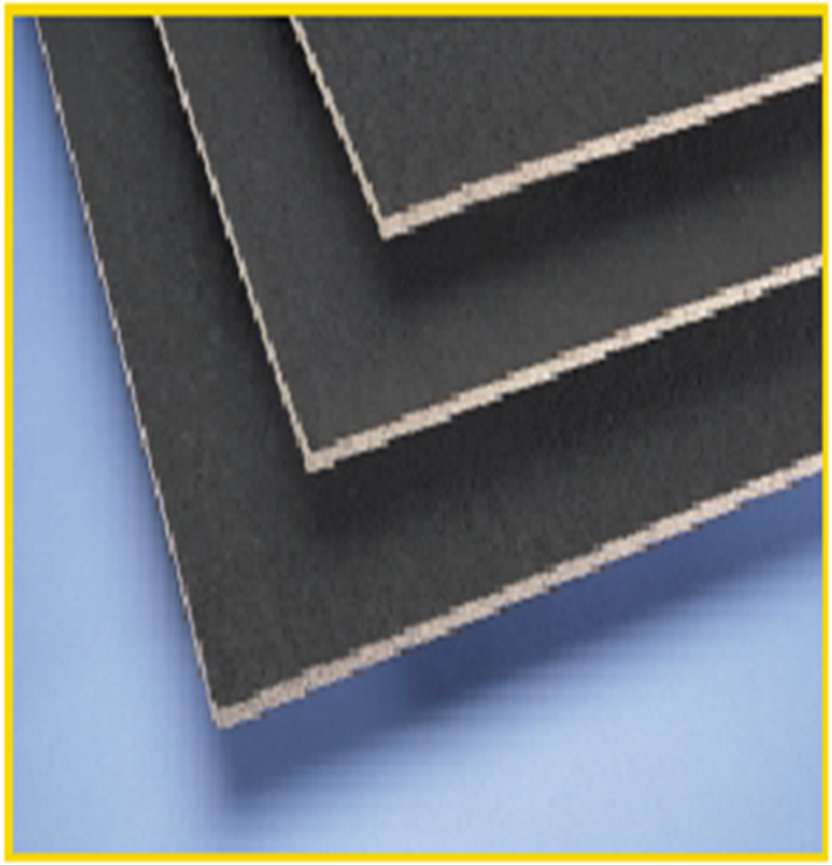
Thickness (nom.)		C-Value (Conductance)		R-Value (Resistance)	
in	mm	BTU/(hr•ft²•°F)	W/m²•°C	(hr•ft²•°F)/BTU	m²•°C/W
0.75	19	0.48	2.73	2.08	0.49
1.0	25	0.36	2.04	2.78	1.26
1.5	38	0.24	1.36	4.17	1.96
2.0	51	0.18	1.02	5.56	2.20

DuraBoard™ is a new perlite-based roof insulation board designed specifically for direct application of heat-weldable SBS and APP membrane systems. The top surface of the board is sealed with a special polymerized asphalt emulsion coating which helps to form good adhesion between the membrane and insulation substrate. The increased strength and durability of this high density board offers excellent handling and compression resistance.

DuraBoard Thermal Values

Thickness		Nominal C-Value (Conductance)		Nominal R-Value (Resistance)	
in	mm	BTU/(hr•ft²•°F)	W/m²•°C	(hr•ft²•°F)/BTU	m²•°C/W
0.5	13	0.83	4.7	1.2	0.21
0.75	19	0.56	3.2	1.8	0.32
1.0	25	0.44	2.5	2.3	0.41

High Density Wood Fiberboard



½" Retro-Fit® Board is a high-density board for both retro-fit and overlay applications, composed of expanded perlite blended with selected binders and fibers. The primary function is to provide an improved substrate for the roofing membrane. It is generally not considered for overall thermal insulation contribution. It meets the physical requirements of ASTM C 728. ½" Retro-Fit Board may be applied with hot asphalt, cold adhesive or mechanical fasteners. It is not recommended for use directly over steel decks.

½" Retro-Fit Board Thermal Values

Thickness (nom.)		C-Value (Conductance)		R-Value (Resistance)	
in	mm	BTU/(hr•ft²•°F)	W/m²•°C	(hr•ft²•°F)/BTU	m²•°C/W
0.5	13	0.76	4.3	1.32	0.23

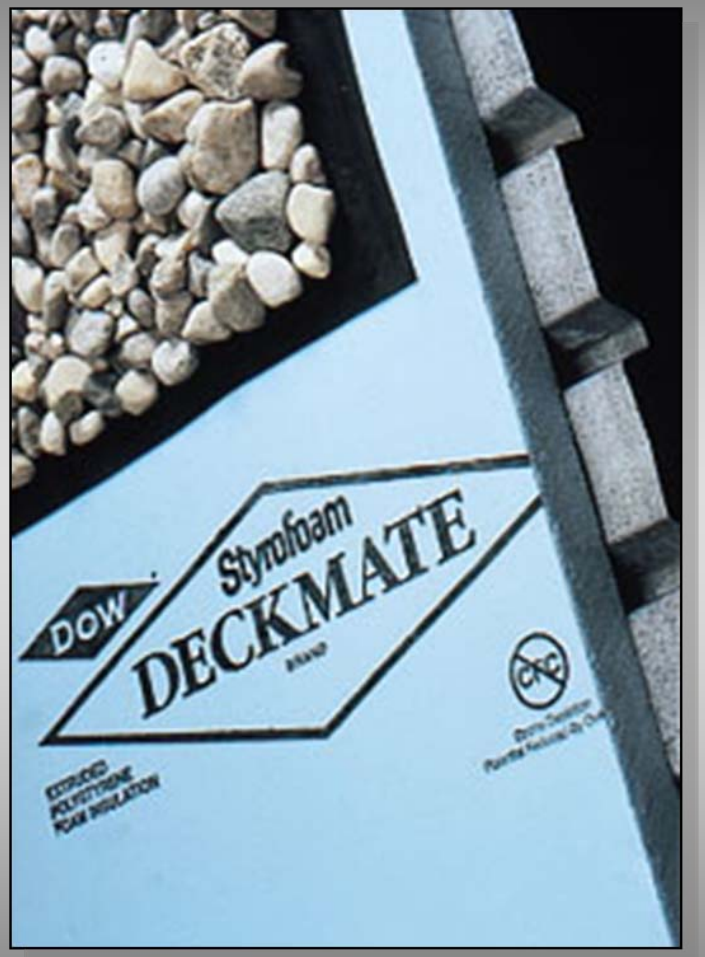
Dens-Deck

- Class –A fire rating
- Excellent cover-board
- 500 psi puncture resistance and hail resistant
- Slightly higher front-end cost

Polystyrene

- Low front-end cost
- Easy to work with, labor friendly
- Recommended to be used with cover boards
- Susceptible chemical damage and fire hazard

"ESP"



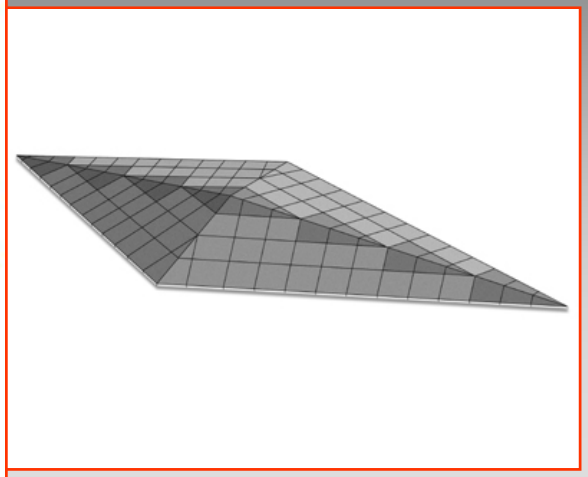
"EXP"

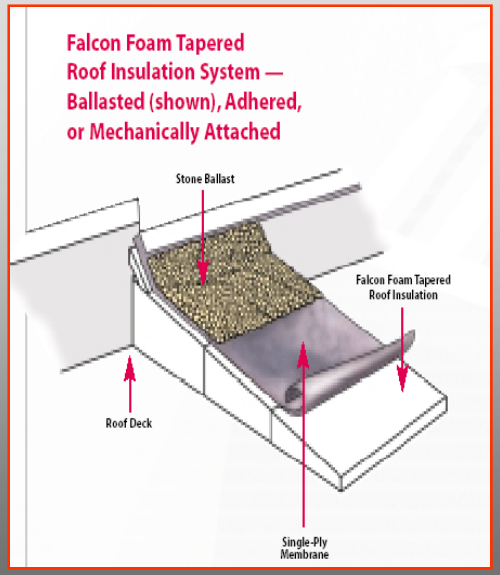
Composite Boards

Durable nailable surfaces with high thermal values accepts adhesives or nailing. Be aware of the need for vapor and air retarders and the staggering insulation layers in lieu of “one” single layer. On shingle roofs “vented” nail boards are recommended with a vent spaces provided between the insulation and nail-board.

Tapered Insulation Systems

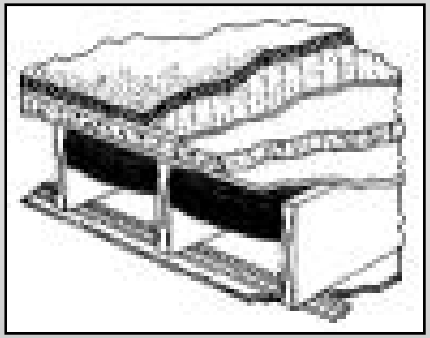
- ¼” per ft. slope generally required by code for “new” construction design.
- Versatile for complicated slope configurations
- High thermal value available

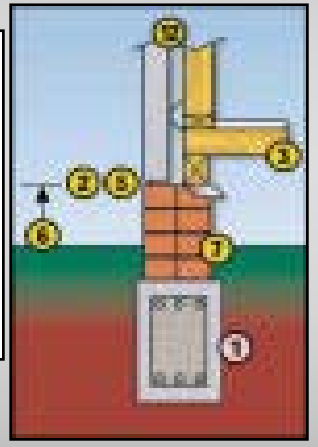




Roof Substrates

- Steel Deck, Fluted Panels
- Site-cast, Poured in Place Concrete
- Pre-cast Concrete Panels, Pre and Post stressed
- Lightweight and Insulating Concrete
- Wood Plank, Sawn Lumber T&G
- Wood Panel, Plywood OSB
- Gypsum Concrete, Poured or Panels
- Cement Fiber, Tectum





Special Features

Vermiculite concrete roof deck systems allow architects, engineers and contractors versatility in design, high performance and reasonable cost. These systems will use a lightweight concrete consisting of Portland cement, water and vermiculite concrete aggregate. It is recommended that all vermiculite roof deck systems be applied by an applicator approved by Strong-Seal® Systems.

Lightweight Concrete Aggregate

Advantages & Features

Lightweight
When compared with structural grade concrete, vermiculite concrete is 15% of the weight. This results in considerable savings from the footings through the structural steel.

Insulation
Vermiculite concrete has excellent insulating properties. Three inches of vermiculite concrete is equivalent to 1-1/2 inches of rigid board insulation layered over steel decks. One inch of vermiculite **concrete** is equal in insulating value to 20 inches of regular concrete.

Ease of Application Vermiculite insulating concrete is easily placed by modern, specially designed pumping equipment. Up to 25,000 square feet can readily be placed in one day.

Fireproof
The fireproofing characteristics of vermiculite concrete are recognized nationwide by insurance companies, state rating bureaus and local building officials. Underwriters' Laboratories have assigned up to 4-Hour ratings to systems that employed vermiculite as one of the components.

Versatile
Vermiculite concrete can be applied over a variety of bases, allowing architects and engineers ample flexibility in their design criteria. The thickness of the concrete can be varied to permit necessary slope to drain.

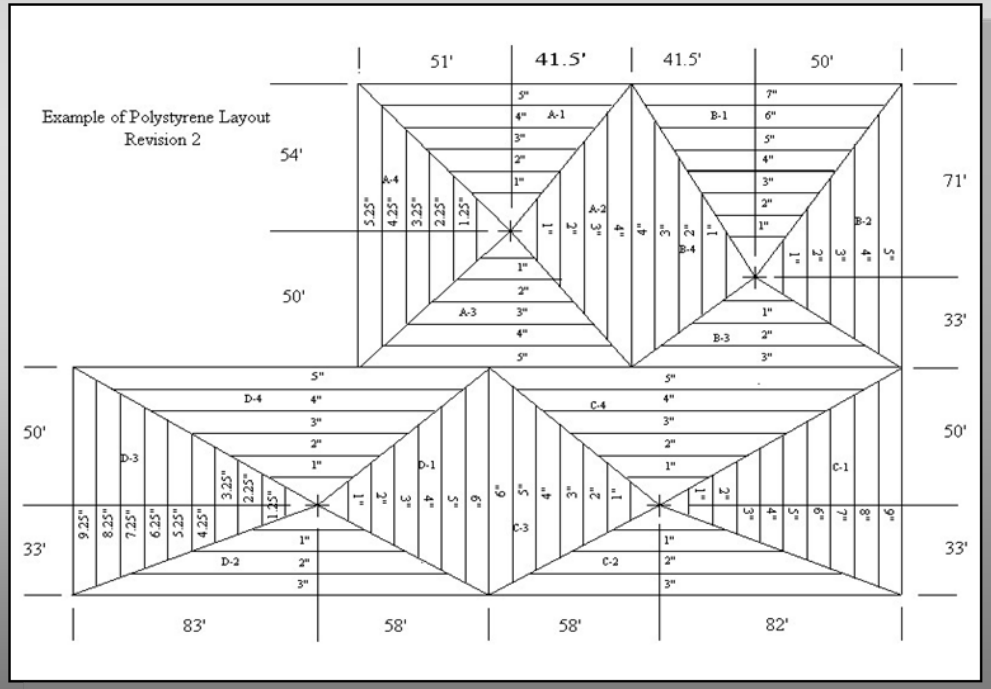
Lightweight Insulating Concrete

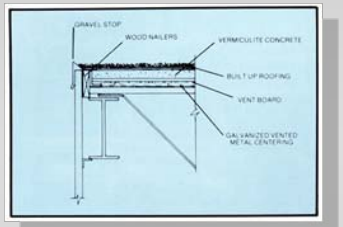
- **Designed to create a fire-proof monolithic tapering substrate**
- **Recommended to be poured over vented steel deck, but can be installed over other vented substrates when necessary.**
- **Higher front-end cost**

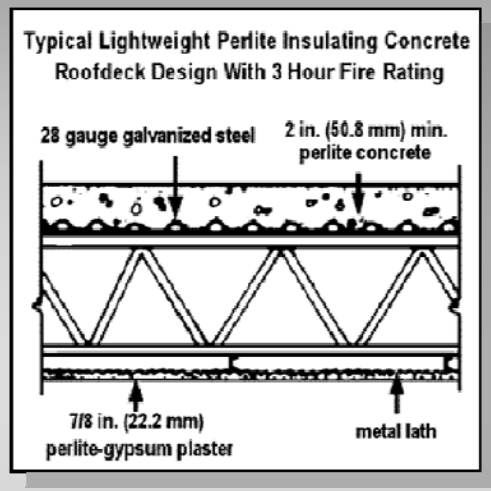
Considerations
- **Type of substrate**
- **Type of insulating concrete (aggregate or cellular)**
- **Minimum thickness of concrete above polystyrene**
- **R-value (minimum or average)**
- **Thickness of slurry coat**
- **Distance between polystyrene steps**
- **Maximum height of polystyrene step**
- **Pre-defined design slope**
- **Slope limited by wall height**
- **Combination of pre-defined slope and wall height limitations in same drainage area**
- **One drain or multiple drains in same drainage area**
- **Height of drains above substrate surface**
- **Distance drain is located from high or low point of drainage area**
- **Cricket design to move water between multiple drains**

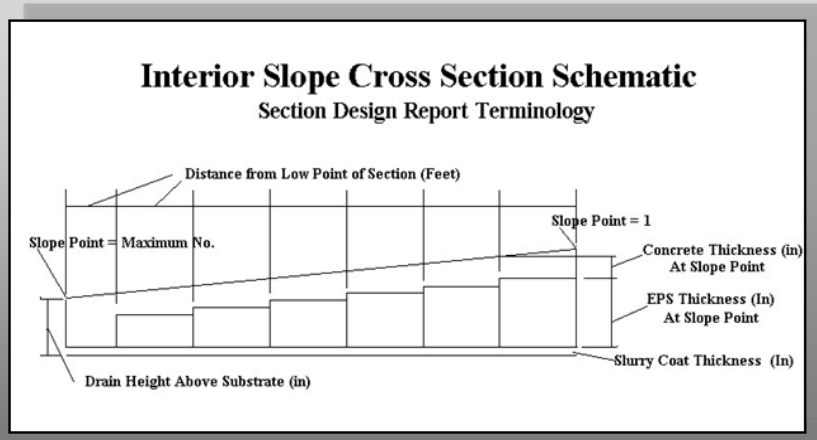
Lightweight Insulating Concrete

Versatile tapering systems









Steel Deck

- Low front-end cost
- Versatile and labor friendly
- Available in many configurations