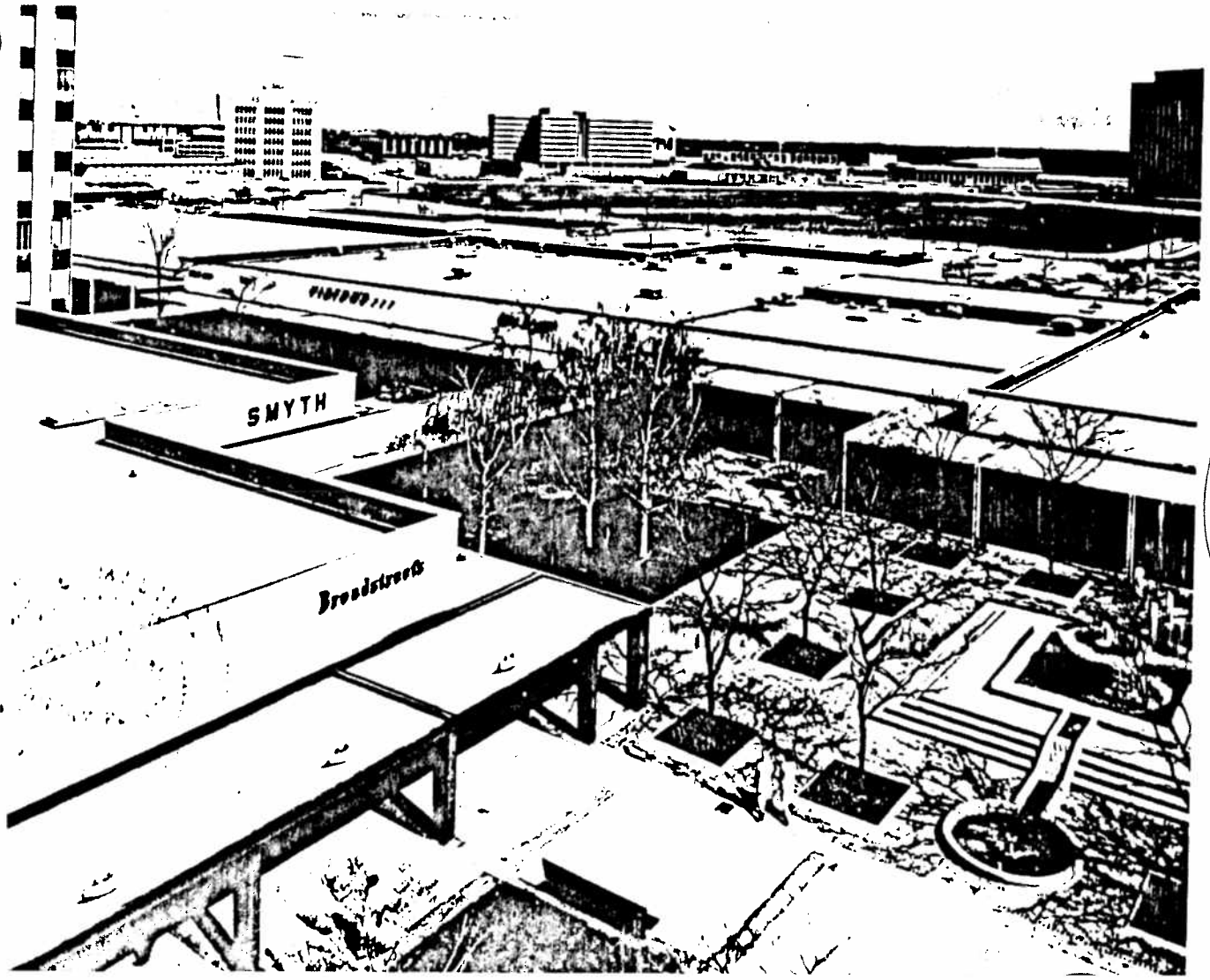
system folder SA-305

...-cost, energy-saving roof ...systems for continuing economy

3.4/Un

Check these important benefits:

- **lower energy demands**
- **low-cost noise control**
- **improved fire protection**
- **lower insurance rates**
- **reduced construction costs**
- **high structural strength**
- **design versatility**
- **all-weather installation**



UNITED STATES GYPSUM
1979-10
3P
CEMENTITIOUS DECKS
gypsum roof systems

wider choice

U.S.G. offers 5 roof deck systems

1. Fire-rated Gypsum Roof Decks of PYROFILL and THERMOFILL Gypsum Concrete are poured in place over galvanized reinforcing mesh and formboards supported by steel sub-purlins. Formboards are left exposed or a rated finished ceiling is suspended below. The result is a rock-hard, monolithic roof deck system that resists hurricane uplift wind forces up to 125 psf; has passed the UL Wind Uplift Class 90 test; resists seismic shock well in excess of building code requirements. Poured gypsum concrete takes any roof shape needed—flat, curved or pitched to match function to form. Gypsum decks are rated noncombustible and their use dramatically reduces insurance rates for lifetime savings. Gypsum sets fast, so roofing can be applied without undue delay. These features make the systems ideal for schools, hospitals, warehouses, industrial construction and other buildings where up to 2-hour fire resistance is required.

THERMOFILL Concrete has all the advantages of PYROFILL Gypsum Concrete plus perlite aggregate for lighter weight.

2. Non-rated Gypsum Roof Decks are poured systems that offer most of the features of rated decks. They meet normal live and dead load requirements for roof purlin spacings up to 12 ft. where roof framing is steel, concrete or wood.

3. USG Double-Board Poured Gypsum Decks have a core of THERMAFIBER Mineral Fiber Insulation up to 1¾" thick inserted between the formboard and gypsum fill. PYROFILL or THERMOFILL Gypsum Concrete is poured in place over galvanized reinforcing mesh, mineral-fiber insulation and glass-fiber formboards supported by truss tee sub-purlins.

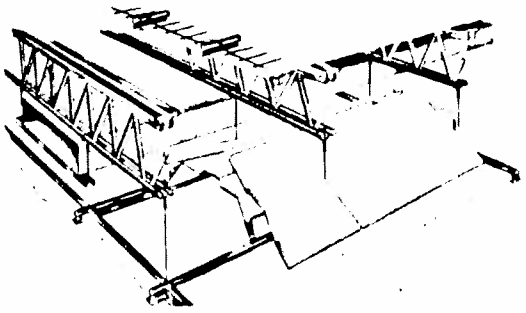
4. UL-tested gypsum roof decks with Dow Chemical Company's IRMA roof combine the superior performance of poured gypsum decks with the excellent thermal insulation and durability found in the inverted roof assembly.

5. SPAN-ROCK Gypsum Roof Planks offer simple-to-install, low-cost, dry-deck systems. These units combine with steel framing to reduce deck weight 30% to 50% under other dry systems. They qualify for 1½-hr. fire rating and provide thermally efficient assemblies meeting most live loads on spans up to 10 ft. The factory-laminated gypsum board planks, 2" thick, 2 ft. wide, and 8 or 10 ft. long, weight 8 psf and are supported by regular roof deck sub-purlins. Refer to page 9 for details, load-span data and specifications.

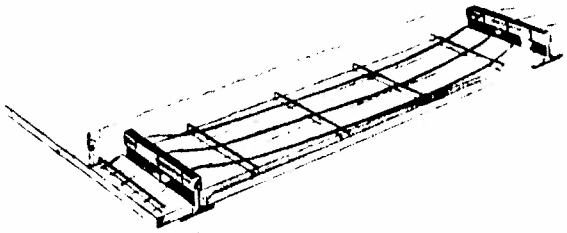
USG Service Ceiling Systems provide walk-deck ceilings to permit full access to the interstitial space between the Service Ceiling and the floor above. There are four versions of this important development, one with poured PYROFILL Gypsum Concrete, the others are dry systems using SPAN-ROCK Gypsum Planks.

limitations

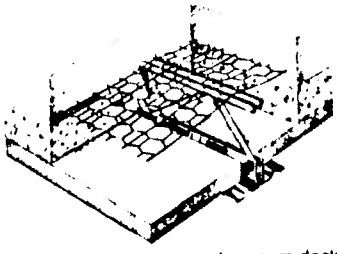
1. Gypsum roof decks are suitable for normal temperature and humidity conditions. Acid fumes, generally not harmful to gypsum, may affect framing. Where such abnormal conditions prevail, consult U.S.G. for recommendations.
2. Certain recommendations concerning drying and ventilation, expansion and contraction, decorating and roofing must be adhered to for satisfactory performance (see Specifications, page 15 for details).
3. Although SHEETROCK Brand Formboard is treated to resist mildew growth, such growth can occur under adverse conditions. See Notes to Architect for details of precautionary measures in notes 1, 2, 3, 4, and 7.



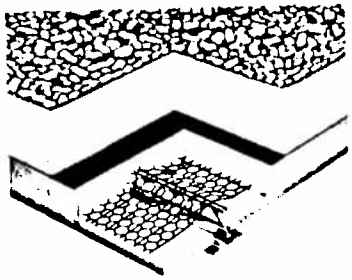
fire-rated deck



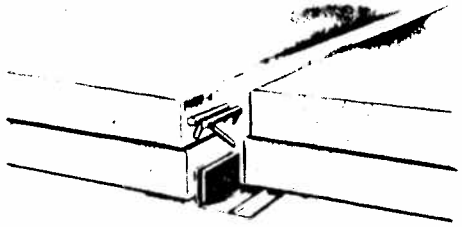
non-rated gypsum deck



USG double-board poured gypsum deck



insulated roof membrane assembly (IRMA)



SPAN-ROCK gypsum roof planks

design versatility

In the roof deck . . .

U.S.G. gypsum concrete can be shaped to virtually any roof configuration—curves, pitches, sawtooth angles or flat. It provides the adaptability needed to design buildings of distinctive appearance with no sacrifice of construction efficiency. Slopes for drainage are easily and readily built into the deck.

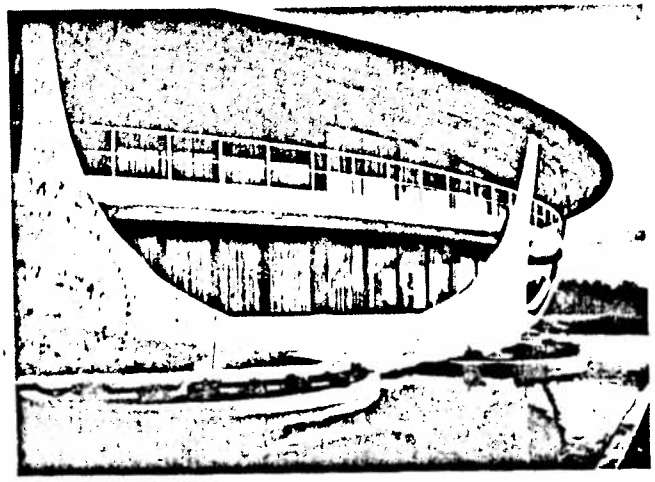
PYROFILL Gypsum Concrete is mill-formulated and composed of calcined gypsum and wood chips or shavings. It is mixed with clean water, only, at the job site and poured in place over permanent formboards or other decks as a drainage fill. Thermal resistance (R) value is 0.67 per inch. It complies with ANSI A59.1-1968 (R1972) and ASTM C317-64 (1970) Standards.

THERMOFILL Gypsum Concrete is mill-formulated and composed of calcined gypsum and graded perlite aggregate. It is mixed with clean water, only, at the job site and poured-in-place over permanent formboards. Thermal resistance (R) value is 0.87 per inch. It complies with ANSI A59.1-1968 (R1972) and ASTM C317-64 (1970) Standards. Not available north of 40th Parallel from Oct. 1 to April 1.

Steel sub-purlins vary in size, weight and shape and are selected according to required span and loading (see page 9). They provide lateral bracing, anchorage against uplift, and restrict deck movement due to temperature change. Sub-purlin spacing accommodates 24" or 32" formboard widths with a slight tolerance for ease of formboard placement. Sub-purlins are spaced approx. 24⅛" or 32⅛" o.c. and are welded to the structural framing members. U.S.G. neither manufactures nor sells bulb or truss tee sub-purlins.

Reinforcing mesh for gypsum concrete is one of following types:
1. KEYDECK—A galvanized wire mesh, woven with 16-ga. straight wires and 19-ga. diagonal wires.
2. 48-1214—A galvanized, welded wire mesh with 12-ga. longitudinal wires at 4" o.c. and 14-ga. transverse wires at 8" o.c.

The effective cross-sectional area of reinforcing mesh placed at 90° to the sub-purlins is .026 sq. in. per foot of mesh width. U.S.G. neither manufactures nor sells reinforcing mesh.



GENERAL TIME BUILDING, Stamford, Conn.
Architect: VICTOR H. BISHARAT

In the formboards . . . concealed or exposed

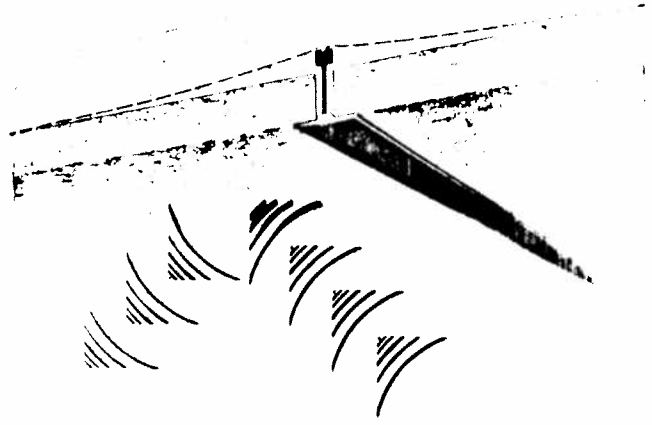
Three types of formboards offer complete freedom of design. They are used singly or in combination to provide insulation, fire resistance, moisture resistance, pleasing appearance, economy of installation, or sound control. They serve both as a formboard for the poured gypsum concrete and, when needed, as semi-finished ceilings eliminating costs of additional ceiling material. Their superior fire resistance often makes added fireproofing materials unecessary and often reduces insurance costs.

SHEETROCK Brand Formboard is a rigid gypsum board, treated to resist mildew* effectively where adequate ventilation is provided. Two-hour fire ratings are available with 2" gypsum slabs and exposed tees. Ideal for almost every roof deck need, concealed or exposed. Makes economical ceilings for warehouses, light manufacturing buildings, schools—any construction where durability and low cost are desired.

Asbestos-cement formboard is a rigid, industrial type board that provides more resistance to heat and humidity than other formboards. Ideal for use on exterior soffits and above heat-producing machinery where temperatures at the board are less than 125°F. U.S.G. neither manufactures nor sells asbestos-cement formboard.

Glass-fiber formboard (not illustrated) is a rigid insulating board of compressed glass fibers with a smooth, mat-faced surface. In gypsum decks, these formboards improve thermal insulation, provide efficient noise control and good light reflectance. U.S.G. neither manufactures nor sells glass-fiber formboard.

* Although SHEETROCK Brand Formboard is treated to resist mildew growth, such growth can occur under adverse conditions. See Notes to Architect for details of precautionary measures in notes 1, 2, 3, 4, and 7.



Low-cost, highly efficient noise control is provided with PYROFILL or THERMOFILL Gypsum Concrete poured over exposed glass-fiber formboards.

3.4/Un

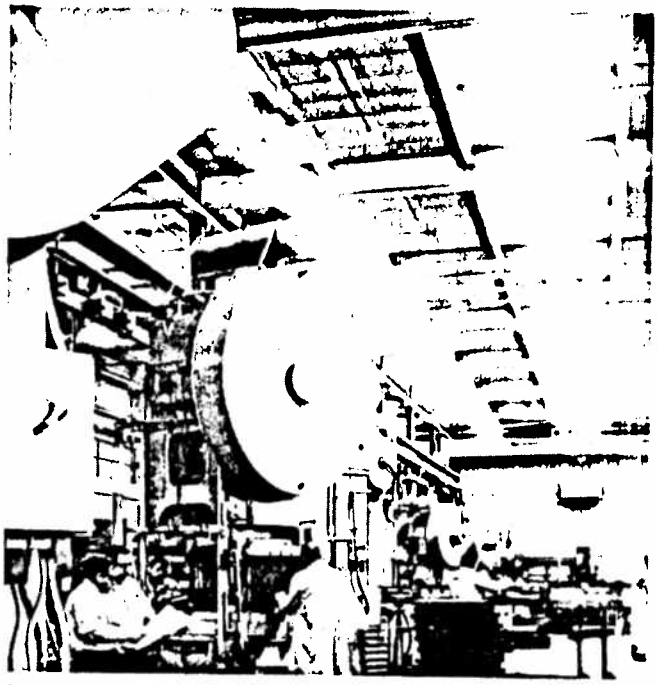
noise control

built-in acoustical performance to help meet OSHA standards

As a result of the Occupational Safety and Health Act of 1970, plant management is faced with the choice of maintaining noise levels within specified ranges, or limiting the duration of employees' exposure to high noise levels. Since reduced exposure has the effect of increasing production costs, every effort should be made in new plant design to limit noise levels.

Another regulation requires all plants with Federal contracts over $10,000 to eliminate continuous noise over 90 dbA where workers are present.

U.S.G. roof deck systems with gypsum concrete poured over exposed glass-fiber formboard offer the most economical method of incorporating a large sound-absorbent surface in new plant construction. The glass-fiber formboards effectively absorb sound and reduce reverberation. Interior noise levels can be reduced up to 7 db with these formboards, which offer .75 to .95 NRC. Glass-fiber formboards are not manufactured by U.S.G.



Gypsum decks help designers comply with OSHA requirements. They effectively control noise and absorb noise created by equipment. Light-reflective U.S.G. formboards lower plant illumination and maintenance costs.

U.S.G. formboards

SHEETROCK Brand Formboard Asbestos Cement Formboard

formboard characteristics

type	thickness in.	thickness (mm)	width in.	width (mm)	length ft.	length (mm)	weight lb/ft²	weight (kg/m²)	thermal resistance R	thermal resistance (K · m²)/W	flame spread	noise reduction coefficient	specification compliance
SHEETROCK brand formboard	½	(12.7)	32	(813)	up to 12' max.	(3658)	2.025	(9.89)	0.45	(0.079)	15-20 (1)	—	Federal Spec. SS-L-30D Type V; ASTM C318-67
asbestos-cement formboard (2)	¼	(6.4)	32	(813)	4	(1219)	2.4	(11.72)	0.06	(0.011)	0-5	—	Federal Spec. SS-B-755a Type U
glass-fiber formboard (2)	1 1½ 2	(25.4) (38.1) (50.8)	32 & 24	(813 & 610)	3 to 8	(914 to 2438)	0.8 1.2 1.6	(3.91) (5.86) (7.81)	4.17 6.25 8.33	(0.734) (1.101) (1.467)	15 (1)	0.77 0.84 0.87	Federal Spec. SS-S-118A Class 25

(1) Flame spread ratings determined by Underwriters Laboratories Inc. (2) Asbestos-cement and glass-fiber formboards are neither sold nor manufactured by United States Gypsum.

structural strength

to withstand hurricane winds, wind uplift and roof loads . . .

U.S.G. roof deck systems form a monolithic unit that structurally integrates the roof deck with the roof framing. Sub-purlins, securely welded to bar joists or purlins, resist uplift and transmit slab loads. Reinforcing mesh provides tensile strength, enables the slab to transmit the load to the framing. With truss tees, the gypsum fill flows through the open web to mechanically key all components into a structural unit. The resulting rigid diaphragm firmly resists horizontal and vertical loading from wind and seismic forces.

Gypsum concrete decks have high structural strength and a hard surface. In tests, standard assemblies supported uniform roof loads over 450 psf when wet and 700 psf when dry. At dry densities of 50 pcf for PYROFILL and 40 pcf for THERMOFILL Gypsum Concrete, the compressive strength of the slab is 500 psi min. This conforms to ANSI A59.1-1968 (R1972) and ASTM C317-64 (1970) for Class A gypsum concrete; exceeds the strength of other insulating fills; provides a better base for roofing and adequate support for normal roofing equipment.

U.S.G. roof decks with long, clear spans can be designed for fewer bar joists to optimize design.

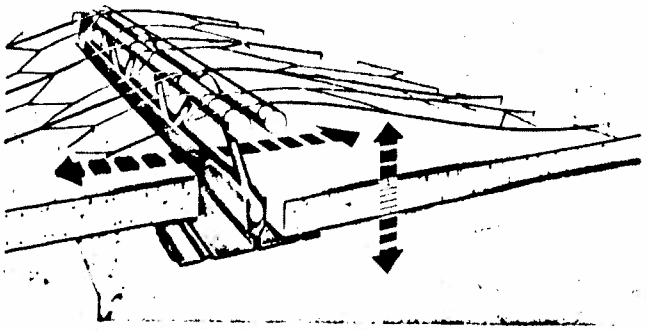
In hurricane areas, such as Florida, standard gypsum roof decks have withstood repeated fierce blows without damage. This is because U.S.G. roof decks resist uplift action by nearly four times the normal requirements of 35 psf when constructed with bulb or truss tee sub-purlins welded to the primary framing.

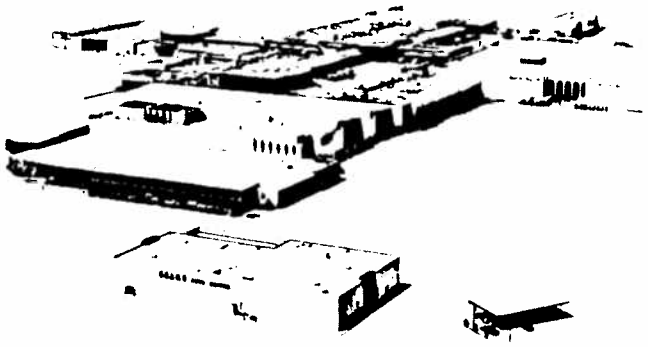
UL Wind Uplift Class 90 has been assigned to a poured gypsum concrete roof deck assembly based on qualified testing (see NM 513 in UL Building Materials Directory). The system tested consisted of PYROFILL Gypsum concrete over SHEETROCK Brand Formboard with bulb tees, KEYDECK mesh and roof covering attached with NAIL-TITE nails. This U.S.G. assembly successfully withstood the rigorous test—while most competitive deck systems have not. Extended coverage insurance rates are generally lower for assemblies having passed the test, especially in Gulf Coast and Prairie States where high wind velocities are prevalent.

to resist seismic shock or to reinforce the building . . .

U.S.G. roof decks provide excellent lateral bracing. They have withstood some of the most severe earthquakes in California and have been approved as rigid diaphragms in Los Angeles and in many of the 1,000 cities which use the Uniform Building Code.

U.S.G. poured gypsum roof decks with bulb tees or truss tees structurally tie the framing system together to reinforce the building and provide resistance to wind and seismic loads.





Open-web construction allows gypsum fill to flow through truss tee to embed it in a solid mass of gypsum concrete. This, plus welding of truss tee to supports, provides strong composite resistance to shear and uplift. The mesh provides tensile strength to reinforce the deck. Cracking and deflection caused by impact and seismic shock are minimized.

economy

U.S.G. decks give more for less . . . in fire-rated systems

Initial savings can amount to thousands of dollars in construction investment when U.S.G. fire-rated roof decks are specified. A UL 2-hour fire-rated system often costs only a few cents per sq. ft. more than a non-rated system . . .and considerably *less* than other types of 2-hour UL fire-rated decks. U.S.G. decks enjoy ready acceptance from major code bodies and insurance companies. Savings are achieved through the unique advantages that U.S.G. roof decks offer in strength, fire resistance and durability.

in fast installation

Up to 30,000 sq. ft. of gypsum deck can be poured in one day. The quick-setting action of gypsum concrete permits roofing almost immediately. There's no wait for curing as with ordinary lightweight concrete decks; no costly delays in erection schedules.

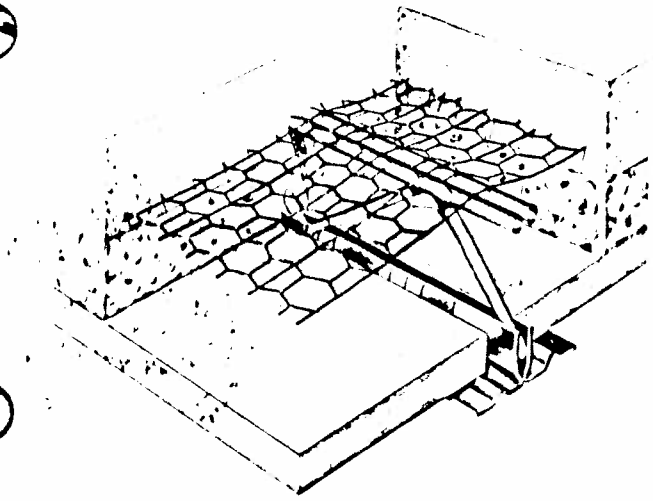
U.S.G. roof decks can be poured in cold weather; in any weather in which men can work. The quick-setting action of gypsum concrete makes it one of the best roof deck materials for winter construction. The exothermic reaction in the slab protects it from freezing before set takes place and the slab is capable of carrying design loads.

in reduced construction costs

U.S.G. gypsum roof decks meet Factory Mutual Noncombustible Classification to qualify for lowest extended-coverage insurance rates without the clear-span limitations imposed upon steel roof deck designs. With gypsum decks, bar joist spacing can be optimized for major cost reductions over steel and lightweight concrete systems.

in total value

U.S.G. gypsum roof decks are the best value in the industry. They offer maximum economy without sacrificing safety or strength. They resist rot, warpage, and deterioration to cut maintenance costs and also reduce insurance rates.



double-board poured gypsum deck

poured installation

insulation-type decks for economy and service

Double-board Poured Gypsum Roof Decks are of conventional poured gypsum construction except for an important additional benefit. A core of mineral-fiber insulation is added between formboards and gypsum concrete for high thermal performance. These decks consist of PYROFILL Gypsum Concrete poured in place over galvanized reinforcing mesh and THERMAFIBER Mineral-Fiber Insulation laid on glass-fiber formboards. These in turn are supported by steel KEYDECK Truss Tee sub-purlins. The gypsum concrete is 2" thick, with insulation a choice of 1, 1½ or 1¾" thick. Formboards are 1" thick, sub-purlins either 2½ or 3" deep, depending on insulation thickness and structural requirements.

Insulation, located between formboards and deck, is low-cost and does not need replacement when roofing is renewed. This deck system offers the all-weather installation and performance advantages of conventional poured gypsum decks, including the "heat-sink" property, which minimizes roofing stresses from thermal shock and significantly prolongs roofing service life. Others are: good light reflectivity on the underside, effective sound attenuation to reduce outside noises, and high sound absorption of formboards to reduce inside noise levels. The exceptional sound control is a key factor in complying with OSHA requirements. Appearance is neat, and versatility is exceptional. Since these roofs are poured, they can be sloped, curved or flat. Double-board Insulating Poured Gypsum Roof Decks meet Factory Mutual Noncombustible Classification to qualify for lowest extended-coverage insurance rates without the clear-span limitations imposed upon steel roof deck designs.

design weight (for USG Double-Board Roof Decks)

insulation type, thickness	dry deck weight psf (kg/m²) (1)
uninsulated	9.3 (45.4)
RD-600, 1" (25.4 mm)	9.8 (47.8)
RD-600, 1½" (38.1 mm)	10.1 (49.3)
RD-400, 1¾" (44.5 mm)	9.1 (44.4)

(1) Includes 1" glass-fiber formboards. THERMAFIBER Insulation indicated. PYROFILL Gypsum Concrete with reinforcing mesh, but not sub-purlins and built-up roofing.

limitations

1. Insulation thickness is limited to the 1" to 1¾" range.
2. Truss tee height must be sufficient to project a minimum ¼" above insulation.
3. Gypsum roof decks are suitable for normal temperature and humidity conditions. Where abnormal conditions are expected, consult U.S.G. for recommendations. Acid fumes, generally not harmful to gypsum, may affect framing materials.

NORTHLAKE MALL, Atlanta, Ga.
Architect: TOOMBS, AMISANO & WELLS

3.4/Un

design data

bulb tee sub-purlins

sub-purlin type	weight—lb/ft (kg/m)	total safe uniform load (psf) with gypsum decks on spans shown—ft (mm) 5'0" (1524)	5'6" (1707)	6'0" (1829)	6'6" (1981)	6'8" (2032)	7'0" (2134)	7'6" (2286)	8'0" (2438)	8'6" (2591)	9'0" (2743)	9'6" (2896)	10'0" (3048)	10'6" (3200)	11'0" (3353)	max. eave overhang—ft (mm)
112	1.40 (2.08)	67	58	47	40											2'2" (661)
158	1.60 (2.38)	92	76	64	54	52	47									2'9" (838)
168	1.75 (2.60)		109	91	78	74	67	58	51							3'4" (1016)
178	2.05 (3.05)			119	101	95	87	76	66	59	52					3'11" (1194)
218	3.00 (4.46)						119	103	91	80	72	64	58	52	48	4'10" (1473)
228	3.65 (5.43)								129	114	102	91	82	74	68	5'10" (1778)

Loads based on 3-span condition and 39,600 psi design stress for 112, 158, 168, 178 tees and 33,000 psi for others. Loads are for bulb tee acting alone, live-load deflection L/240 or less and 32⅝" spacing; for 24⅛" spacing, multiply by 1.32. Eave overhang based on 45 psf load. With nailers, angles, gutters or soffits supported by tees, calculate overhang separately. For wt./sq. ft., multiply wt./lin. ft. by .49 for 24⅛" tee spacing, .37 for 32⅝" spacing and .25 for 48⅛" spacing. For conversion to metric pascals (Pa.), multiply loads shown by 47.88.
Note: Bulb tee height must be sufficient to project ¼" min. above top surface of formboard.

truss tee sub-purlins

sub-purlin type	weight—lb/ft (kg/m)	total safe uniform load (psf) with gypsum decks on spans shown—ft (mm) 5'0" (1524)	5'6" (1707)	6'0" (1829)	6'6" (1981)	6'8" (2032)	7'0" (2134)	7'6" (2286)	8'0" (2438)	8'6" (2591)	9'0" (2743)	9'6" (2896)	10'0" (3048)	10'6" (3200)	11'0" (3353)	11'6" (3505)	12'0" (3658)	max. eave overhang—ft (mm)
5-6-17-1¾"	1.03 (1.53)	65	54	45														2'7" (787)
5-6-17-2"	1.03 (1.53)	76	63	53	45	43	39											2'9" (838)
2-5-17-2"	1.20 (1.79)	119	90	82	70	67	61	53	46	41								3'6" (1067)
1-5-17-2"	1.26 (1.88)		107	90	76	73	66	57	50	45	40							3'7" (1092)
000-5-14-2"	1.78 (2.65)						89	77	68	60	54	48	43	39				4'2" (1270)
5-6-17-2½"	1.05 (1.56)	96	80	67	57	54	49*	43*	38*									3'1" (940)
2-3-17-2½"	1.27 (1.89)			107	91	86	78	68	60	53*	47*	43*						3'11" (1194)
1-3-17-2½"	1.32 (1.96)			116	98	94	85	74	65	58	52	46*	42*					4'1" (1245)
000-3-14-2½"	1.85 (2.75)							101	89	78	70	63	57	51	47			4'9" (1448)
5-6-17-3"	1.07 (1.59)	118	96	82	70*	67*	60*	53*	46*	41*								3'5" (1041)
2-3-17-3"	1.30 (1.93)			131	111	106	96	84	73*	65*	58*	52*	47*	43*				4'4" (1321)
1-3-17-3"	1.35 (2.01)				121	115	104	91	80	71	63*	56*	51*	46*	42*			4'6" (1372)
000-3-14-3"	1.88 (2.80)						141	123	108	96	86	77	69	63	57	52	48	5'3" (1600)

Loads based on 3-span condition, truss tee acting alone, and 32⅝" spacing. For 24⅛" spacing, multiply by 1.32; for 2-span condition, multiply by .8; for single span condition, multiply by .72. Eave overhang based on 45 psf load. With nailers, angles, gutters or soffits supported by tees, calculate overhang separately. For wt./sq. ft., multiply wt./lin. ft. by .49 for 24⅛" tee spacing; 37 for 32⅝" spacing and .25 for 48⅛" spacing. For conversion to metric pascals (Pa), multiply loads shown by 47.88. * Welding both sides of sub-purlin at all intersections with supports is recommended for better lateral stability for formboard installation. Note: Truss tee height must be sufficient to project ¼" min. above top surface of formboard or embedded insulation.

nail-holding power (1)

description of nail	PYROFILL gypsum concrete removal—1 day	removal—7 days	removal—slab dry	THERMOFILL gypsum concrete removal—1 day	removal—7 days	removal—slab dry
1½" ES NAIL-TITE—plain finish(2) (1¼" penetration)	67(3) (30.4)	77 (34.9)	136 (61.7)	60(3) (27.2)	67 (30.4)	141 (64.0)
1¾" SIMPLEX gypsum deck—plain finish (4) (1½" penetration)	6 (2.7)	23 (10.4)	119 (54.0)	2 (0.9)	17 (7.7)	50 (22.7)
6d cornice—plain finish (1½" penetration)	3 (1.4)	18 (8.2)	152 (68.9)	8 (3.6)	22 (10.0)	81 (36.7)

(1) Resistance to direct pull in lb. (kg), for nails placed 24 hr. after pouring slab. Test slabs had 2" min. thickness and dry density of 48 pcf for PYROFILL and 38 pcf for THERMOFILL. Nailholding power decreased at densities less than those cited.
(2) Manufactured by E.S. Products, New Rochelle, N.Y., and recommended for smooth coat type roofing.
(3) Provides min. 40 lb. immediate holding power required by roofing manufacturers.
(4) Manufactured by Simplex Nail & Mfg. corp., Americus, Ga.

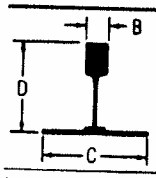
design weight (for fire-rated and non-rated decks)

deck system	dry deck weight psf (kg/m²) (1)
2" PYROFILL Gypsum Concrete ½" SHEETROCK Brand Formboard (2)	11 (53.7)
2¼" PYROFILL Gypsum Concrete ¼" Asbestos-Cement Formboard (2)	12 (58.6)
2" THERMOFILL Gypsum Concrete ½" SHEETROCK Brand Formboard (2)	9 (43.9)

(1) Weight of sub-purlin or roofing not included. PYROFILL Concrete density approx. 50 lb. per cu. ft. THERMOFILL Concrete density approx. 40 lb. per cu. ft. (2) Sub-purlins should extend min. of ¼" above the top surface of formboard.

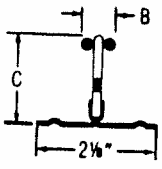
physical properties—dimensions in inches (mm)

bulb tee



type	B	C	D
112	⅜ (9.5)	1½ (38.1)	1½ (38.1)
158	⅜ (9.5)	1⁹/₁₆ (39.7)	1⅝ (41.3)
168	⁷/₁₆ (11.1)	1½ (38.1)	2 (50.8)
178	⁹/₁₆ (14.3)	1⅝ (41.3)	2 (50.8)
218	¹¹/₁₆ (17.5)	2⅛ (54.0)	2⅛ (54.0)
228	⅞ (22.2)	2¹/₁₆ (52.4)	2⁹/₁₆ (58.7)

truss tee



type	B	C	chord wire gage
5-6-17-1¾	⁹/₁₆ (14.3)	1¾ (44.6)	5
5-6-17-2	⁹/₁₆ (14.3)	2 (50.8)	5
2-5-17-2	²¹/₃₂ (16.7)	2 (50.8)	2
1-5-17-2	²³/₃₂ (18.3)	2 (50.8)	1
000-5-14-2	⅞ (22.2)	2 (50.8)	000
5-6-17-2½	⁹/₁₆ (14.3)	2½ (63.5)	5
2-3-17-2½	²³/₃₂ (18.3)	2½ (63.5)	2
1-3-17-2½	¾ (19.1)	2½ (63.5)	1
000-3-14-2½	²⁹/₃₂ (23.0)	2½ (63.5)	000
5-6-17-3	⁹/₁₆ (14.3)	3 (76.2)	5
2-3-17-3	²³/₃₂ (23.0)	3 (76.2)	2
1-3-17-3	¾ (19.1)	3 (76.2)	1
000-3-14-3	²⁹/₃₂ (23.0)	3 (76.2)	000

Properties shown are taken from data furnished by manufacturer.

approved seismic diaphragm

U.S.G. poured gypsum roof decks with truss tees and reinforcing mesh offer an approved construction to resist seismic shock. The gypsum fill flows through the truss tee to form a rigid diaphragm with excellent resistance to shear and uplift. Design procedure is similar to that of reinforced concrete using gypsum stress values allowed by the applicable code (see table). See U.S.G. Bulletin IR-61 for complete design and supporting test information.

allowable shear — reinforced gypsum concrete

gypsum concrete thickness, in. (1)	reinforcing mesh type	allowable shear values, lb. per lin. ft (2) PYROFILL (3) with truss tees	THERMOFILL (4) with truss tees
2	4" x 8" #12— #14	840	710
2	KEYDECK	1060	910
2½	4" x 8" #12— #14	890	760
2½	KEYDECK	1120	960

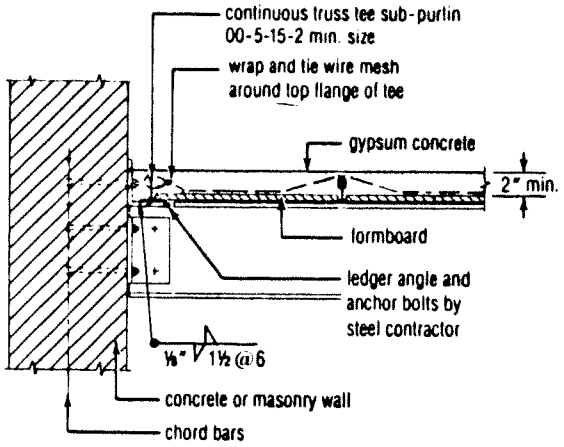
(1) Based on 500 psi compressive strength gypsum concrete Class A.

(2) California Administrator Code — Title 21 data varies slightly in shear calculations and field application. Consult U.S.G. representative for assistance.

(3) See UBC Std. No. 24-13 and Research Recommendation 1312, ICBO.

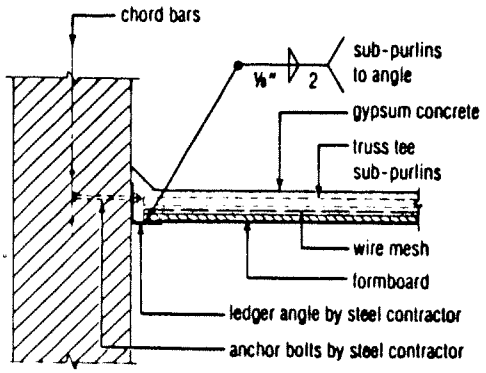
(4) See Research Recommendation 1683, ICBO.

sub-purlins parallel to shear-resisting elements

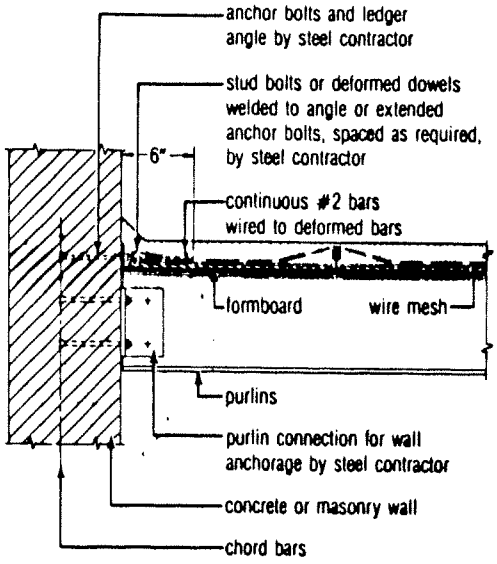


truss tee shear transfer element

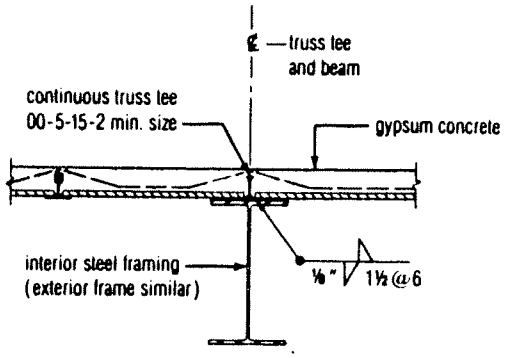
sub-purlins perpendicular to shear-resisting element



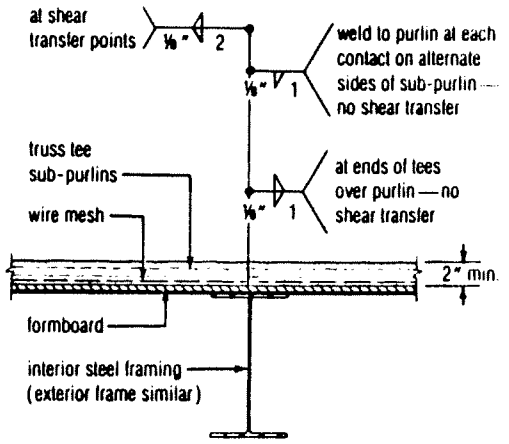
sub-purlins parallel to shear-resisting elements



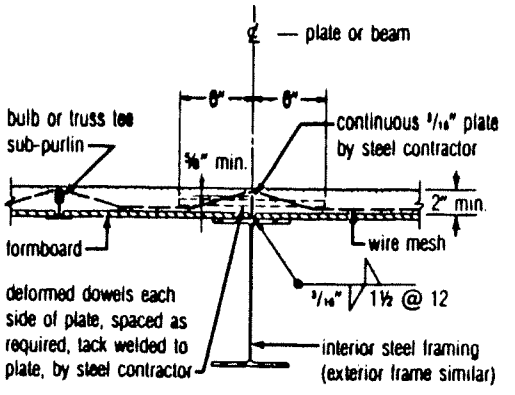
rod dowel shear transfer element



truss tee shear transfer element



truss tee shear transfer element



rod dowel shear transfer element

Cancelled 9-81

International Conference of Building Officials

RESEARCH REPORT

Not Current Report

Report No. 1683
September, 1980

Filing Category: FIRE-RESISTIVE CONSTRUCTION—Other Fire-Resistive Construction

THERMOFILL® AND PYROFILL® GYPSUM CONCRETE
UNITED STATES GYPSUM COMPANY No
DEPARTMENT 133 GEO. PACIFIC IS SUPPLIER
101 SOUTH WACKER DRIVE PERLITE AGGREGATE PYROFIL
CHICAGO, ILLINOIS 60606

I. **Subject:** THERMOFILL® and PYROFILL® Gypsum Concrete as a horizontal diaphragm and as a vertical load carrying element.

II. **Description: General:** The poured-in-place THERMOFILL or PYROFILL is placed on SHEETROCK® gypsum, insulation, acoustical or FIRECODE® mineral formboards which are supported on the lower flanges of steel subpurlins. The poured-in-place gypsum is reinforced with wire mesh draped over the subpurlins and lapped at least 4 inches or one mesh dimension on ends and edges whichever is greater. The wire mesh reinforcement is electrically welded, galvanized wire fabric or "Keydeck" mesh manufactured by Keystone Group, Peoria, Illinois. The Keydeck is composed of a 2-inch hexagonal mesh woven of No. 19 gauge galvanized wire with additional longitudinal No. 16 gauge galvanized wires spaced every 3 inches across the width of the mesh. Dowels or Keydeck subpurlins are used to transfer diaphragm shears to perimeter members.

THERMOFILL: The THERMOFILL gypsum concrete is a premixed mixture of gypsum with perlite aggregate packaged to the specifications of United States Gypsum Company. A minimum oven-dry compressive strength of 500 pounds per square inch is required when tested in conformance with U.B.C. Standard No. 47-17. The dry density is approximately 40 pounds per cubic foot.

PYROFILL: The PYROFILL gypsum concrete is a premixed mixture of gypsum with wood chips or shavings packaged to the specifications of United States Gypsum Company and conforming to Section 2407 (a) of the Uniform Building Code with a dry density of approximately 50 pounds per cubic foot.

Two-hour Fire-resistive Roof Construction—Bulb Tees: The two-hour fire-resistive roof construction consists of a 2¼-inch-thick reinforced THERMOFILL or PYROFILL gypsum concrete slab supported on a 1-inch-, 1¼-inch-, or 1½-inch-thick FIRECODE mineral formboard, or 2½-inch-thick reinforced THERMOFILL or PYROFILL gypsum concrete slab supported on ½-inch-thick SHEETROCK gypsum formboard spanning between bulb tees spaced 2 feet 8⅝ inches on center. Bulb tees must be continuous for at least two spans and have a maximum span of 6 feet 8 inches. End joints between adjacent formboard sheets are supported by cross tees spanning between the bulb tees unless end joints are located at supporting beams.

Two-hour Fire-resistive Roof Construction—Keydeck Subpurlins: The two-hour fire-resistive roof construction consists of a 2-inch-thick reinforced THERMOFILL or PYROFILL gypsum concrete slab supported on a 1-inch-, 1¼-inch-, or 1½-inch-thick FIRECODE mineral fiber formboard or ½-inch-thick SHEETROCK gypsum formboard spanning between Keydeck subpurlins spaced 2 feet 8¾ inches on center. The Keydeck subpurlins must be continuous for 2 spans and have a maximum clear span of 8 feet 0 inch. End joints between adjacent formboard sheets are supported by cross tees spanning between the Keydeck subpurlins unless end joints are located at supporting beams.

One-hour Fire-resistive Roof Construction—Keydeck Subpurlins: The construction is identical to that described above except that the clear span may be increased to 10 feet maximum.

Keydeck Subpurlins: Keydeck subpurlins are composed of steel elements machine-welded together and are used as a shear transfer element or as vertical load carrying members. The tee section consists of two straight cold-rolled wires acting as a top flange, a bent cold-rolled wire acting as a web and two sheet steel angles acting as the lower flange.

Design: The design is based upon the following criteria:

Minimum compressive strength, psi (f_a)	500
Modulus of elasticity, psi (E)	80,000
Modulus of rigidity, psi (G)	.36 E
n	375
Flexural compression equals	0.25 f_a
Flexural tension (nonreinforced gypsum concrete) equals	0.10 f_a
Axial bearing equals	0.20 f_a

fs = 20,000 psi for tension reinforcement.
u = .03 f_a for deformed reinforcement bars or electric welded mesh.
u = 0.02 f_a for plain reinforcement bars.

Shear in THERMOFILL gypsum concrete diaphragm construction is determined by the formula:

$$Q = [.16 f_a t C_1 + 1000 (K_1 d_1 + k_2 d_2)] C_2 C_3$$

Q = Allowable shear per foot on diaphragm in pounds per lineal foot which includes a one-third increase for short-time loading.
f_a = Oven-dry compressive strength of gypsum in pounds per square inch as determined by tests conforming to U.B.C. Standard No. 24-26.
C_1 = 1.0.
t = Thickness of gypsum between subpurlins in inches.
k_1 = Number of mesh wires per foot passing over subpurlins.
d_1 = Diameter of mesh wires passing over subpurlins in inches except hexagonal mesh of keydeck.
k_2 = Number of mesh wires per foot parallel to subpurlins or .7 times the number of hexagonal wires in keydeck. Note that $k_2 = 8.5$ for keydeck.
d_2 = Diameter in inches of mesh wires parallel to subpurlins or of hexagonal wires in keydeck.
C_2 = 1.0.
C_3 = 0.85.

Solution of the above equation for commonly used THERMOFILL thicknesses and mesh types results in the allowable shears set forth in Table No. I-A.

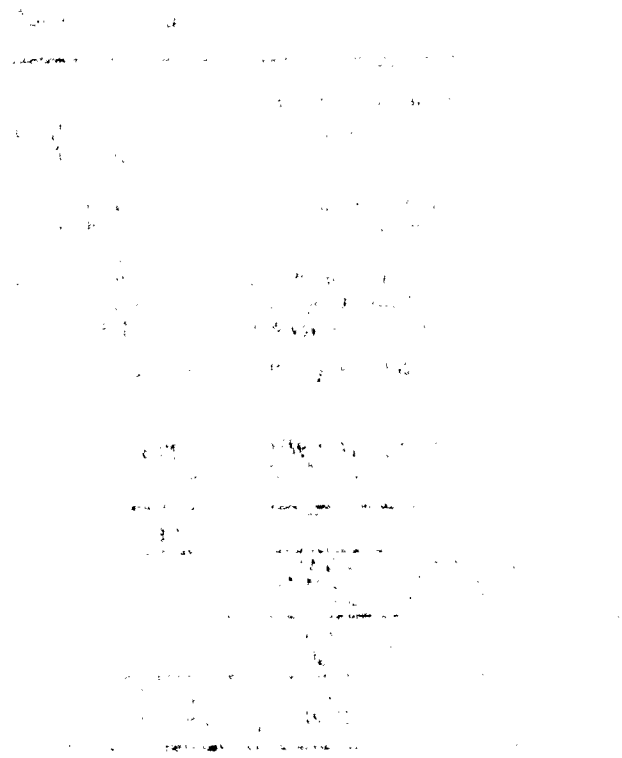
Identification: The FIRECODE formboard is packaged with two or four pieces per bundle, labeled as United States Gypsum Company's FIRECODE and available in custom or economy patterns. SHEETROCK gypsum formboard is shipped two pieces per bundle and is identified with the board size and thickness and the product name on the end bundle tapes. The PYROFILL is shipped in 80-pound papers and the THERMOFILL is shipped in 67-pound papers and they are identified with the product name and manufacturer imprinted on the bag.

III. **Evidence Submitted:** Load tests on eight specimens measuring 8 feet by 16 feet were submitted, together with an analysis of the test data.

Findings

IV. **Findings: That the use of THERMOFILL or PYROFILL as a horizontal diaphragm using Keydeck or bulb tee subpurlins are alternate types of construction to that specified in the 1979 Uniform Building Code, subject to the following conditions:**

1. **The materials and design conform to this report.**
2. **The allowable shears set forth in Tables Nos. I-A and I-B are not increased for short-time loading such as wind or seismic forces.**
3. **The thickness of the gypsum between the top of the formboard and the bottom of the top chord wire is not to be less than ⅝ inch, or less than 2 inches total thickness over the formboard where diaphragm action is required.**
4. **The allowable shear on anchor bolts or dowels shall not exceed values in Table No. 24-F of the code.**
5. **That where continuous Keydeck subpurlins are used as dowels to transmit diaphragm shears into vertical shear-resisting elements, the allowable shear per foot shall not exceed 710 pounds for THERMOFILL or 840 pounds and 1140 pounds per lineal foot with Class A and Class B PYROFILL, respectively within the following conditions:**
   (a) **The Keydeck subpurlins are well embedded in the gypsum and are welded to the structural frame with fillet welds not less than ⅛ inch by 1½ inches, spaced 6 inches on center on both sides of the bottom flanges of subpurlins added at the edges of diaphragms, and over shear-resisting elements within diaphragm, running parallel to the shear-resisting elements, to transfer the diaphragm shears indicated above.**
   (b) **The mesh is tied to the top flange of the subpurlins.**



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6. The size of mesh is:
   Minimum—4" x 8" No. 12 to No. 14
   Maximum—6" x 6" No. 10 to No. 10
   Keydeck as described in Part II

7. The allowable vertical load capacity using THERMOFILL or PYROFILL gypsum concrete and Keydeck subpurlins for a three-span condition shall be as set forth in Table No. II. Deflection shall be investigated in accordance with the criteria set forth in Table No. III.

8. The fire-resistive roof construction with bulb tees be recognized within the following conditions:

   (a) The construction complies with this report.
   (b) The bulb tees have a minimum yield strength of 50,000 pounds per square inch and a minimum depth of 1⅞ inches.
   (c) The stresses in the top and bottom flange of the bulb tees due to negative moments at supports do not exceed 27,000 and 21,600 pounds per square inch, respectively.
   (d) The stresses in the top and bottom flange of the bulb tees due to positive moment between supports do not exceed 15,500 and 12,000 pounds per square inch, respectively.

This report is subject to re-examination in one year.

TABLE NO. I-A — ALLOWABLE DIAPHRAGM SHEAR VALUES FOR THERMOFILL IN POUNDS PER FOOT[1]

TYPE OF GYPSUM CONCRETE	THICKNESS (In Inches)	TYPE OF SUBPURLIN					
		Bulb Tee Reinforcing Mesh			Keydeck Reinforcing Mesh		
		4-8 12-14	6-6 10-10	Keydeck	4-8 12-14	6-6 10-10	Keydeck
THERMO-FILL 500 psi	2	510	590	650	710	840	910
	2½	540	630	680	760	890	960

[1]See Research Report No. 1312 for diaphragm values for PYROFILL with Keydeck subpurlins.

TABLE NO. I-B — ALLOWABLE SHEAR VALUE IN POUNDS PER FOOT USING BULB TEE SUBPURLINS — PYROFILL

CLASS OF GYPSUM CONCRETE	SLAB THICKNESS (In Inches)	MESH TYPE		
		4" x 8" No. 12-No. 14 (Galvanized)	6" x 6" No. 1-No. 10	Hexagonal Mesh (Galvanized)
A (500 psi)	2	600	700	760
	2½	640	740	800
B (1000 psi)	2	920	1020	1080
	2½	1040	1140	1200

TABLE NO. I-C — ALLOWABLE SHEAR VALUE IN POUND PER FOOT USING KEYDECK SUBPURLINS — PYROFILL

TYPE GYPSUM CONCRETE	THICKNESS (In Inches)	TYPE OF MESH		
		4" x 8" No. 12-No. 14	6" x 6" No. 10-No. 10	Keydeck
A (500 psi)	2	840	980	1060
	2½	890	1040	1120
B (1000 psi)	2	920	1020	1080
	2½	1040	1140	1200

TABLE NO. II—TOTAL ALLOWABLE VERTICAL LOAD IN POUNDS PER SQUARE FOOT[1 2 3]

STYLE	SPAN														MAX. EAVE OVERHANG
	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"	9'0"	9'6"	10'0"	10'6"	11'0"	11'6"	12'0"	
5-6-17-1¾"	55	46	39													2'4"
5-6-17-2"	76	63	53	45	39											2'9"
2-5-17-2"	83	68	57	49	42	37										3'7"
1-5-17-2"	81	67	56	48	41	36										2'10"
000-5-14-2"			88	75	65	56	50	44	39							3'7"
5-6-17-2½"	101	83	70	60	51	45	39									3'2"
2-3-17-2½"			72	61	53	46	40	36								3'3"
1-3-17-2½"			75	64	55	48	42	37								3'4"
000-3-14-2½"					87	76	67	59	53	48	43	39				4'2"
5-6-17-3"	122	100	84	72	62	54	48	42	38							3'6"
000-3-14-3"					94	82	72	64	57	51	46	42	38			6'0"
5-6-17-3½"		115	96	82	71	62	54	48	43	38						3'11"
2-3-17-3½"			110	93	81	70	62	55	49	44	39					4'0"
000-3-14-3½"					130	113	99	88	78	70	63	58	52	48	44	5'1"

[1]The tabulated allowable loads include the dead weight of the construction. To determine the allowable superimposed live loads, dead loads must be deducted. Tabulated loads are based on

$$W = \frac{11M}{L^2}$$

[2]Loads based on three-span condition, truss tee acting alone, and 32⅝-inch spacing. For 24⅛-inch spacing, multiply by 1.32; for two-span condition, multiply by .8; for single-span condition, multiply by .72. Eave overhang based on 45 psf load. With nailers, angles, gutters or soffits supported by tees, calculate overhang separately. For wt./sq. ft., multiply wt./lin. ft. by .49 for 24⅛-inch tee spacing and .37 for 32⅝-inch spacing.

[3]To compute deflection, see criteria set forth in Table No. III.

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TABLE NO. III—MOMENT OF INERTIA FOR DEFLECTION DETERMINATION ONLY[1]

KEYDECK SUBPURLIN SIZE	COMPOSITE MOMENT OF INERTIA FOR LIVE LOAD DEFLECTION[2] (Comp.) (Inch⁴)										MOMENT OF INERTIA FOR KEYDECK SUBPURLIN FOR DEAD LOAD DEFLECTIONS[3] (In Inch⁴)
	2-Inch Gypsum Over ½-Inch Gypsum Formboard		2-Inch Gypsum Over 1-Inch Insulation Formboard		2-Inch Gypsum Over 1½-Inch Insulation Formboard		2-Inch Gypsum Over 2-Inch Insulation Formboard		2-Inch Gypsum Over 2½-Inch Insulation Formboard		
	32¾" Spacing	24¾" Spacing	32¾" Spacing	24¾" Spacing	32¾" Spacing	24¾" Spacing	32¾" Spacing	24¾" Spacing	32¾" Spacing	24¾" Spacing	
5-6-17-1¾"	.480	.410									.116
5-6-17-2"	.507	.438	.559	.524							.156
2-5-17-2"	.539	.470	.576	.541							.213
1-5-17-2"	.541	.472	.573	.537							.223
000-5-14-2 (4)"	.635	.566	.683	.647							.320
5-6-17-2½"			.614	.579	.806	.771					.255
2-3-17-2½"			.633	.598	.811	.776					.327
1-3-17-2½"			.659	.623	.832	.796					.369
000-3-14-2½ (4)"			.825	.790	1.011	.975					.537
5-6-17-3"					.886	.850	1.105	1.070			.377
000-3-14-3 (4)"					1.197	1.161	1.420	1.384			.812
5-6-17-3½"									1.337	1.301	.493
2-3-17-3½"									1.383	1.348	.668
000-3-14-3½ (4)"									1.761	1.726	1.075

[1]Deflection shall be limited as specified in Section 2307 and set forth in Table No. 23-D of the Uniform Building Code.

[2]For roof members supporting plastered ceilings, the live load deflection shall not exceed $L/360$ and deflection calculations shall be based on the tabulated composite moments of inertia as follows:

a. For single span construction:

$$\Delta = \frac{5\ w\ l^4 \times 1728}{384\ EI\ (\text{comp.})}$$

WHERE:

Δ = Mid-span deflection in inches.
w = Uniform load in pounds per lineal foot.
l = Span in feet.
E = 30,000,000 pounds per square inch.
I (comp.) = composite moment of inertia of gypsum concrete and keydeck Subpurlin in (inches).[4]

b. For two- or three-span construction, live load deflection shall be determined assuming alternate spans are loaded using accepted design criteria.

[3]The tabulated moments of inertia are for the Keydeck Subpurlin only and are to be used to compute the dead load deflection using beam criteria. For roof members supporting plaster, the dead and live load deflection "ΔT" shall not exceed $L/240$ and shall be determined as follows:

$$(a) \quad \Delta T = \Delta LL + \Delta DL\ (1) + \Delta DL\ (2)$$

WHERE:

ΔT = Total live load plus dead load deflection in inches.
ΔLL = Live load deflection determined as set forth in Footnote No. 2 or No. 3 above.
ΔDL (1) = Deflection in inches due to the weight of the gypsum, formboard, Keydeck Subpurlins and other dead loads added prior to the gypsum setting, based on the moment of inertia of the Subpurlin (1).
ΔDL (2) = Deflection in inches due to the dead load after gypsum sets such as roofing, ceiling, equipment, etc. "ΔDL (2)" is determined using beam deflection criteria and a "K" factor of 2 as set forth in Table No. 23-D of the Uniform Building Code and is based on the amount of inertia of the composite section.

[4]To maintain minimum distance of ¾ inch between the top of the formboard and the bottom of the top chord wire, as required for deck used as horizontal diaphragms, the maximum thickness of insulation formboard for 000-5-14-2 is ⅞ inch, for 000-3-14-2½ is 1⅜ inches, for 000-3-14-3 is 1⅞ inches, for 000-3-14-3½ is 2⅜ inches. The total thicknesses of the gypsum shall be increased ⅛ inch to 2⅛-inch minimum to achieve the composite moments of inertia indicated.