SKANSKA

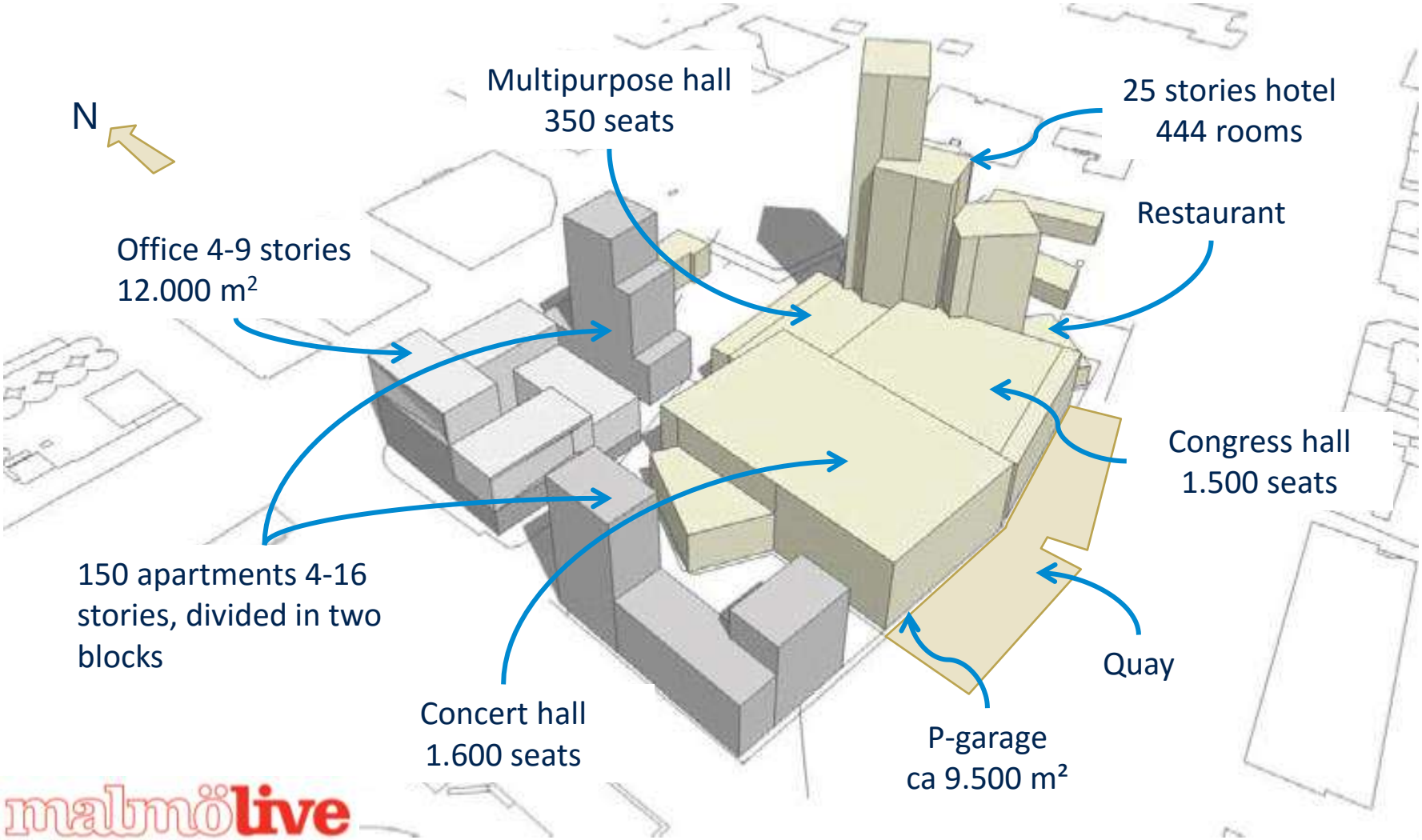
Good & Bad Vibrations

2015-10-21// Carl Jonsson
Skanska Sverige, Teknik

1. The project and major challenges
2. The Structure
3. BIM
4. Structural design

1 The Project

- Competition by the City of Malmö to develop the site in May 2008.
- Skanska was selected in June 2010.
- Construction start May 2012.
- Project completed April 2015.


N
Multipurpose hall
350 seats
25 stories hotel
444 rooms
Restaurant
Office 4-9 stories
12.000 m²
Congress hall
1.500 seats
150 apartments 4-16
stories, divided in two
blocks
Quay
Concert hall
1.600 seats
P-garage
ca 9.500 m²
malmölive


11 November 2013
18mnths done
18mnths to go

STORA KONTRASTER I BEBYGGELSENS FORM OCH UTTRYCK ÄR EN DEL AV MALMÖS STADSIDENTITET

Malmös identitet *kan förstärkas genom att det ortsspecifika uppmärksammas och tillvaratas vid färgsättning. Malmö har en grafiskt ren och kontrastrik färgskala, där svalt gult och varmt rött tegel dominerar och bildar ett uttrycksfullt färgackord, med vilket omgivande kulörer bör samspela. Malmöfärgskalan beskriver översiktligt olika färgmässiga samband som kan underlätta färgrådgivning, färgsättning och färgplanering vid nyproduktion och renovering.*

Två grundläggande principer *har tillämpats i detta färgprogram som 1 Arkitekturuttryck från skilda tidsepoker bör kunna upplevas med de 2 Den svalt gula tegelbebyggelsen, speciell för Malmö, är uttrycksfull da tegelkulörerna. Rödgula kulörer (C) som genom färgpåverkan (induktion) ge*

MALMÖFÄRGSKALAN

A

B

C

FÄRGKARAKTÄR A + B

NCS FÄRGTONCIRKEL

KULÖRTONER MELLAN G – Y, Y – R

KULÖRERNA NR 1 – 24 ÄR AVSEDDA FÖR MILJÖER MED SVALT GULT TEGEL

TEGEL- OCH NATURSTENS-KULÖRER KAN ÖVERSÄTTAS TILL PUTS.
TEGEL NR 9 OCH 10 ENDAST I UNDANTAGSFALL.

NYANS FÄRGTON

FÄRGKARAKTÄR C

NCS FÄRGTONCIRKEL

KULÖRTONER MELLAN Y20R – Y60R

KULÖRERNA NR 25 – 36 ÄR AVSEDDA FÖR ÄLDRE BEBYGGELSE I MILJÖER UTAN SVALT GULT TEGEL

TEGELKULÖRER 90-TAL SEKELSKIFTE

BALKONGKULÖRER

- KOPPARGRÖNA
- OLIVGRÖNA
- LJUST GULGRÅ
- GRÅ - VARMGRÅ

TAK

- KOPPARGRÖNT
- MÖRKRÖD PLÅT
- RÖTT TAKTEGEL
- GRÅTT - SVART

SOCKLAR MM. NATURSTENSKULÖRER

FÖNSTERKULÖRER

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Materials

Undertak

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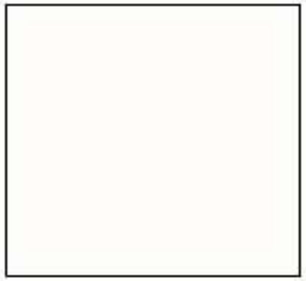
(RAL 7030 [illegible])



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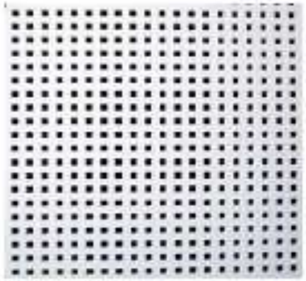
(RAL 9016)



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(RAL 9016)

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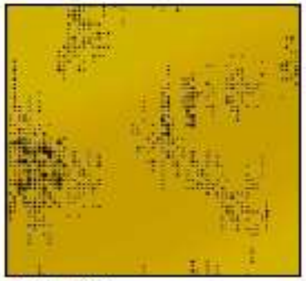
(RAL 7021)

[illegible]
(RAL 9016)

Vägg

[illegible]



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(RAL 7030 [illegible])

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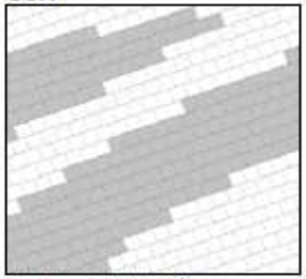
Golv



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[illegible]

[illegible]

[illegible]

Environment

En del av Skanskas Gröna Initiativ
SKANSKA

U.S. GREEN BUILDING COUNCIL
LEED PLATINUM
USGBC

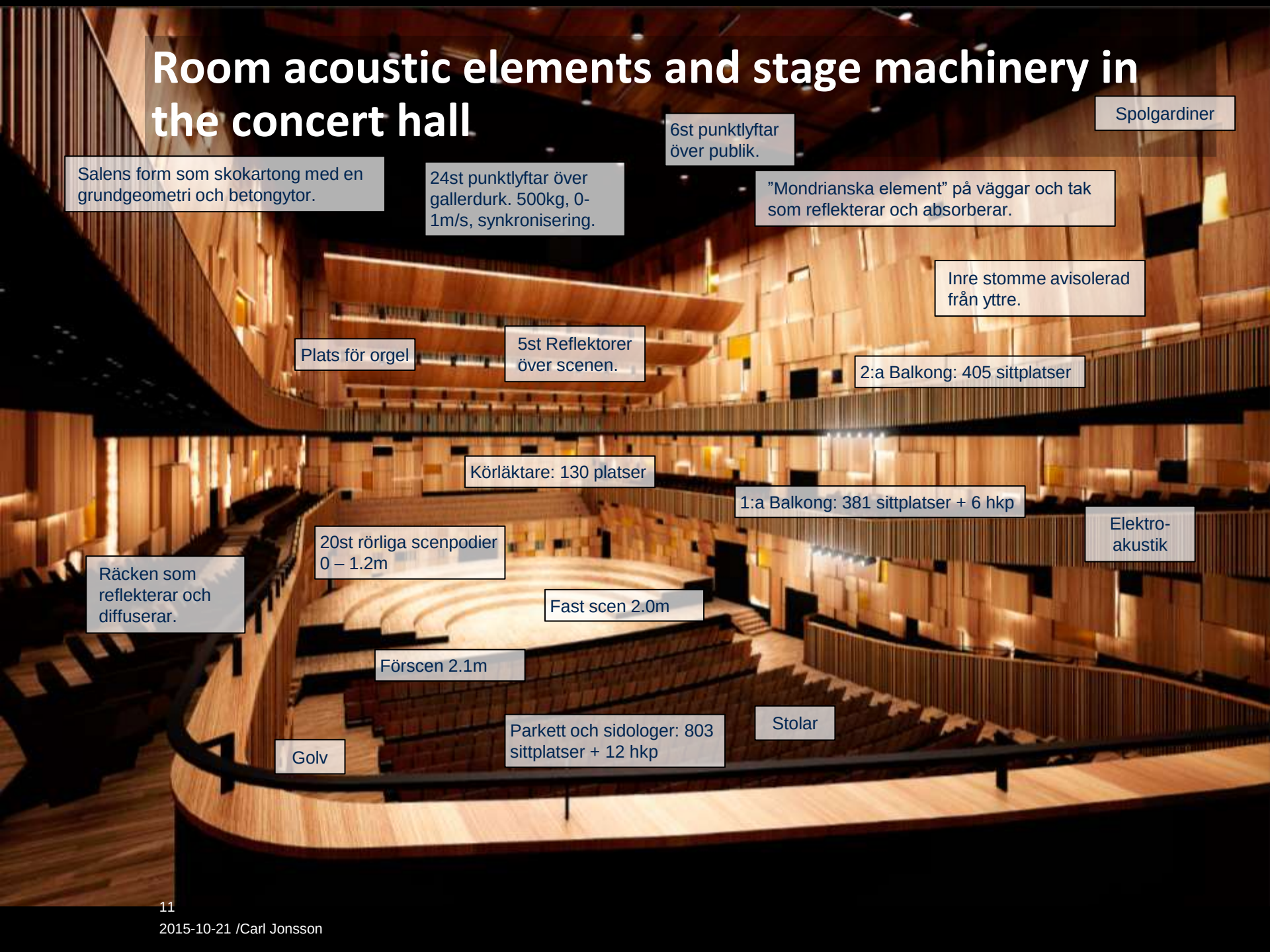
BUILDSMART
Energy efficient solutions ready for market

World class acoustics

Good sound is not just acoustics. It is also visual impression, comfort and climate!

Room acoustic elements and stage machinery in the concert hall

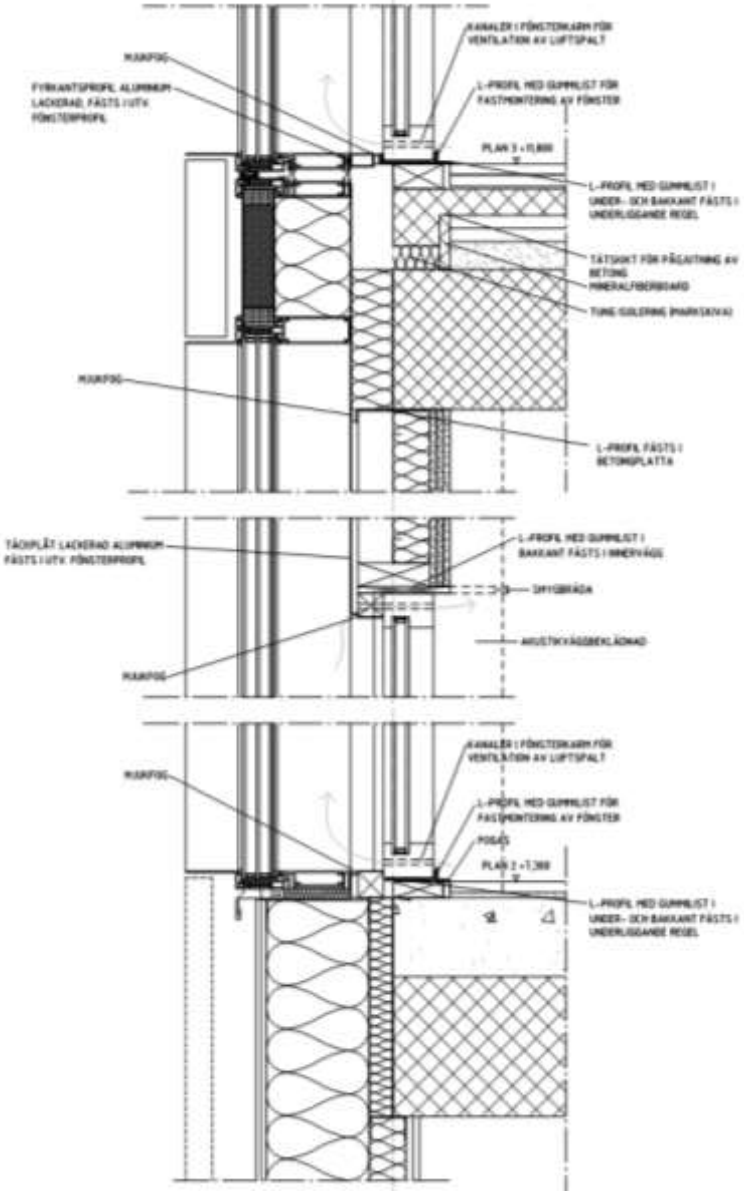
Room acoustic elements and stage machinery in the concert hall



Room acoustic elements and stage machinery in the concert hall

Noise insulation

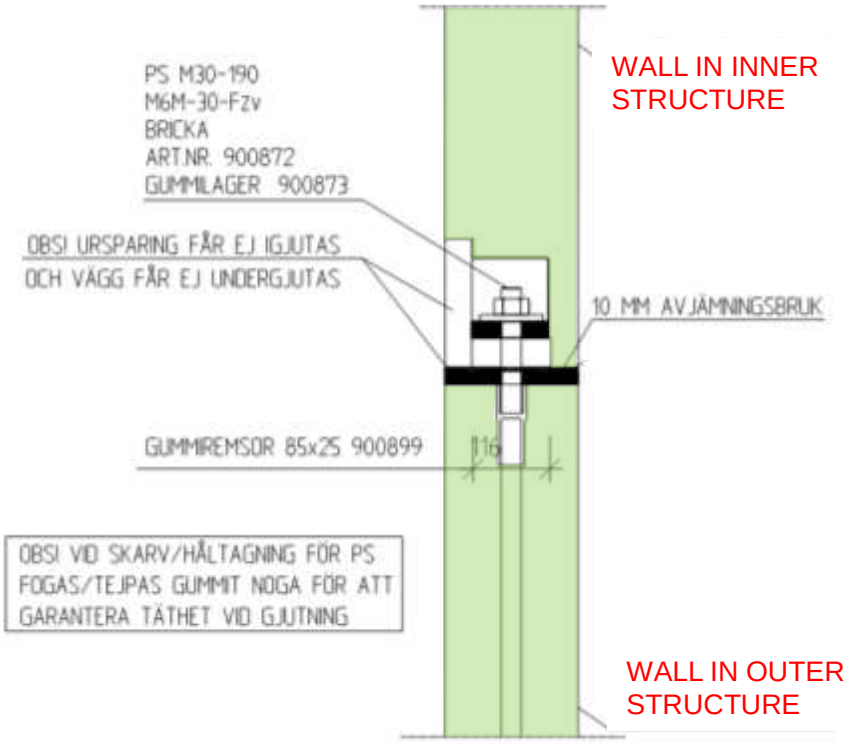
- Continuous monitoring

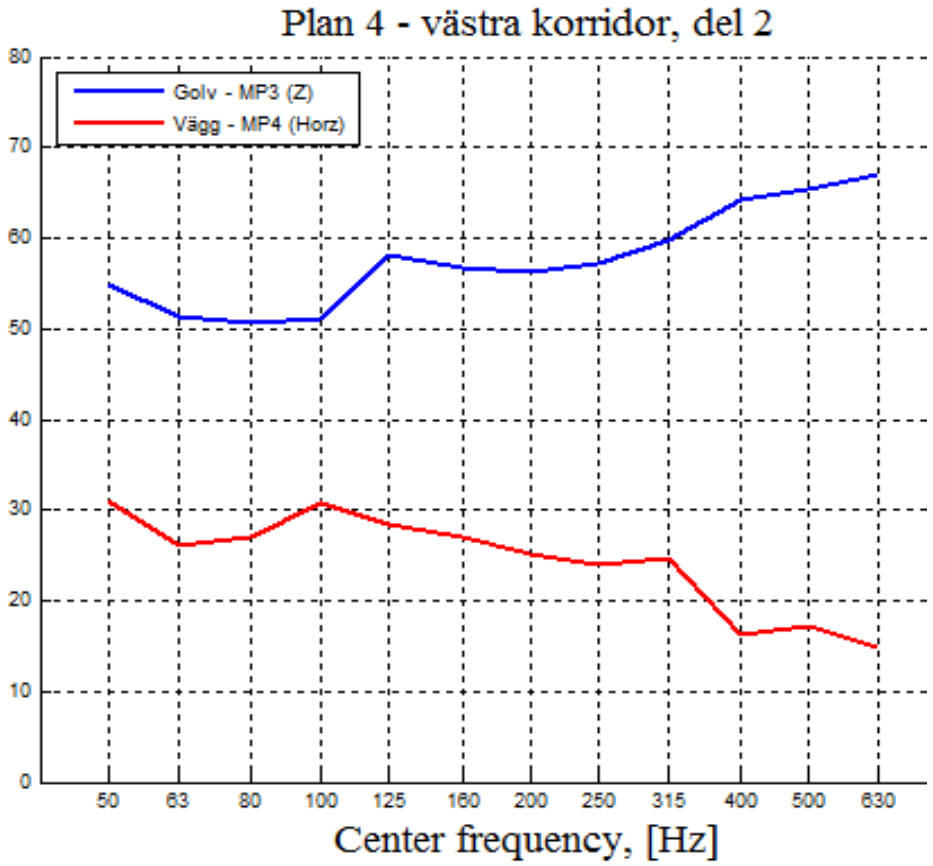


Outer structure

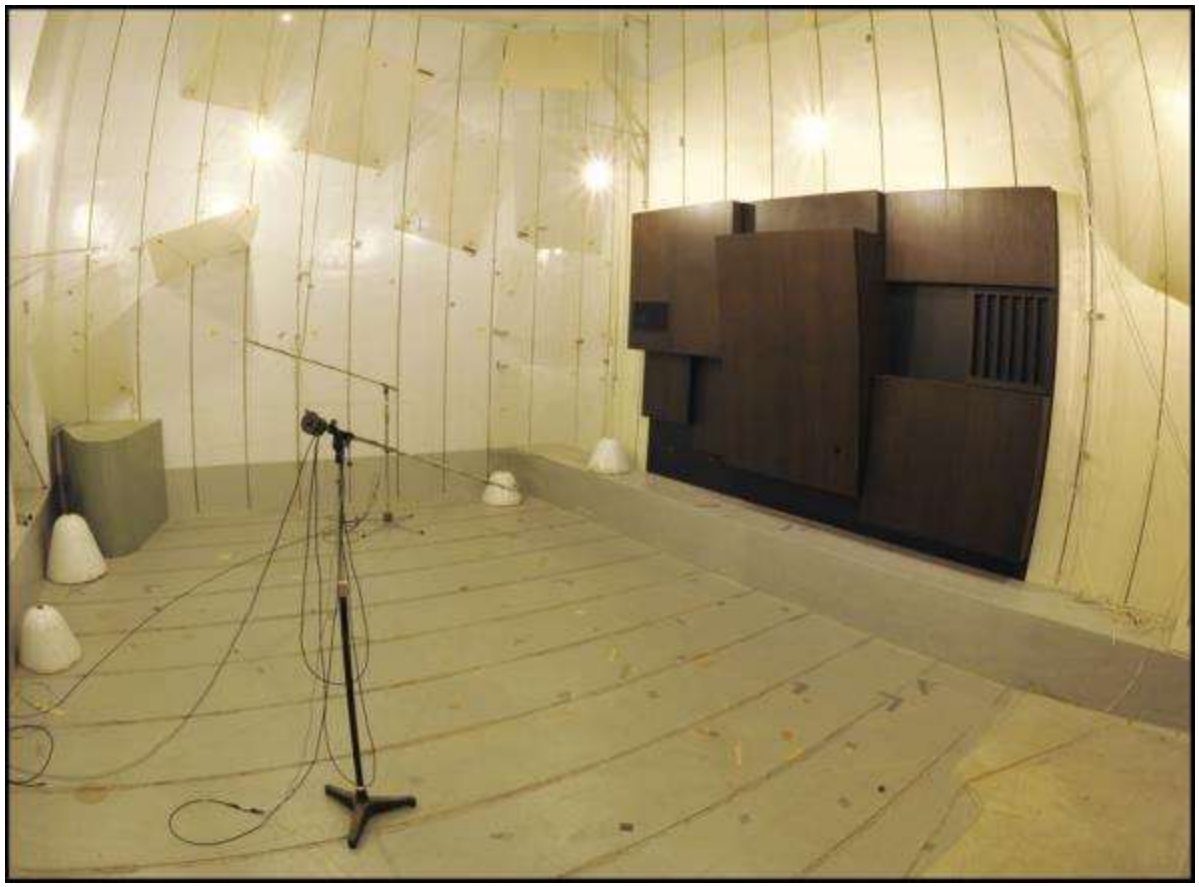
Inner structure

Structure borne noise to concert hall



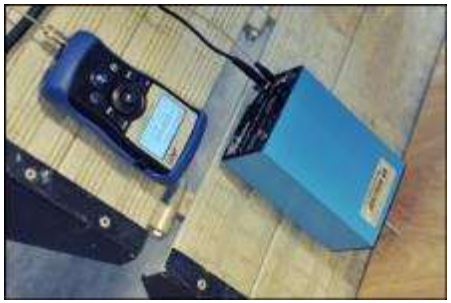


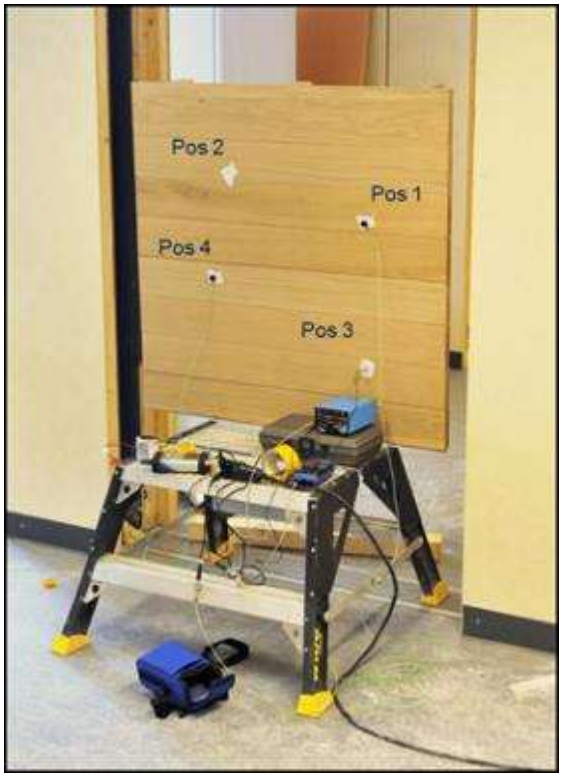
Mondrian elements and variable acoustics



Room acoustic elements

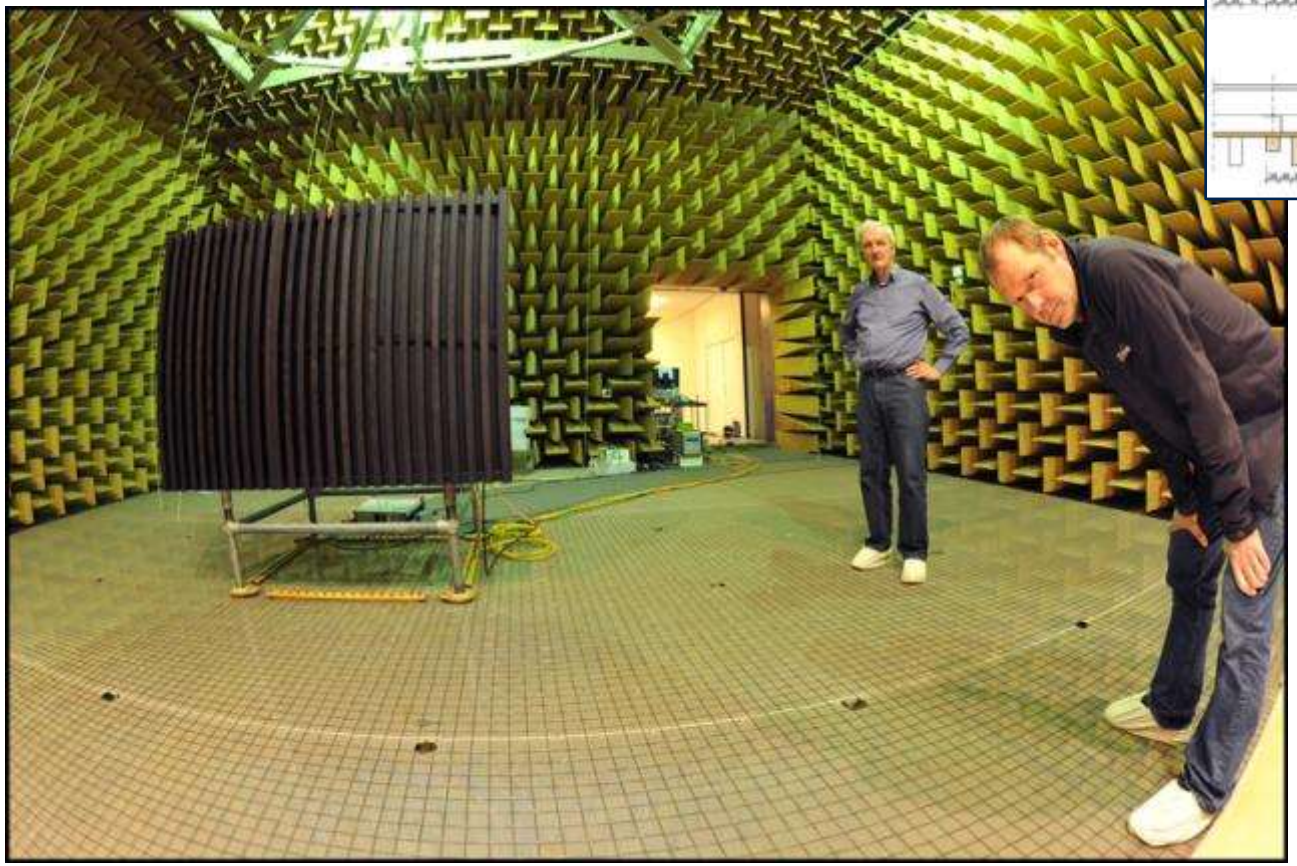
Cello test playing of two different floor structures.

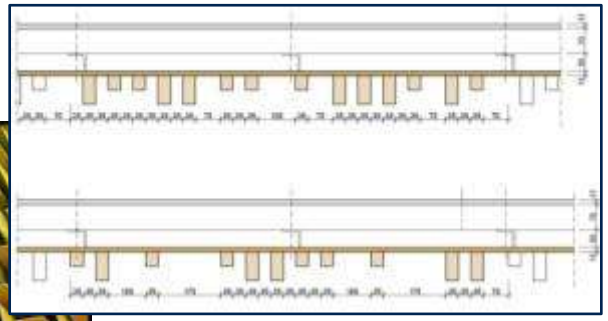


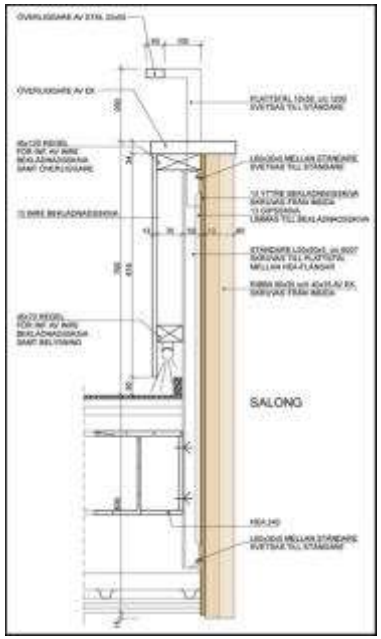


Measurements of response spectra.

Timbre measurements







Test of diffussion properties in Lyngby anechoic chamber (1000m^3)

Laser scanning of Vienna Grosser Musikvereinsaal

- The idea was to compare the ultimate shoebox design and to analyse certain characteristics.
- The acoustic space of Malmö Live is very similar.
- The timbre in Musikverein is exceptionally full and builds up from a high density of evenly spread reflexes.

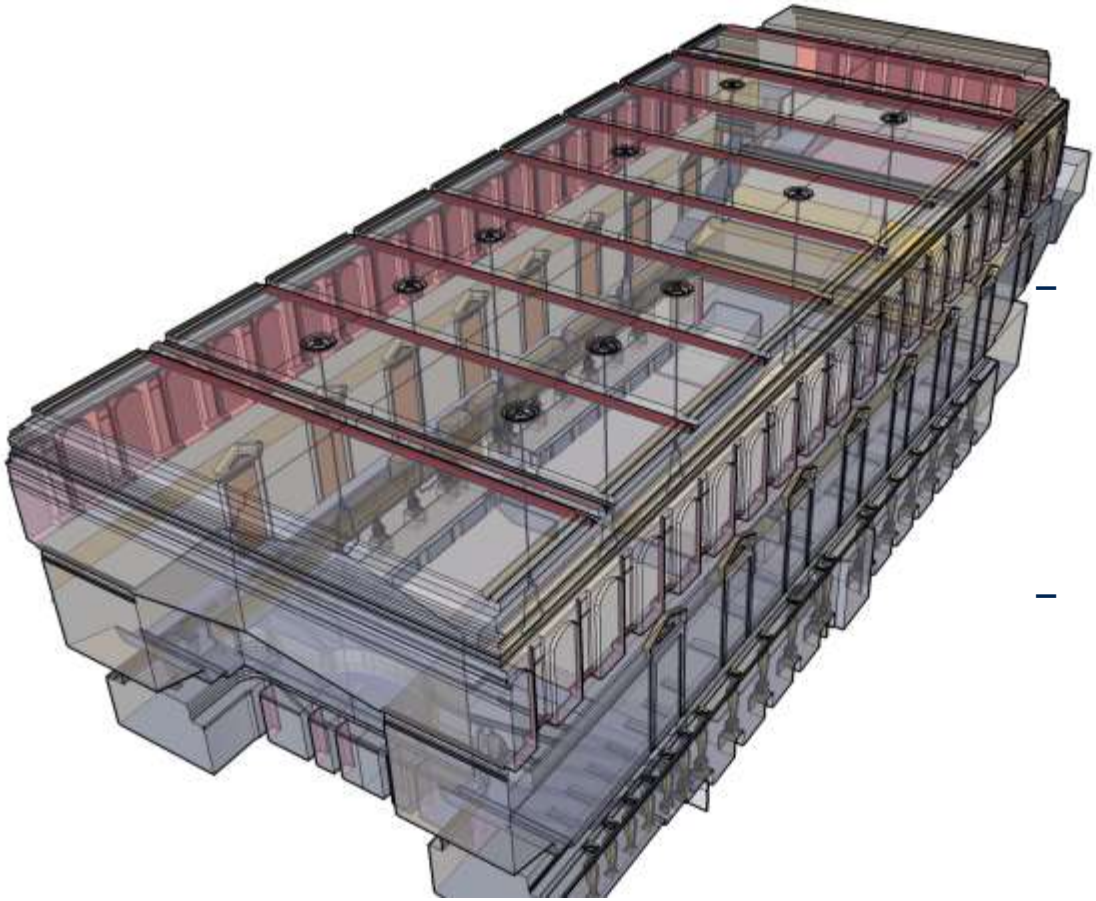
Laser scanning of Vienna Grosser Musikvereinsaal

- The timbre is mainly due to the shape of the hall and to the well balanced diffussion.
- Some views from the 3D scan:



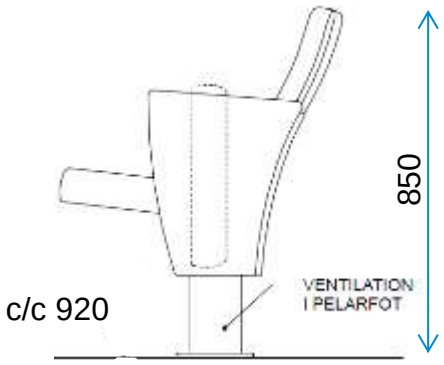

Laser scanning of Vienna Grosser Musikvereinsaal

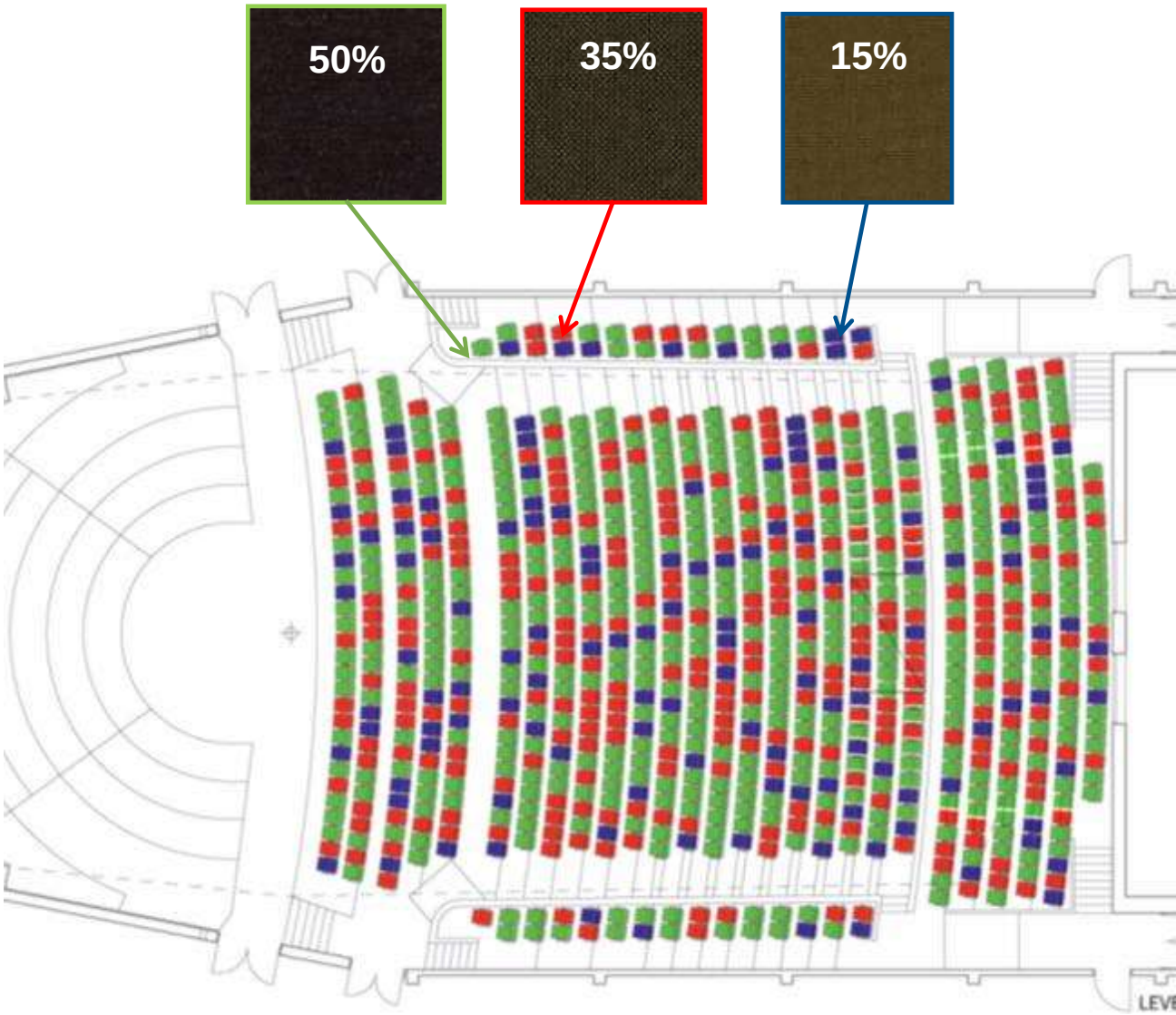
- Both Odeon and CATT models have been created based on the scanning:



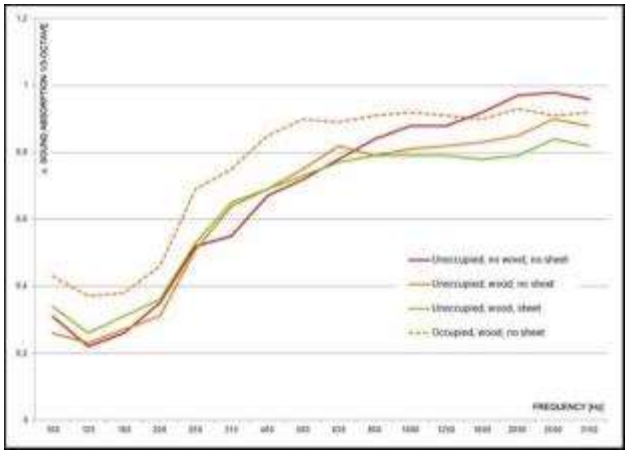
- The model was used to create simulations which could be compared and calibrated to the measurements made in the hall.
- The conclusions could be used as basis for the KKH models.

Room acoustic elements

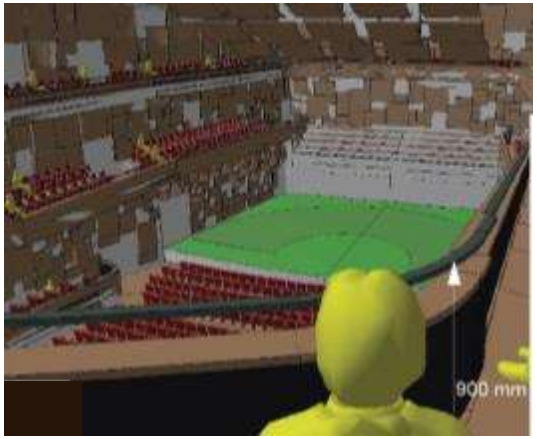


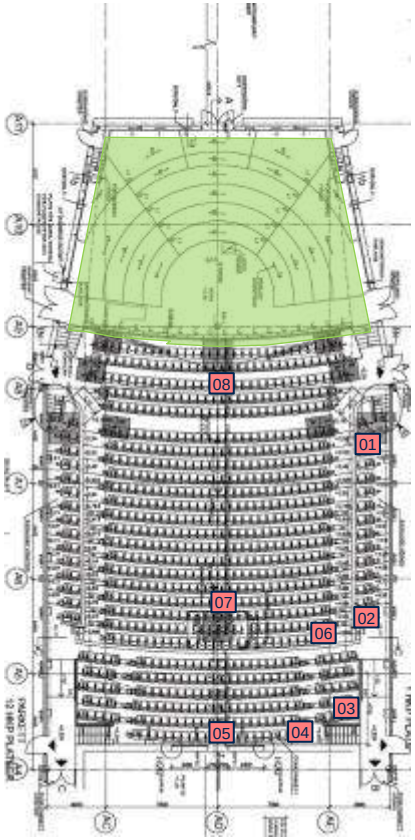


Room acoustic elements



Line of sight





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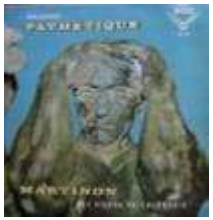
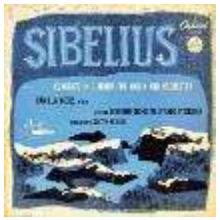
Try-out!



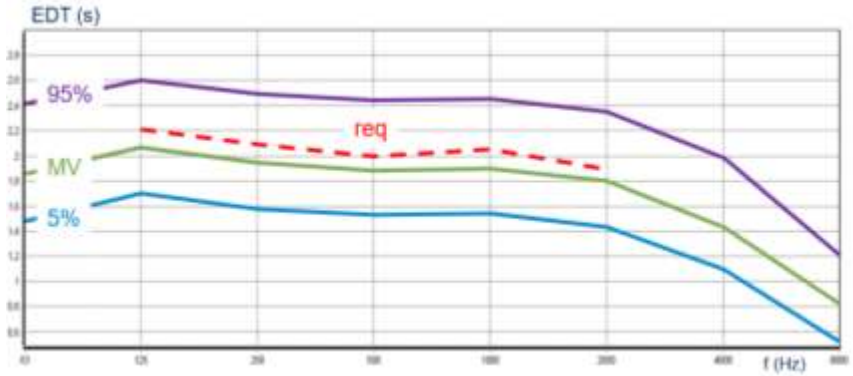


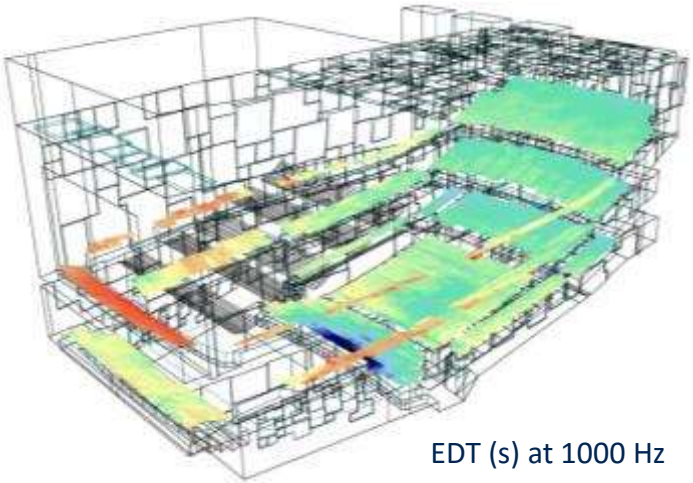
30 Mar – 2 Apr 2015

Concert Hall reverberation T30

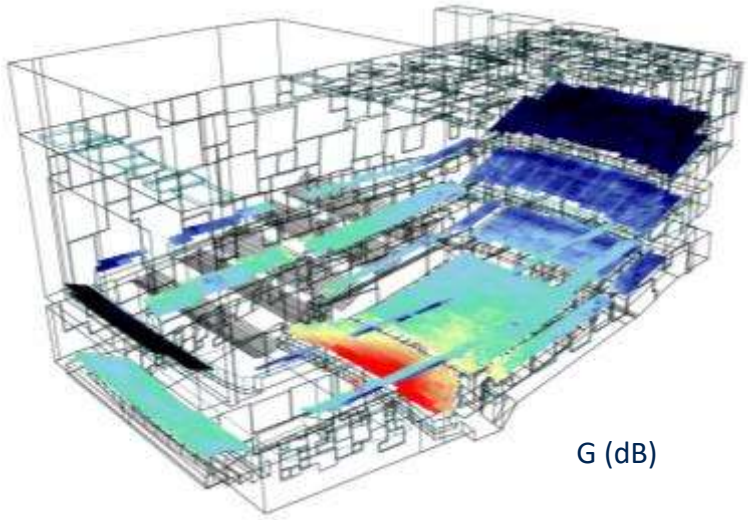
Eveness in the hall – tolerances

90% of the seats deviate less than 0.5 sec from the requirements.





EDT (s) at 1000 Hz



G (dB)

Congress Hall

Congress Hall

Telferbalkar i tak

Nedpendlat perforerat gipsundertak i hela salen, med ovanliggande 100mm absorbent (50mm vid begränsat utrymme).

Gradäng med 490 fasta stolar

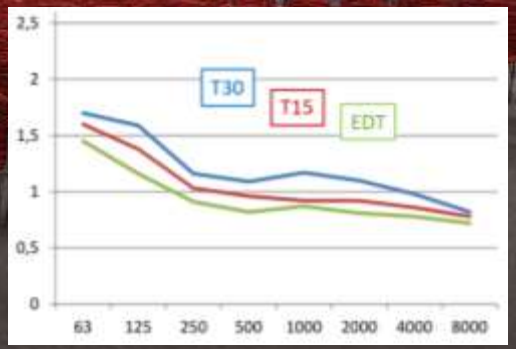
Sidoväggarna GLS med mix av 38x28 + 38x34 + 38x44 c/c100. Del av ytan förses med absorbent bakom ribbor.

Balkongräcke och sidoväggar GLS med mix av 38x28 + 38x34 + 38x44 c/c100. Absorbent bakom ribbor.

Blockväggar

Plats för 1.000 lösa stolar

Sidoväggar vid podie förses med 12 mm board på 45 reglar. 45 mm mineralull i mellanrummet.



Textilmatta

Multipurpose hall

Multipurpose hall

360m2
Spolgardiner

Traversbanor med
plats för 15st telfrar.

Galleri för montering
av ljus, högtalare,
kulisser mm.

Väggar med variant av
mondrianska element

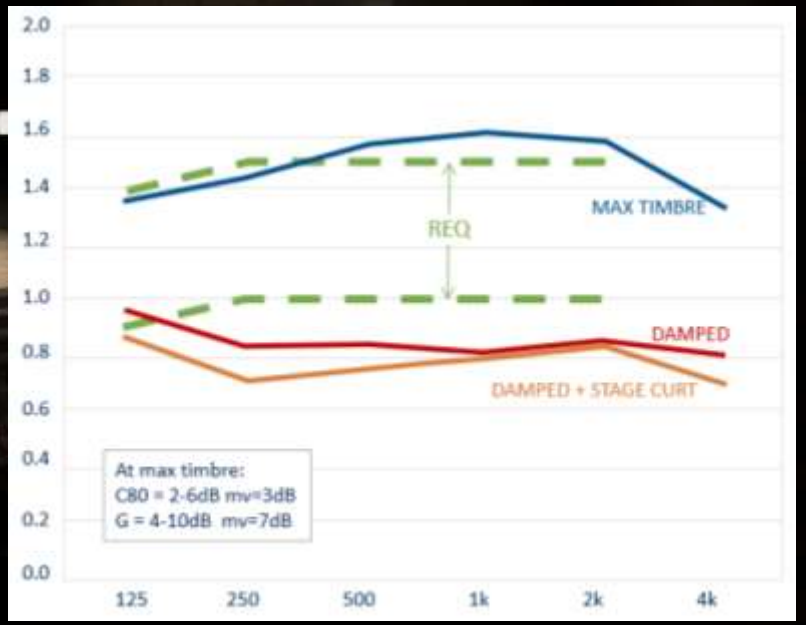
42st flyttbara podier
2.0x1.0x0.4 m

Mobila reflektorer

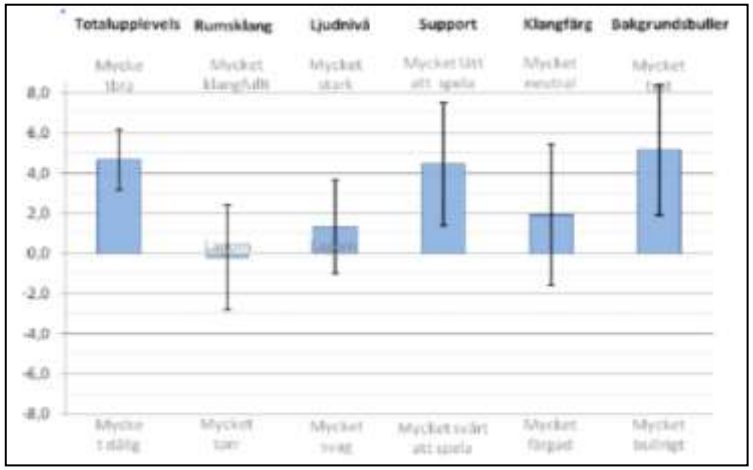
Avisolerat
parkettgolv

Plats för 150
lösa stolar

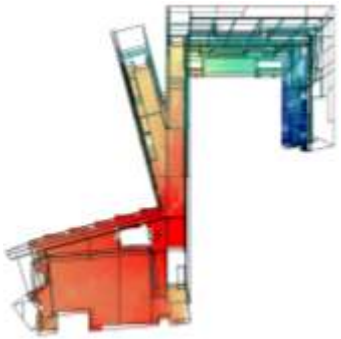
Mobil teleskopläktare
för 200 pers

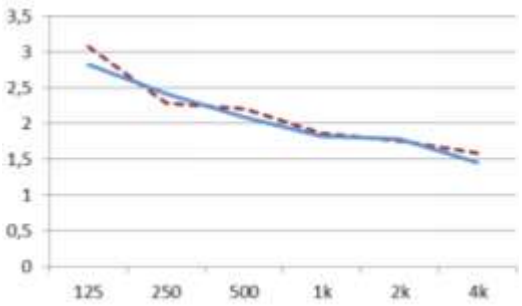


Rehearsal rooms and studios



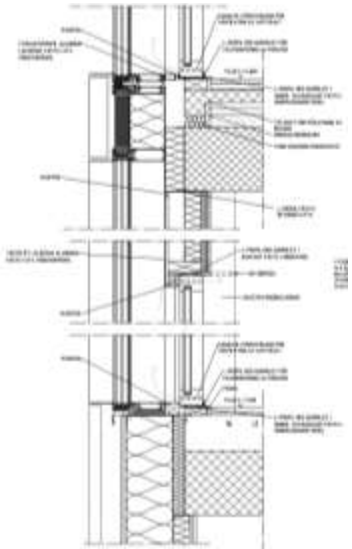
Common area





Common area – ”Kasseväggar”

Structure borne noise

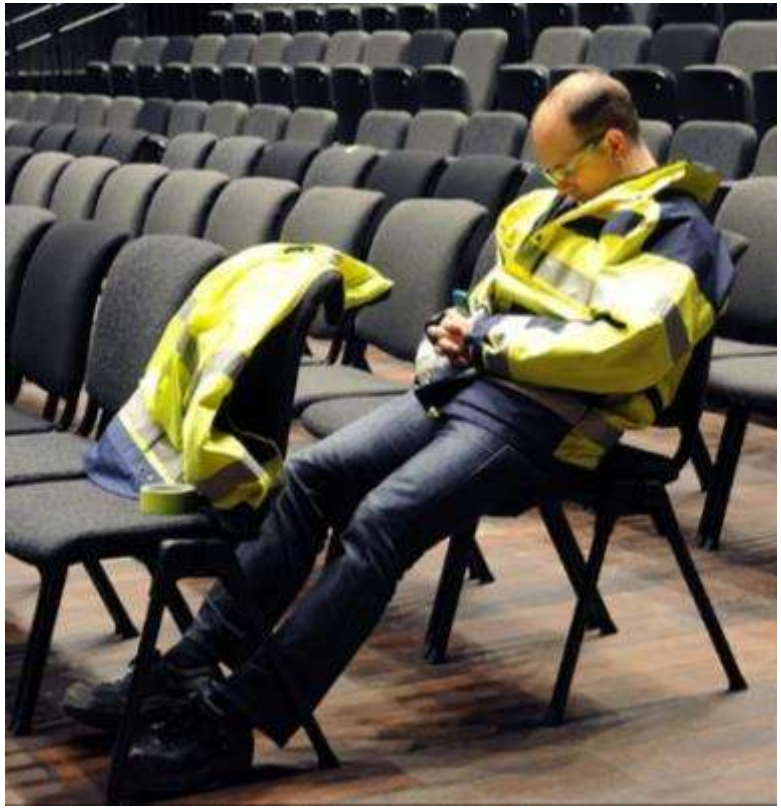


Up to 75dB reduction in floors and walls.

Noise from services

Max 10dB noise at 1000Hz
in the concert hall.

Summary



Reverberation:

Concert Hall = 2.1 sec
Multipurpose Hall = 1.5 sec
Congress Hall = 1.1 sec

High level of diffusion and somewhat longer reverb in the bass to achieve warm timbre.

Can be damped in concert and multi with 0.5 sec.

2 The Structure

- Excavation, sheet piling, water, City tunnel, temporary structures
- In-situ raft slab and basement perimeter wall
- Prefabricated steel-concrete superstructure
- Steel roof trusses
- Bays for concert and congress
- Joints and decoupling
- Quay
- Secondary structures
- Façade
- Stage machinery

Superstructure sequence

Logistics

Hotel and facade sequence

Congress and Multi-hall sequence

Concert Hall sequence

- Design, planning & procurement.
- Manufacturing.
- Work force.
- Cranes.
- Assembly stability.
- Tight building.

Hotel

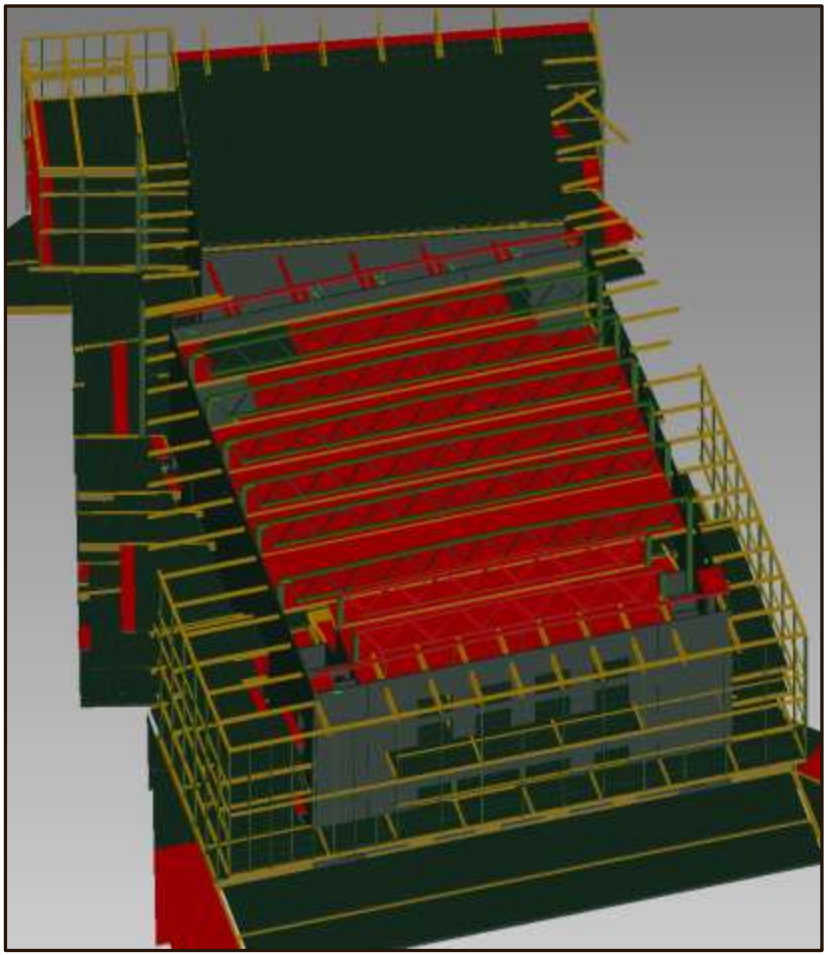
- Every second room partition loadbearing shear walls.
- Steel beam-column facade structure.
- Combination of HCS and massive floors.
- Transfer structure in 3rd floor.

2013-09-11

Pods

- 4000 EUR
- 2 M€

Congress



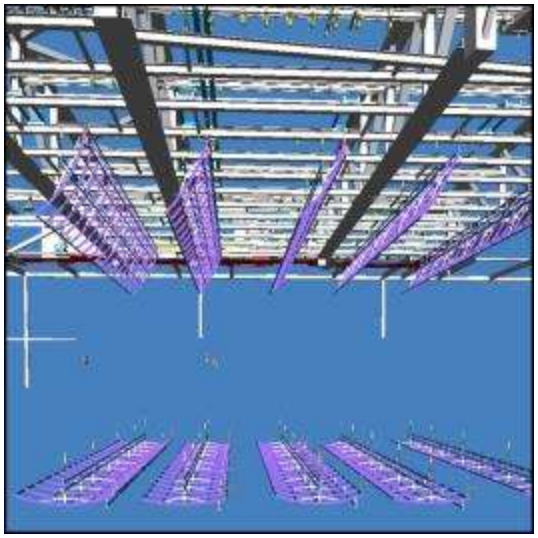
- Inner box with concrete walls and columns.
- Steel beam-column facade structure.
- Combination of HCS and massive floors.
- 36m steel roof trusses.
- Suspended 500 pers seating.
- Bay steel structure.

2013-09-11

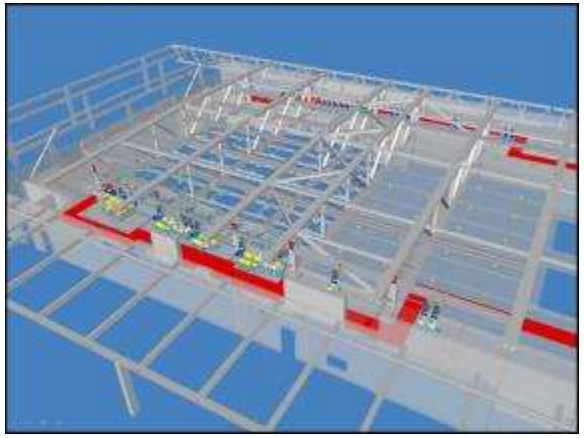
Concert Hall

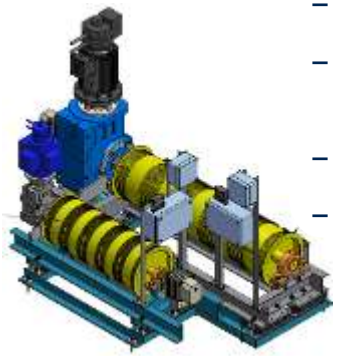
- Inner box with concrete walls and columns.
- Isolated from outer structure.
- Steel beam-column structure.
- Combination of HCS and massive floors.
- 30m steel roof trusses.
- Bay steel structure.

Point Hoists & Reflectors

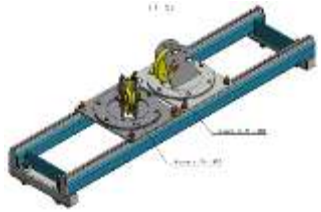


- 26 point hoists above grid, 6 above audience.
- 500 kg/each, 0 – 1 m/s.
- Pulleys and bridges for full flexibility above stage.
- 4 point hoists for FoH.



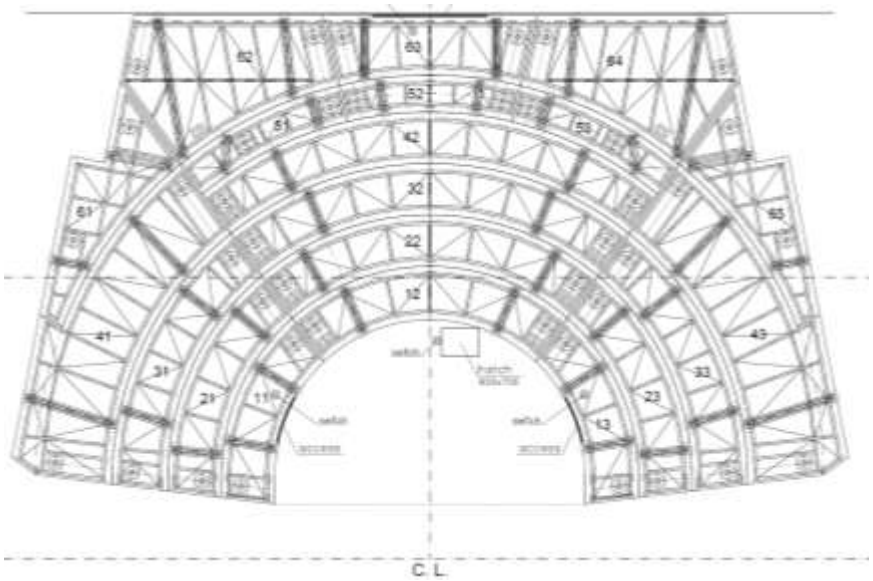


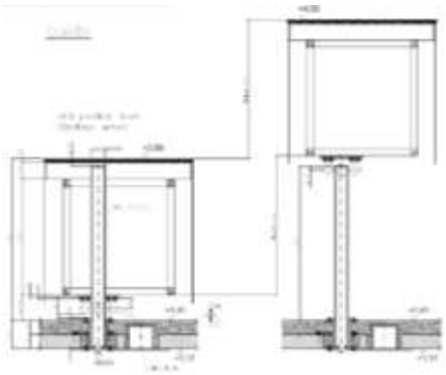
- Total 160 sqm reflector surface.
- Motor control for vertical and rotational movement, 0 – 0.3m/s.
- 5 preset positions , 0 – 19m.
- Integrated podium lighting.



Stage podiums

- 20 stage podiums 0 – 1.20m.
- 500 kg/sqm alt. 2x1 tons.
  In princ 50% in oper.
- 0 – 4 cm/s.
- 10 outlet boxes.

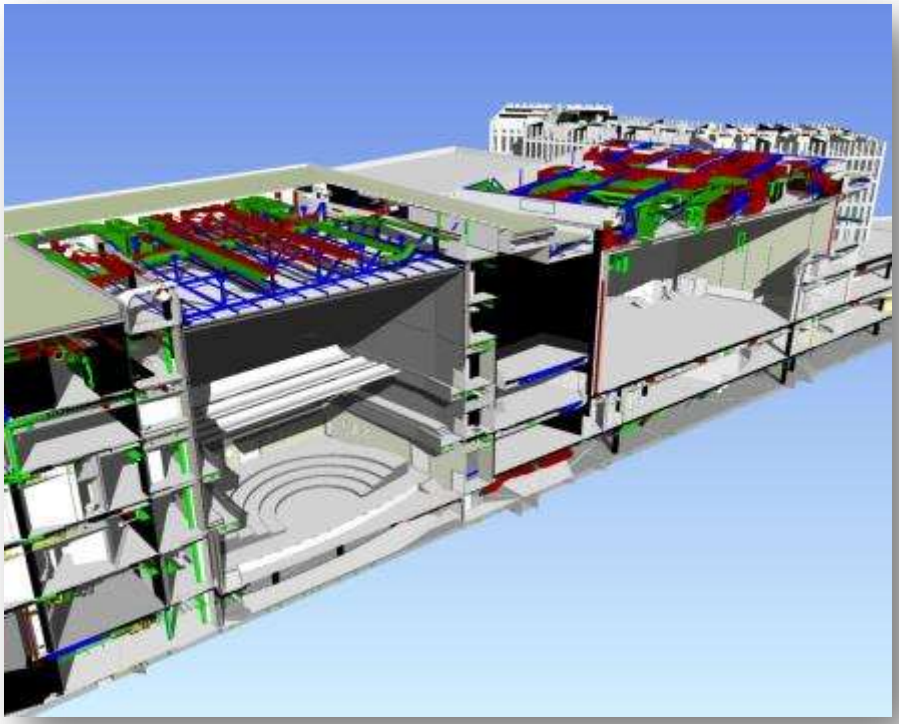


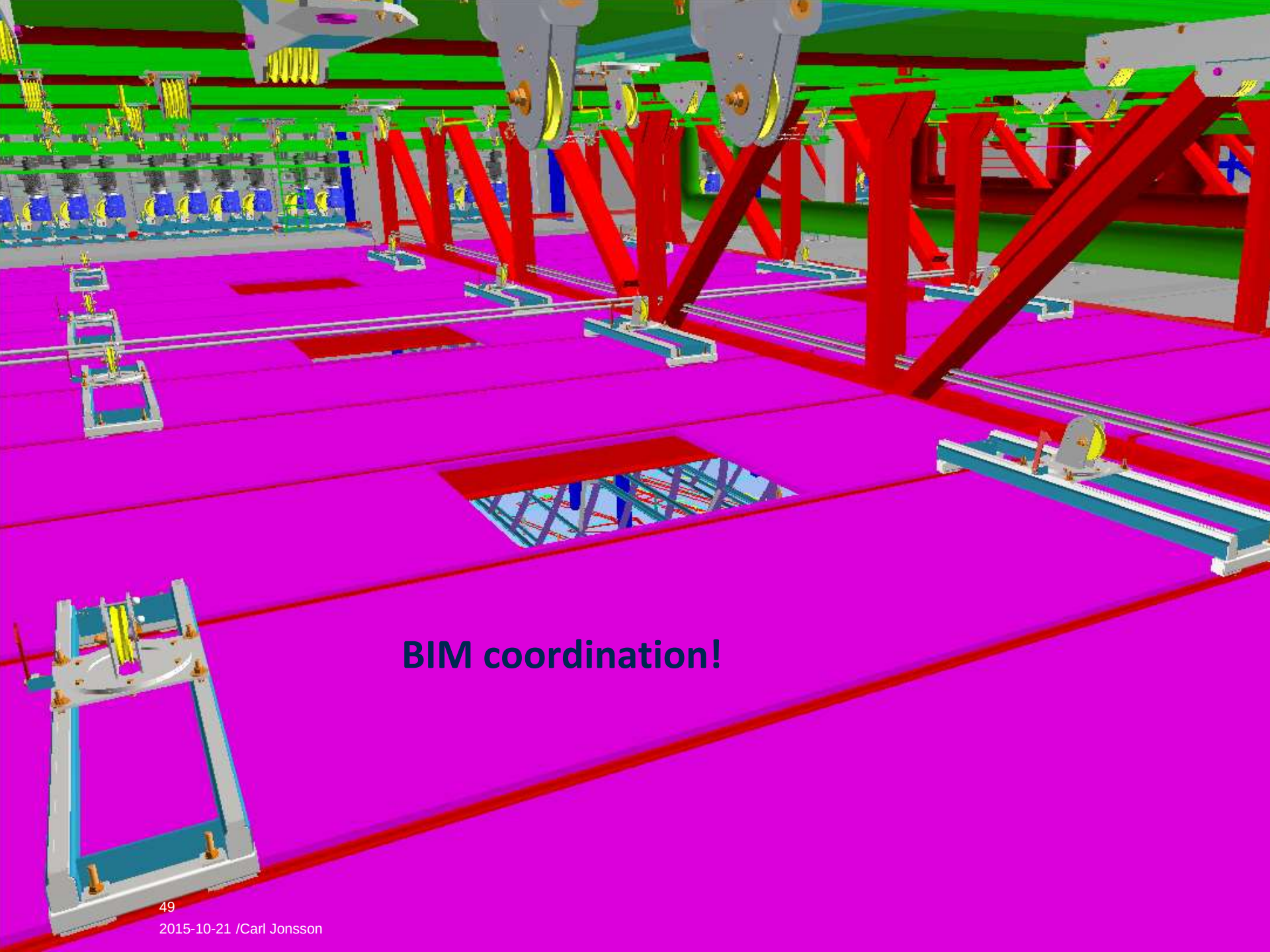


Challenges in the superstructure

- HCS, tolerances and setting out.
- Common areas, facades, railings – prep for completions.
- HCS surfaces and screeds.
- Roof panels.
- Water in HSQ.
- Tendons in hotel.
- Load transferring floors hotel.
- Sven.

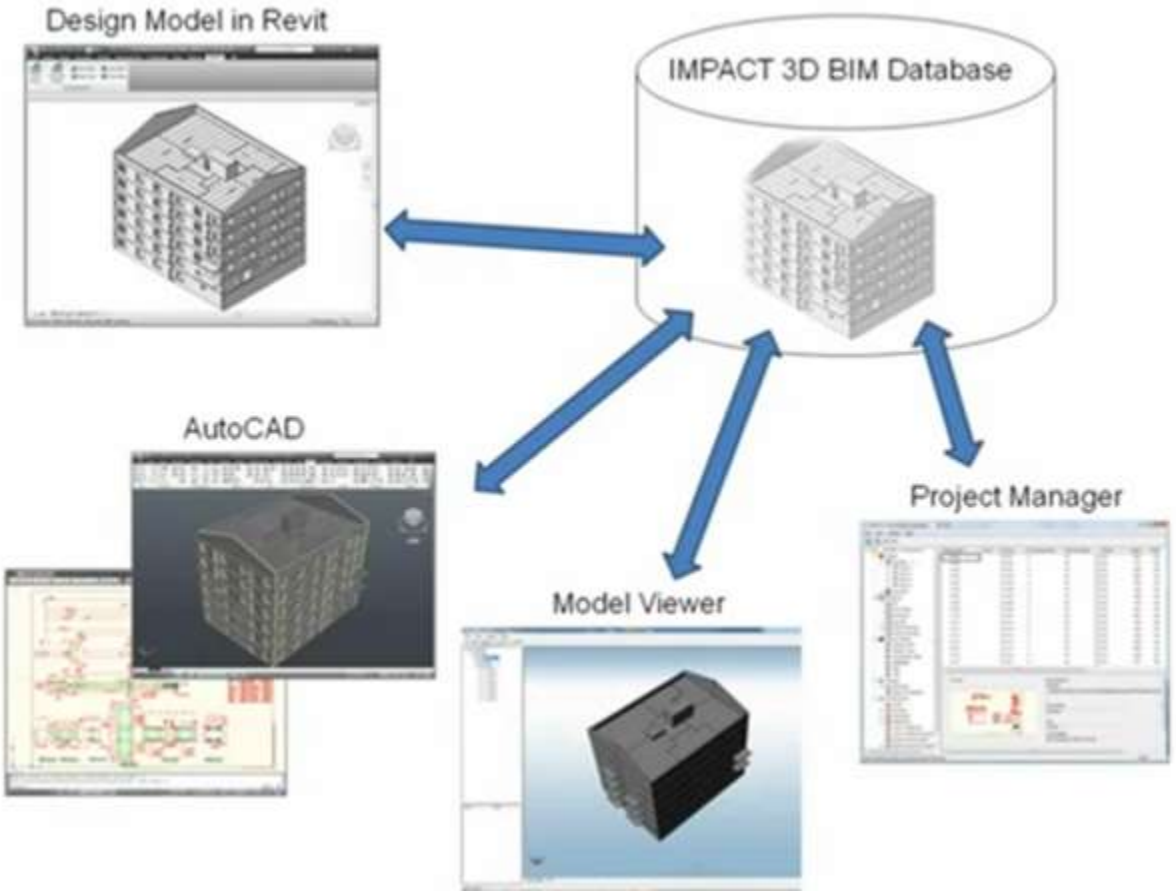
3 BIM



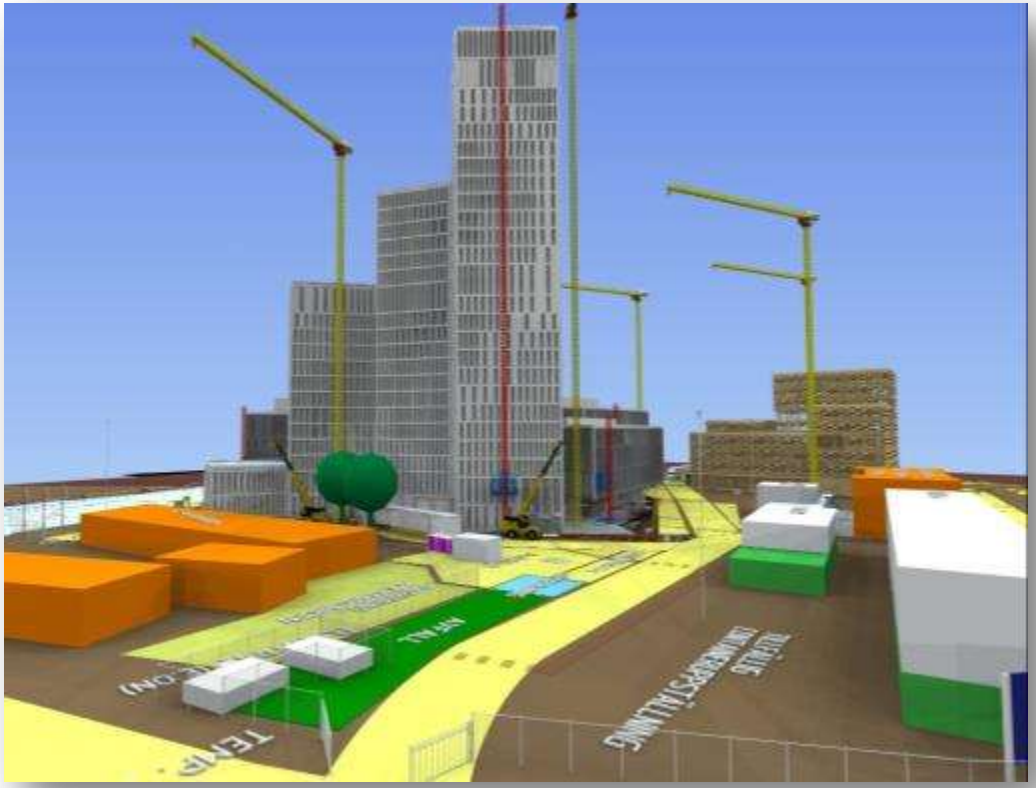

BIM coordination!

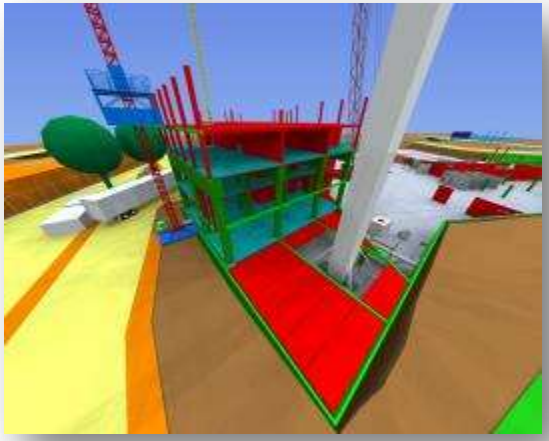
Structural model

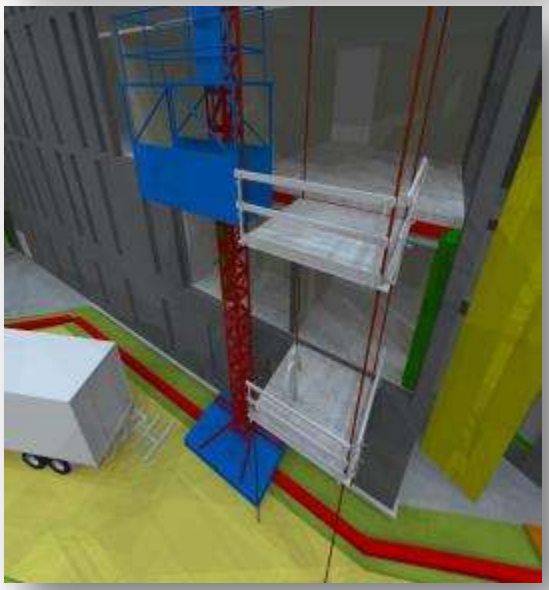
- Workflow for using the design model from Revit to create shop drawings in Impact Precast



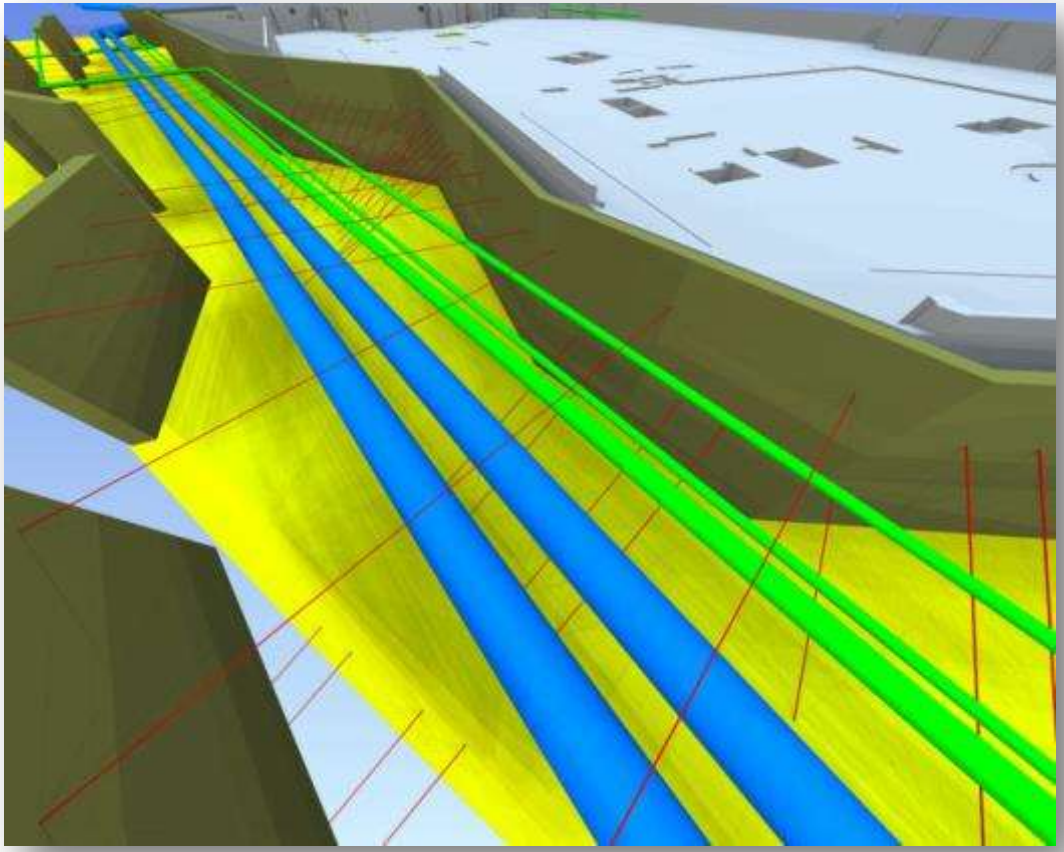
Production site planning

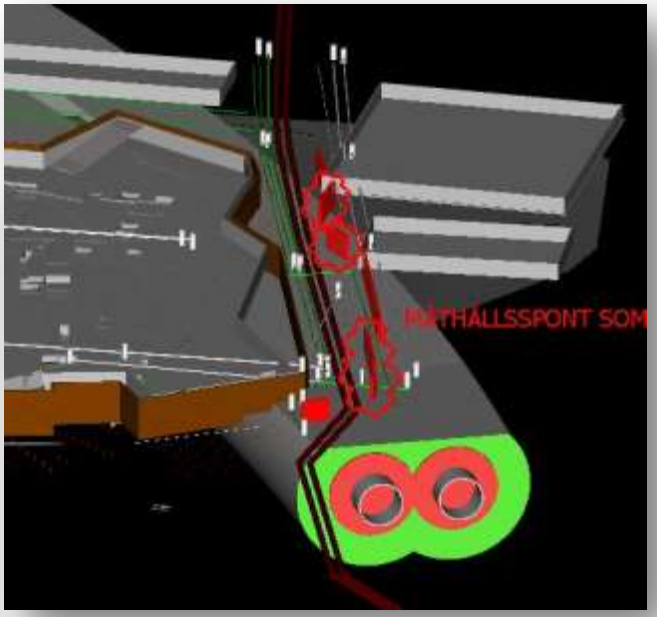


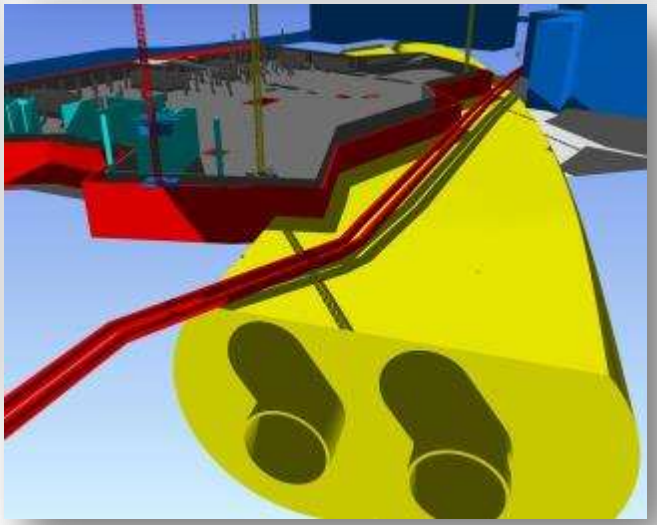




Production site planning

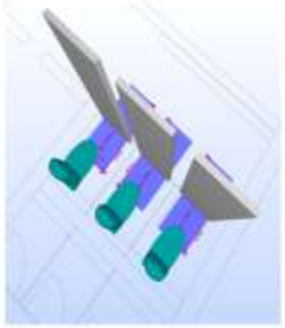


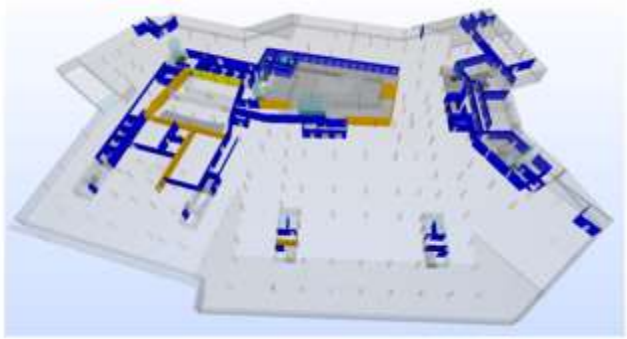


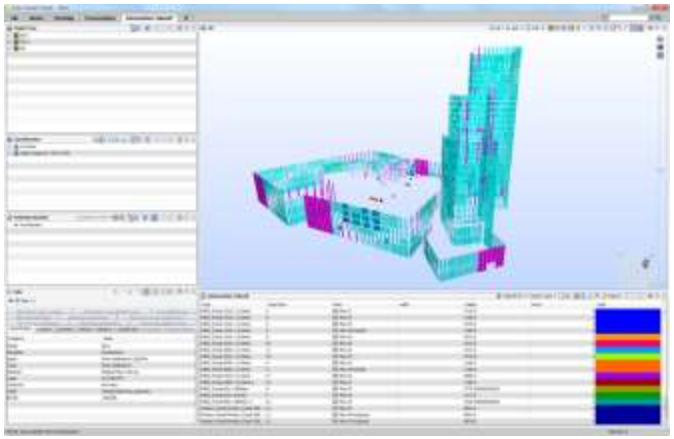


Information takeoff

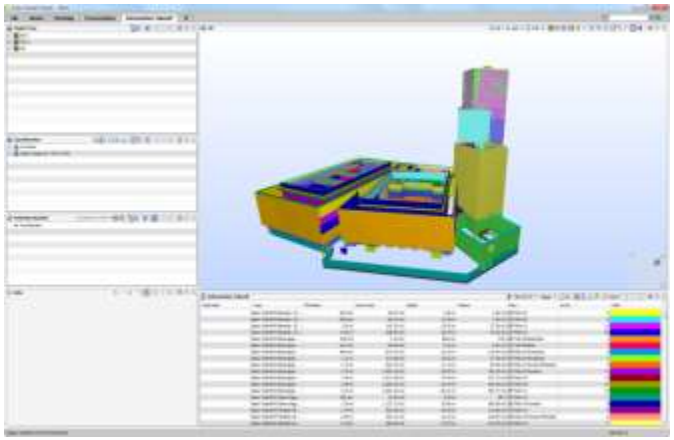
Basic Wall:IV12	R'w 60dB	1
Basic Wall:IV30	R'w - dB	1
Basic Wall:IV32	R'w 35dB	1
Basic Wall:IV33	R'w 35dB	4
Basic Wall:IV50	R'w 40dB	86
Basic Wall:IV51	R'w 40dB	40
Basic Wall:IV52	R'w 52dB	4
Basic Wall:IV53	R'w 52dB	6

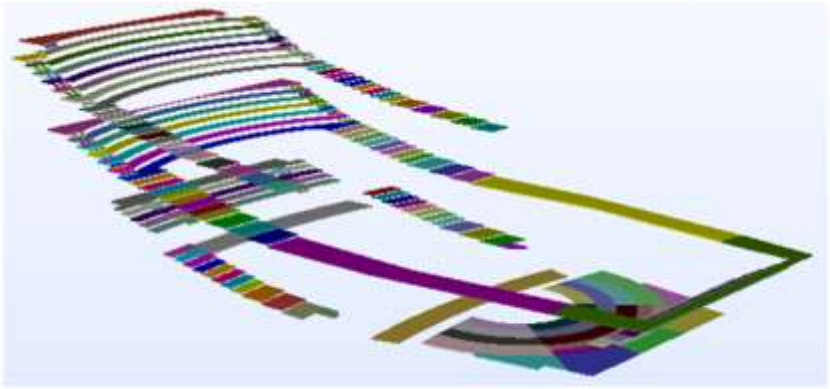






Name	Area	BAT ID	Color
Lättgolv, Koncert-: 1008327	48,64	1008327	
Lättgolv, Koncert-: 1064884	2,52	1064884	
Lättgolv, Koncert-: 1064893	2,5	1064893	
Lättgolv, Koncert-: 1064900	2,48	1064900	
Lättgolv, Koncert-: 1064907	2,47	1064907	

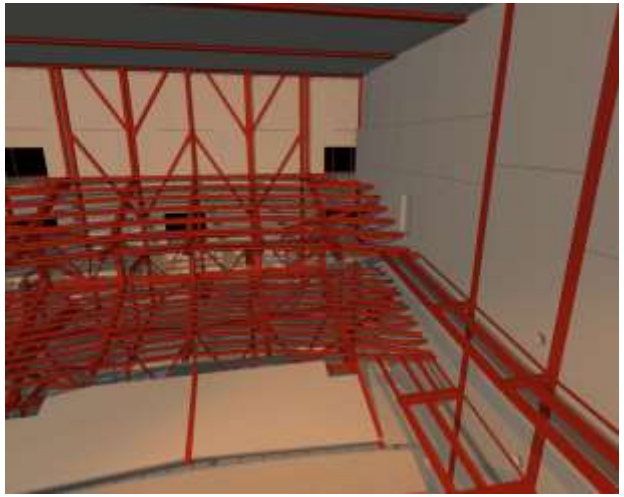




Mobile IT Tools

Challenges in BIM

- Coordinate systems.
- Process for model detailing; vertical or horizontal or?
- Arch model with integrated structural model.
- Combined structural models still a major problem for coordination.
- 11 structural 3D-models in total, in progress at the same time, and made in 4 different softwares.
- It is not easy to instruct the architect how to build the model in order to use it for sequence studies later on, i.e. to import time schedule.

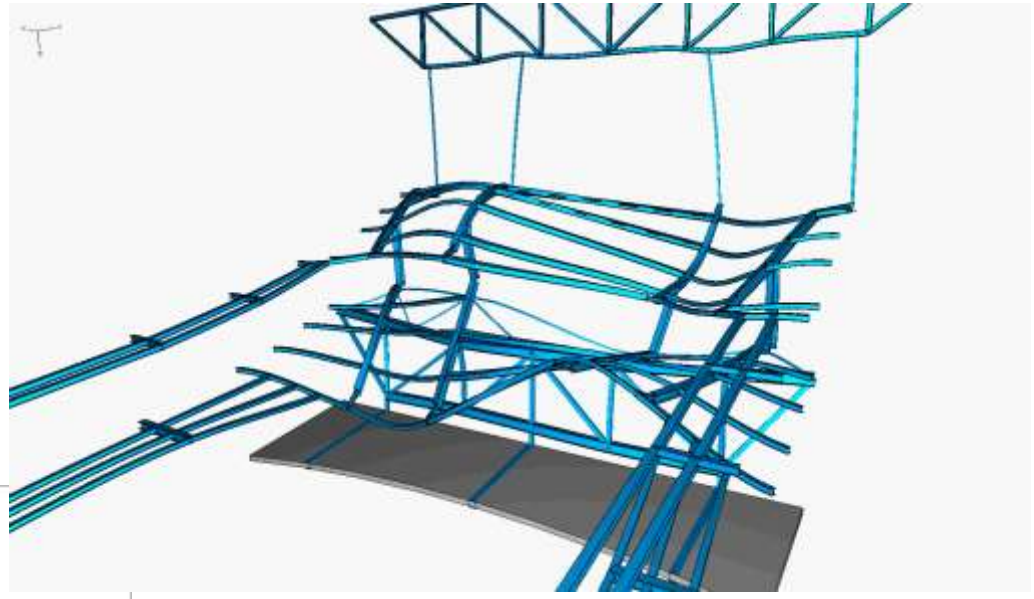


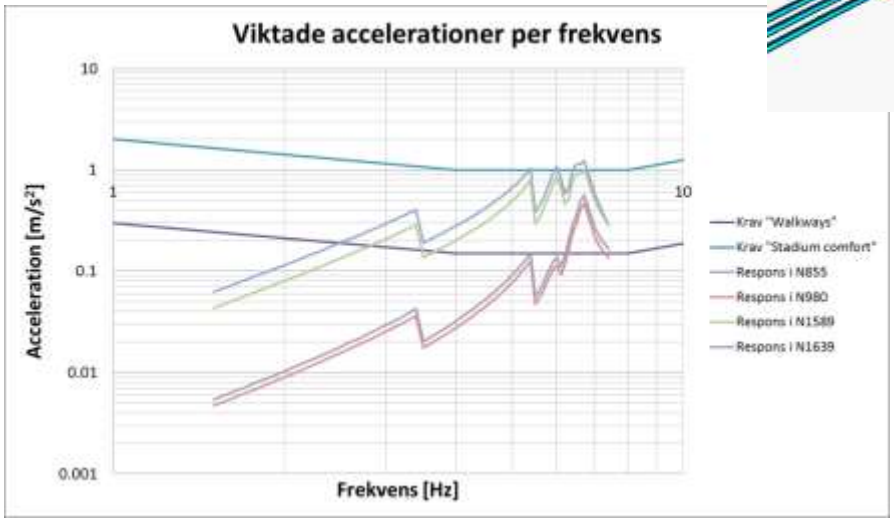
4 Structural Design

- Split up in physical and competence areas.
- Skanska Teknik, Prekon, Sweco, Ramböll, WSP, Byggkonstruktörerna, Skanska CZ, Novoscen, TTS.
- Design-To-Cost setup.

Comfort and jumping audience

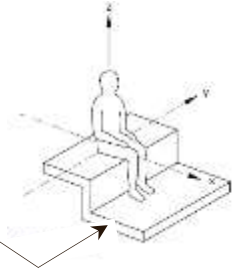
- A series of structures subject to vibration requirements which where decisive for the design.
- E.g. suspended structure in the congress hall was essentially reinforced to achieve acceptable accelerations.





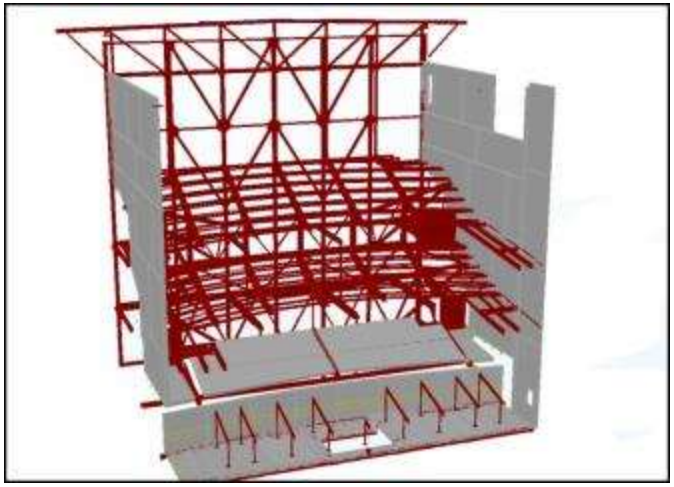
SS-ISO 10137:2008

$$F_v(t) = Q\left(1 + \sum_{n=1}^{k} \alpha_{n,V} \sin\left(2\pi n f t + \phi_{n,V}\right)\right)$$



Comfort and jumping audience

- Numerical and experimental analysis of 1st and 2nd balcony in concert hall.
- Test by 4x10 jumping persons in 10 sequences.

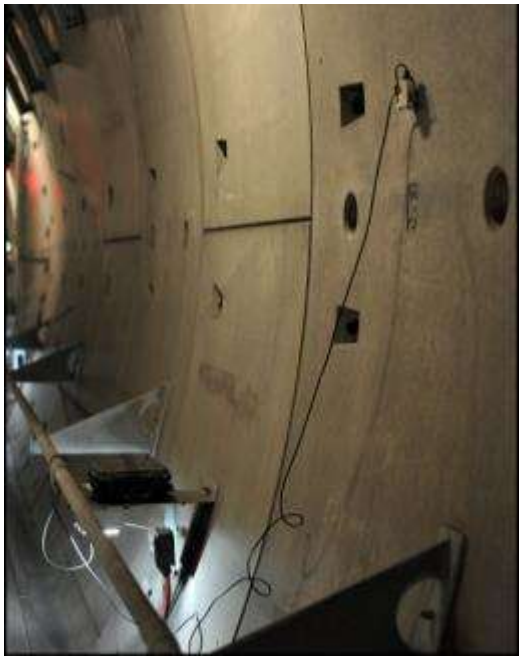


Disturbances from the city tunnel. Monitoring of vibrations

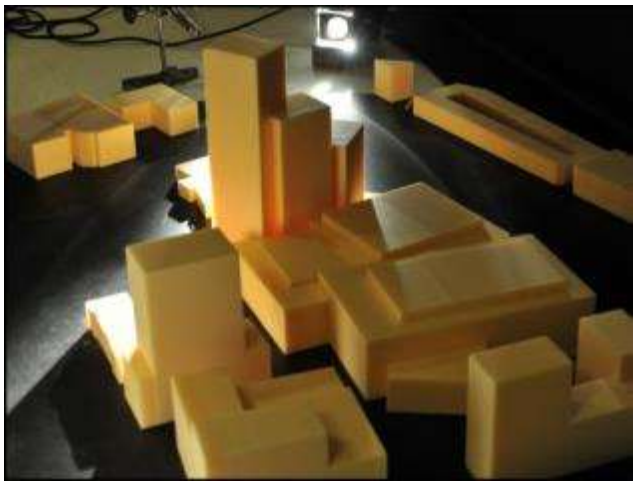
Four vibration meters in the tunnel. Alarm level 3mm/s.

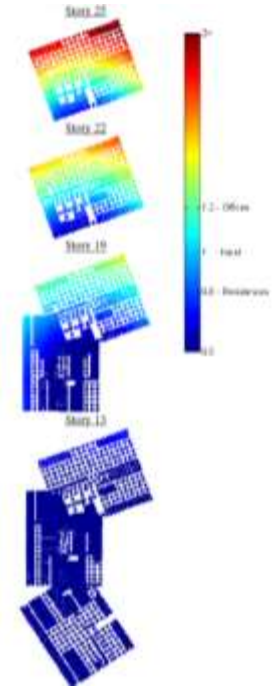
Three meters on the church. Alarm level 2mm/s

One meter on the Västra Station. Alarm level 3,5mm/s.



Wind induced vibrations





- Foam model and gauge placed on rotatable disc in one end of the 20m long tunnel.
- A 1.6m diameter fan creates the wind pressure in the other end of the tunnel.

Challenges in structural design

- To prepare idealised models.
- To establish, agree and communicate requirements and performance.
- To handle history cases.
- To manage comfort criteria.
- To conduct vibration studies.

SKANSKA

http://www.euphonia-audioforum.se