

De Karel Doorman, Rotterdam: An Ultra-Lightweight Vertical Extension Using Steel Beams and Stud Walls

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Leading Professional, Royal HaskoningDHV



CTBUH 2022
Steel-Timber Conference

De Karel Doorman, Rotterdam

*An Ultra-Lightweight Vertical Extension Using
Steel Frame and Timber Floors*

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Leading Professional Structural Design
Advanced Technology & Research

24 May 2022

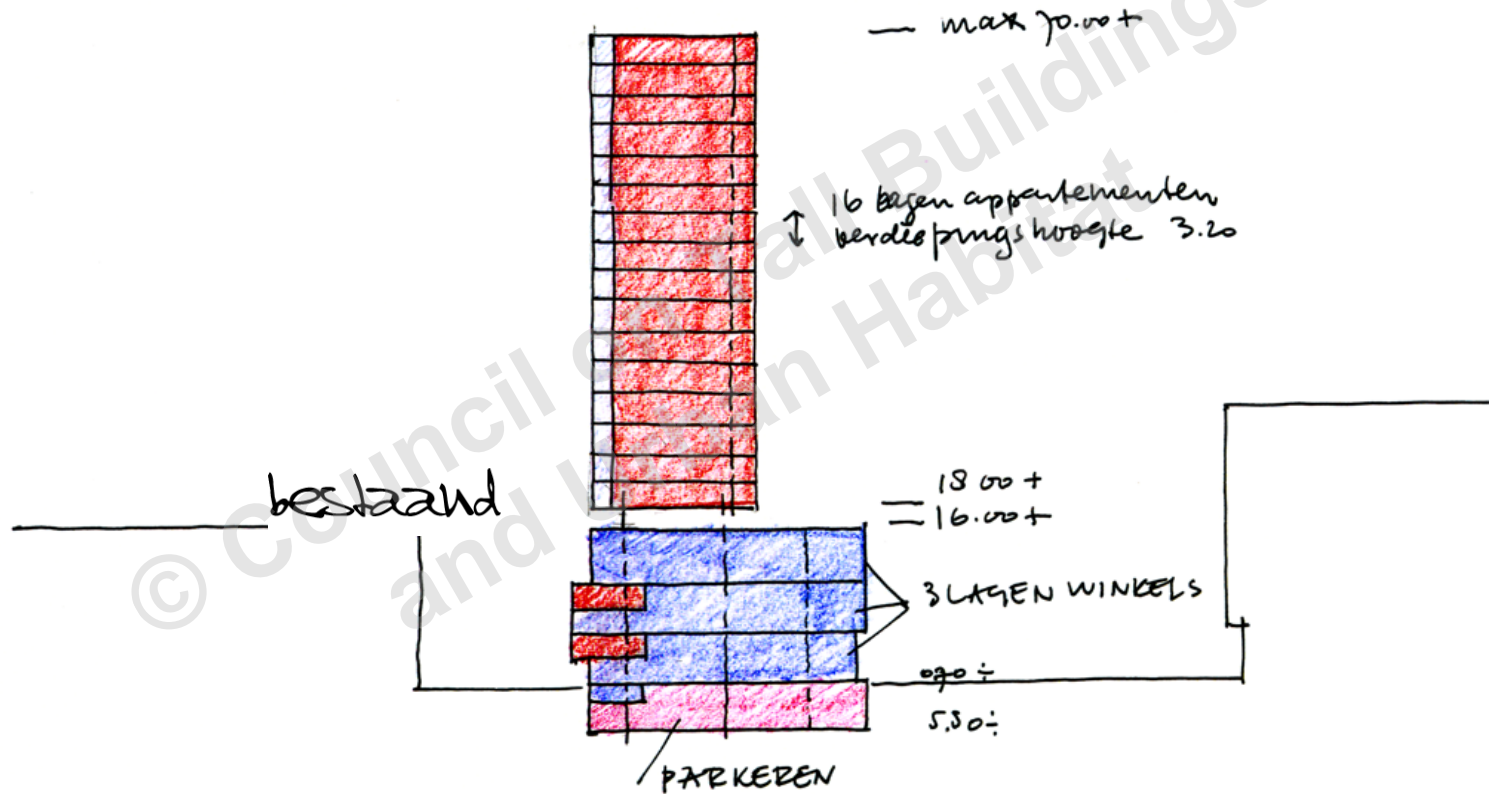
CTBUH 2022 Steel-Timber
Hybrid Buildings Conference

Involved Companies

Owner:	Private owners (Owners' Association)
Client:	DW Nieuwbouw; WM Projectontwikkeling
Architect:	Ibelings Van Tilburg Architecten
Structural Engineer:	Royal HaskoningDHV
MEP Engineer:	Wichers & Dreef
Contractor:	Van Wijnen
Consultant Acoustics:	Peutz Associates
Consultant Fire Safety:	Peutz Associates
Structural steel structure:	Oostingh
Structural timber:	Forger Houtconstructies; Heko Spanten

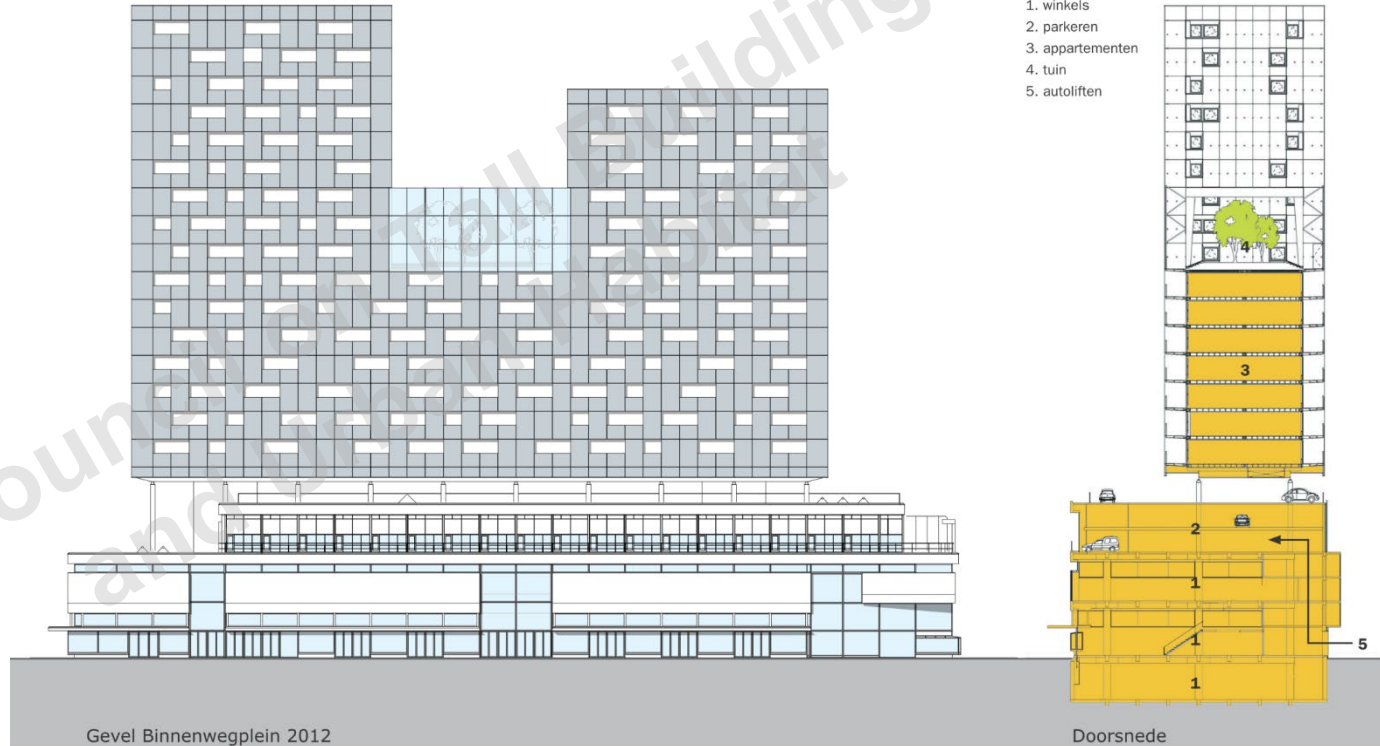
See also: <https://www.skyscrapercenter.com/building/de-karel-doorman/5562>

2002 - Architect's question: "Can we do this?"

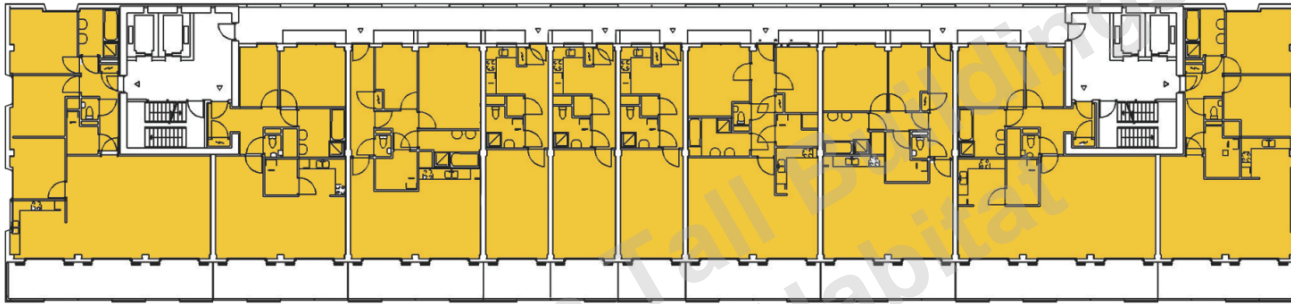


Functional Design

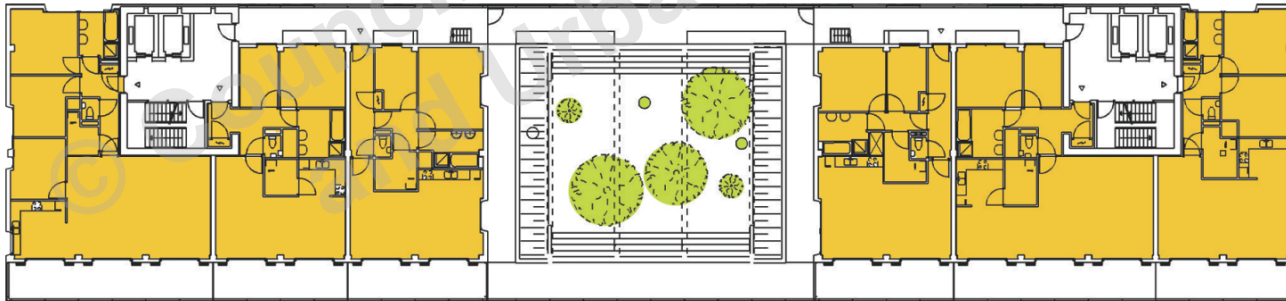
- 16 / 7 / 13 stories
- 105 apartments
- Multiple functions in existing building
 - Entrance
 - Parking
 - Shops



Functional Design



9^e verdieping woongebouw met appartementen van 44,5m² t/m 124m² bvo



10^e verdieping woongebouw met in het midden de gemeenschappelijke daktuin



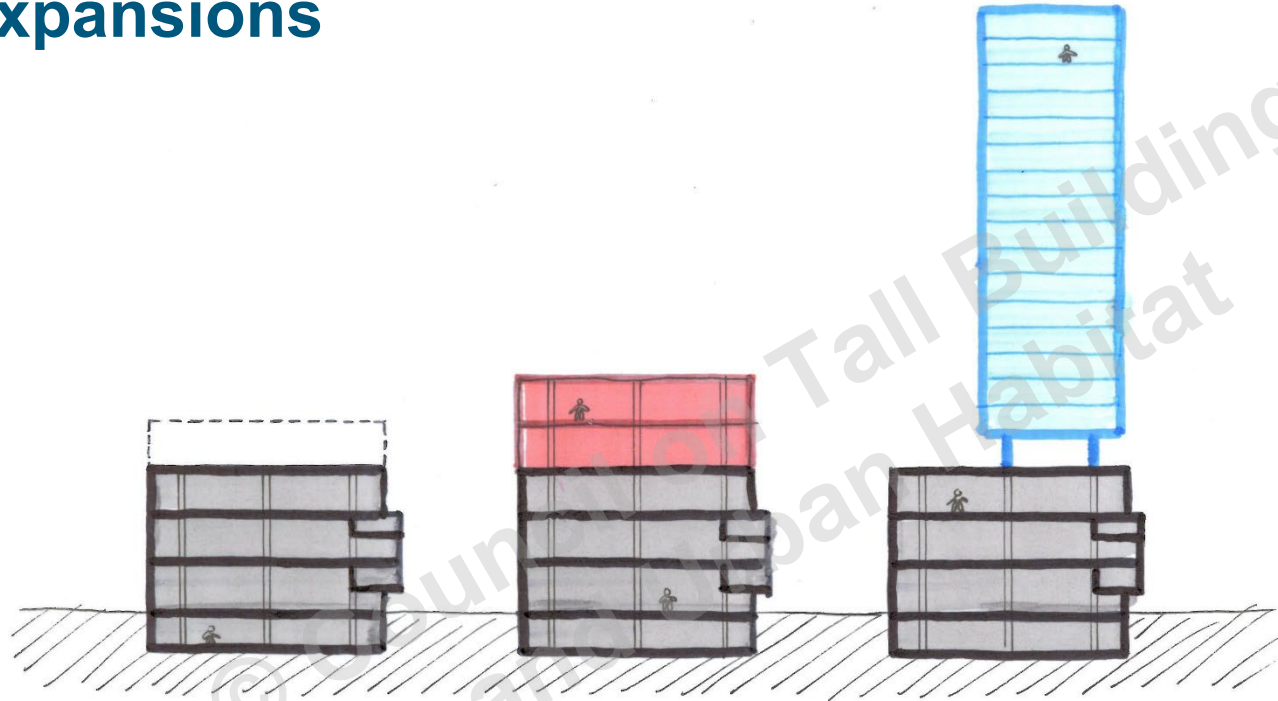
Existing Building



Existing shopping Mall 'Ter Meulen'
Realized between 1948 and 1951
Architect: Van den Broek & Bakema



Expansions



1948-1951

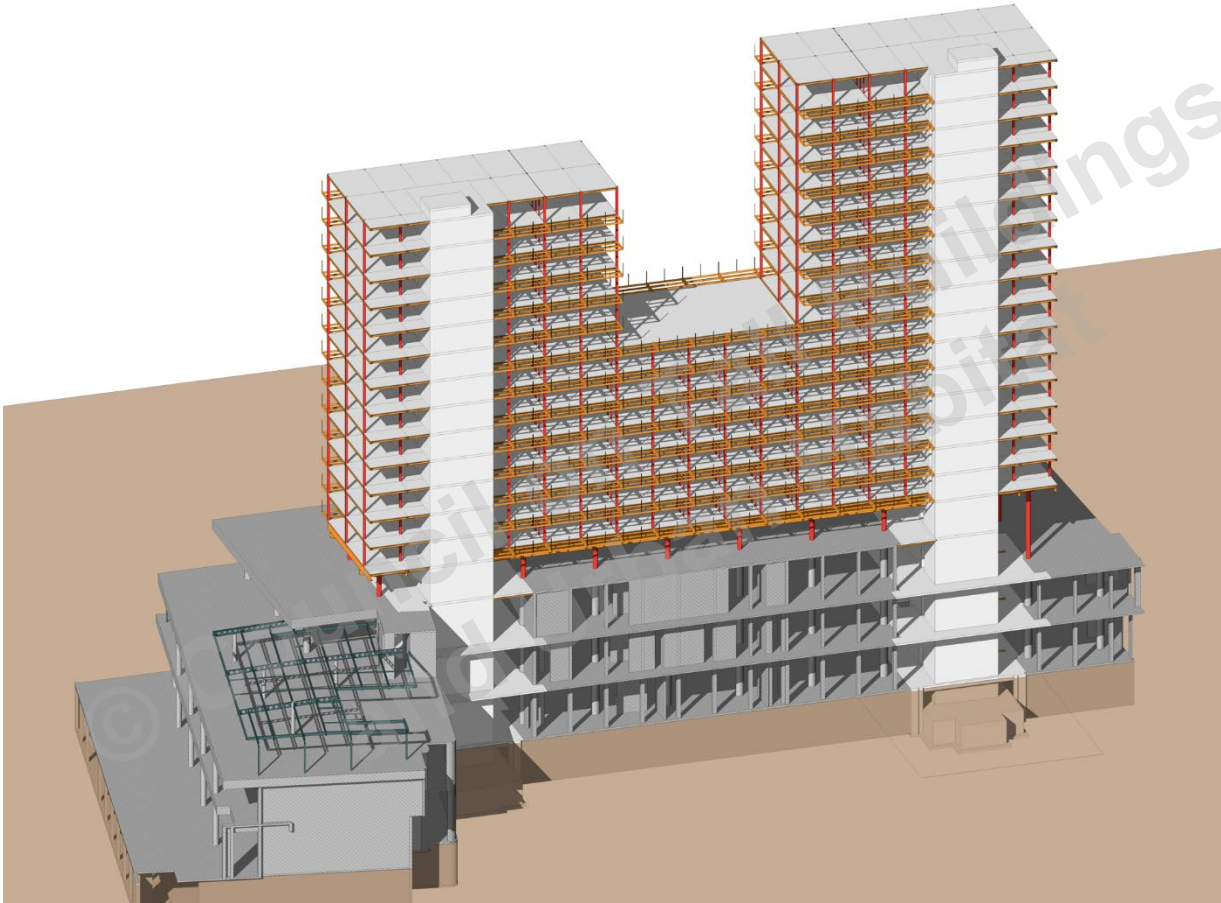
Concrete floor

Late 1970s

steel/concrete

2002-2012

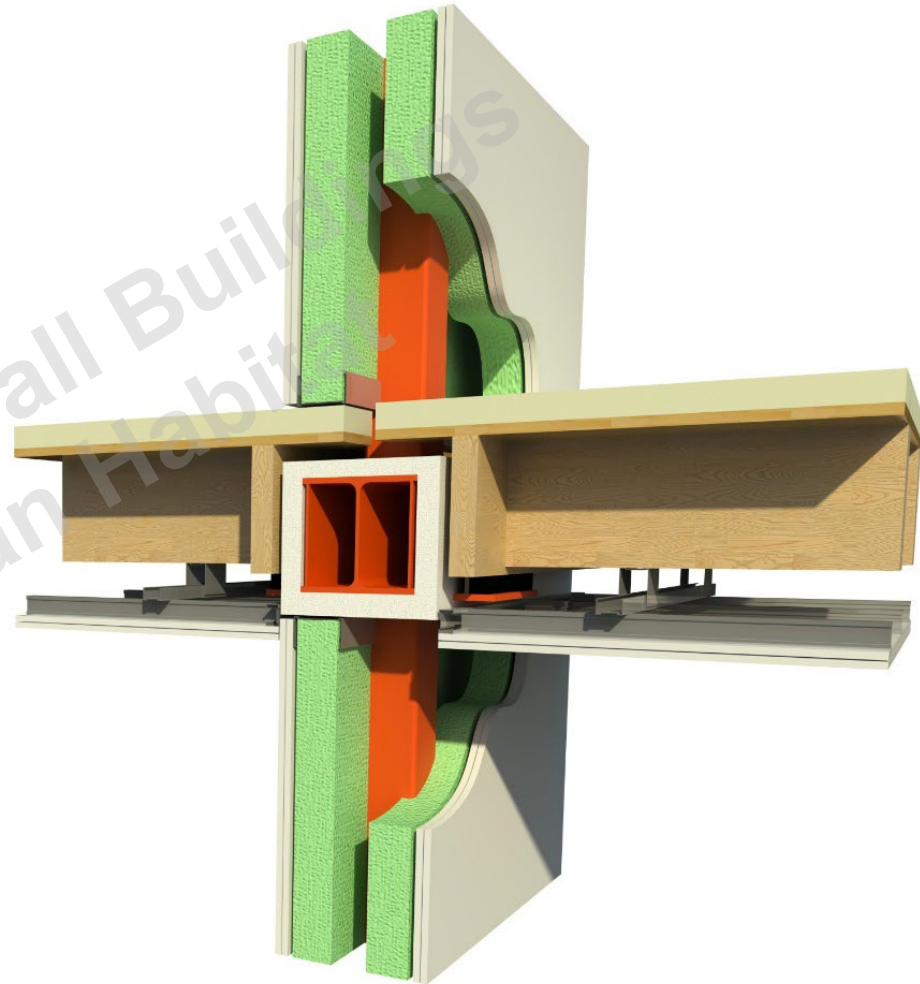
Steel-Timber 250 kg/m²

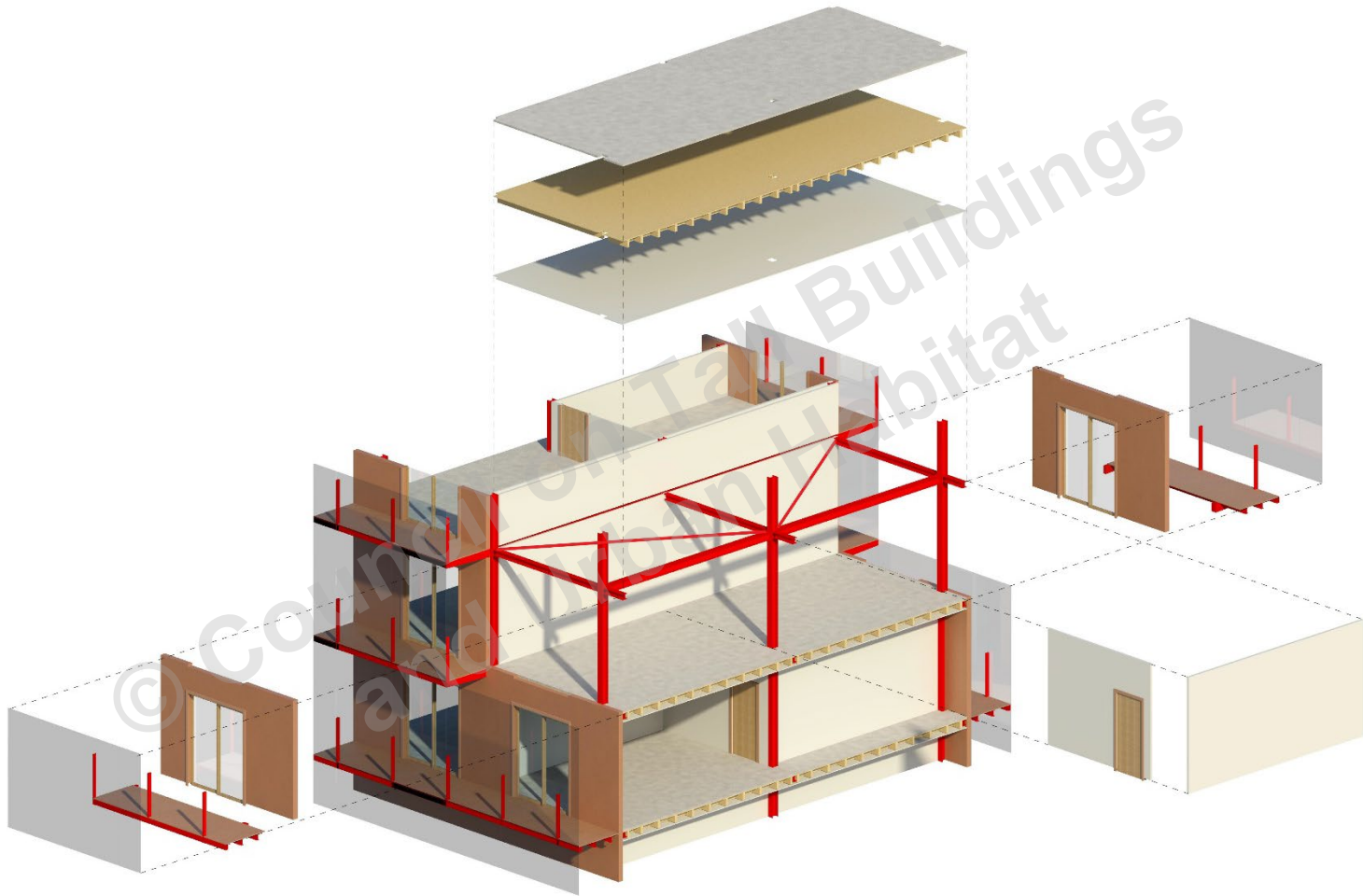




Building System

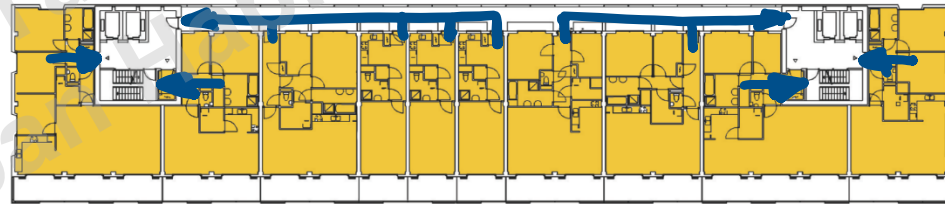
- Steel braced frame
 - HE.. columns and beams, fire proofing
 - Strip steel diagonals
 - Square tubes as vibration blockers
- Timber floor with screed, on dampers
 - LVL beams 2 x 45x225 mm in both directions
 - Multiplex plates
 - Screed 55mm
- Metal stud walls, separated
 - Cold formed thin walled profiles
 - Double gypsum board
 - Insulation
- Suspended ceiling
 - Cold formed thin walled profiles
 - Double gypsum board



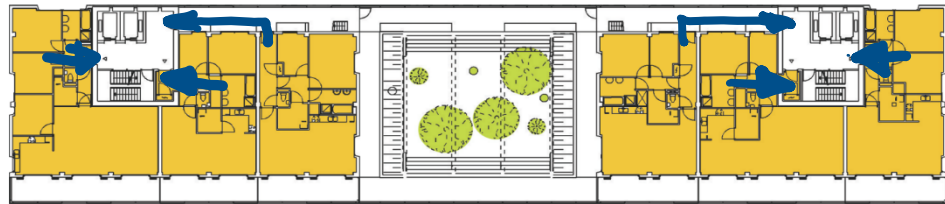


Fire Safety

- Fire resistance of main load bearing structure 120 minutes
 - Fire proofing by fire proofing board around steel structure
- Fire resistance between apartments 60 minutes
 - Double gypsum board 12mm
- Escape Routes to concrete cores



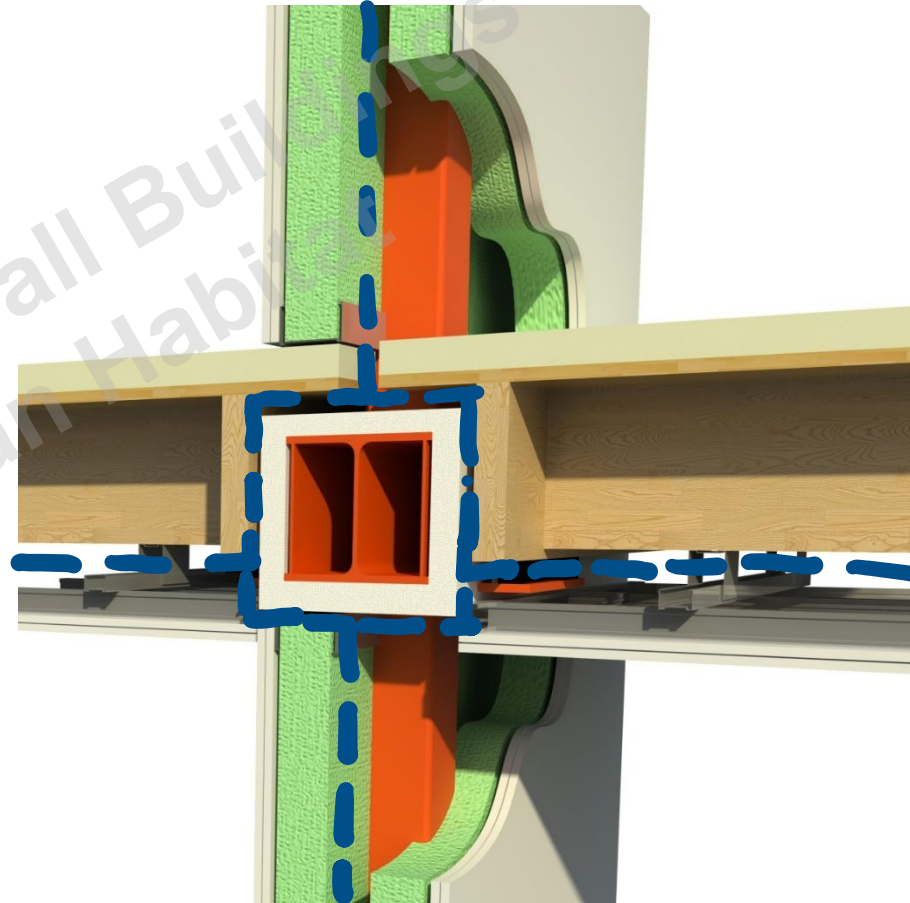
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10^e verdieping woongebouw met in het midden de gemeenschappelijke daktuin

Acoustic Isolation Between Apartments

- High requirement between apartments
- Acoustic separation of apartments
 - Floors on 25 mm CDM rubber dampers
 - Double separated walls
 - Suspended ceilings
- System tested in laboratory



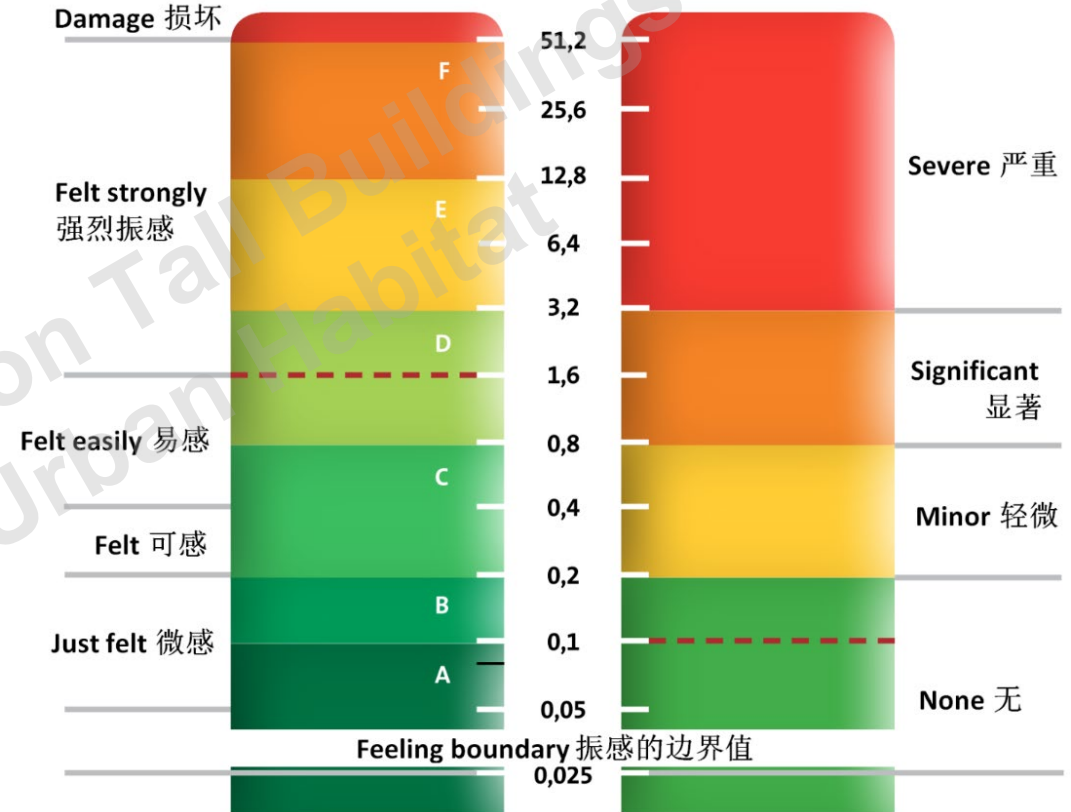
Footfall Vibrations

- Own vs neighboring apartment
- Perception / nuisance
- Target values
 - 1.6 mm/s vs
 - 0.1-0.2 mm/s

PERCEPTION BY PERSON IN OWN APARTMENT 公寓内个体的感受

ES-RMS₉₀

NUISANCE IN NEIGHBORING APARTMENT 对隔壁公寓的影响



Modelling, Testing & Calibration

Dynamic behaviour depends strongly on dynamic properties

- Dynamic damping ratios
- Dynamic behavior of
 - connections/nodes
 - interior walls and ceilings

Approach (in collaboration with TNO, Delft (NL))

- 3D dynamic FEM analyses
- Dynamic measurements in test apartment
- Calibration of FEM model
- Design adaptations

Modelling, Testing & Calibration



Results

Design adaptations

- Own apartment: reduce vibration level
- Neighboring apartment: energy transfer block

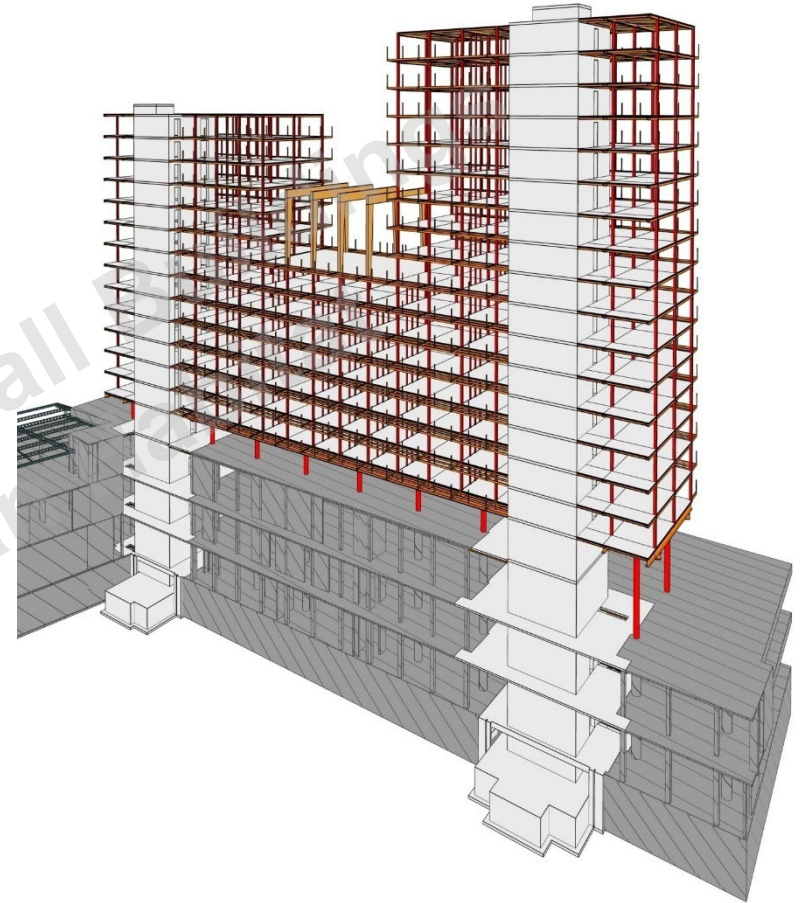
Results

- High level of comfort
- Sound isolation
- Low transfer of vibrations
- Sense of 'concrete building'

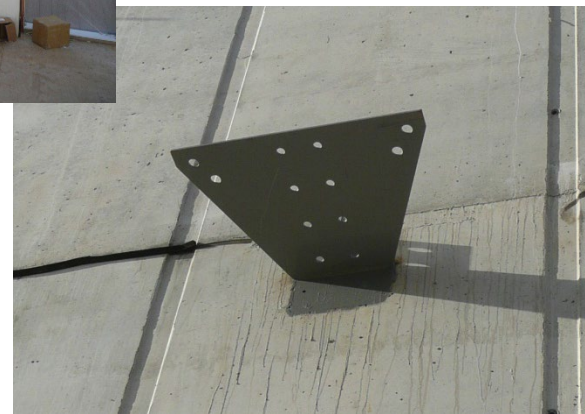


Wind Vibrations

- Concrete cores
- Steel braced frame
- Most important parameters
 - Stiffness
 - ~~Mass~~
 - **Damping**
 - Used materials
 - Friction details designed



Friction details



Balconies, facades and roof garden

© Council on Tall Buildings
and Urban Habitat



Credit: Ossip van Duivenbode



Credit: Ossip van Duivenbode

Considerations and outlook

Considerations

- Prevent added mass to the timber and steel structure

Outlook/recommendations

- Research into more generally applicable ultra-light weight structures in steel-timber hybrids
- Validation & Calibration of Design is important to guarantee quality
- Develop design guidelines



Credit: Ossip van Duivenbode