

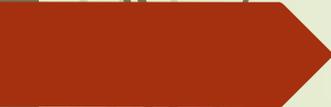
QS Online

Cost Consultants

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PRESENTATION PLAN

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A MODEL COMPARISON
FLOOR CONSTRUCTION



An overview of costing strategies for wood framed construction elements



CREATING A PROJECT – ENDLESS POSSIBILITIES



COMPATORS LIST – A FLOOR

- Cast in Place Concrete
 - Structural Steel Frame
 - Wood I Joist
 - CLT Analysis
- 



COMPARATOR PARAMETERS

- ▶ The test area is 1 bay of 20' x 20' = 400 SF (6.096 x 6.096m = 37.16 m²)
- ▶ Single span (means that joists reach 20' span)
- ▶ Vertical and horizontal support elements are excluded (posts and beams)
- ▶ Live load 40 lbs / SF
- ▶ Dead load based on individual assembly
- ▶ Since concrete does not require fire protection – like for like requires..
- ▶ Fire proofing spray to be allowed on steel
- ▶ Gypsum board finish – 2 layers to be allowed on wood framing
- ▶ CLT to remain exposed, visual grade finish



CONCRETE SUSPENDED SLAB

- Process includes
 - Set up floor framework
 - Lay form plywood
 - Spray form release to deck
 - Lay rebar grid as required
 - Layout sleeves and bulkheads for penetrations thru slab
 - Install slab edge bulkheads
 - Brace floor pour and re-shore levels below
 - Pour concrete, float and finish, allow hydration process (curing) to complete



FLOOR FRAME WORK USING WOOD AND POSTS

THIS FRAMING IS KNOWN AS STICK FRAMING FORMWORK AS EACH PIECE YOU SEE HAS TO BE PLACED INDIVIDUALLY



FORMWORK USING ALUMINUM JOISTS AND WOOD JOISTS

ALUMINUM JOISTS ARE ABOUT 6 ½" AND USUALLY PLACE ABOUT 16" ON CENTRE, DEPENDING ON SLAB THICKNESS, THE WOOD JOISTS ARE 2 X 10 SPF ON SIMILAR SPACING



LAYOUT OF REBAR ON PLY DECK – FORM RELEASE APPLIED

SLAB EDGE FORMWORK IS IN PLACE, PENETRATIONS LAYOUT AT COLUMNS IN PLACE



RESHORE POSTS IN PLACE WITH FLY FORMS IN BACKGROUND

RESHORE IS USUALLY CARRIED ABOUT 3 FLOORS BELOW THE ACTUAL POUR LEVEL



STRUCTURAL STEEL FLOOR

- ▶ Process Includes

- ▶ Pick up by crane, Open Web Steel Joist (OWSJ) and set in place on beam
- ▶ Lay out corrugated metal decking
- ▶ Lay out welded wire mesh (WWM)
- ▶ Place sleeves and bulkheads for penetrations thru slab
- ▶ Install slab edge bulkheads
- ▶ Brace floor pour and re-shore levels below as required
- ▶ Pour concrete, float and finish, allow hydration process (curing) to complete



JOIST ARE STORED ON SITE OR LIFTED DIRECTLY FROM TRUCK

LAYING THE JOISTS DOWN ON SITE MEANS ADDITIONAL HANDLING VS. OFF LOADING DIRECTLY FROM TRUCK BED AND PLACING ON REQUIRED FLOOR AREA



JOISTS ARE PLACED ON SUPPORT STRUCTURE

THIS APPLICATION INCLUDES STEEL JOIST PARTITION WITH HSS TOP PLATE



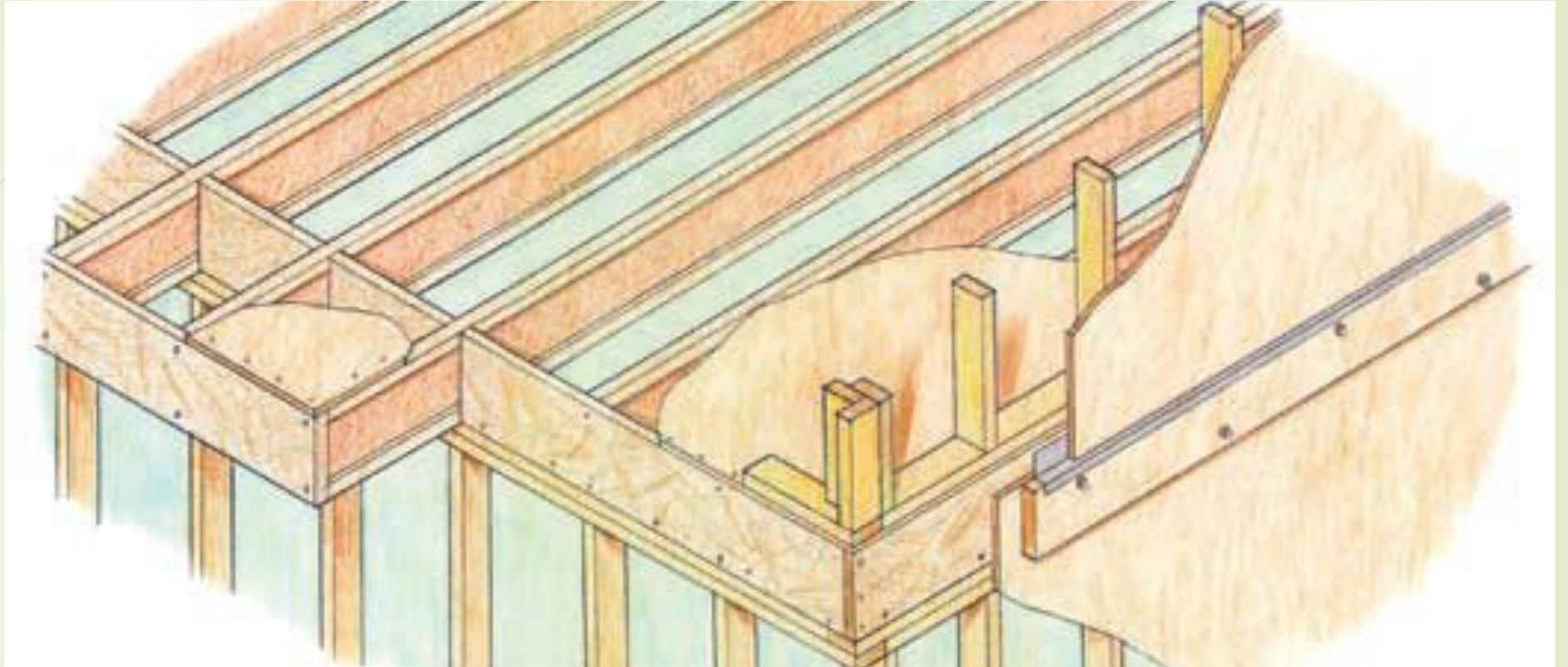
WIRE MESH LAID ON DECK – READY FOR POUR

PHOTO SHOWS WOOD DECK VS. CORRUGATED METAL



WOOD I-JOIST FRAMING

- ▶ Process includes (comes with concrete topping)
 - ▶ Either dropping joist bundle on beam and spreading out by hand
 - ▶ Or carrying each joist to location, set in place, fasten / nail
 - ▶ Lay out decking sheathing
 - ▶ Lay out welded wire mesh (WWM)
 - ▶ Place sleeves and bulkheads for penetrations thru slab
 - ▶ Install slab edge bulkheads
 - ▶ Brace floor pour and re-shore levels below as required
 - ▶ Pour concrete, float and finish, allow hydration process (curing) to complete



Framing includes Joists, Rim Board, Bridging, Sheathing

Normally fixed to a sill plate



View from underside of framed floor

Note limited penetrations – only vertical



OSB sheathing on floor deck

Platform framing method shown



Gypsum wall board “fire proof” layer – taped only

Note vertical penetrations are fire stopped – steel not sprayed



CLT Framing

- ▶ Process includes,
 - ▶ Receiving panels on site by truck – are 8' x 40' and 10' x 40 standard, and
 - ▶ Either off load directly to install location or place in laydown area
 - ▶ Panels are numbered as per install sequence
 - ▶ Crane lifts swing panels in place similar to process to precast hollow core slab
 - ▶ Panels are shop fabricated and milled
 - ▶ Panels are 3, 5, 7, and 9 layers and lay up material varies but standard is 2 x 6
 - ▶ On a easy production installation – 4 to 7 panels per hour can be install

CLT



CLT – JOINTED / FINISHED



CLT – EARTH SCIENCES BUILDING and TELUS GARDENS - BC



CLT – VARIOUS CNC CUTS



CLT – PHYSIO GYM





COMPARATOR ANALYSIS - WEIGHT

- ▶ The test area is 1 bay of 20' x 20' = 400 SF (6.096 x 6.096m = 37.16 m²)
- ▶ Single span (means that joists reach 20' span)
- ▶ Vertical and horizontal support elements are excluded (posts and beams)
- ▶ Live load 40 lbs / SF
- ▶ Dead load based on individual assembly
- ▶ Since concrete does not require fire protection – like for like requires..
- ▶ Fire proofing spray to be allowed on steel
- ▶ Gypsum board finish – 2 layers to be allowed on wood framing

CAST IN PLACE CONCRETE

- ▶ 8" flat slab – no drop panels (200 mm thick)
- ▶ 4,000 PSI concrete (1 MPa = 145 PSI – so $4,000 / 145 = 27.58$ MPa so allow 30 MPa)
- ▶ Reinforcing rate of 5 Lbs / SF
- ▶ Weight of high density concrete ranges from 135 to 160 Lbs / CF
 - ▶ So $20 \times 20 \times .66 = 264$ CF \times 135 Lbs = 35,640 Lbs to 42,240 Lbs
 - ▶ Rebar $20 \times 20 \times 5 = 2,000$ Lbs
- ▶ Total assembly weight may range from 37,640 to 44,240 Lbs

STRUCTURAL STEEL

- ▶ 2 ½" 4,000 PSI conc. c/w 6x6 x 6/6 welded wire mesh (WWM)- 42 Lbs /100 SF
- ▶ 1 ½" 22 gauge composite metal deck – 1.74 Lbs / SF
- ▶ 20" deep joist @ 5'– 0" o.c.– 8 Lbs / FT + 10% misc. metals + 10% connections
- ▶ Weight of high density concrete ranges from 135 to 160 Lbs / CF
 - ▶ So $20 \times 20 \times .21 = 84 \text{ CF} \times 135 \text{ Lbs} = 11,340 \text{ Lbs to } 13,340 \text{ Lbs}$
 - ▶ Deck $20 \times 20 \times 1.74 = 696 \text{ Lbs}$
 - ▶ WWM $20 \times 20 \times 42/100 = 168 \text{ Lbs}$
 - ▶ 20" Joist $((20 / 5) + 1) = 5 \text{ joists} \times 20 \times 8 = 800 \times 10\% = 880 \text{ Lbs} \times 10\% = 968 \text{ Lbs}$
- ▶ Total assembly weight may range from 13,172 to 15,172 Lbs

WOOD

- ▶ 1 ½" 4,000 PSI concrete
- ▶ ¾" T & G plywood – 1.72 Lbs / SF
- ▶ 14" deep wood I - joist @ 12" - o.c. + 2 rows solid bridging – 3.3 Lbs / FT
- ▶ 1 ¼" rim board – 5.1 Lbs / FT
- ▶ 5/8" Gypsum wall board – 1.9 Lbs / SF
- ▶ Weight of lightweight concrete ranges from 135 to 160 Lbs / CF
 - ▶ So $20 \times 20 \times .13 = 50 \text{ CF} \times 135 \text{ Lbs} = 6,750 \text{ Lbs to } 8,000 \text{ Lbs}$
 - ▶ Plywood $20 \times 20 \times 1.72 = 688 \text{ Lbs}$
 - ▶ 14" Joist $((20 / 1) + 1 + 2) = 23 \text{ joists} \times 20 \times 3.3 = 1,386 \text{ Lbs}$
 - ▶ 1 ¼" Rim board $((20 + 20) * 2) = 80 \times 5.1 = 408 \text{ Lbs}$
 - ▶ 2 layers 5/8" GWB $20 \times 20 = 400 \times 2 \times 1.9 = 1,520 \text{ Lbs}$
- ▶ Assembly weight range from 10,752 to 12,002 Lbs – 26.9 to 30 Lbs / SF

CLT – TEST PANEL 8' x 30'

(source – Standard for performance rated cross laminated timber)

(source – Lumber Store – Online data)- weight approximate

- ▶ 2 x 4 – about 1.1 Lbs / Ft
- ▶ So, Weight of CLT panel
- ▶ CLT 2 x 4 – 3 ply – $((96 / 3.5) \times 30 \times 3) = 2,469 \times 1.1 = 2,715 \text{ Lbs} = 11.3 \text{ Lbs / SF}$
- ▶ CLT 2 x 4 – 5 ply – $((96 / 3.5) \times 30 \times 5) = 4,114 \times 1.1 = 4,526 \text{ Lbs} = 18.85 \text{ Lbs / SF}$
- ▶ CLT 2 x 4 – 7 ply – $((96 / 3.5) \times 30 \times 7) = 5,760 \times 1.1 = 6,336 \text{ Lbs} = 26.4 \text{ Lbs / SF}$
- ▶ CLT 2 x 4 – 9 ply – $((96 / 3.5) \times 30 \times 9) = 7,406 \times 1.1 = 8,146 \text{ Lbs} = 33.94 \text{ Lbs / SF}$

COMPARATOR WEIGHT ANALYSIS

CONCRETE & STEEL

- ▶ Concrete assembly weight
 - ▶ 37,640 to 44,240 Lbs
 - ▶ 94.1 to 100.6 Lbs / SF
- ▶ Structural steel assembly weight
 - ▶ 13,172 to 15,172 Lbs
 - ▶ 32.9 to 37.9 Lbs / SF

WOOD

- ▶ Wood assembly weight
 - ▶ 10,752 to 12,002 Lbs
 - ▶ Wood is about 71 to 73 % lighter than concrete assembly
 - ▶ Wood is about 18 to 20 % lighter than structural steel assembly
- ▶ CLT – 5 layer
 - ▶ $4,526 + 1,520 \text{ (GWB)} = 6,046 \text{ Lbs}$
 - ▶ CLT is about 84 to 86 % lighter than concrete assembly
 - ▶ About 54 to 60% lighter than steel

SUSPENDED SLAB PRICING – 400 SF

- Concrete supply \$1,245
 - Concrete finish \$600
 - Rebar \$2,100
 - Formwork \$4,800
 - Total \$8,745
 - Suspended Slab = \$21.86 / SF
- $20 \times 20 \times .66 / 27 = 9.8 \text{ CY} \times \$127 = \$1,245$
 - $20 \times 20 = 400 \times \$1.50 = \$600$
 - $20 \times 20 = 400 \times 5 = 2,000 \text{ Lbs} \times \$1.05 = \$2,100$
 - $20 \times 20 = 400 \times \$12.00 = \$4,800$
 - $\$8,745 / 400 = \$21.86 / \text{SF}$

STRUCTURAL STEEL PRICING – 400 SF

- Concrete supply \$395
- Concrete finish \$600
- Welded wire mesh \$2,100
- Metal deck \$1,600
- OWSJ \$1,440
- Fire Proof Spray \$700
- $20 \times 20 \times .21 / 27 = 3.1 \text{ CY} \times \$127 = \$395$
- $20 \times 20 = 400 \times \$1.50 = \$600$
- $20 \times 20 = 400 \times \$0.55 = \$220$
- $20 \times 20 = 400 \times \$4.00 = \$1,600$
- $960 \text{ Lbs} \times \$1.50 = \$1,440$
- $20 \times 20 = 400 \times \$1.75 = \$700$
- Total \$6,835
- $\$6,835 / 400 = \$17.09 / \text{SF}$
- Structural Steel = \$17.09 / SF



WOOD I-JOIST – 400 SF

- ▶ Wood I Joist – installed - \$2,215
- ▶ ¾" SPF select T&G plywood - \$1,171
- ▶ Rim board, strapping and sill plate - \$932
- ▶ Small tools - \$143
- ▶ GWB 2 layers 5/8" - \$1,440

- ▶ Total \$5,901
- ▶ I JOIST BEFORE DRYWALL = \$11.74 / SF
- ▶ AFTER DRYWALL = \$15.34 / SF



CLT FRAMING – 400 SF – 4 panels / hr

- ▶ CLT 3 layers - \$5,943 = \$14.86 / SF
- ▶ CLT 5 layers - \$8,371 = 20.93 / SF
- ▶ CLT 7 layers - \$10,803 = 27.01 / SF
- ▶ CLT 9 layers - \$13,236 = 33.09 / SF



COST COMPARISON TO WOOD

- ▶ Suspended Slab - \$21.86 / SF
 - ▶ Structural steel - \$17.09 / SF
 - ▶ CLT 3 layer - \$14.86 / SF
 - ▶ CLT 5 layer - \$20.93 / SF
 - ▶ CLT 7 layer - \$27.01 / SF
 - ▶ CLT 9 layer - \$33.09 / SF
- ▶ Wood I Joist Framing
 - ▶ Before GWB - \$11.74 / SF
 - ▶ After 1 Layer Taped - \$12.99 / SF
 - ▶ After 2 layer paint ready – \$15.34 / SF



QUICK COMMENT ON COST CONTROL

- ▶ In estimates and for unit rates generally
 - ▶ The fixed portion of any unit rate is the material
 - ▶ The variable rate is labour and equipment, each based on productivity
 - ▶ The efficient management of each of these elements is key for finishing on budget
 - ▶ Each task must be broken down to material, labour and equipment
 - ▶ You must know how much time you have for each task
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SOME SUGGESTIONS ON APPROACH



THE PLANNING PHASE

- Identify building elements that could be wood framed
- Structural considerations early to determine like for like substitutes
- Estimate these substitutes
- Consideration of direction of joist framing to best suit services
- Consider use of service plenum to minimize joist penetrations



GREEN IMPACTS FROM WOOD DESIGN

- ▶ Wood is lighter so, in lower capacity soil conditions, allows for lesser footing point load bearing capacity requirements
 - ▶ Carbon reduction due to reduced concrete / steel in footing
- ▶ Hybrid structure design allows options for form, esthetics, acoustics, finish, and thermal
- ▶ Sustainable forest development, increased use boosts economy



THE WOOD SHIP – Project Delivery

- Identify contractors who are able and willing to work with wood options
- If using CLT, consider including Owner supplied price carried by all bidders – Levels playing field
 - Competitive bids will be based on productivity not buying power



COSTING COMPARISON - RESULT

- Use of wood framing is cost effective when considered in a like for like comparator basis
- Structural steel floor framing is most cost competitive to wood framing, has weight issue
- CLT horizontal install cost is on par basis with suspended slab but is much faster to install
- Project Owners may benefit from esthetics provided by wood finish



