## **BUILDING TECH I** MATERIALS, PROPERTIES and STRUCTURAL SYSTEMS



# BUILDING TECH I MATERIALS, PROPERTIES and STRUCTURAL SYSTEMS: wood | steel | reinforced concrete

spanning systems

photo:1881 mcny collection

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Structural Systems --Module 3:Structural Study <u>Assignment for this week</u>

- Choose I of 3 structural systems
- Draw column grid to case study dimensions; determine span dimensions
- Determine beam + decking layout + dimensions based on span rating + rules of thumb [information from Ching BCI readings]
- Start axonometric of floor framing

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Structural Systems --

a few examples from last week...

## **STRUCTURAL SYSTEMS wood**: heavy timber (plank + beam)

### wood joist



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**STRUCTURAL SYSTEMS steel**: (2-way frame)





16. Details of column and pin-joint.



## **STRUCTURAL SYSTEMS concrete**: sitecast | precast



Photo: Ezra Stoller 1949

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Framing and Floor Decking Systems --Module 3:Structural Study

Assignment 3A review from last week

- Resources Ching book, Building Construction Illustrated
- Calculations + Sketches

### STRUCTURAL SYSTEMS wood plank + beam | heavy timber

142 / Chapter 4 • Heavy Timber Frame Construction



#### Solid Sawn Lumber

In the selection of a wood beam the following should be considered: lumber species, structural grade, modulus of elasticity, allowable bending and shear stress values, and the minimum deflection permitted for the intended use. In addition, attention should be paid to the precise loading conditions and the types of connections used. See Bibliography for sources of more detailed span and load tables. Rule of thumb for estimating the depth of a wood beam: span/15
Beam width = <sup>1</sup>/<sub>3</sub> to <sup>1</sup>/<sub>2</sub> of beam depth
Limit deflection to <sup>1</sup>/<sub>360</sub>th of span

WOOD BEAMS 4.35

NOTE: GIRDER (primary beam) SPANS LONGER DIMENSION; USE SECONDARY BEAM FOR SHORTER SPANS

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### STRUCTURAL SYSTEMS wood plank + beam | glue-laminated timber





#### **Glue-Laminated Timber**

Glue-laminated timber (CSI MasterFormat O6 18 00) is made by laminating stress-grade lumber with adhesive under controlled conditions, usually with the grain of all plies being parallel. The advantages of glued-laminated timber over dimension lumber are generally higher allowable unit stresses, improved appearance, and availability of various sectional shapes. Glue-laminated timbers may be end-joined with scarf or finger joints to any desired length, or edge-glued for greater width or depth.





Engineered to span up to 80' (24 m)
 Rule of thumb for estimating the depth of a glue-laminated beams: span/20
 Beam width = <sup>1</sup>/4 to <sup>1</sup>/3 of beam depth

## STRUCTURAL SYSTEMS wood plank + beam | wood decking

#### Figure 1 Comparison of Plank-and-beam System With Conventional Framing



Simple Span Double Span · Planks simply supported at each end have the most deflection for a given load

Types of Spans

· Most efficient structural use of material of a given length

Continuous Span · Planks span continuously over four or more supports. · Use of random lengths reduces waste. · Layout must be carefully controlled.

> · 2'(610) minimum between end joints in adjacent courses

Types of Wood Decking



Solid

· 3x6, 4x6 nominal





Striated

span/30

allowable spans.

Rule of thumb for estimating depth of decking

· Limit deflection to 1/240 th of decking span. Consult manufacturer for available sizes and

· V-groove

.40 WOOD DECKING

Solid

· 2x6, 2x8 nominal

Surface Patterns for Exposed Ceilings

Laminated

· 3x6, 3x8, 3x10; 4x6, 4x8; 6x6, 6x8 nominal

• 2x decking can span up to 6' (1830)

• 3x decking can span 6' to 10' (1830 to 3050)

• 4x decking can span 10' to 14' (3050 to 4265)

6x decking can span 12' to 20' (3655 to 6095)

#### Span Ranges



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CSI MasterFormat 06 15 00 Wood Decking

### STRUCTURAL SYSTEMS steel beam | metal deck | concrete slab



4.14 STRUCTURAL STEEL FRAMING

- More structurally efficient wide-flange (W) shapes have largely superseded the classic I-beam (S) shapes. Beams may also be in the form of channel (C) sections, structural tubing, or composite sections.
- Rules of thumb for estimating depth:
- beams: span/20
- girders: span/15
- Width = 1/3 to 1/2 of depth
- The general objective is to use the lightest steel section that will resist bending and shear forces within allowable limits of stress and without excessive deflection for intended use.
- In addition to material costs, also consider the labor costs required for erection.

Steel framing is most efficient when the girder and beam
 supports are laid out along a regular grid.
 Resistance to lateral wind or earthquake forces requires
 the use of shear walls, diagonal bracing, or rigid framing with
 moment-resisting connections.
 For nonbearing or curtain wall options, see 7.24.

## STRUCTURAL SYSTEMS steel beam | metal deck | concrete slab





Metal decking is corrugated to increase its stiffness and spanning capability. The floor deck serves as a working platform during construction and as formwork for a sitecast concrete slab.

· The decking panels are secured with puddle-welds or shear studs welded through the decking to the supporting steel joists or beams.

The panels are fastened to each other along their sides with screws, welds, or button punching standing seams. · If the deck is to serve as a structural diaphragm and transfer lateral loads to shear walls, its entire perimeter must be welded to steel supports. In addition, more stringent requirements for support and side lap fastening may apply.

There are three major types of metal decking.

Form Decking

· Form decking serves as permanent formwork for a reinforced concrete slab until the slab can support itself and its live load.



### STRUCTURAL SYSTEMS

#### precast concrete



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#### Precast concrete slabs, beams, and structural tees are one-way spanning units that may be supported by sitecast concrete, precast concrete, or masonry bearing walls, or by steel, sitecast concrete, or precast concrete frames. The precast units are manufactured with normal-density or structural lightweight concrete and prestressed for greater structural efficiency, which results in less depth, reduced weight, and longer spans.

The units are cast and steam-cured in a plant off-site, transported to the construction site, and set in place as rigid components with cranes. The size and proportion of the units may be limited by the means of transportation. Fabrication in a factory environment enables the units to have a consistent quality of strength, durability, and finish, and eliminates the need for on-site formwork. The modular nature of the standard-sized units, however, may not be suitable for irregular building shapes.

 A 2" to 3-1/2" (51 to 90) concrete topping reinforced with steel fabric or reinforcing bars bonds with the precast units to form a composite structural unit.
 Grout key

<u>D.O.O.(0.0.0.(</u>

- The topping also conceals any surface irregularities, increases the fire-resistance rating of the slab, and accommodates underfloor conduit for wiring.
- When the flooring is to be pad and carpet, the topping may be omitted if smooth-surface units are used.

## PRECAST CONCRETE FLOOR SYSTEMS 4.11 Span of precast slab TODDDDDDDDDDD Small openings may be cut in the field. Narrow openings parallel to slab span are preferred. Engineering analysis is required for wide openings Precast slabs may be supported by a structural frame of sitecast or precast concrete girders and columns, or by a loadbearing wall of masonry, sitecast concrete, or precast concrete.

### STRUCTURAL SYSTEMS

#### precast concrete



#### PRECAST CONCRETE UNITS 4", 6", 8" (100, 150, 205) • 4'-0" (1220) typical width • 12' to 24' (3.6 to 7 m) span range Solid Flat Slabs • Rule of thumb for depth: span/40 1. Г. Т. Г. Г. Г. Г. Г. 6", 8", 10", 12" (150, 205, 255, 305) · 1'-4", 2'-0", 3'-4", 4'-0", 8'-0" · 12' to 40' (3.6 to 12 m) span range (405, 610, 1015, 1220, 2440) • Rule of thumb for depth: span/40 Hollow Core Slabs - 24", 32", 40" · 1'-0" (305) 1'-0" (305) (610, 815, 1015) ·· 6" (150) T L I I I L · 12" or 16" 1/3 to 1/2 of 20" to 60" 15' to 75' (4.5 to 22 m) span range (305 or 405) (510 to 1525) • Rule of thumb for depth: span/15 total depth Rectangular Beams L-Shaped Beams Inverted Tee Beams • Use the span ranges indicated for preliminary sizing only. Consult manufacturer for availability of sizes, exact dimensions, connection details. and span-load tables. 3'-0", 3'-9", 4'-6" (915, 1145, 1370) AASHTO: American Association of State - 1'-0", 1'-4", 1'-8" (305, 405, 510) • 36' to 60' (10 to 18 m) span range Highway and Transportation Officials · Designed originally for bridge structures but AASHTO Girders used sometimes in building construction.

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Framing and Floor Decking Systems --Module 3:Structural Study Assignment this week

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# Structural Study -- Choose one system



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#### Structural Study -- scale: 1/8"=1'-0"

- Draw column grid + columns to case study dims.
- Column size: 18"x18"
- Determine span dimensions
- Calculate primary beam size see next slide

#### Axonometric drawing - see next slide

- Calculate <u>decking</u> spacing rules of thumb
- Calculate <u>secondary beam</u> span + size
- Start axonometric



# BUILDING TECH I MATERIALS, PROPERTIES and STRUCTURAL SYSTEMS: wood | steel | reinforced concrete Structural Study

Calculate beam and deck dimensions based on span rating/rules of thumb [BCI]







**PRECAST CONCRETE**