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H 400 MATERIALS AND DESIGN SPECIFICATIONS

H 410 CONCRETE

Specifications for materials and design of concrete structures (both reinforced and prestressed) are referenced in this subsection and exceptions noted.

H 411 MATERIAL SPECIFICATION

Materials should be as specified in the Standard Specifications and Standard Plan S-610. Reference specifications for additional information are:

a. Standard Specifications, Caltrans.

b. City of Los Angeles Building Code.

c. Building Code Requirements for Reinforced Concrete, ACI 318.

d. Standard Specifications for Highway Bridges, AASHTO.

e. AREA Manual, Volume I, Chapter 8.

H 411.1 PORTLAND CEMENT CONCRETE

The general requirements for portland cement concrete are published in the Standard Specifications Subsection 201-1. The concrete classes to be specified for various types of structures are listed.

H 411. 2 STEEL REINFORCEMENT

Steel reinforcement specifications for reinforced concrete and prestressed concrete are published in the Standard Specifications, Subsections 201-2 and 303-3.3, respectively.

H 412 CONCRETE DESIGN

Except for the structures listed below, concrete structures should be designed in accordance with State of California, Department of Transportation's "Bridge Planning and Design Manual" (BPDM), Volume I, Sections 6 and 8, Concrete Design and Prestressed Concrete, respectively. This manual is almost entirely exerpted from AASHTO which should be used as its supplement of in lieu of the manual where no conflict arises.

H 412.1 TREATMENT PLANT STRUCTURES

Concrete buildings, retaining walls, tanks and other structures designed for wastewater processing plants or related facilities are designed in accordance with other sections of this manual except as described in this subsection. Such structures are often subject to corrosive environments which are defined as:

a. **Severe exposure:** face of concrete exposed to liquid sewage or condensation of sewage fumes or gasses. (pH less than 5 and sulfate solutions greater than 1500 ppm).

b. **Normal exposure:** face of concrete opposite to liquid sewage or sewage fumes or gasses; remote from direct exposure but in the vicinity of and occasionally subject to diluted effects of sewage or gasses. (pH greater than 5 and sulfate solutions less than 1500 ppm).

c. **No exposure:** concrete not exposed to sewage or gasses.

H 412.11 CORROSION PROTECTION

Service load stresses in reinforcing or bar distribution should be modified (Z-factor) and minimum concrete cover over reinforcing should be increased for exposure to corrosive environment (unless a protective coating or liner is used):

TYPE OF STRUCTURE	EXPOSURE		
	NONE	NORMAL	SEVERE
Buildings & Related Structures	ACI 318 Sec. 7.7 Sec. 10.6	Add 1/2" Cover Z=115	Add l" Cover Z=95
Highway & Sanitary Structures	BPDM Vol. I Table 6-11 AASHTO 1.5.39	Add 1/2" Cover Z=115	Add 1" Cover Z=95

Increased concrete cover is not cumulative with that required for marine, sulfate or chloride environments, but should be at least the greatest of the three requirements.

The reinforcement distribution factors, Z, listed above, are based on concrete covers such that B=1.35, where B is the ratio of distances to the neutral axis from the extreme tension fiber and the centroid of reinforcing. They should be adjusted proportionally for actual B. (See ACI 318-77 Commentary 10.6.4 for details.)

Bar spacing for principal reinforcing should not exceed 12" for severe exposure nor 18" for normal exposure. Minimum bar sizes are #5 and #4, respectively. Reinforcing transverse to principal reinforcing should be #4 at 18".

H 412.12 LIVE LOADS AND SEISMIC FORCES

Live loads for building structures and highway structures may be those of LABC, Chapter 23, and BPDM, Chapter 1, except as follows for specialized structures (use actual loadings if larger):

STRUCTURE TYPE	LIVE LOAD
Electrical Control Room	250 psf
Heavy Equipment Room	300 psf
Tank Cover	100 psf
Galleries	100 psf
Hydrocrane Traffic	H-15 Truck
Roadway Traffic	HS-20 Truck

Hydraulic impact and sloshing effects under seismic loading are analyzed in accordance with "Nuclear Reactors and Earthquakes", published by the Atomic Energy Commission.

412.2 STRUCTURES DESIGNED UNDER OTHER CODES

Structures which are to be constructed under the jurisdiction of other departments or agencies should be designed in accordance with the applicable codes and specifications:

a. **Buildings** or related structures where a building permit is required are designed in accordance with LABC, Chapters 23 and 26.

b. **Railroad Bridges** or related structures to be maintained by a railroad company for supporting their tracks are designed in accordance with AREA Manual, Vol. I, Chapter B (See Section H 270).

c. **Flood Control** structures to be maintained by LACFCD are designed in accordance with LACFCD Structural Design Manual.

H 413 CORROSION PROTECTION FOR CONCRETE

The minimum concrete cover and the type of cement to be used for the protection of reinforcing steel in concrete structures is dependent upon the corrosiveness of the environment and, for hydraulic structures, the velocity of flow. The Geology

and Soils Engineering Section can furnish data regarding the chloride and sulfate content of the soil. The appropriate design office will furnish the velocity of flow.

Concrete cover is measured from the surface of the concrete to the face of the reinforcing steel. The minimum cover based on velocity of flow for normal and marine environment is listed in the following subsections. Additional protection against soil containing high chlorides and sulfates is discussed in Subsection H 412.15 and H 412.2.

H 413.1 CHLORIDE AND VELOCITY OF FLOW PROTECTION

A marine environment is defined to exist within 1,000 feet (304.8m) of ocean or tidal water. Concrete in marine or high chloride soil environment should contain a minimum of seven sacks of cement per cubic yard.

For piles in a marine environment, a protective coating is often applied to that portion above the ground or water line. The limits of coating should be shown on the plans.

H 413.11 BRIDGE, PUMP PLANT, AND RETAINING STRUCTURES

For these structures in normal and marine environments the minimum cover for reinforcing steel is shown in Table A, Figure H 412.1.

H 413.12 RC BOX, RC ARCH, AND RECTANGULAR CHANNEL STRUCTURES

For these structures in normal and marine environments the minimum cover for reinforcing steel is shown in Table B, Figure H 412.1.

H 413.13 REINFORCED CONCRETE PIPES

The minimum cover for reinforcing steel is specified in Section 207-2 of the Standard Specifications. Additional cover due to velocity of flow and marine environment is as follows:

a. For flow velocity between 20fps and 40fps (6.1 m/s & 12.19 m/s), add 1/2 inch (13 mm), inside face. (Flow velocity should not exceed 40fps.)

b. For marine environment, add 1/2 inch (13 mm) minimum inside and/or outside face.

H 413.14 HIGH CHLORIDE ENVIRONMENT

For pipe conduits to be placed in a high chloride soil or ground water environment, add a minimum of 1/2 inch (13 mm) cover to the inside and outside faces. Higher values may be necessary based on the chemical analysis of the groundwater or soil.

For structural members exposed to a high chloride soil or goundwater environment, the minimum cover for reinforcing steel is shown in Table C, Figure H 412.2.

H 413.2 SULFATE RESISTANCE

Resistance to concrete attack by high sulfate content in the water or soil is provided by increasing the Type II cement factor, using Type V cement, or by combining class F fly ash with Type II cement. Cement content and type to be used are shown in Table D, Figure H 412.2. The limits should be shown on the plans.

H 414 SEISMIC DESIGN CRITERIA

Seismic design of concrete bridges should be in accordance with Subsection H 233, and BPDM, Volume I, Section 2-16. Connections and restraining features should be detailed to provide ductility and prevent sudden collapse as a failure mechanism. Concrete buildings should be designed in accordance with LABC, Chapters 23 and 26. Tanks for treatment plants are discussed in Subsection H 412.1.

H 415 LAP SPLICING OF REINFORCEMENT

Lap splicing of Grade 60 reinforcement should be specified on the plans in accordance with Figure H 411. Splicing of Grade 40 reinforcing is specified in SSPWC, Section 303-1.7.2. All bars larger than #8- should always be spliced only as detailed on the plans.

H 416 SKEWED STRUCTURES

Exterior girders of concrete T-beams and box girders at the obtuse corners of skewed structures are subject to high shears. Exterior and first interior girders should be designed for additional shear stresses in accordance with Figure H 415.

H 417 CONCRETE OVERLAYS

Overlays on existing concrete sidewalks and roadways are usually made with either epoxy or portland cement mixes, or a combination of the two. In general, epoxy is an excellent adhesive,

and epoxy grout provides a good wearing surface, but is relatively costly. Portland cement mixes are economical, and usually give satisfactory results for overlays over 3/4" in thickness.

Based on experience and economics, the following materials should be specified on the plans when overlays are required on existing concrete sidewalks and roadways:

Overlay Thickness	0 to 3/4"	Epoxy grout
Overlay Thickness	3/4" to 2"	Portland cement grout over epoxy bonding coat.
Overlay Thickness	over 2"	Portland cement concrete over cement bonding coat.

Portland cement concrete over cement bonding coat provides a good bond of moderate strength (200 psi). Epoxy bonding coat may be used when higher strength is necessary.

Epoxies and epoxy grouts should be specified in accordance with Caltrans Standard Specifications, either on the plans or in the Special Provisions.

H 418 PRESTRESSED CONCRETE

Design of post-tensions structures should acommodate stressing from one end only, to minimize the cost of the jacking operation. In simple spans, and in approximately symmetrical multiple spans, half the tendons are jacked from each end to provide symmetry of prestressing forces.

In unequal double (or multiple) spans, all jacking is usually from the long span end to locate the higher prestressing forces at the point of maximum positive moment. However, where negative moment over a pier controls the magnitude of prestressing force, it may be economical to design for all jacking to be done from the short span end to minimize frictional losses over the pier. Both options should be considered. Where total length of tendons exceeds 350 feet, jacking simultaneously from both ends should be considered. Stressing location and forces applied should be clearly specified on the plans or in the special provisions. The option of jacking from both ends should be provided. If steel quantity reduction is significant the reduced prestressing force should be shown for the two-end jacking option.

H 420 MASONRY

Specifications for materials and design of masonry structures are referenced in this Subsection.

H 421 MATERIAL SPECIFICATION

The general requirements for masonry materials including brick, concrete block, mortar, grout, and plaster are listed in the Standard Specifications, Section 202. Masonry materials not covered in the Standard Specifications should conform to the requirements of LABC, Division 24, Masonry.

Steel reinforcement is specified in the Standard Specifications, Subsection 201-2.

H 422 MASONRY DESIGN

The design of masonry members should conform to the requirements of LABC, Division 24. Design loads are as specified in BPDM, Volume I, for highway structures and LABC, Division 23, for building structures.

H 422.1 CONCRETE BLOCK

Concrete block should be specified on the plans to be grouted solid. The ultimate compressive strength, f ' m, is assumed to be 1500 psi (10.342 MPa). Allowable stresses should comply with LABC, Table No. 24-H, "Special Inspection Required".

H 422.2 REINFORCEMENT

The allowable reinforcing steel stresses shall conform to LABC, Section 91.2417(m).

Lap splice requirements are specified in the Standard Specifications, Subsection 303-4.1.3.

H 423 SPECIAL DESIGN REQUIREMENTS

Architectural requirements may call for special construction materials or methods involving masonry products. These requirements should be included in the project's Special Provisions. Copies of the following are available from the Structural Engineering Division:

a. Cement plaster (stucco) coating to be placed on concrete block masonry.

b. Quarry tile pavers for placement on stairway treads and landings.

c. Masonry veneer, surface preparation, anchorages, application, etc.

Color and texture of masonry surfaces should be specified on the plans or in the Special Provisions.

H 430 TIMBER

H 431 GENERAL

The quality and design of wood members, materials, and fastenings should conform to the specifications listed in the following list of terms:

Grade (lumber) - The classification of lumber by strength and utility in accordance with the grading rules of an approved lumber grading agency.

National Design Specification - "National Design Specification for Wood Construction", a publication of the National Forest Products Association.

Nominal Size - The commercial size designation (before planning) of lumber by thickness and width (or width and depth) for standard sawn lumber in accordance with American Softwood Lumber Standard, PS-20 (refer to Figures H 433A, B and C).

Timber Construction Manual - A manual published by the American Institute of Timber Construction (AITC) which contains design data, construction information, and recommended standards and specifications for engineered timber construction.

H 432 MATERIAL SPECIFICATION

The materials used for timber construction should conform to the following:

H 432.1 STRUCTURAL TIMBER

Structural timber and lumber, unless specified otherwise, should conform with the listed rules, specifications, and standards for Douglas Fir, California Redwood, and plywood in Subsection 204-1, Standard Specifications. This subsection lists lumber uses and corresponding minimum grades.

H 432.2 CONNECTORS AND FASTENERS

Hardware used for timber connections generally consists of fasteners as listed in the National Design Specification. The type and size should be shown or specified on the plans.

Bolts, nuts and steel hardware are specified in Section 206, "Miscellaneous Metal Items", Standard Specifications. Fasteners and miscellaneous metal hardware should be specified on the plans to be hot-dip galvanized per Subsection 210-3 of the Standard Specifications. Zinc-coated nails should be specified.

H 432.3 PRESERVATIVES

When preservative treatment is required, the type of preservative should be specified. Treatment should conform to Subsection 204-2 "Treatment with Preservatives", Standard Specifications. All lumber in contact with the ground or in a marine environment, or subject to rot or attack by borers or other insects should be treated. Creosote is the preferred preservative. ACA, CCA or pentachlorophenol (penta) may be used where creosote is unavailable or unsuitable (such as for painted surfaces). Minimum retention should be specified on the plans. Depth of penetration "**and**" percent of sapwood should also be specified.

The following minimums are for use with Coast Region Douglas Fir (See AWPA Manual of Recommended Practice for additional requirements):

WOOD PRESERVATIVES

MINIMUM RETENTION AND PENETRATION

LUMBER & TIMBERS	ABOVE GROUND	GROUND CONTACT FRESH WATER	MARINE ENVIRONMENT
Creosote	8.00	10.00	25.00
Penta	0.40	0.50	N.R.
ACA or CCA	0.25	0.40	2.50

(Example of callout: 0.50 INCHES PENETRATION AND 90% OF SAPWOOD)

PILES	**ABOVE GROUND**	**GROUND CONTACT FRESH WATER**	**MARINE ENVIRONMENT**
Creosote	12.00	17.00	20.00
Penta	0.60	0.85	N.R.
ACA or CCA	0.60	1.00	2.50

(Example of callout: 1.00 INCH PENETRATION AND 85% OF SAPWOOD)

H 433 SIZE OF STRUCTURAL MEMBER

Sizes of lumber specified on the plans are nominal sizes. Computations should be based on the net dimensions (actual sizes). (Refer to Figures H 433A, B, and C.)

Lumber with dimensions other than nominal dressed sizes should be detailed with actual dimensions shown on the plans. For properties of rough-sawn lumber, refer to Appendix A-7.

For plywood thicknesses and section properties, refer to Section 2 of the Plywood Design Specification, published by the American Plywood Association (APA) or to the Timber Construction Manual.

H 434 ALLOWABLE DESIGN STRESSES

Allowable unit stresses for structural timber are discussed in this subsection. Allowable stresses are subject to adjustments set forth in the footnotes to the appropriate stress tables for effects of wet conditions, preservative treatment, fire retardant treatment, duration of loadings and other special conditions.

H 434.1 STRESS-GRADE LUMBER

Bridges and Highway Structures: Allowable stresses are listed in Table I of the National Design Specification (excerpts are listed in AASHTO Table 1.10.1A).

Buildings: Allowable stresses are tabulated in LABC Table 25-A-1.

Additional design values, such as for bending stress of repetitive member uses, allowable stresses for machine stress-rated lumber and for dense Douglas Fir are also available in the WWPA Standard Rules.

H 434.2 PLYWOOD

Allowable stresses are tabulated in the American Plywood Association's Plywood Design Specification, Table 3, or AITC, Table 4.13, or LABC, Table 25-B.

H 434.3 GLUED-LAMINATED STRUCTURAL MEMBERS

Allowable unit stresses are tabulated in the National Design Specification, Part IX, AITC 117-76, AITC Tables 2.9 and 2.10, and LABC 25-C-1. Excerpts are listed in AASHTO 1.10.1B.

H 434.4 TIMBER PILES

Timber piles are designed as structural columns in accordance with National Design Specifications, Part X, and AASHTO 1.4.4 using the allowable unit stresses therein. See also Subsection H 513.1, Maximum Design Loads. For building structures, refer to LABC 91.2808.

H 435 LOADS AND DISTRIBUTION OF LOADS

Loads, forces, and their distribution are discussed in Chapter H 300, Design Loads and Distribution of Loads. Live load impact is generally neglected in the design of timber structures.

H 436 FORMULAS FOR DESIGN COMPUTATION

For the design of beams, columns, and other members, refer to Part 4 of the AITC Manual or to the National Design Specification or AASHTO 1.10.2 for bridge and highway structures. Also refer to LABC Chapter 25 for buildings and related structures.

For the design of plywood members, refer to the American Plywood Design Specification, Section 4, Design Loads and Design Formulas, or to the AITC Manual, Part 4.

H 437 FASTENERS AND CONNECTIONS

Mechanical fastenings used to transmit stress between wood members and between wood and metal members are designed in accordance with the National Design Specifications, Parts IV - V III.

Safe loads and design parameters for commercial connectors not specified in NDS should be verified by an approved testing agency and approved by the Structural Engineering Division.

H 437.1 LAG SCREW JOINTS

Lag screws inserted parallel to the grain of the wood should not be used for resisting withdrawal forces.

The spacings, end distances, edge distances, and net section for lag screw joints should be the same as for joints with bolts of a diameter equal to the shank diameter of the lag screw used (see National Design Specification, Section 601).

H 437.2 WOOD SCREW JOINTS

Wood Screws inserted parallel to the grain of the wood should not be used for resisting withdrawal forces.

H 437.3 NAILED AND SPIKED JOINTS

H 437.31 SAFE LATERAL STRENGTH

Common wire nails and spikes driven perpendicular to the grain of the wood, may be used to resist lateral loads as shown in the National Design Specification.

The lateral strength of box wire nails shall be three-fourths of the values for common wire nails.

A wire nail driven parallel to the grain of the wood or toe nailed is limited to two-thirds of the allowable lateral load allowed when driven perpendicular to grain.

H 437.32 SAFE RESISTANCE TO WITHDRAWAL

Nails or splices driven parallel to the grain of the wood should never be used for resisting withdrawal forces. The use of nails or splices perpendicular to the grain in withdrawal should be avoided and, if used, should be clinched.

H 437.33 SPACING AND PENETRATION

Nails or spikes for which the wire gages or lengths are not listed in the National Design Specification tables are subject to required penetration and allowable loads interpolated between tabulated values.

Nail spacing center-to-center should not be less than the required penetration.

Edge and end distances should be not less than one-half of the required penetration where nail load is directed toward the edge or end.

H 437.34 PREDRILLED HOLES

Where necessary to prevent splitting, holes should be pre-drilled to a diameter not exceeding three-fourths the diameter of the nail or spike.

H 437.35- SPLIT WOOD

Nails causing a split in the wood should be rejected in the field and replaced.

H 438 STRUCTURES DESIGNED UNDER OTHER CODES

Timber structures which are to be constructed under the jurisdiction of other departments or agencies are designed in compliance with their codes and specifications. For example:

LABC, Division 25, Wood.

AREA, Manual of Railway Engineering, Volume I, Chapter 7, Timber Structures.

AASHTO, Standard Specifications for Highway Bridges, Sections 10 and 20, Timber Structures.

State Division of Industrial Safety, Construction Safety Orders, Article 6, Section 1540 and Plate C-24.

H 440 STEEL

Specifications for the materials and design of steel structures are listed below.

H 441 MATERIAL SPECIFICATION

Steel materials should conform to the ASTM designation listed in the Standard Specifications, Section 206.

H 442 STRUCTURAL STEEL DESIGN

The design of steel bridge and highway structures should conform to BPDM, Volume I, Section 5 or AASHTO Standard Specifications for Highway Bridges, Section 7, Structural Steel Design.

Railroad bridges and related structures should comply with AREA Manual for Railway Engineering, Volume II, Chapter 15, Steel Structures.

Steel building structures should be designed in compliance with LABC, Division 27, Steel.

H 443 FABRICATION AND CONSTRUCTION

When welding is required for major structural steel members, a supplemental specification pertaining to welder qualification, welding operator qualification, qualification of welding procedures, testing and radiographic inspection should be included in the project's Special Provisions. Copies are available from the Structural Engineering Division.

Electroslag and electrogas welding procedures should not be used on structural members. Fatigue failures (due to brittleness) have led to their restriction on Federally funded (FHWA) projects.

H 444 PAINTING STRUCTURAL STEEL

For exposure under outdoor weathering conditions, two paint systems should be considered.

a. Vinyl based paint system.

b. Alkyd based paint system.

The vinyl system is superior and should generally be specified. Alkyd systems may be preferable where careful surface preparation or old paint removal is not possible, or coatings will be applied over rust. Alkyds will penetrate rust and other contaminants and adhere better to the metal.

A vinyl system will last about twice as long as an alkyd system under similar exposure conditions. The initial cost will be higher due to the higher cost of materials and the degree of surface preparation required. However, the cost per year of service will be lower.

If the existing paint on a steel structure to be repainted is not the same type as proposed vinyl or alkyd, consult with the paint manufacturer regarding compatibility of the two types. It may be necessary to test the adherence to the existing paint.

Selection of a paint system should be by references to appropriate Federal or State specification numbers to obtain the proper paint at competitive prices. A paint system should always be selected first and a color second. Although most paints can be obtained in many colors, certain pigments or excessive pigmentation may produce unstable paints.

Color selection for paints is made by reference to a color number in Federal Standard No. 595a, COLORS, or by reference to the Standard Specifications for Public Works Construction or the State Standard Specifications. For Federally funded highway improvement projects, references to brand names should be avoided. On other projects, colors and paints may be selected by brand name.

Special Provisions for painting structural steel are available from the Structural Engineering Division.

H 450 ALUMINUM

Specifications for the materials and design of aluminum alloy structures are listed below.

H 451 MATERIAL SPECIFICATION

Aluminum alloys are specified by ASTM designation for extrusion or rolling in Standard Specifications, Section 206-5, AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, Table 1.5.1, and AASHTO Standard Specifications for Highway Bridges, Section 8. For buildings and related structures refer to Uniform Building Code, Chapter 28.

H 452 ALUMINUM DESIGN

Aluminum members are designed by the elastic method. Allowable stresses and section properties are listed in "Standard Specifications for Aluminum Structures" published by the Aluminum Association.

H 453 FABRICATION AND CONSTRUCTION

When aluminum is to be used, a supplemental specification should be included in the project special provisions for fabrication, anodized finish, and construction. Copies are available from the Structural Engineering Division.

H 454 ALUMINUM RAILING

Aluminum railings are highly susceptible to vandalisim damage. Each element (pickets, mullions, posts, rails, etc.), and all connections and fasteners should be designed and details to prevent vandalism, especially when located in public right-ofway. Design loads are discussed in Subsection 333.1.

The use of slip joints which can be pried loose should be avoided unless bolted or riveted through slotted holes to limit travel, especially on curved alignments. Non-shrink grout should be used in post anchorages, and embedment should be at least lO inches to prevent removal.

Exposed threads on fasteners should be burred.

Post spacing should be reduced on curved alignment and vertical forces on curved and straight rails should be considered.

The use of slender pickets should be avoided unless stresses and deflections are analyzed and connections are adequate to prevent damage by vandals.