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Standard Specifications

Reinforced Gypsum Concrete

GYPSUM ASSOCIATION

Gypsum Association

20 NORTH WACKER DRIVE · CHICAGO 6, ILLINOIS

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AMERICAN STANDARD SPECIFICATIONS for REINFORCED GYPSUM CONCRETE

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NOTE: These Specifications are intended to describe *Minimum Requirements*. The use of equivalents or better is permissible. Other formboards or structural components may be used, provided tests and field performance have demonstrated them to be the equivalent of the requirements herein specified.

SECTION 1. SCOPE

These specifications cover the design and installation of poured-in-place reinforced gypsum concrete. The *installation provisions* cover only those types of slabs poured over permanent formboards, including slabs where formboards are supported by sub-purlins and ones where formboards are supported by primary framing members spaced as herein specified and do not cover gypsum concrete cast over temporary or removable forms, though the provisions for storage of materials and for mixing, depositing and finishing of the gypsum concrete are identical, as are the general notes regarding precautions, limitations and use of supplementary materials. (Note 1)

SECTION 2. MATERIALS

The materials shall conform to the applicable requirements of the following specifications:

MATERIAL	SPECIFICATIONS
(a) Steel; Sub-Purlins	Steel sub-purlins shall conform to the requirements of: Standard Specifications for Billet Steel Concrete Reinforcement Bars ASTM Designation: A15, ASA A50.1; Standard Specifications for Rail-Steel Concrete Reinforcement Bars ASTM Designation: A16, ASA A50.2; Standard Specifications for Open Hearth Carbon Steel Rails ASTM Designation: A1. They shall be bulb tees, standard structural or bar size tees, A.A.R. or A.S.C.E. rails, special flanged sections, or other sections having the required structural characteristics to carry the dead and live loads. They shall be shop painted with one coat of rust inhibitive paint.
(b) Steel; Reinforcing Fabric (Mesh)	Reinforcing fabric shall conform to the requirements of ASTM Designation A185-37 and shall be galvanized, welded wire fabric having an effective cross sectional area of not less than 0.026 sq in. per ft of width, equivalent to No. 12 gauge longitudinal wires spaced not over 4 in. on centers and transverse wires shall be equivalent to No. 14 gauge and be spaced not over 8 in. on centers.

NOTE 1: Where reference is made by abbreviation, the abbreviation shall have the following meaning: **A** shall mean appendix; **ASA** shall mean the American Standards Association; **ASTM** shall mean the American Society for Testing Materials; **AAR** shall mean the Association of American Railroads; **ASCE** shall mean the American Society of Civil Engineers; **AREA** shall mean the American Railway Engineering Association.

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MATERIAL	SPECIFICATIONS
(c) Gypsum Concrete Mill Mixture	The gypsum concrete mixture shall conform to the requirements of the Standard Specifications for Gypsum Concrete ASTM Designation C317.
(d) Water	Water shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.
(e) Formboards	
(1) Gypsum	Gypsum formboard shall conform to the requirements of Standard Specifications for Gypsum Formboard, ASTM Designation C318.
(2) Insulating Fiberboard	Shall conform to the requirements of ASTM Specifications Designation C-208, or Federal Specifications designated LLL-F-321 b. The board may be factory finish or natural finish and shall be treated to provide effective resistance to attack from mildew rot and termites. The board shall be of not less than nominal 1 in. thickness.
(3) Acoustical Fiberboard	Shall be mat surfaced, perforated or slotted or, of other surface finish providing the desired acoustical absorption, painted or unpainted, made from insulating fiberboard conforming to the requirements specified in Section 2(e)(2) above. It shall be not less than 1 in. thick. The formboard shall be treated to provide effective resistance to attack from mildew, rot and termites.
(4) Cement — Asbestos	Shall conform to the requirements of ASTM Specification Designation C220, Type I or II, or Federal Specifications SS-S-283 Type I or II. Sheets shall be not less than $\frac{3}{16}$ in. nor more than $\frac{1}{2}$ in. in thickness. Edges and ends shall be square.
(5) Fibrous Glass (Insulating-Acoustical)	Shall be made of glass fibers bound together into a rigid board having a density of not less than 9.0 lb per cu ft. The exposed side of the formboard when installed shall have glass mat surface or be a smooth sanded finish. The thickness shall be not less than nominal 1 in. for the mat surface and nominal $1\frac{1}{4}$ in. for the sanded surface type. Formboard shall sustain without breaking a uniform loading of 20 lbs per sq ft when tested by the "Bag Method" described in ASTM E72-51T, "Strength Test of Panels for Building Construction." Test samples shall be 24 in. wide by 32 in. long with not less than 1 in. bearing of ends on flat supports in the apparatus.
(f) Joint Tees	Joint tees shall be hot rolled or sheet metal tees. They shall be shop painted one coat of rust inhibitive paint or shall be galvanized.

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SECTION 3. STRENGTH OF GYPSUM CONCRETE

3-1. **Classification**—Gypsum Concrete shall be classified by strength in accordance with the requirements of Standard Specifications for Gypsum Concrete ASTM Designation C317-54.

NOTE: ASTM Designation C317-54 requires the mill-mixed gypsum concrete to have the following compressive strengths when tested in accordance with the applicable requirements of ASTM Designation: C26:

	Compressive strength min psi
Class A	500
Class B	1000

3-2. **Determination of Strength.** The strength of gypsum concrete (f_g) shall be determined in accordance with requirements of Standard Methods of Testing Gypsum and Gypsum Products ASTM Designation C26-54.

SECTION 4. WATER RATIO

The water ratio shall not exceed 11.0 gallons of water per 100 pounds of Class A mill mixed Gypsum Concrete and not more than 9.0 gallons of water per 100 pounds of mill mixture for Class B mill mixed gypsum concrete.

SECTION 5. ALLOWABLE STRESSES

5-1. **Reinforced Gypsum Concrete.** In the design of reinforced gypsum concrete the stresses in the concrete shall not exceed the following values:

In this tabulation f_g indicates the compressive strength of the concrete mixture as determined in accordance with Section 3.

Compressive stress in bending	$0.25f_g$
Axial compressive or bearing stress	$0.20f_g$
Bond stress	$0.02f_g$*
Shearing stress	$0.02f_g$*

*Gypsum concrete reinforced with electrically welded wire fabric meeting the requirements of Section 2(b) meets the bond and shear requirements of this section.

5-2. Steel

(a) **Sub-purlins.** Design stress in tension of steel sub-purlins (f_s) shall not exceed the minimum yield strength of the steel when divided by 1.85.

(b) **Wires or Wire Fabric Reinforcement.** Stress in tension (f_s) shall not exceed 50% of the minimum yield point of the steel used but in no case shall exceed 25,000 psi.

5-3. **Modulus of Elasticity.** In the design of reinforced gypsum concrete, the applicable value given below shall be used as the modulus of elasticity of the gypsum concrete:

Class of Gypsum Concrete	*Modulus of Elasticity psi*
A	200,000
B	600,000

SECTION 6. DESIGN, *See A(g)*

6-1. **General.** Reinforced gypsum concrete shall be designed to support the loads and to withstand the forces to which it is subject without exceeding the stresses permitted in Section 5. Except as hereinafter provided, methods of design admitting of rational analysis according to established principles of mechanics shall be used. The general assumptions and principles established for reinforced concrete shall also apply to reinforced gypsum concrete in so far as they are pertinent except that the minimum ratio of reinforcement to concrete area for shrinkage and temperature reinforcement shall not apply to gypsum concrete.

NOTE: Two general methods of installations over permanent formboards are available. In the first, sub-purlins are used to span across the primary framing members to receive formboards. In the second, formboards are applied directly over the primary framing members. The first method in itself provides anchorage in lateral and vertical directions. The second method does not provide such resistance to lateral and vertical forces unless added anchorage precautions such as suggested in *A(g)(2)* are incorporated.

NOTE: These constructions are not intended as a final surface to bear traffic or other loads. Adequate protective floor or roof coverings shall be provided.

6-2. **Protection.** The top side of the gypsum concrete slab shall be protected by others with an adequate water proof covering *see A(e)*. Where such roofs overhang the eaves or are similarly exposed, they shall either be poured on cement-asbestos formboards or the undersides shall be otherwise protected against wetting. *See A(a)(2).*

6-3. **Minimum Thickness.** The minimum thickness of gypsum concrete used structurally shall be 2 in. from the top of the formboards except in the suspension system, where it shall be not less than 3 in. Measurement for minimum thickness shall be taken over primary framing members and at the center line between sub-purlins where such members are used. (NOTE: *Formboards for suspension system not described herein.)*

6-4. **Maximum Spans.** The maximum clear span of the gypsum concrete slab between supports shall not exceed (1) 32⅝ in. when using sub-purlins and permanent formboards as specified herein, and (2) shall not exceed 3 feet for gypsum concrete over permanent formboards applied directly to primary framing members, and (3) shall not exceed 8 feet for the suspension system.

6-5. **Suspension System.** In the construction of slabs by the suspension system, the forms used are temporary, being removed when slabs are set and adequately strong. In this construction the reinforcement shall consist of wires with continuity through multiple spans and anchored at the ends. Anchorage shall be such as to provide adequate re-

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sistance to tensile stresses developed in the wire by the design load. The top of the slab shall be not less than ½ in. above the roof or floor beams. The wires shall be encased in gypsum concrete, shall be supported in the top of the slab by the roof or floor beams, and shall be tightly drawn down as near to the bottom of the slab at midspan as fire protection requirements will allow, but not closer than ½ in. Provision shall be made in the framing of the end bays of this system for resisting the forces due to end anchorage of the wires. The wires shall be designed for a tension in pounds per ft width of slab equal to:

$$\frac{wL^2}{8d}$$

in which: w is the total load in lb per sq ft
L is the clear span in ft
d is the sag of the wires in ft

SECTION 7. INSTALLATION OVER PERMANENT FORMBOARDS, *See Section 1*

7-1. General Provisions

(a) The work includes all materials, labor, services, equipment, hoisting and scaffolding and performing all operations required to complete the installation of reinforced gypsum concrete in accordance with the drawings and the specifications. This includes the supplying and installing of the sub-purlins for systems that require them, the formboards, the reinforcing fabrics, the gypsum concrete and the gypsum roof cants, curbs and drainage fills.

(b) Scaffolding and hoists shall be constructed in strict conformance with applicable laws and ordinances and in such a manner as to avoid undue interference with the work of others.

(c) The work shall be properly coordinated with the work of others.

7-2. Definitions

(a) **Primary Framing.** The term "Primary Framing" is used herein to define those structural members provided by others to receive the reinforced gypsum roof deck assemblies specified in this section.

(b) **Sub-Purlins.** Where the term "Sub-Purlins" is used, it refers to those steel members applied transversely to the primary framing and used to support the formboards and the gypsum concrete roof slabs.

(c) **Formboard.** Where the term "Formboard" is used it refers to the sheet material spanning between sub-purlins or across primary framing members and used as a form to receive the gypsum concrete. For the purpose of this specification, these formboards are permanent formboards, remaining in place as part of the finished structure.

(d) **Joint Tees.** Where the term "Joint Tees" is used, it refers to steel tee sections or other steel shapes used to support formboard edges at right angles to the sub-purlins or to the primary framing where sub-purlins are not used.

(e) **Reinforcing Fabric.** The term "Reinforcing Fabric" refers to the steel wire fabric used to reinforce the gypsum concrete.

7-3. Delivery and Storage of Materials

(a) All materials shall be stored off the ground and shall be kept dry until use, preferably by being stored inside a building under roof. Where necessary to store mill mixtures for gypsum concrete and formboards outside, they shall be properly supported and fully protected from the weather. Materials left on the roof structure between working periods shall be similarly kept dry.

(b) Formboards shall be neatly stacked and handled to minimize damage to edges, ends and surfaces.

(c) Prolonged storage of the gypsum concrete mill mixture should be avoided, particularly in humid localities or during humid weather.

7-4. Installation Procedures

(a) Forms and Reinforcing *(Where sub-purlins are used.)*

(1) Sub-purlins shall be welded to each primary framing member on which they bear by using fillet welds not less than ½ in. long placed on alternate sides of sub-purlins. Sub-purlins shall be properly spaced to receive the formboards specified.

(2) Formboards shall be placed on flanges of sub-purlins with all end joints falling over walls, purlins, other primary framing members or joint tees. Cross joints of formboards with tongue and groove or similar interlocking designs do not require support. Formboards shall be cut to fit neatly, including fitting at all walls, curbs, openings, etc., as required. Where a suspended ceiling is to be hung below the slab, end joints may occur at random and be supported by use of suitable wire or sheet metal joint clips.

(3) Reinforcing fabric shall be placed with the longitudinal wires at right angles to the sub-purlins. Ends of fabric shall be lapped not less than 6 in. Sides of fabric shall be butted or spaced apart not more than 4 in. Reinforcing fabric shall be cut to fit at all walls, curbs, openings etc. Reinforcing fabric shall be carried into all areas where gypsum concrete is to be placed, including poured curbs.

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(b) Forms and Reinforcing—*(Where sub-purlins are not used.)*

(1) Joint tees shall be placed across primary framing members, spacing them to receive exposed sides or ends of formboards. For spans up to 32⅝ in., the formboards shall be parallel or at right angles to the supports. Where spans exceed 32⅝ in., the formboards shall be placed at right angles to the supports.

(2) Formboards shall be placed on steel framing and joint tees, being sure all edges and ends are supported. Where a suspended ceiling is to be hung below the slab, end joints may occur at random and be supported by use of suitable wire or sheet metal joint clips. Cut formboards to fit neatly at walls, curbs, openings, etc., as required.

(3) Reinforcing fabric shall be carried over the formboards with the longitudinal wires running at right angles to the primary framing members. Ends of fabric shall be lapped not less than 6 in. Sides of fabric may be butted or spaced apart not more than 4 in. Cut reinforcing fabric to fit at all walls, curbs, openings, etc. Reinforcing fabric shall be carried into all areas where gypsum concrete is to be placed, including poured curbs.

7-5. Mixing Concrete

(a) Gypsum concrete mill mixture shall have water only added at the site. The amount of water added shall not exceed that specified in Section 4.

NOTE: The water ratio determines to a major degree the ultimate compressive strength of the dry gypsum concrete. All necessary precautions should be taken to be sure that excessive water is not added. Proper devices for accurate measurement of water or consistency of mixture should be used.

(b) Either manual mixing or mechanical mixing may be employed. In either case the concrete shall be thoroughly mixed. The concrete shall not be mixed through its setting time. Mixing boxes, tools, mixers, hoses, etc., shall be kept clean and free from excessive amounts of set material.

7-6. Depositing Concrete

(a) Care shall be taken in depositing the gypsum concrete to insure against impact on the formboards to a degree which causes them to excessively deflect or crack. "Double pouring" shall not be employed.

NOTE: "Double pouring" means the application of gypsum concrete over substantial areas in more than one layer to complete the full slab thickness. This is to be distinguished from the common practice of "scratching in" gypsum concrete ahead of the general pour to "seal" joints etc.

(b) Pour the gypsum concrete over the forms and reinforcing to a thickness of not less than 2 in. over the formboards.

(c) In all cases, pouring of the gypsum concrete shall follow the installation of the formboards as promptly as possible. No more formboards shall be laid in one day than will have gypsum concrete poured over them in that day.

(d) Screeds, such as metal bars or wood strips shall be placed as guides to screeding the gypsum concrete to the specified thicknesses. Immediately on pouring, the gypsum concrete shall be spread and screeded. Surface of concrete shall be left smooth enough to receive the roof covering specified for the job.

(e) Pour all gypsum concrete cants, curbs and drainage fills specified, or shown on the drawings.

NOTE: Drainage fills shall not exceed 8 in. in depth. *See A(g)(5).* If the framing is not arranged to provide such a limit and deeper fills are still required, it is recommended the precast gypsum partition or roof tile be placed over the cast roof deck to build up to a rough outline of fill at a level averaging minus 2 in. from the finished lines and that an average of 2 in. of gypsum concrete be then poured over them to form the proper drainage slope.

(f) Curbs around openings may be formed with formboard and have poured gypsum concrete placed to complete the curb ready for waterproof roof covering *or,* the space between the steel framing of the curb can be filled with precast gypsum roof tile set in poured gypsum concrete mortar, ready to receive waterproof roof covering.

7-7. Cold Weather Operations

Gypsum concrete shall not be mixed or poured during weather when the temperature and job exposure will allow the concrete to freeze before it takes its complete chemical set.

NOTE: Since the setting action of gypsum concrete generates considerable heat within the slab, it is usually safe to pour such slabs in the coldest weather during which mechanics normally work. However, at such periods, extra effort should be exerted to apply the built-up roof covering as promptly after pouring of slab as is possible.

7-8. Clean-Up

After the slab has been poured, clean all surfaces of debris and loose particles occasioned by this division of the work and leave the slab surface free and clean, ready to receive the roof covering.

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APPENDIX

A. Appendix

NOTE: Section A gives general information and also suggestions for inclusions to be made elsewhere by specifier. It is not part of this specification.

(a) Limitations of Use

(1) Roof Shapes and Designs—Gypsum roof decks meeting these specifications can be employed on flat, warped, sawtooth, curved or pitched roofs.

(2) Moisture Exposure—Poured gypsum concrete is not recommended for general use in occupancies where it will be wetted by exposure to unusually high humidities. The manufacturer of the gypsum concrete used should be consulted regarding questions of such high humidity occupancies.

(3) Temperature Exposures — Where intermittent or extended exposures to high temperatures are to be expected such as in slabs directly exposed to radiant heat over furnace breechings, etc., the gypsum concrete manufacturer should be consulted for his special recommendations.

(4) Acid Fumes—Acid Fumes are not generally more objectionable with poured gypsum construction than with other constructions, particularly those having exposed steel. If acid fumes are considered a possibility, the manufacturer of the gypsum concrete should be consulted for his special recommendations.

(5) This construction is not intended as a final surface to bear traffic or other loads. Adequate protective floor or roof coverings shall be provided.

(b) Support for Suspended Ceilings, Etc. Suspended ceilings should preferably be hung from the primary framing itself. They can be hung from the sub-purlins only if a design check is made to determine that the added weight of the ceiling will not cause the sub-purlins to deflect more than $\frac{1}{360}$ of their span. In no case, should hangers be fastened into or through the poured gypsum concrete slab or the formboards. Similar precautions should be followed for the suspension of unit heaters, light troffers, piping, etc.

(c) Drying of Slabs. Subsequent to the pouring of gypsum concrete, adequate ventilation accompanied by heat as required is recommended below the slabs to remove the excess moisture resulting from the slab pouring, placement of concrete floors, masonry, plastering and other similar construction work. Where windows cannot be opened and in windowless buildings, adequate mechanical ventilation is required to remove construction moisture from the building. When suspended ceilings are installed below the slabs, adequate provisions should be made to permanently vent the enclosed space. using sufficient gravity or mechanical ventilation to remove all construction moisture and excessive moisture vapor resulting from subsequent use or occupancy.

(d) Provisions for Expansion and Contraction. Provision for relief of expansion and contraction should be considered for all poured roof decks of substantial area. Wherever expansion joints have been provided in the main structure, they must also be provided in the roof deck and roof covering. The use of suitable expansion strips at the junction between roof slabs and parapets, etc.. is recommended for further relief of expansion and contraction stresses in the slabs. Where sub-purlins are used, such edge expansion strips need be used only at walls where sub-purlins abut walls at right angles.

(e) Roof Coverings. Built-up type of roof coverings should generally be specified over poured gypsum concrete roof slabs.

(1) The application of metal or other rigid types of roof covering over poured gypsum concrete decks is not generally recommended. If sheet metal roof coverings are required over portions of a poured gypsum concrete deck, their anchoring members must be attached either by the use of toggle bolts passing entirely through the slab and formboards or by suitable fastening to the primary members. Where shingle type roof covings are contemplated, the gypsum concrete manufacturer's recommendations for attachment should be followed.

(2) Provisions for furnishing and installing roof sumps should be included elsewhere in the specifications.

(3) The application of roof covering should follow as promptly after the pouring of gypsum concrete as possible, it being necessary to wait only until the top surface of the slab is reasonably dry as indicated by the disappearance of visible moisture gloss from its surface.

(4) If a bonded roof is applied, the recommendations of roofing manufacturer should be followed in regard to its installation. In other cases, the following recommendations should be considered: The first two plies of the built-up roofing felts should be nailed to the slab. Nails should be 5d or 6d cut nails, bright or galvanized. The nails must be driven through conventional type tin roofing discs.

(f) Painting Undersides of Poured Gypsum Concrete Slabs. The underside of the poured gypsum deck is usually not further decorated. If painting is desired, it should be deferred until the formboard and the slab are thoroughly dry throughout their total thickness.

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(g) **Framing Requirements.** The primary framing to receive sub-purlins and the primary framing spaced so as to directly receive the formboards for the gypsum concrete are not part of the gypsum concrete specifications. However, it is essential that the following provisions regarding such framing be elsewhere incorporated:

(1) Spacing of primary structural supports to receive the sub-purlins of the reinforced gypsum concrete assembly must be such that design stresses in the specified sub-purlins are not exceeded.

(2) When sub-purlins are not used, provisions should be made to anchor the slab to the primary framing members to help resist temperature movements and uplift forces. The following methods have been used, but other provisions can be made:

(a) Weld "Zee" shaped formed steel clips to the top flanges of the joists, providing one clip per not more than 10.5 sq ft of roof area. Clips should be made from steel at least 1/8 in. thick and 1 in. wide formed to project approximately 1 in. above the top of the formboards and having at least 1¾ in. long embedment in the slab. Stock 1¾ in. x 1¾ in. x 1¾ in. "Zee" bars weighing 3.16 pounds per foot and cut to a minimum width of 1 in. may be used.

(b) Weld steel Tee bars sized from 1 in. x 1 in. x 1/8 in. to 1½ in. x 1½ in. x 3/16 in. across the joists at approximately 32 in. to 48 in. on center spacings, depending on type of formboard used. The reinforcing mat must then be wire tied to these cross tees.

(3) Heavy concentrated loads, such as water tanks, large fan bases, cooling towers, flag poles, etc., must not be imposed directly on the poured gypsum concrete roof deck. Details must provide for transmitting such loads directly to the walls or the primary framing.

(4) The architect or engineer should definitely assign by specification the responsibility for furnishing and installing of roof nailers, framings at openings and expansion joints, eave and wall angles and similar special items.

(5) It is generally good practice for the architect or engineer to provide as much as possible of the slope required for drainage in the steel framing itself. This is sometimes accomplished by the method of "warped" framing.

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