WOOD DESIGN FOR 6-STOREYS

OPTIONS AND OPTIMISATION

Kevin D. Below ing, P.Eng., Ph.D.
(Douglas Consultants)

Wood Design Seminar
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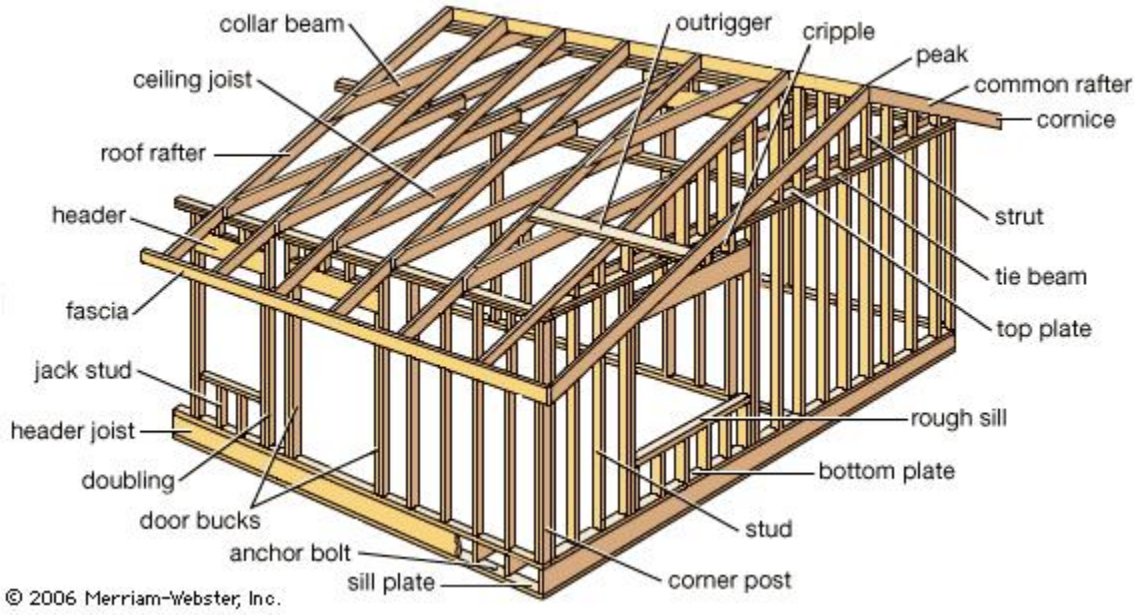
What we will see:

- Structural types
  - Light-frame, CLT, post and beam, hybrids
- What do you need to consider?
  - Acoustics, Fire protection, Shrinkage, Crushing, Vibrations, Water, Market perception
- Optimisation – more for less
  - Quantity of wood, Speed of construction, Simplicity of connections
  - Yeah, that's good, but how much does it cost?

STRUCTURAL TYPES
LIGHT-FRAME

Light-frame = made in dimension lumber, roof trusses and floor joists:



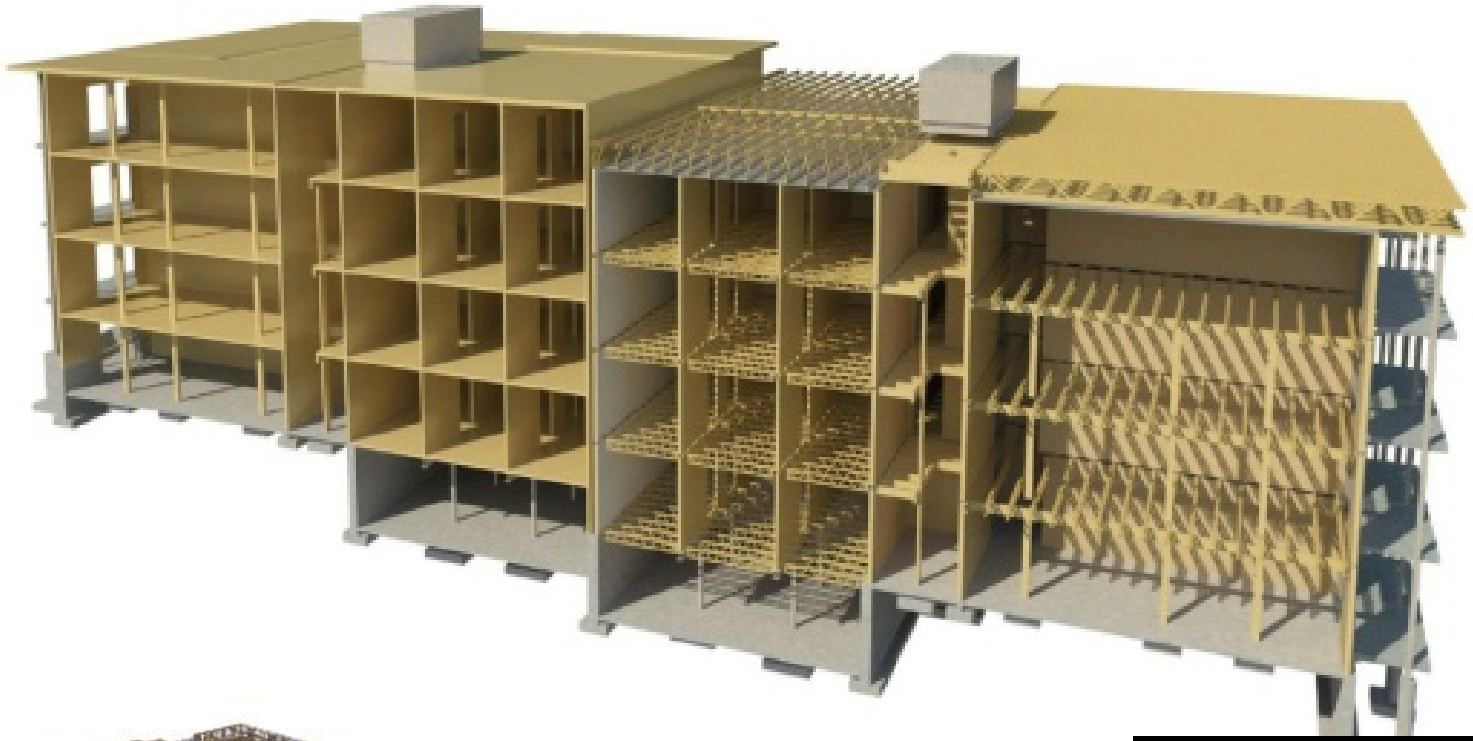
STRUCTURAL TYPES
LIGHT-FRAME

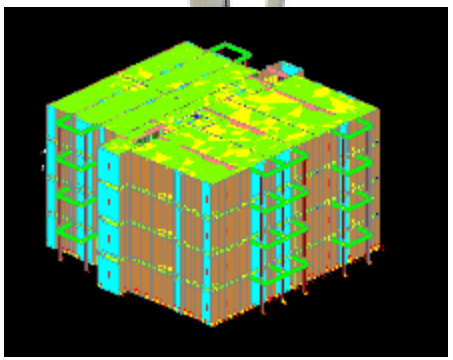
Light-frame = made in dimension lumber, roof trusses and floor joists.

STRUCTURAL TYPES
LIGHT-FRAME

Light-frame = made in dimension lumber, roof trusses, floor joists, and
lots of OSB.

STRUCTURAL TYPES
CLT





STRUCTURAL TYPES
CLT

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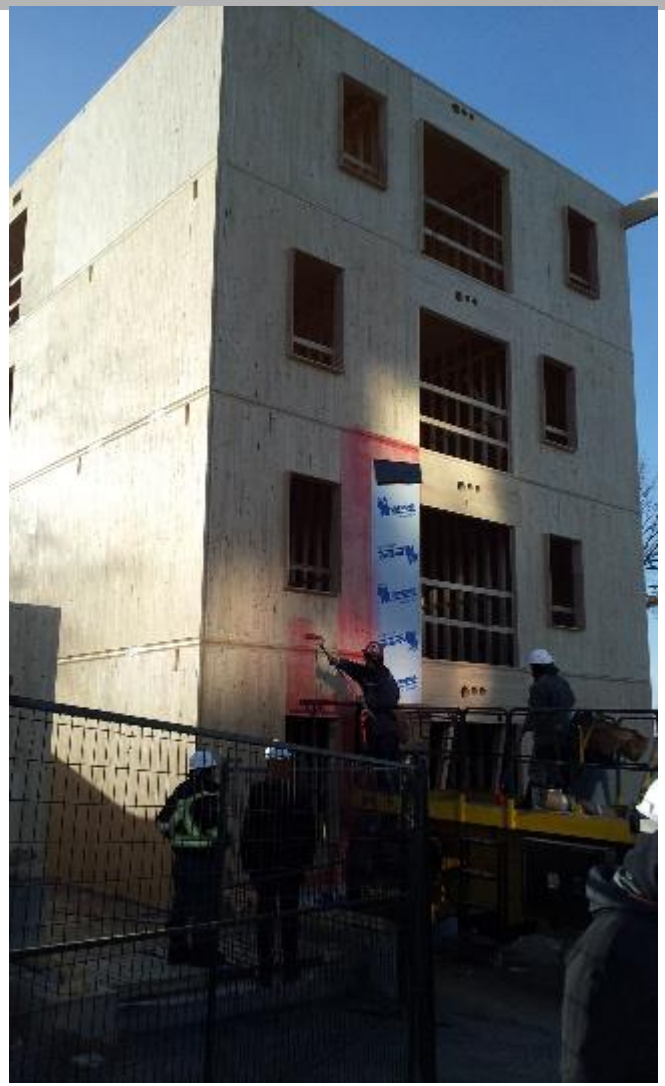


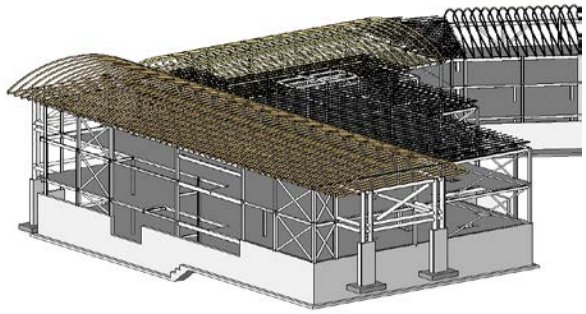
STRUCTURAL TYPES
CLT

STRUCTURAL TYPES
CLT

STRUCTURAL TYPES
CLT

Jaettegryde, a private residence in Tewkesbury

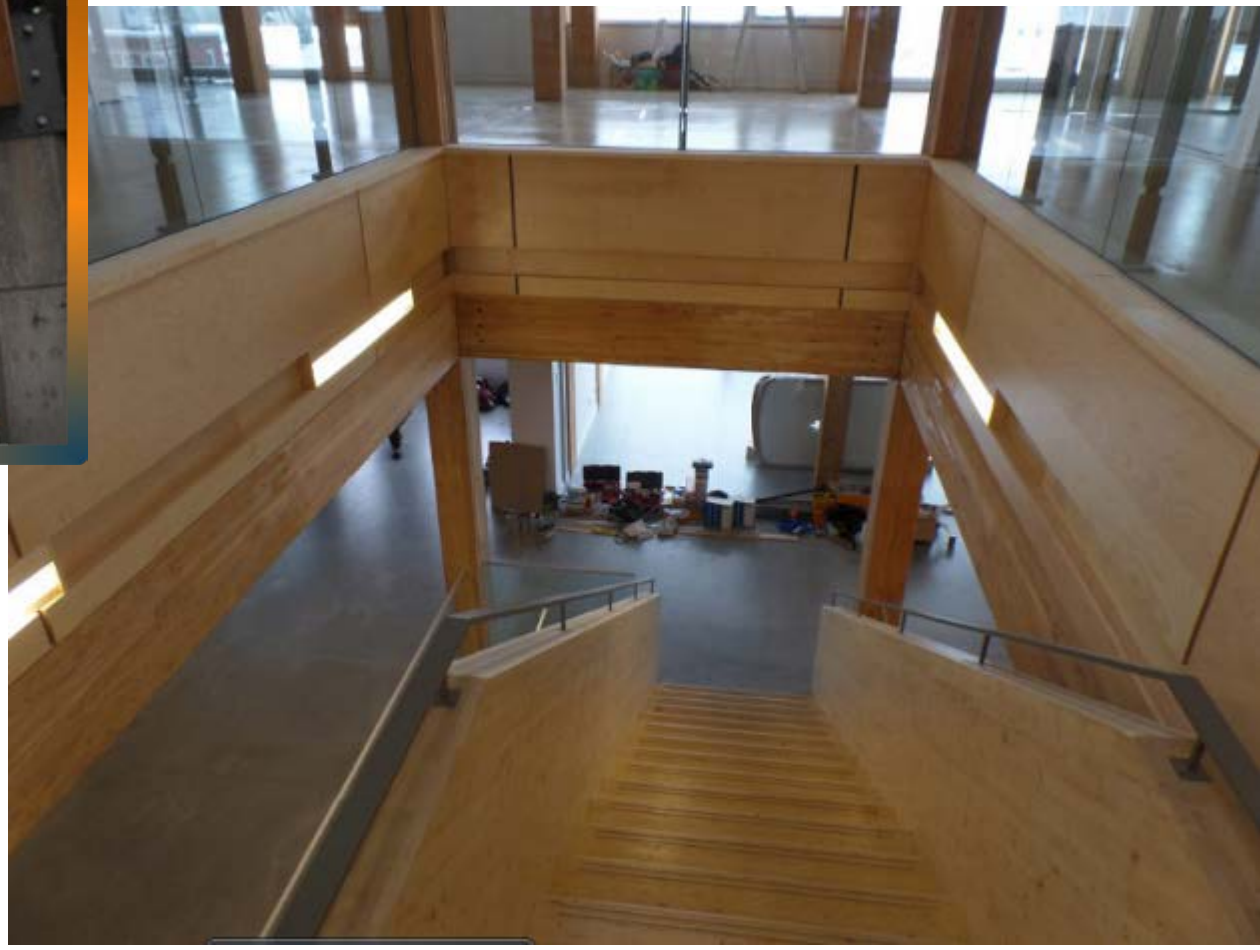
STRUCTURAL TYPES
POST and BEAM



Hotel Wendake, Quebec

STRUCTURAL TYPES
POST and BEAM

Caisse Desjardins, Louiseville



STRUCTURAL TYPES
ARCH

Museum Oujé-Bougoumou

STRUCTURAL TYPES
HYBRID STRUCTURES

Why would you want to do that?

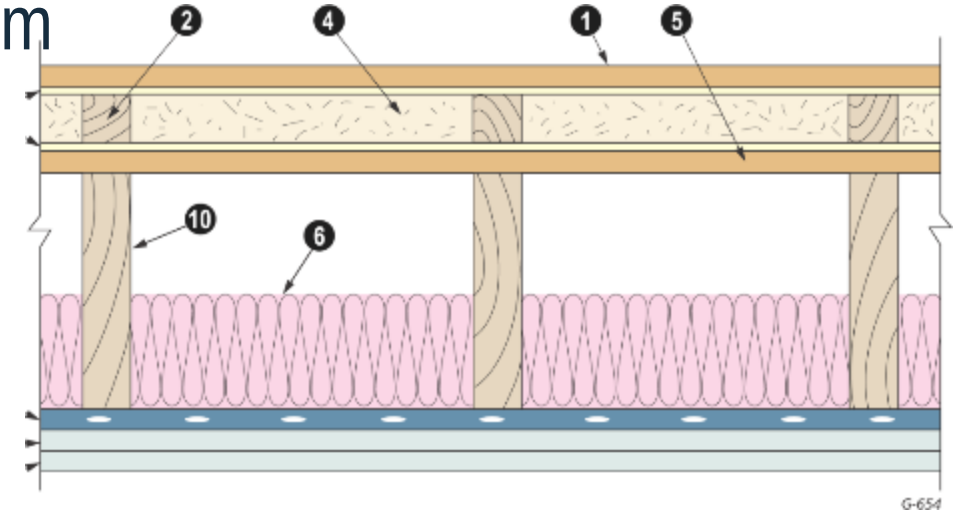
Concrete for foundations

Steel for connections

Wood for everything else

STRUCTURAL TYPES
HYBRID STRUCTURES

- OSB 16 mm on membrane
- Wood-fibre panel and furring strips 38 mm on membrane
- OSB 20 mm
- I-joists or open-web joists with stone wool
- Resilient channels and gypsum



Acoustic Performance:

STC 64 dB

STC minimum = 55 dB
(SCHL recommendation)

STRUCTURAL TYPES
HYBRID STRUCTURES

STRUCTURAL TYPES
HYBRID STRUCTURES

Let me explain … I love concrete, I did my doctorate in concrete … and you can do all sorts of fun shapes with it, unless you want to respect the budget.

STRUCTURAL TYPES
HYBRID STRUCTURES

But it sure does complicate a work site.

To begin, we build a wood structure – temporary – so we can pour concrete over everything and get it all dirty.

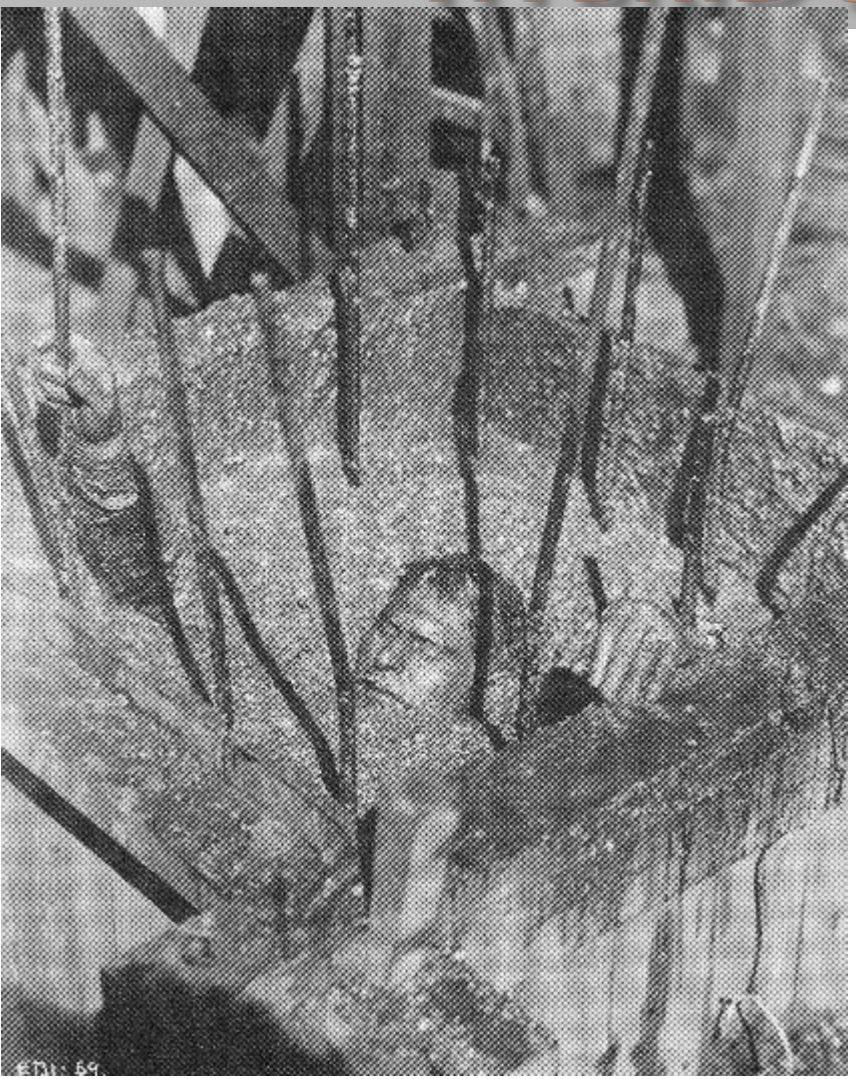
STRUCTURAL TYPES
HYBRID STRUCTURES

Then the concrete freezes if we don't heat it with a temporary tent. So we have to fight with the contractor to get him to heat and cure it properly, and we keep the temporary wood structure in place, and it gets in everybody's way for a month or two so we can slow the pace and make them suffer.

STRUCTURAL TYPES
HYBRID STRUCTURES

and then we take down the temporary wood structure so we can see the concrete, but it's not pretty so we hide it behind gypsum panels and suspended ceilings.

STRUCTURAL TYPES
HYBRID STRUCTURES



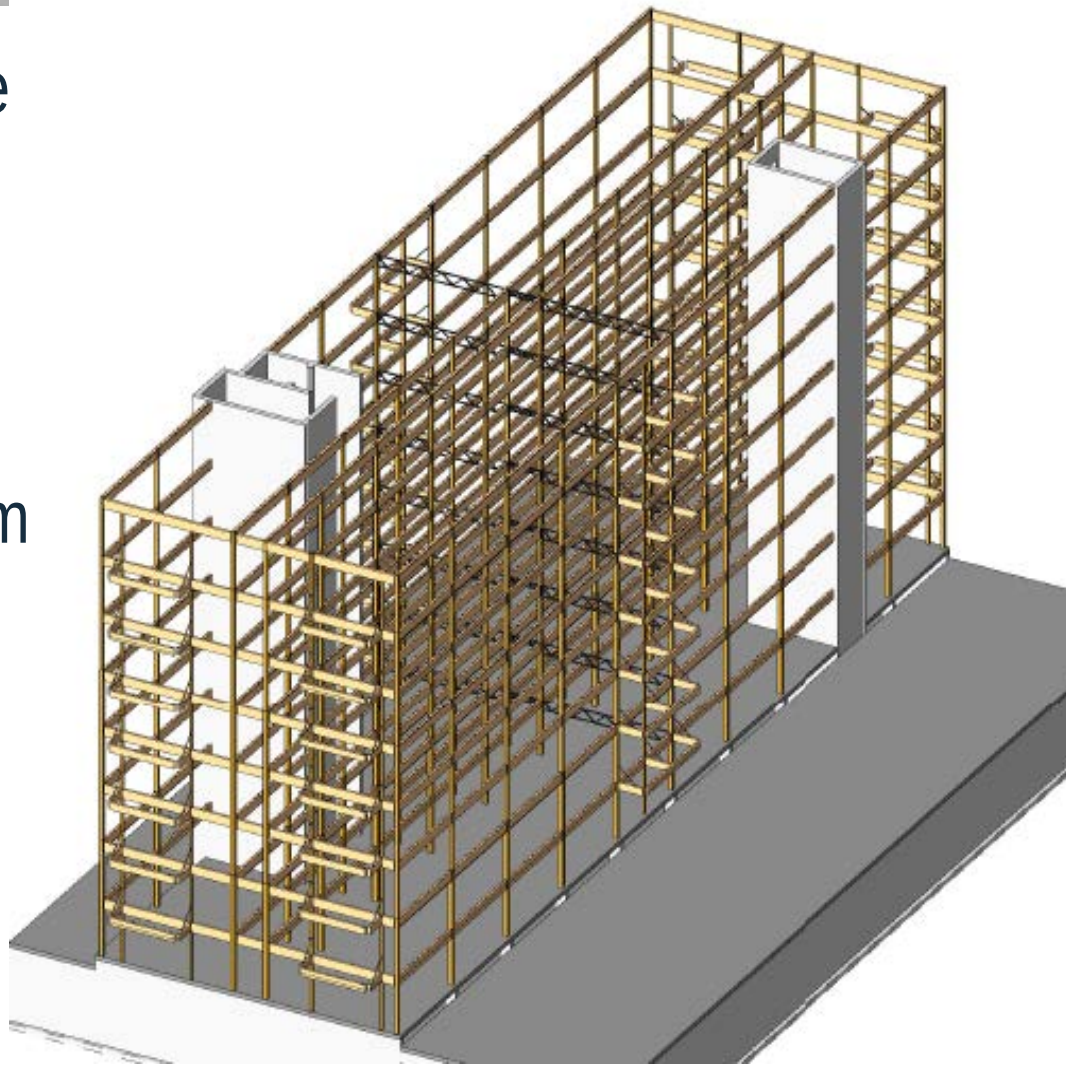
But we have to admit that there are some things you can do in concrete that are pretty well impossible in wood.

STRUCTURAL TYPES
POST and BEAM

Caisse Desjardins, Louiseville

STRUCTURAL TYPES
HYBRID STRUCTURES

- Columns wood vs concrete
- Douglas Fir-L 16c-E vs 30 MPa concrete
- Maximum de 275 x 266 mm on ground floor in wood
- 350 x 600 for the concrete building alternative



STRUCTURAL TYPES
HYBRID STRUCTURES

Hang on there !

Did you just say that the columns in the wood building were smaller than those in the concrete building?

STRUCTURAL TYPES
HYBRID STRUCTURES

Much lighter in wood? Does that mean we'll save on foundations?

And that shear wall lateral thingy?

DESIGN FACTORS – FLOOR VIBRATION

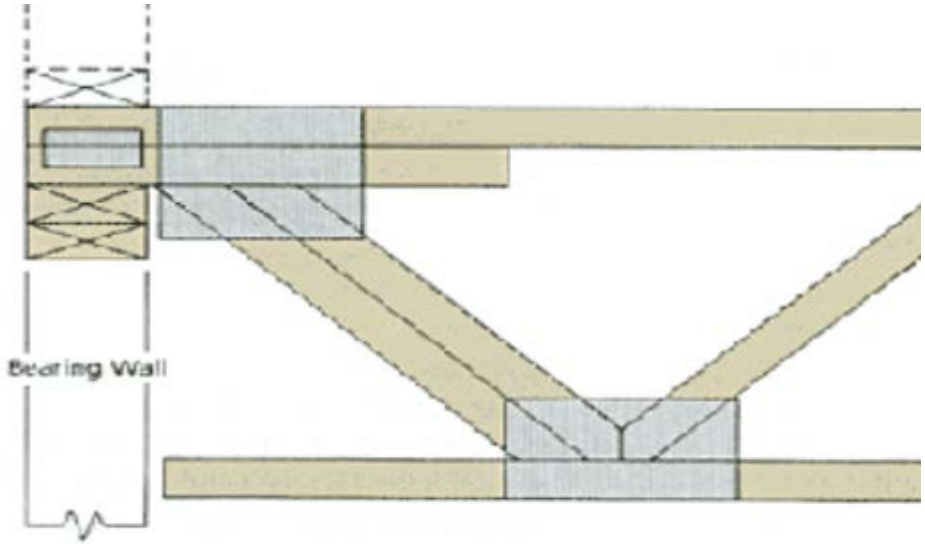
The floor panels need to be verified for vibration performance under walking.

DESIGN FACTORS – FLOOR SHRINKAGE AND HUMIDITY

Shrinkage can be a problem for 6-storey light-frame buildings, and must be considered.

Since most of the shrinkage is cross-grain, almost all of it occurs in the plates and joists.

So we need to consider use of low-shrinkage wood for the plates.

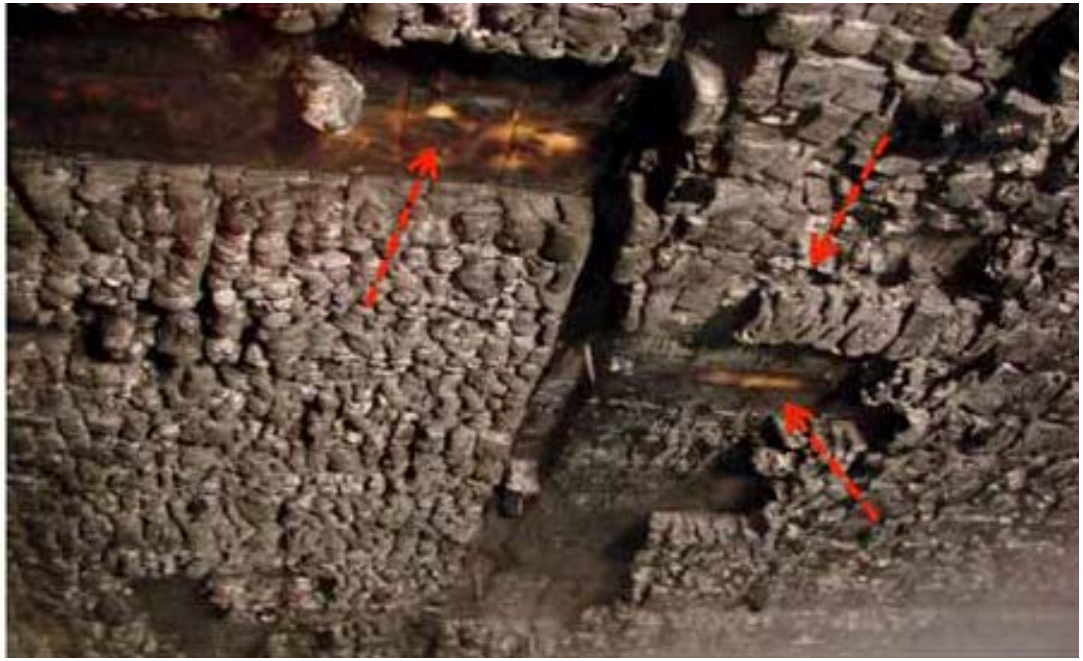


DESIGN FACTORS – FLOOR SHRINKAGE AND HUMIDITY

If there is exposed wood, we need to control the humidity in the building, to minimise shrinkage cracking (checking). That means humidification in winter, dehumidification in summer. The mechanical engineer is not used to that. He likes to lower humidity in winter to avoid condensation in the windows. That's when the checking starts.

DESIGN FACTORS – FIRE RESISTANCE

Solid wood burns slowly, about 0.65 mm per minute. So for 60-minute fire resistance, we could burn about 40 mm. Fire tests show that a char layer forms and slows the fire.



DESIGN FACTORS – FIRE RESISTA

The NBCC specifies minimum dimensions for heavy timber, in order to ensure a certain degree of fire safety.

Table 3.1.4.6.
Heavy Timber Dimensions
Forming Part of Sentence 3.1.4.6.(2)

Supported Assembly	Structural Element	Solid Sawn (width x depth), mm x mm	Glued-Laminated (width x depth), mm x mm	Round (diam), mm
Roofs only	Columns	140 x 191	130 x 190	180
	Arches supported on the tops of walls or abutments	89 x 140	80 x 152	—
	Beams, girders and trusses	89 x 140	80 x 152	—
	Arches supported at or near the floor line	140 x 140	130 x 152	—
Floors, floors plus roofs	Columns	191 x 191	175 x 190	200
	Beams, girders, trusses and arches	140 x 241 or 191 x 191	130 x 228 or 175 x 190	—

Engineers, you need to be aware of the fire prescriptions in the Code. If you specify wood members, they must conform! Fire resistance is not the exclusive domain of the architect.

DESIGN FACTORS – FIRE RESISTA

The NBCC 2005 assigns fire resistances for some floor and roof assemblies in solid wood in Table D-2.4.1, applicable to mill floors, tongue-and-grooved planks and solid-wood walls.

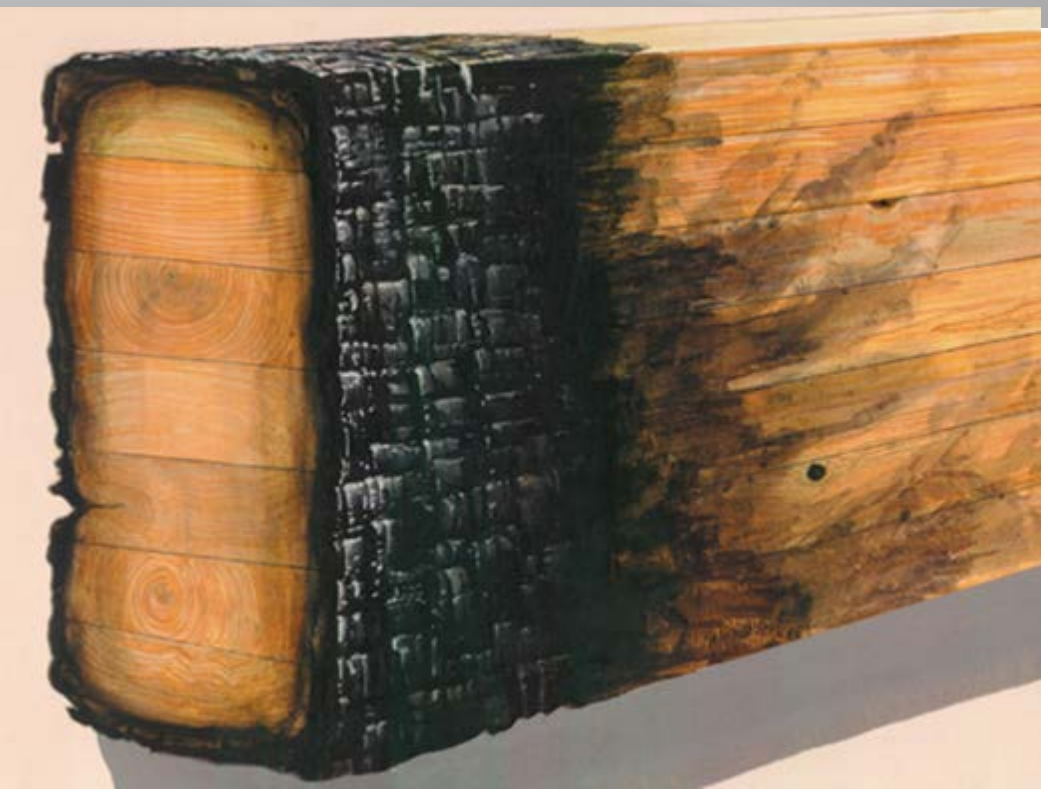
Table D-2.4.1.
Minimum Thickness of Solid Wood Walls, Roofs and Floors, mm(1)(2)

Type of Construction	Fire-Resistance Rating			
	30 min	45 min	1 h	1.5 h
Solid wood floor with building paper and finish flooring on top(3)	89	114	165	235
Solid wood, splined or tongued and grooved floor with building paper and finish flooring on top(4)	64	76	—	—
Solid wood walls of loadbearing vertical plank(3)	89	114	140	184
Solid wood walls of non-loadbearing horizontal plank(3)	89	89	89	140

DESIGN FACTORS – FIRE RESISTA

But wait, there's more. Sub-section D-2.11 specifies fire resistances for glulam beams and columns, as a function of the degree of loading. Heavily loaded elements fail earlier, because they are already more highly stressed before the fire starts.

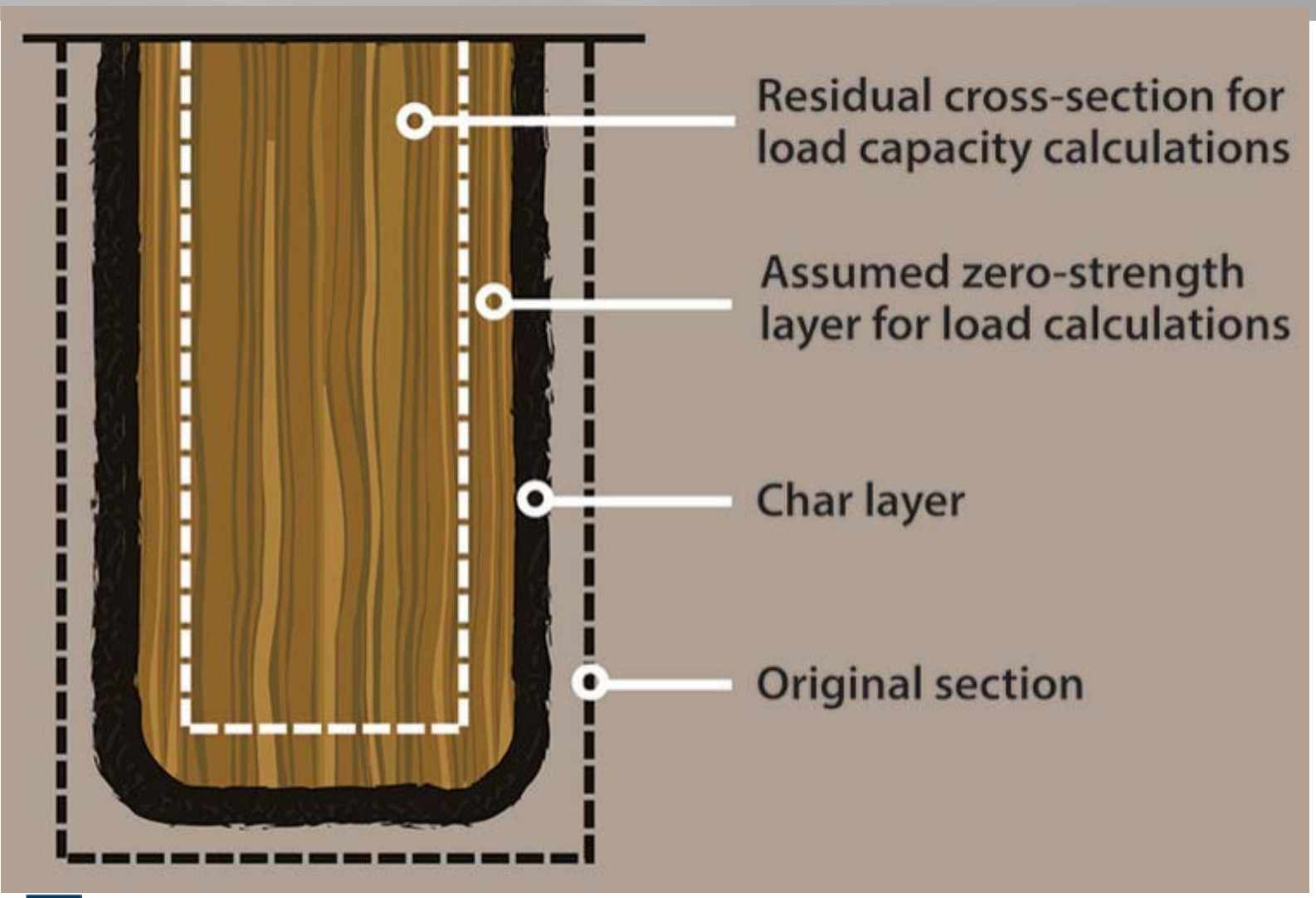
DESIGN FACTORS – FIRE RESISTA



Future provisions will be based on charring rates, the rate at which solid wood burns. You know how hard it is to get a fire started when you want one. You need kindlin' !
You won't get it started with big pieces only.

5 **Gather small dry twigs and the skin of trees.** It may take time to search for these small dry twigs so be patient and give time to do this, unless or course, there are many in one place for you to use! 'Dump' them near the campfire. When they are gathered, carefully place them against the supporting stick in the middle of the fire pit.

DESIGN FACTORS – FIRE RESISTAN



DESIGN FACTORS
ACOUSTIC PERFORMANCE

Acoustic performance is like Carly Simon said … you don’t know what you got ‘til it’s gone.

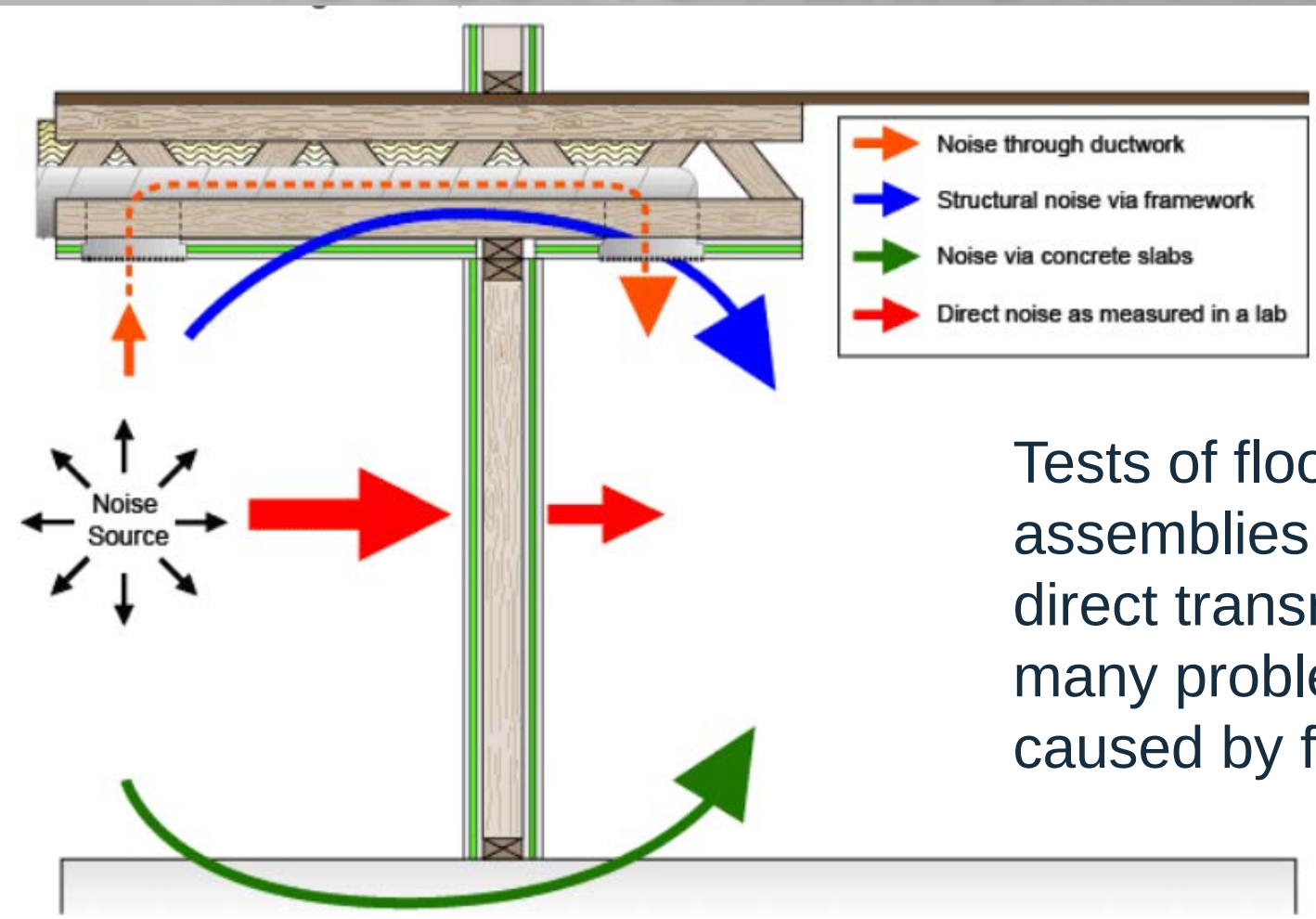
There are two types of acoustic transmission – aerial (the neighbour’s TV) and impact (her high heels on the floor above.)

DESIGN FACTORS
ACOUSTIC PERFORMANCE

To absorb aerial sound, we need mass. That's why concrete is popular. Wood is lighter than concrete, so we need to add some cheap mass. Like gypsum, which also helps for fire resistance.

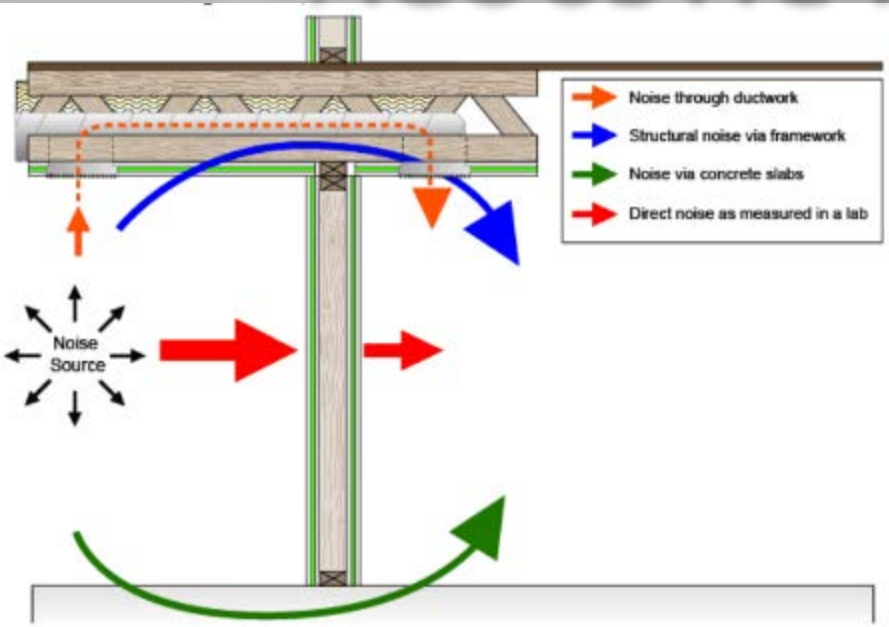
To absorb impact noise, we need flexibility. That's where concrete is terrible. Wood is better. But we need to add some cheap flexibility, like stone wool, or sand.

DESIGN FACTORS
ACOUSTIC PERFORMANCE



Tests of floor and wall assemblies evaluate direct transmission, but many problems are caused by flanking.

DESIGN FACTORS
ACOUSTIC PERFORMANCE



The STC rating corresponds to the dB absorbed by the wall. This wall is rated at STC = 55, so a sound of 80 dB should be heard at 25 dB on the other side of the wall.

But if the ductwork lets through 40 dB, the slab lets through 30 dB and the floor above 25 dB, then we've still got 40 dB on the other side because of the ductwork, and the system only stops 40 dB, for an effective rating of 80 – 40 = STC 40, not STC 55.

DESIGN FACTORS
ACOUSTIC PERFORMANCE

Good acoustical performance requires planning and execution, and on-site inspection. Some of the details become apparent only when you see the real thing on site.

If light, air or snow gets through, so will sound. And even if you hide it with gypsum board, a lot of noise will still get through.

How much does it cost?

The experience in BC seems to show an average economy of 10 to 15% with light-frame wood when compared to concrete structures.

Nobody is very candid when asked, for competitive reasons, but they're still building a lot of them.

The difference is even more appreciable on poor soils in high seismic zones.

How much does it cost?

Another study shows a 12 – 15% savings compared to light-frame steel.

How much does it cost?

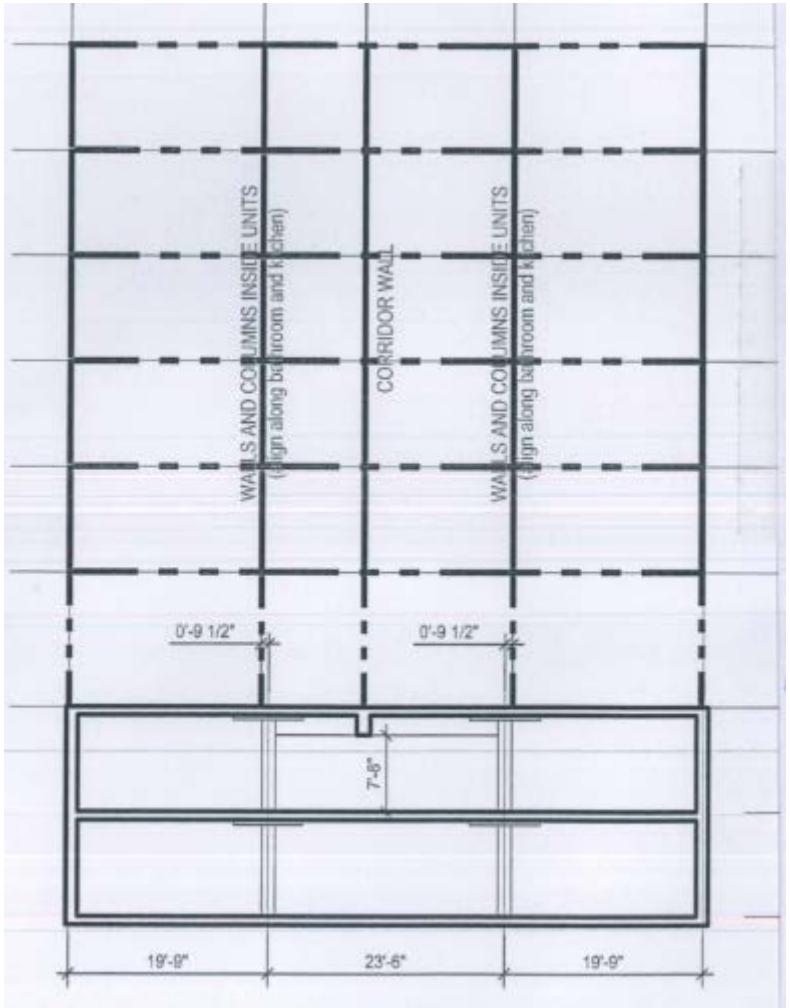
Modular construction may not be as economical as we thought, because of the extra structure required for the ceiling of the units during transport and installation, and the difficulty of access for all the interconnections required for structural integrity.

How much does it cost?

But you definitely need to use prefabrication of walls and floor sections.

Better cost, speed and quality control.

How much does it cost?



Underground parking becomes more expensive because of the transfer slab required to transfer the loads from the bearing walls to the columns.

…unless you have a planning session with the structural engineer before doing the conceptual layout.

How much does it cost?

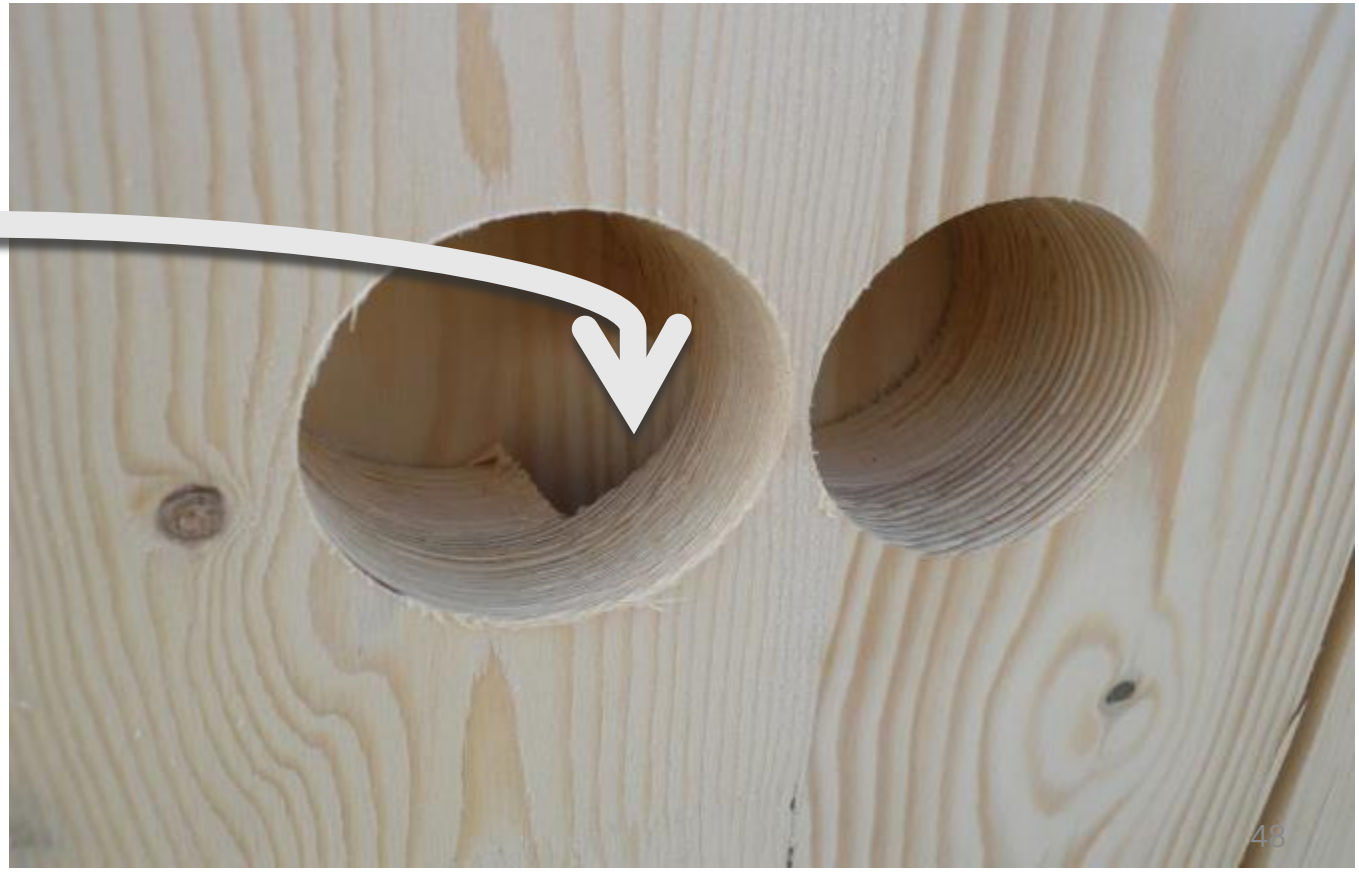
If you build for the concrete clientele, then you may want to go to CLT, for the perception of solidity.

If it is well planned, it will be more economical than concrete, and much faster.

It is possible to expose the wood ceilings with extra thickness for fire resistance and with treatment of the upper surface for acoustic performance.

OPTIMISATION – CLT 2.0

Hidden recess for electrical wiring.



Build in wood
Soon to be mandatory

Douglas Consultants inc.
3604, chemin Royal
Québec, QC Canada G1E 1W9
1.418.660.1221