Tall wood buildings!

Zhouyan Xia
Jan-Willem van de Kuilen

Higher and higher....

Roller Coaster

Amusement Park, Heide-Park Soltau, Germany

Height 52 m, length ca.1300 m, 120 km/h

Timber Wind Turbine Tower

Hannover Marienwerder/Germany 2012

100m height, 100t weight, 1.5 MW, supplies 1000 households with electricity

multi-storey buildings with wood is good for the environment!

COST Action E5

Timber Frame Buildings

5-storeys HSB, Delft, Ecodus, 1992

TU Delft

Murray Grove – KLH

Apartment building in London
9 storeys
4 apartments / storey
crosslam elevator shaft
17 weeks time saving during construction

Limnologen, Sweden
8 Storey CLT

Figure 5-8: Limnologen building complex (by Kirsi Jarnero)

Limnologen, Sweden
Floor plan

- CLT Walls and floors
- TF Internal walls
- Tension bars for prestressing
- Sprinkler system

Limnologen, Sweden Sprinkler system

Reduced requirements for:

- Combustible façade cladding up to eight storeys;
- Surface linings in apartments in multi-storey buildings, down to class D-s1,d0;
- Fire spread through windows in the same building;
- Walking distance in escape routes.

LIFECYCLE TOWER

Research projekt Highrise Timber Buildings (Austria)

FÖRDERUNGSPROGRAMM HAUS DER ZUKUNFT

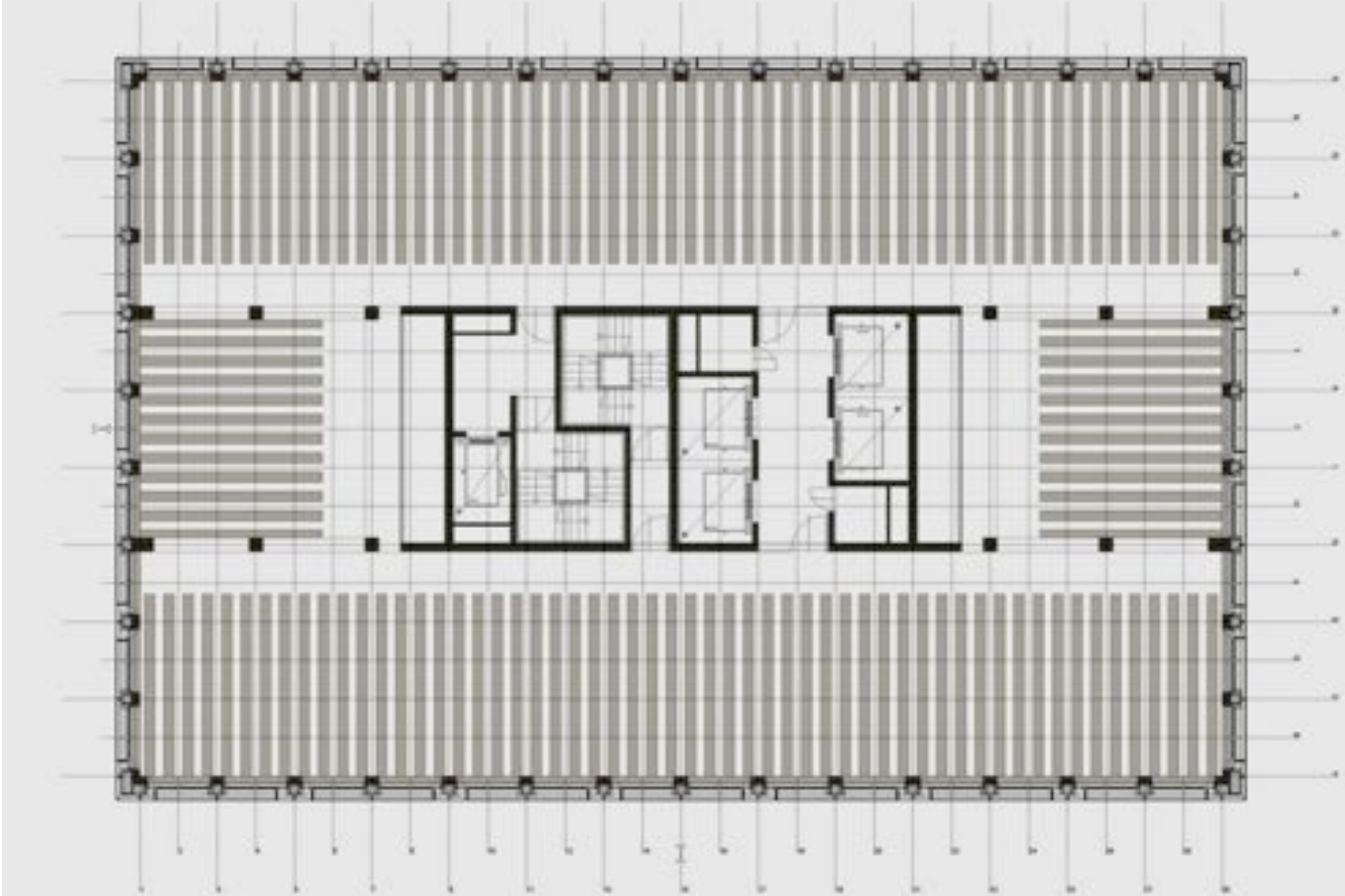
May 6, 2015

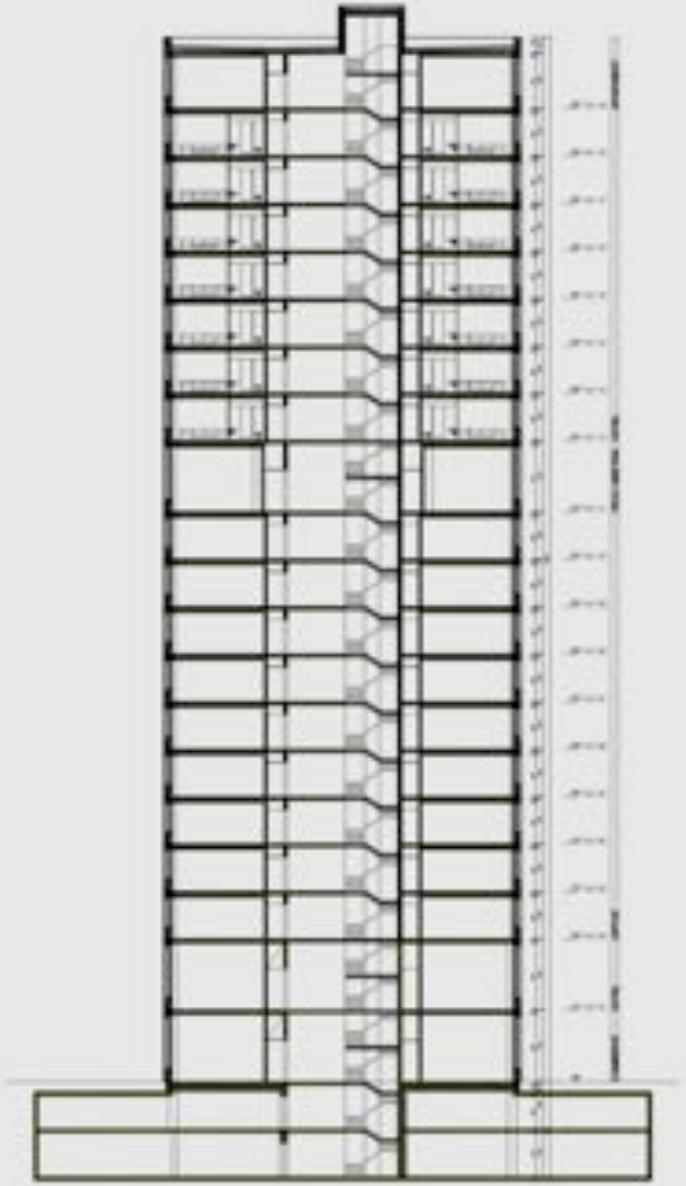
TEAM: RHOMBERG BAU, OVE ARUP, WIHAG, ARCHITEKTENHERMANN KAUFMANN ZT GMBH

Lifecycle Tower, Dornbirn, Oostenrijk

Architect Herman Kaufmann
Prof. Holzbau TU München

Construction speed: 8 dagen





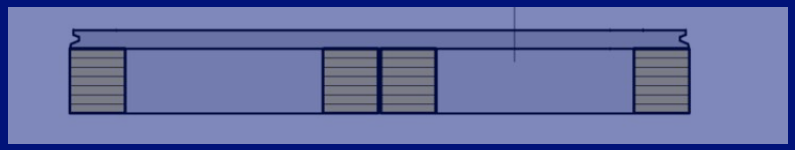
Scale model, 20 storeys

Stiffness of the core???

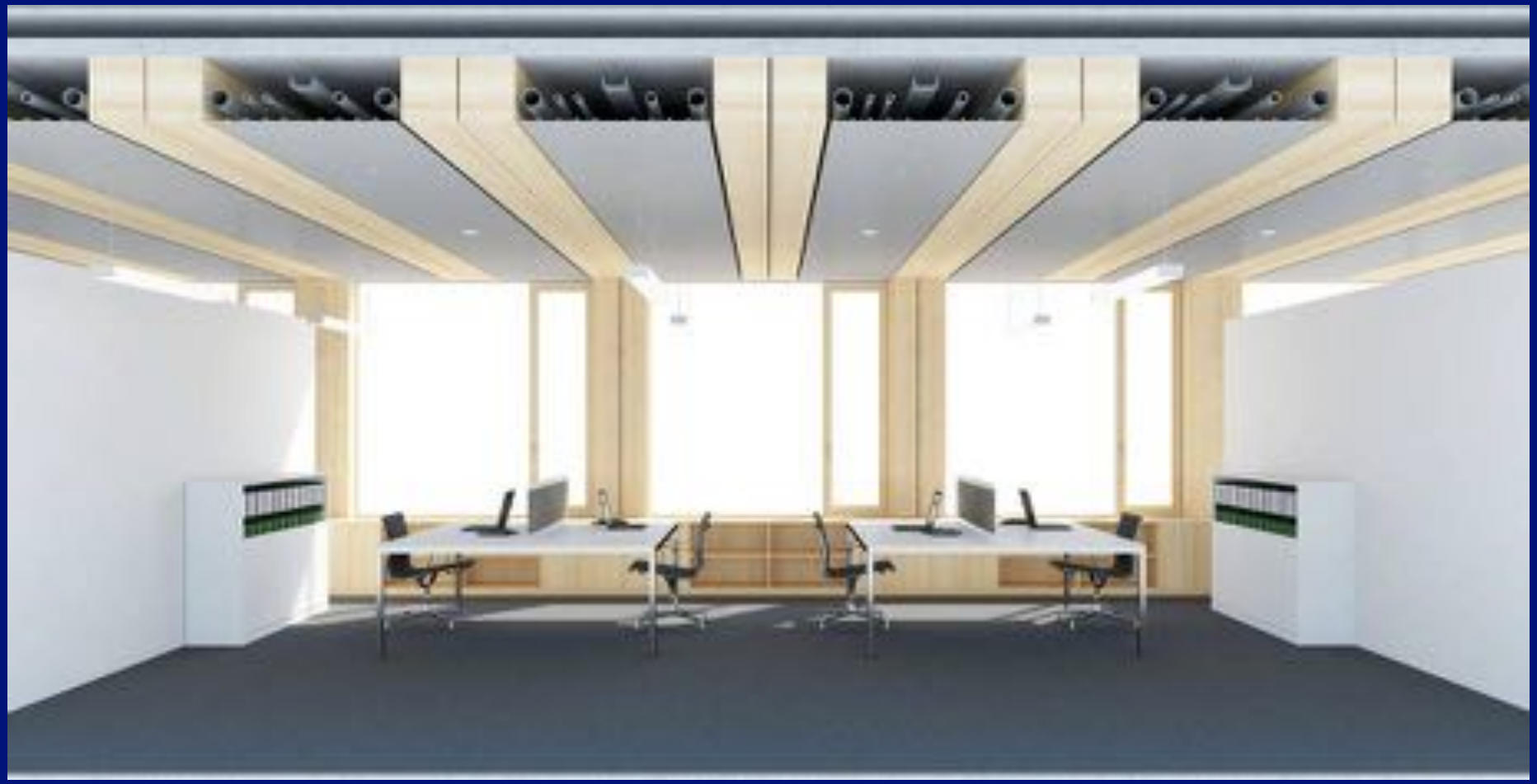
Prefabricated elements

REI 90 (90 min. fire safety)
(R= Load carrying capacity,
E=Integrity, I=insulation)
SPAN 8.50 M
WIDTH 2.70 – 3.00 M

Concrete D = 80 mm



2 x BSH 26/26



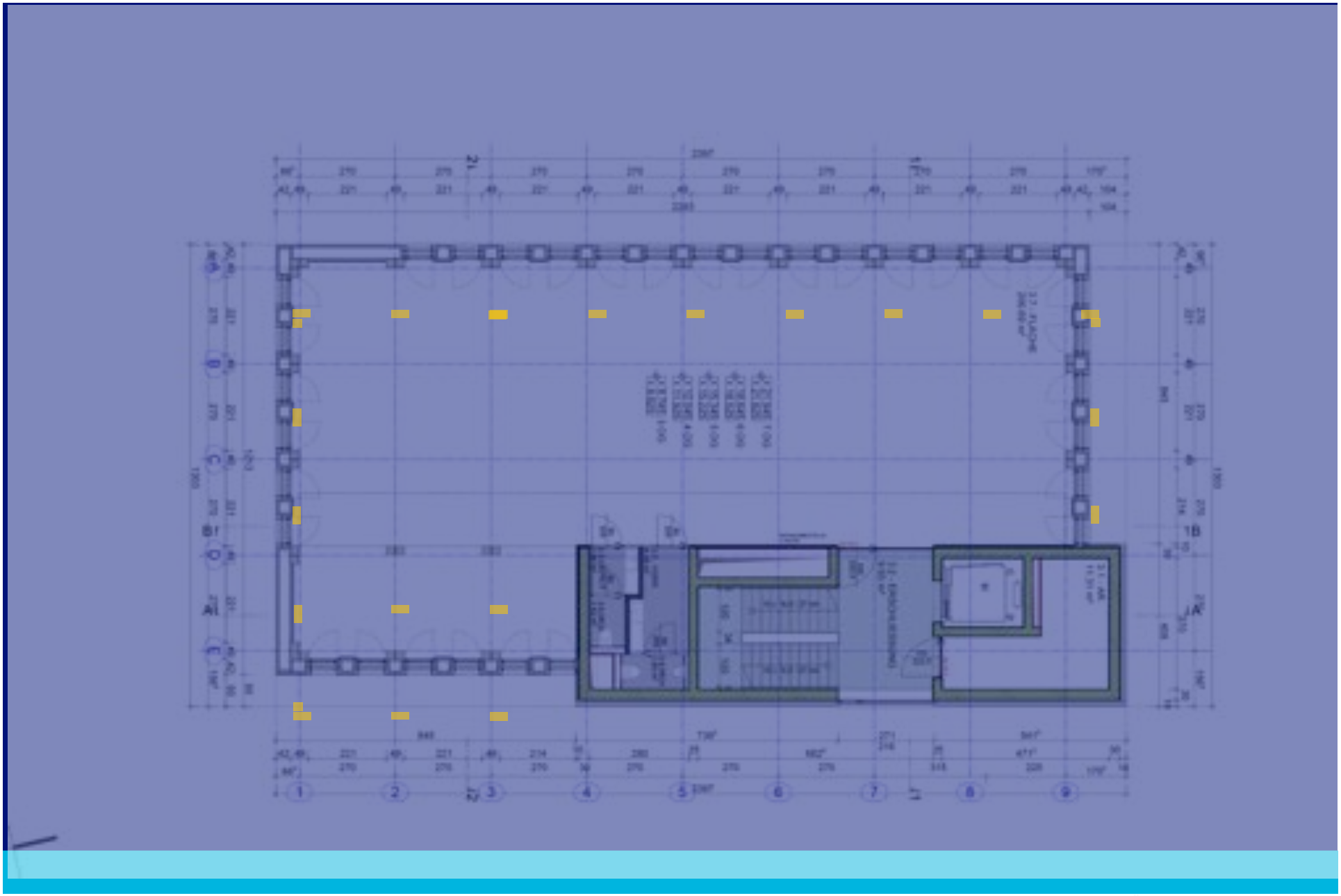
Timber-Concrete Floors

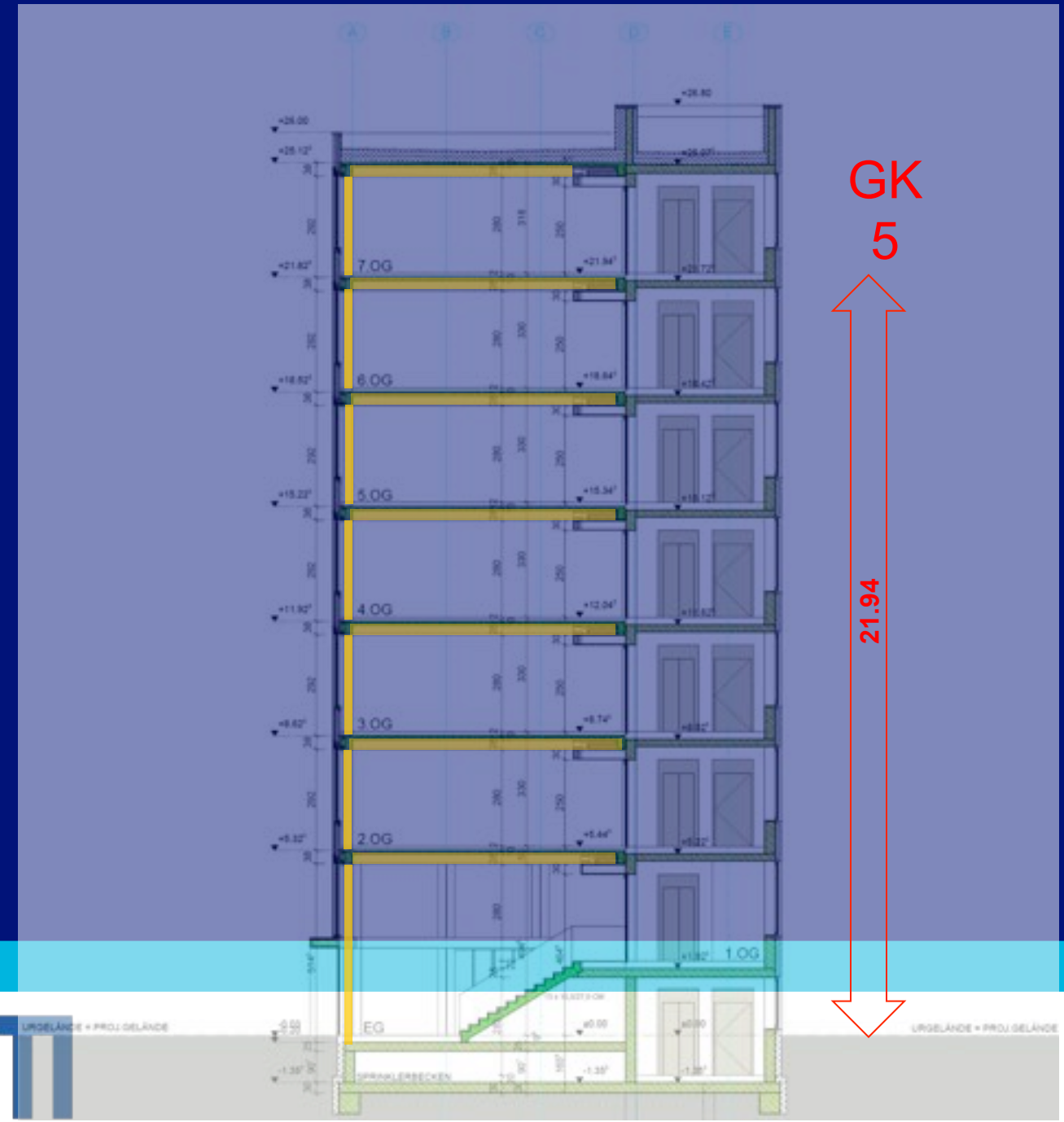
Core structures – Modular surrounding

LCT DEMONSTRATION PROJECT

Realisation of the building system to the high-rise building level:
8 storeys!

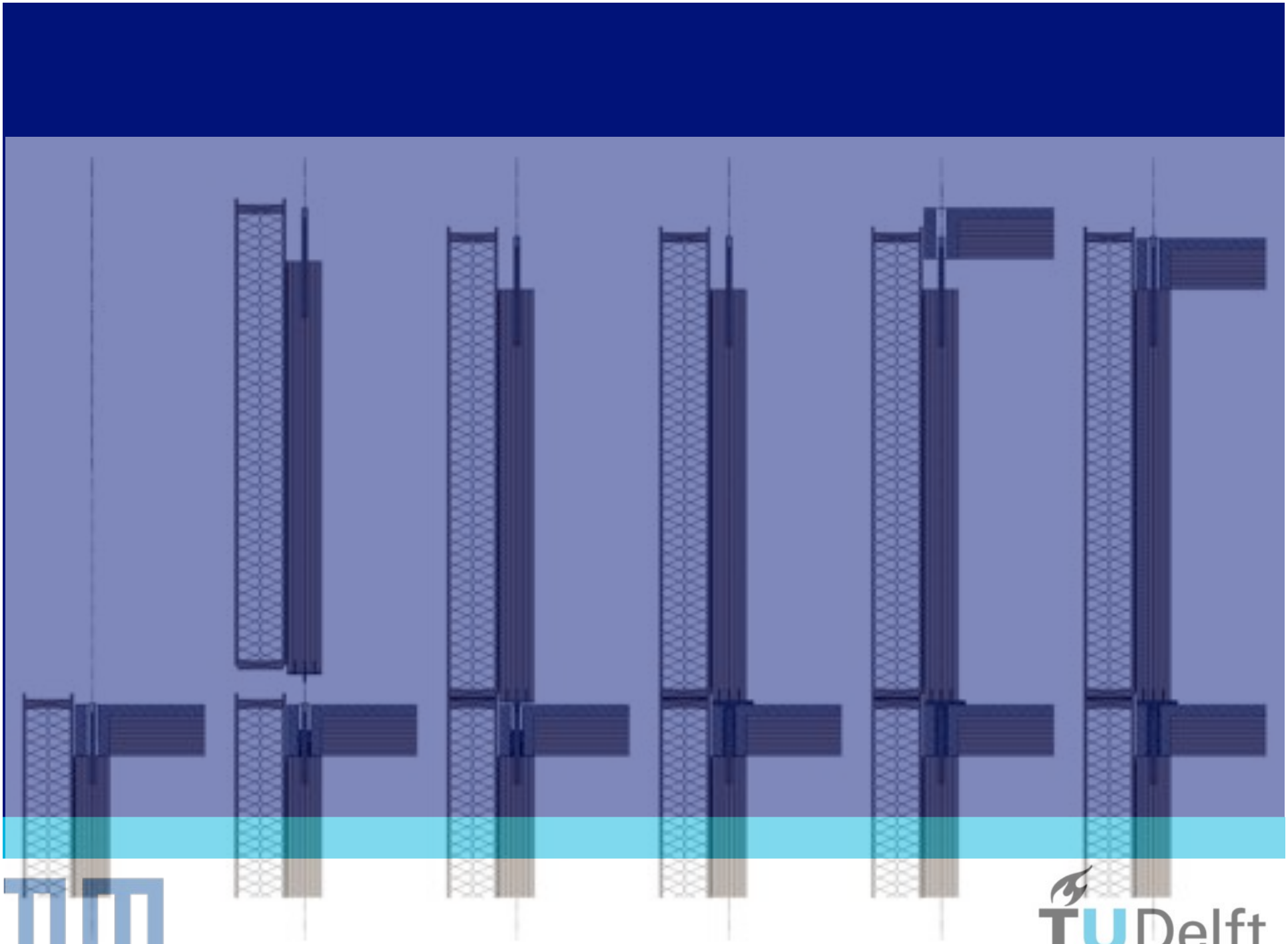
May 6, 2015

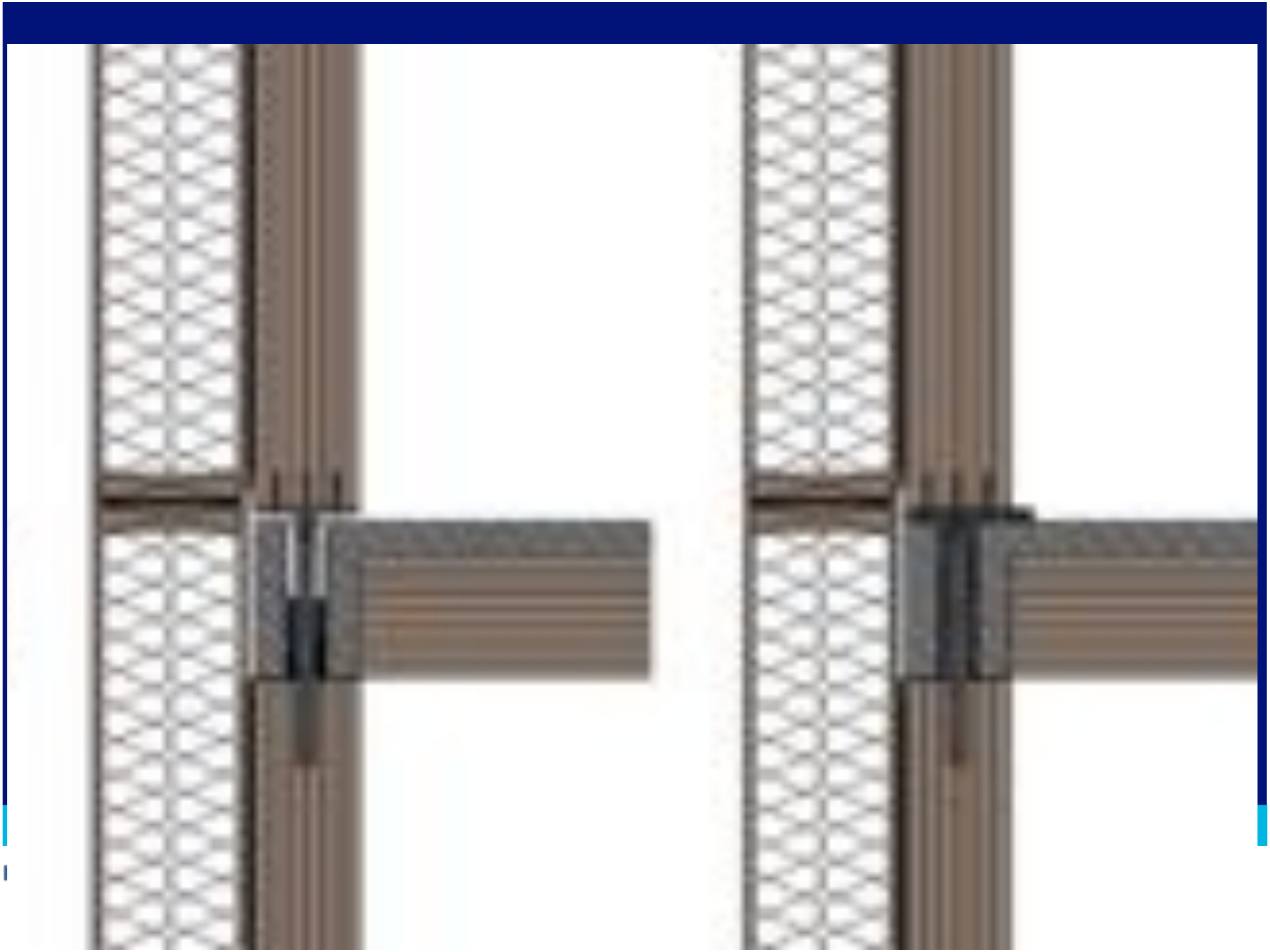



GK
5
21.94
7.OG
6.OG
5.OG
4.OG
3.OG
2.OG
1.OG
EG

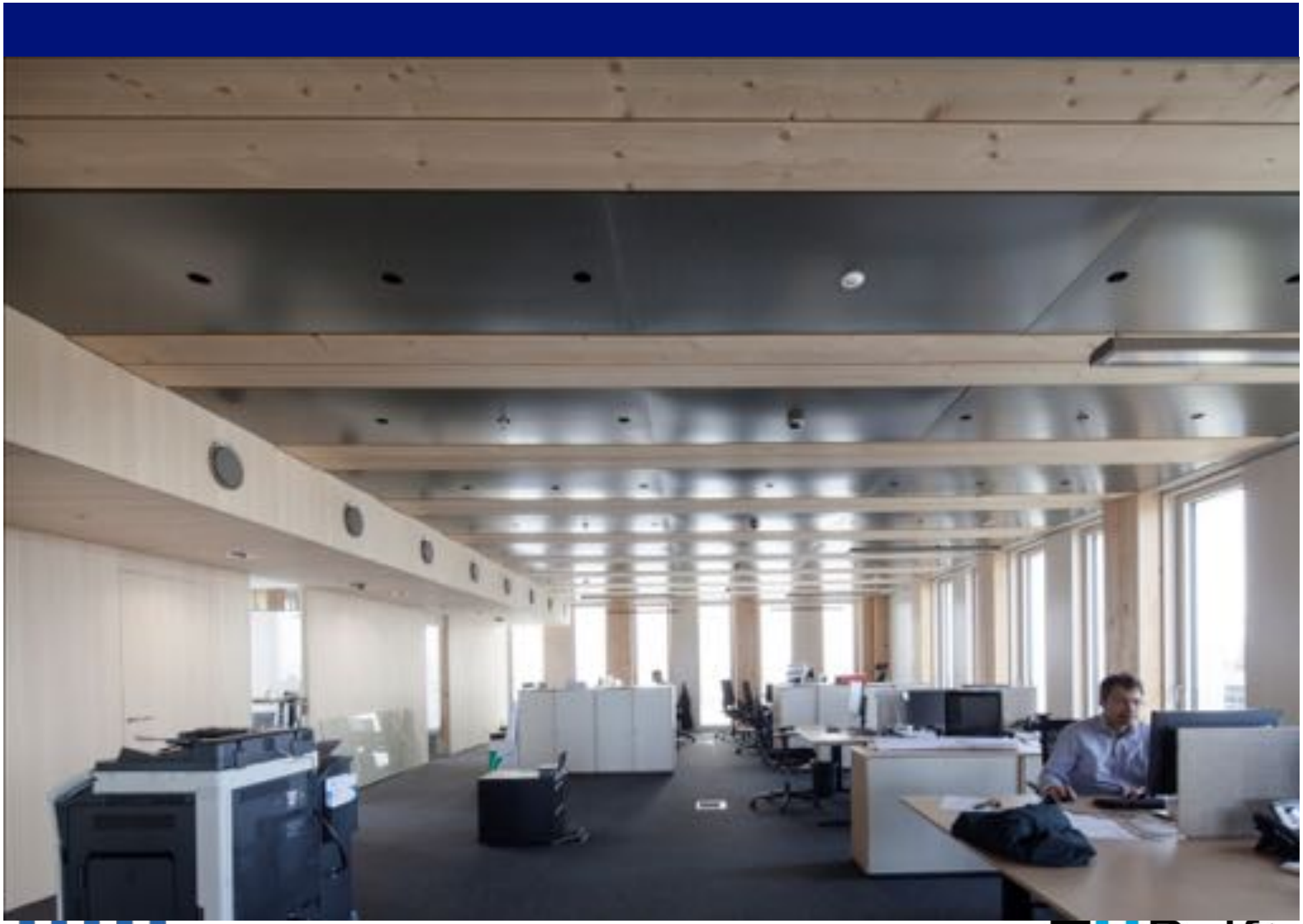

TUDelft


TUDelft





- http://www.youtube.com/watch?v=AVzfDoKernk




CREE


TU Delft

Thanks to Hermann Kaufmann, Architect

Forte Building, Melbourne

- 10 Storeys
- 32.2 Metres
- 23 appartements

Forte Building, Melbourne

- Investor:
- …..A ton of steel produces 1,5 tons of carbon in the making. A ton of cement 1,125 tons. And they aren't as interesting, as versatile, as expressive. A tree produces oxygen, and absorbs 1,42 tons of carbon for every ton of timber grown…

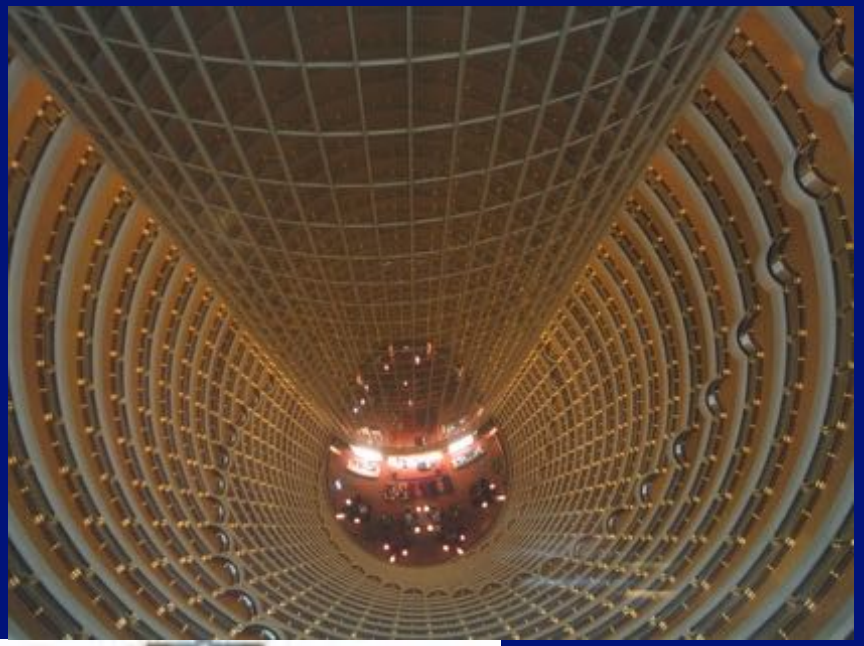
- …. Commercially speaking, the biggest thing is speed. With it being pre-fabricated, all of the main penetrations were already taken care of, and fixing into timber is a lot easier than fixing into concrete, so for the electricians, plumbers, plasterers and others, it's a lot easier job [working with a CLT structure] than working with concrete.


EG Wand 5.1


LENOTEC
P.T. BASSO
LOC. SUD
LATO NORD
ANG. W

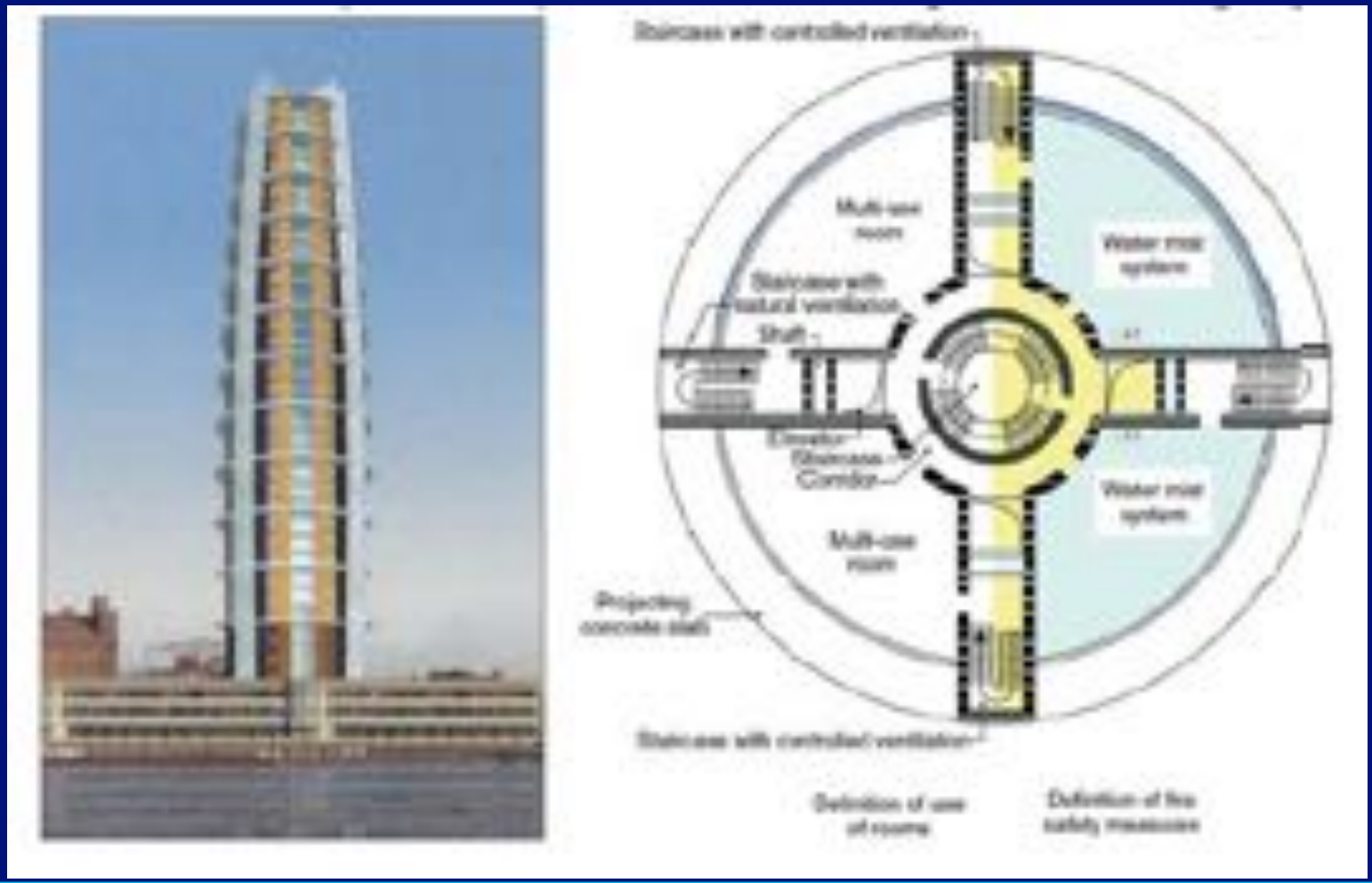
Wood-concrete skyscrapers

Skyscrapers



Outrigger concepts

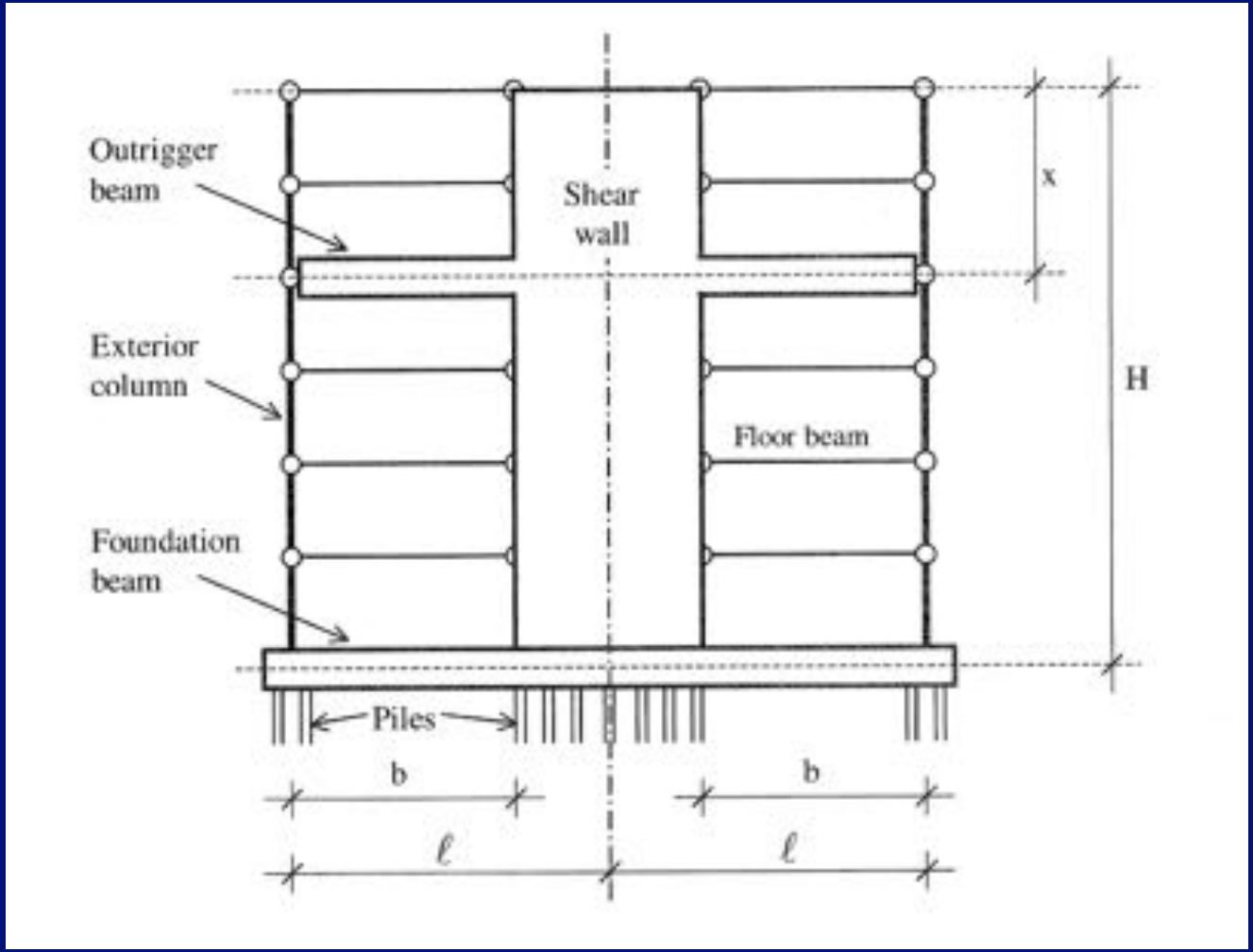
Dock tower (120 m)



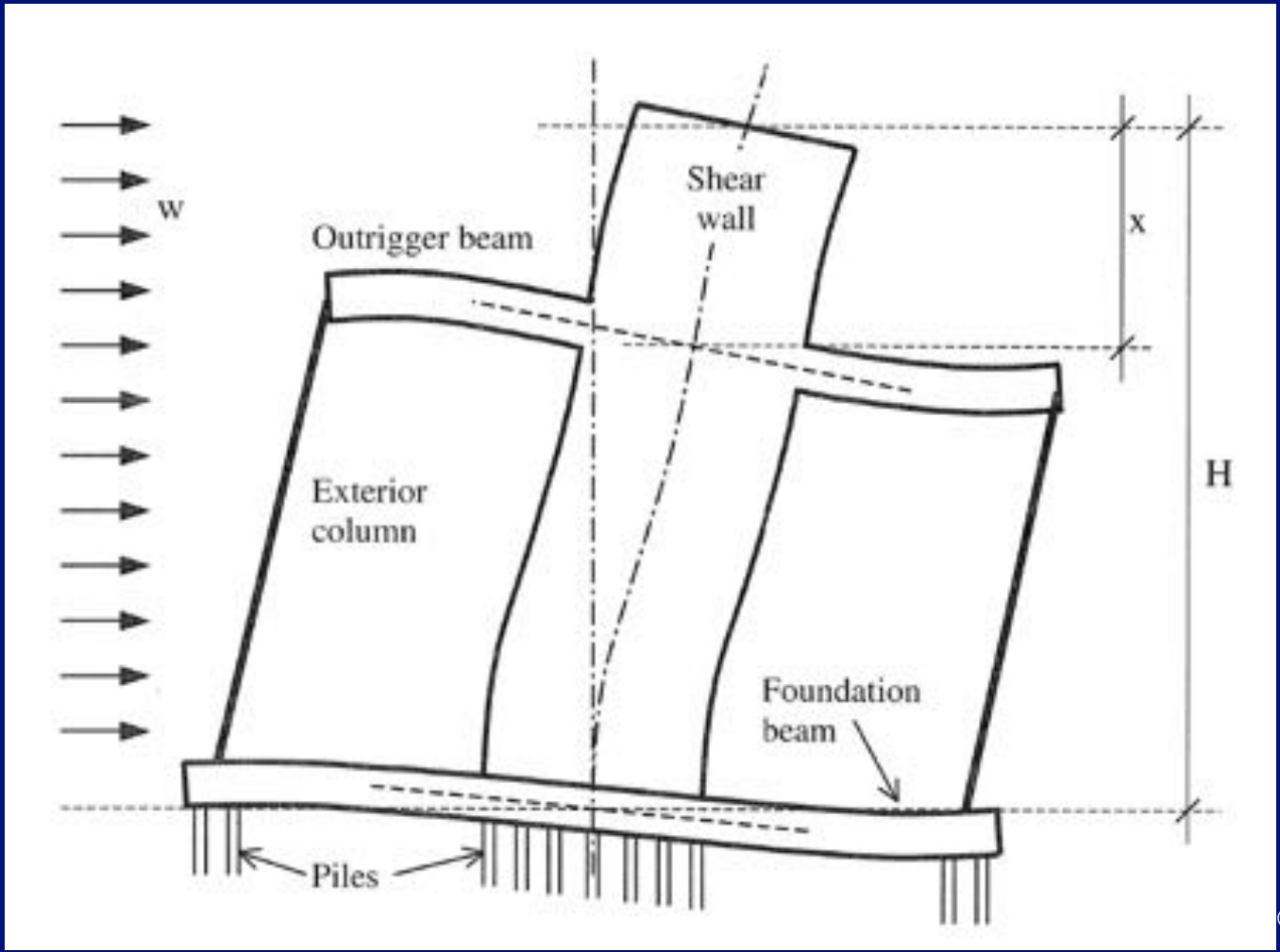
Outrigger function

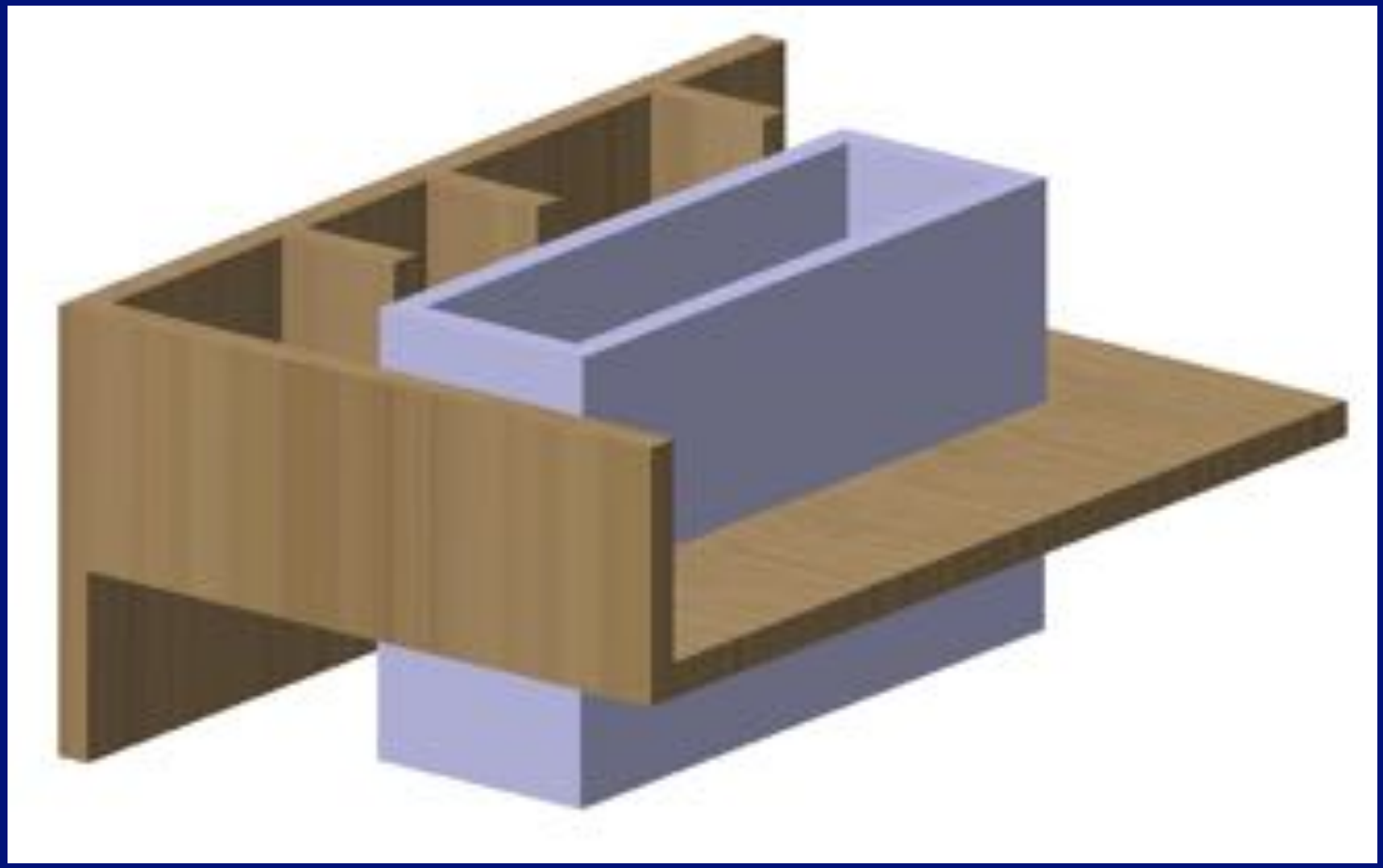
- Providing stability to the core
- Providing a lever arm for the global bending moments
- Providing a division between timber sections for fire safety
- Allowing for building services (equipment)
- Shelter spaces in case of emergencies

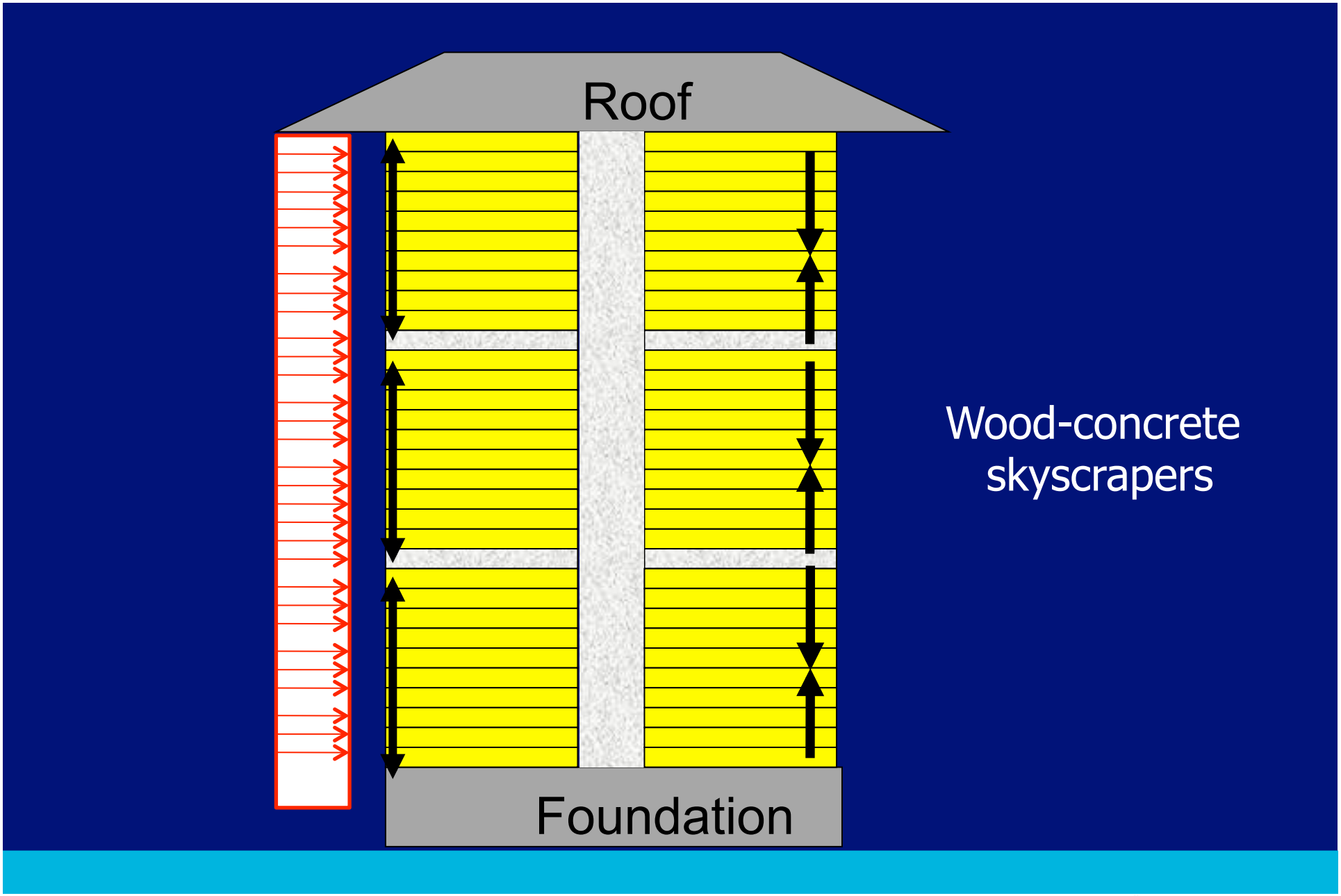
Outrigger concept

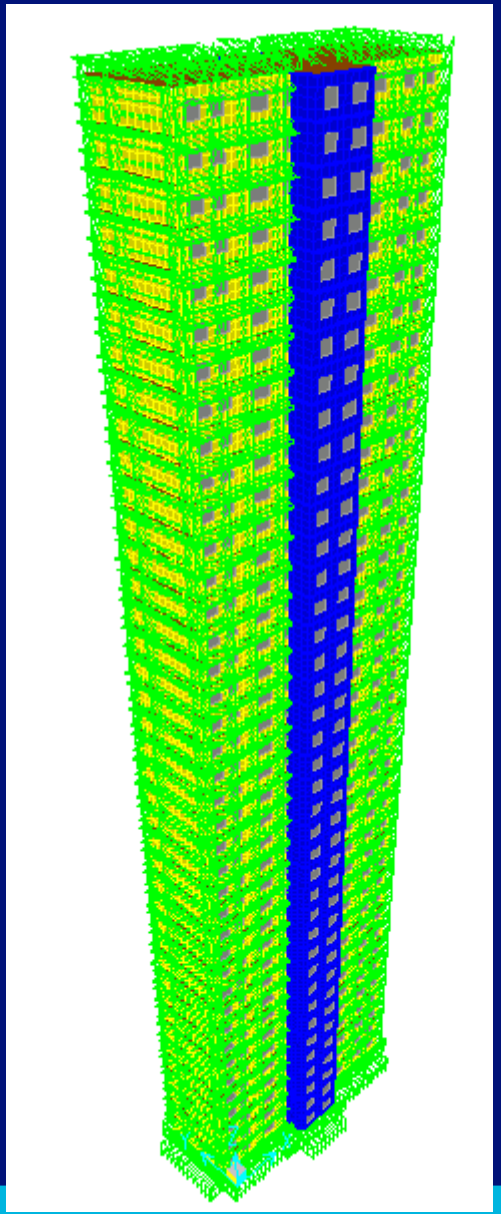


Outrigger concept

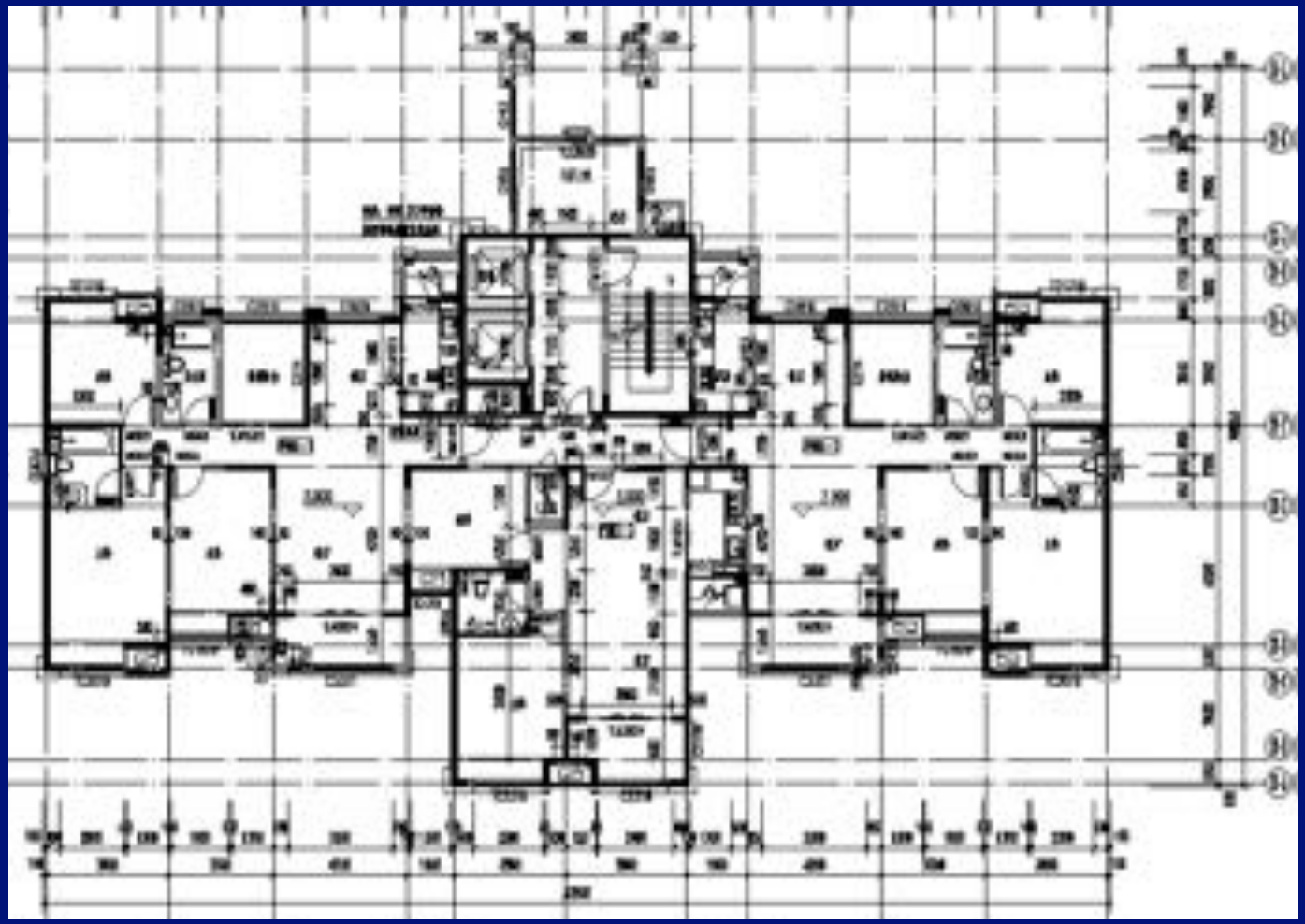




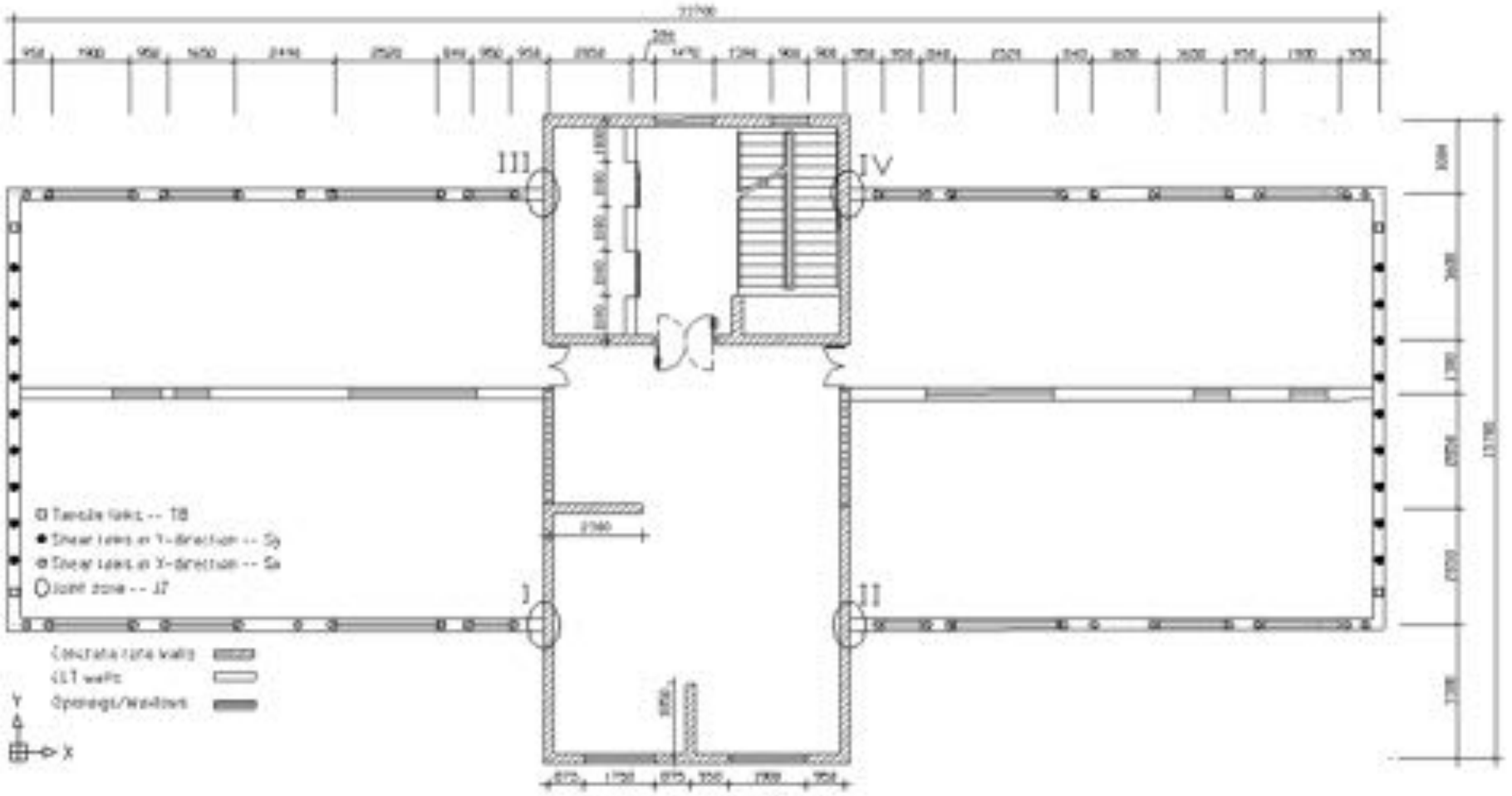

Roof
Foundation
Wood-concrete
skyscrapers



Typical Shanghai Building Lay-out



Model Lay-out with CLT - Concrete

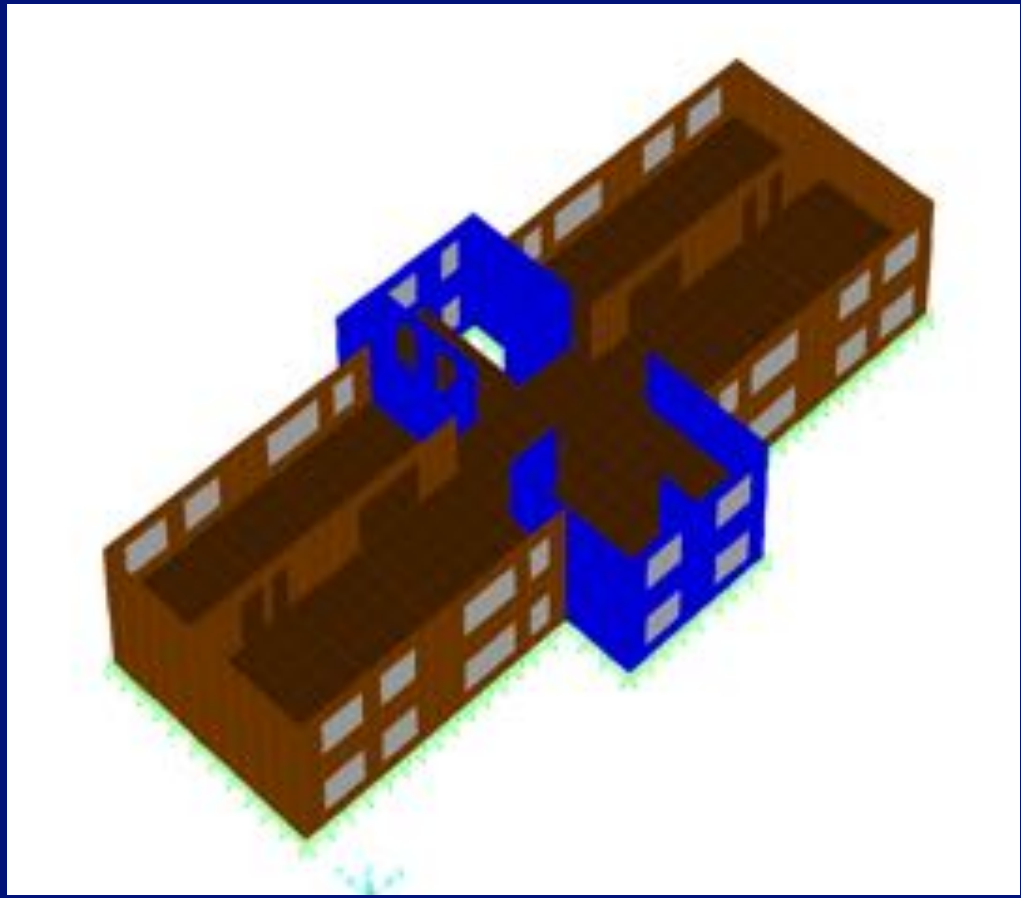


Modelling aspects

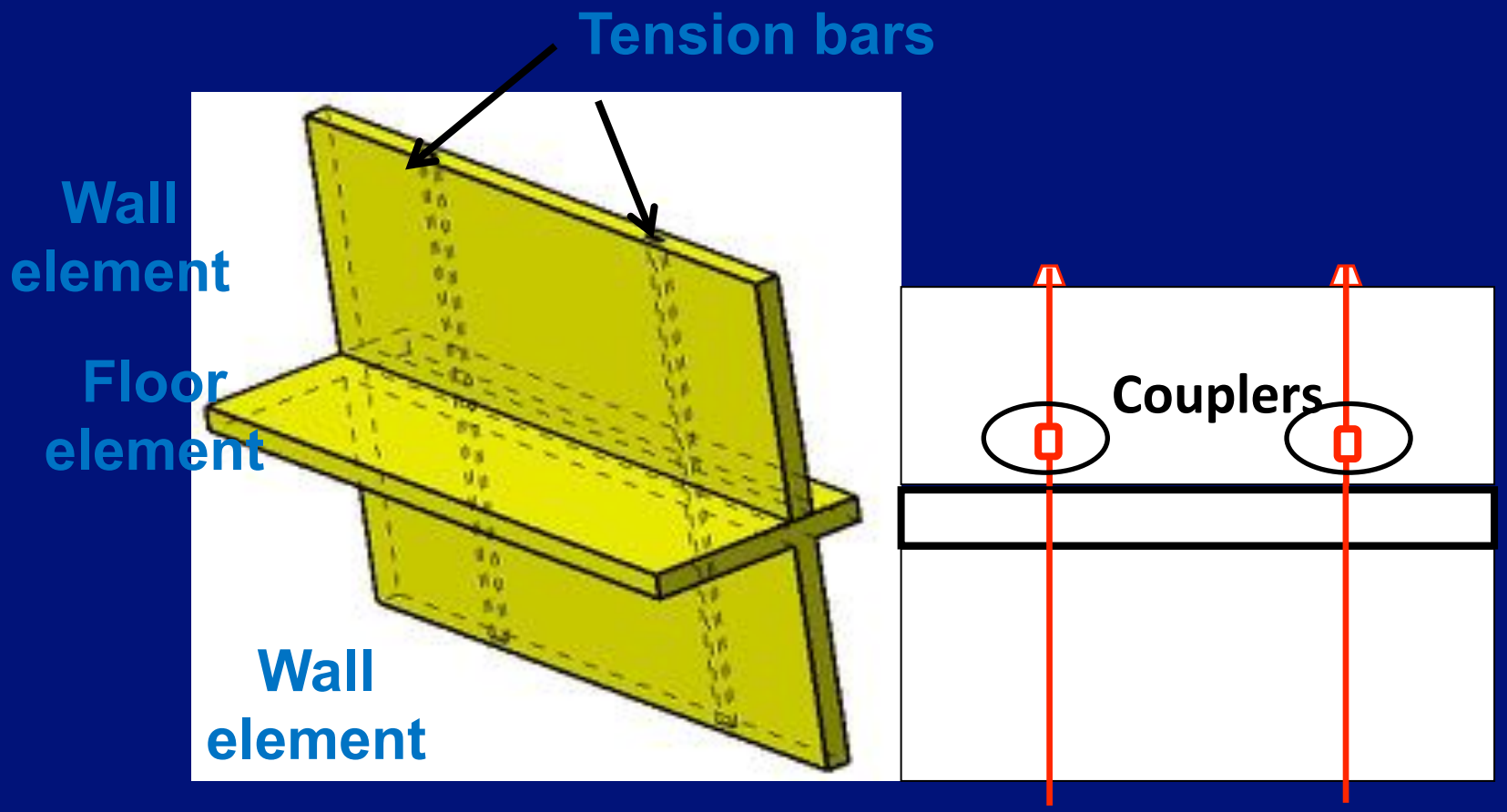
- Shell elements
- Springs

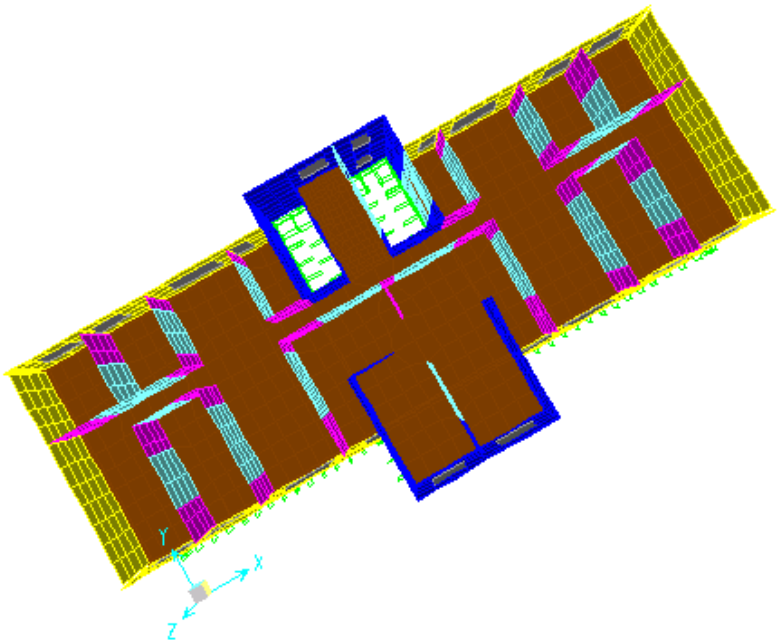
  Compression – Tension

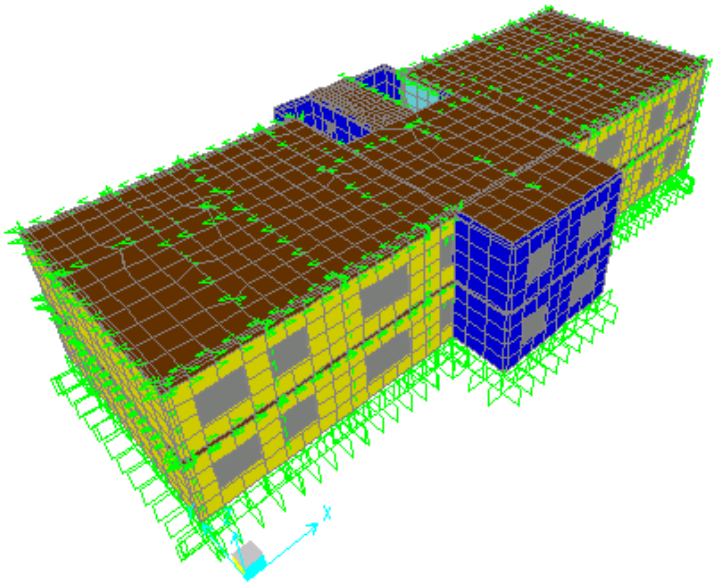
- Floor-floor (CLT)
- Wall-Wall (CLT)
- Wall-Wall (CLT-Concrete)

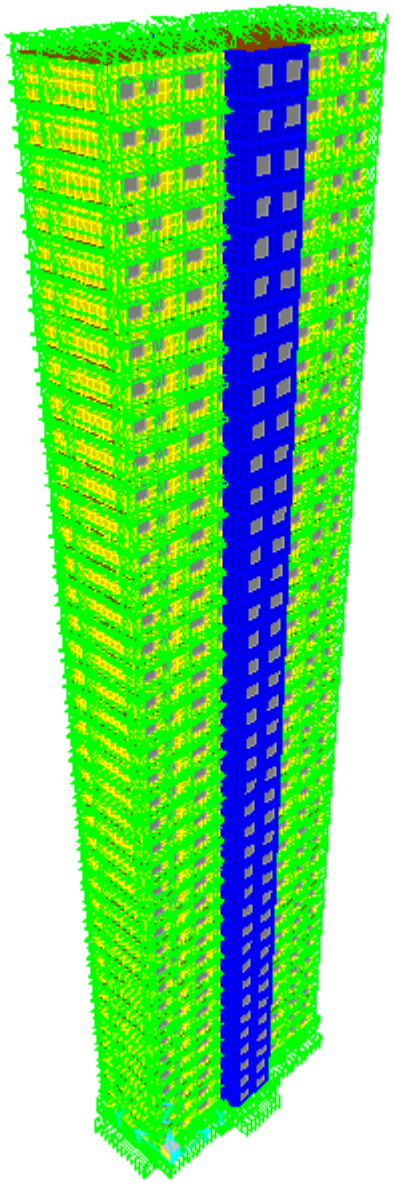


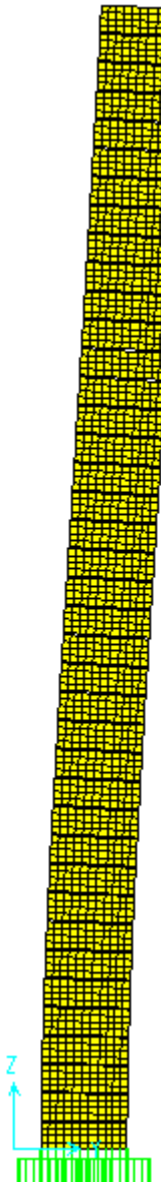
Integrated tension bars




Y
X
Z


X

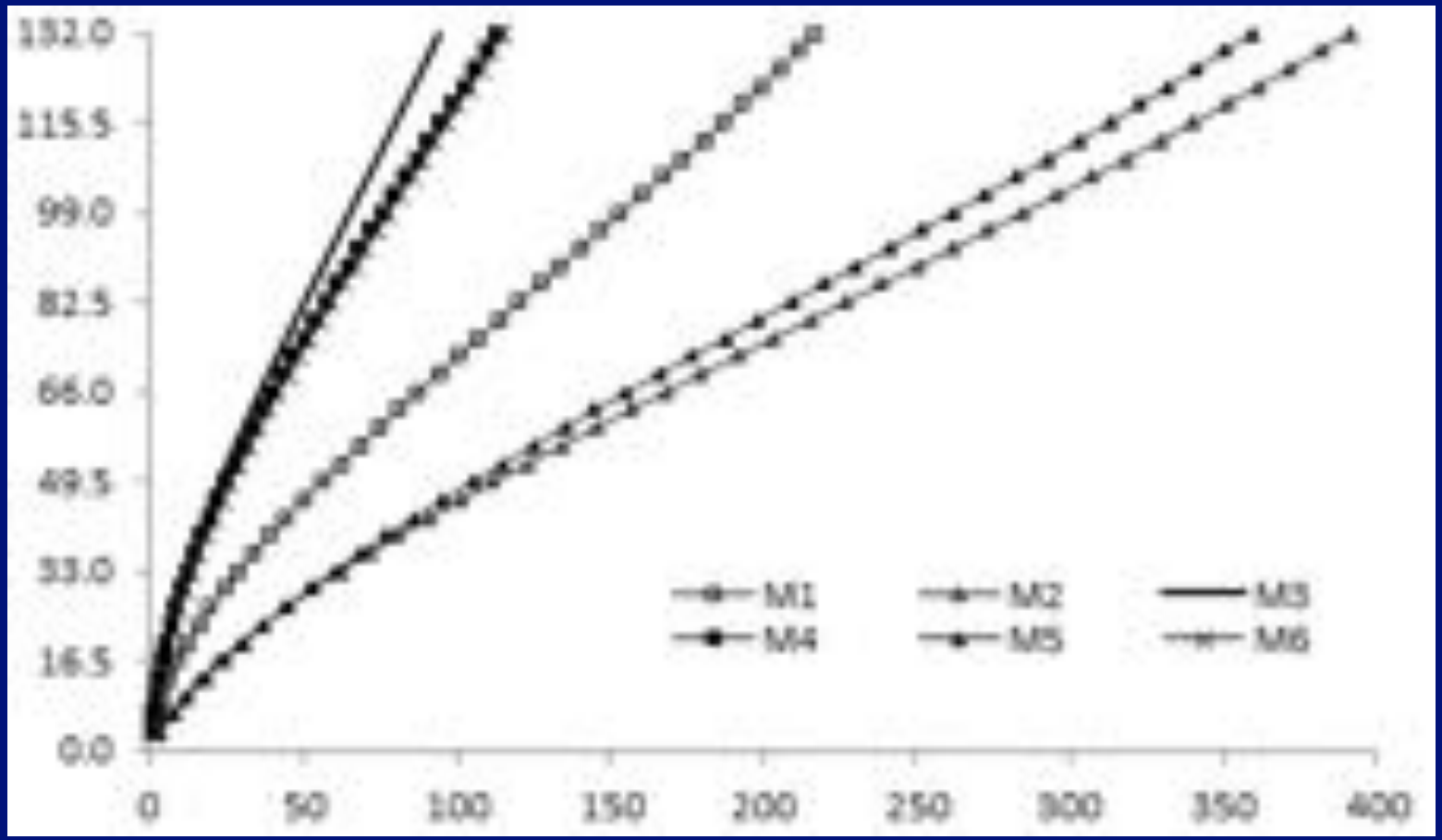



Z

- M1: CLT + 2 Concrete (half) cores, rigid connections
- M2: CLT (Full)
- M3: Concrete (Full building)
- M4: CLT + 1 Concrete (Full) core
- M5: CLT + 1 CLT (Full) core

Table 3: Deflections, compressive stress and tensile stress of rigid building models

	M1	M2	M3	M4	M5
max. deflection from SAP2000 (mm)	217	392	94	113	359
interstory drift index	1/480	1/280	1/1110	1/870	1/310
Period of first mode (s)	2.5	2.9	2.9	2.0	2.3
max. σ_c of core (N/mm²)	15.1	6.7	13.8	12.7	6.8
max. σ_t of core (N/mm²)	4.2	3.3	--	2.3	3.9
max. σ_c of sidewall (N/mm²)	4.9	8.9	15.0	3.2	6.9
max. σ_t of sidewall (N/mm²)	0.7	4.6	--	--	2.8


132.0
115.5
99.0
82.5
66.0
49.5
33.0
16.5
0.0
0
50
100
150
200
250
300
350
400
M1
M2
M3
M4
M5
M6

Results

- Sway: 1/770***H*** with ***H*** is building height
- Sway: shear/bending ratio ≈ 1 to 5
- Compression stresses timber < 5 N/mm^2
- Tension bars # 26, Ø 30 mm
  - Reduction of bars over the building height

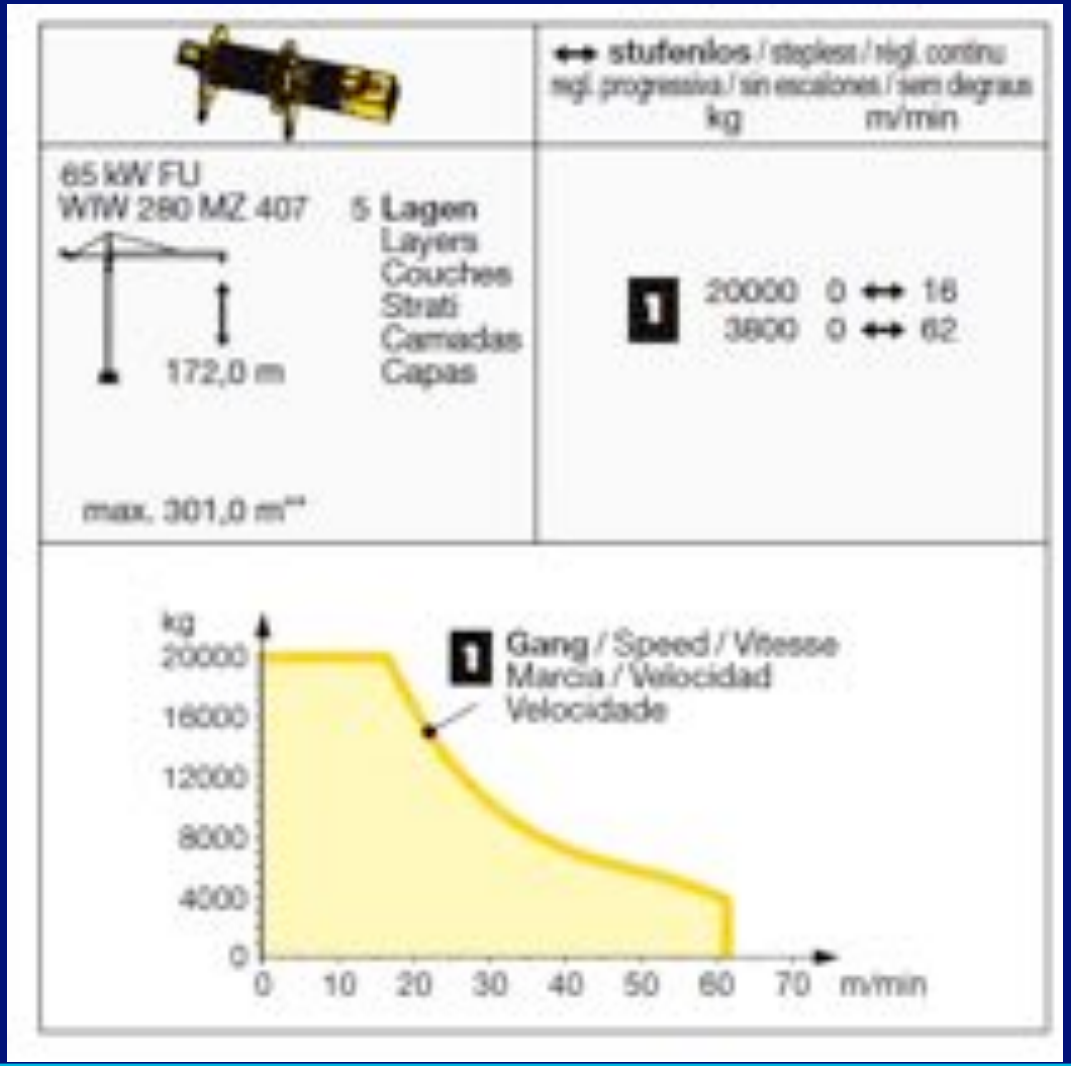
For Architects: mechanically seen:

40 Storeys is possible, also with a wood core

Architects need to make their buildings slightly more ´square´ (or less slender)

Building process

Building process



Crane times

- One-third of hoisting time.
- Building speed of 1 storey per day
- Cheaper cranes (> 6000 USD per month)
- Longer reach → Fewer cranes

Environmental impact

- Wood stores CO_2
- 0.8 – 0.9 tons of CO_2 per m^3
- Savings in other materials 1.1 tons of CO_2
- 26.300 m^3 for a 40 storey building
- 50.000 tons of CO_2 emissions can be avoided
- Eq. of 33000 car emissions/year.

Ongoing work on safety and robustness:

:

- What happens if I have local failures

- How can fires develop?

-What is the risk of 2nd flashover?

-Do sprinklers bring enough safety?

-What is the risk of moisture infiltration in the façade and how to repair?