

# Analyzing Building Acoustics and Vibrations

scripting researchers become OOPing developers

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**Research consultants**

**Level.Tools**

**June 20<sup>th</sup> 2017**

# Key Takeaways

1. OOP (initially) increases preparation time, but
2. OOP improves recyclability
3. OOP improves neatness
4. OOP improved our programming skills

# About us

Sven =

[Research.Consultant](#) with properties:

```
Year: 1978
Areas: {'FEM' 'Mechanics' 'Dynamics'}
Company: {'Level.Tools' 'Lentzeneering'}
Skills: {'Basic' 'Fortran' 'MATLAB' 'C#'}
Email: sven.lentzen@leveltools.nl
Previous: {'RWTH' 'TNO' 'Philips'}
```

Show [all properties](#)

Arnold =

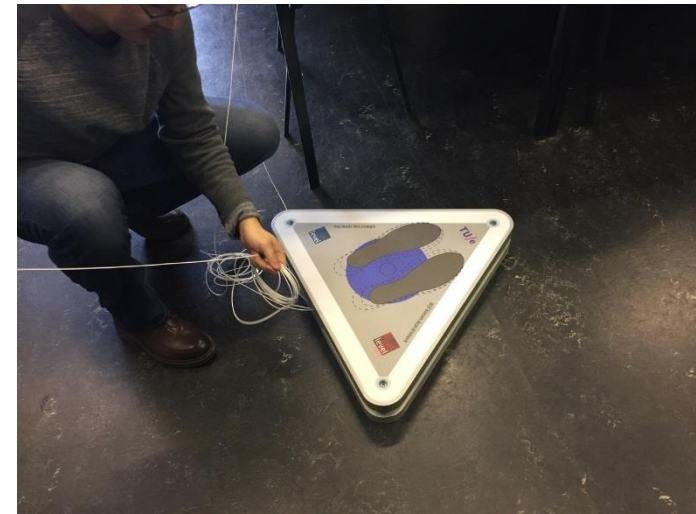
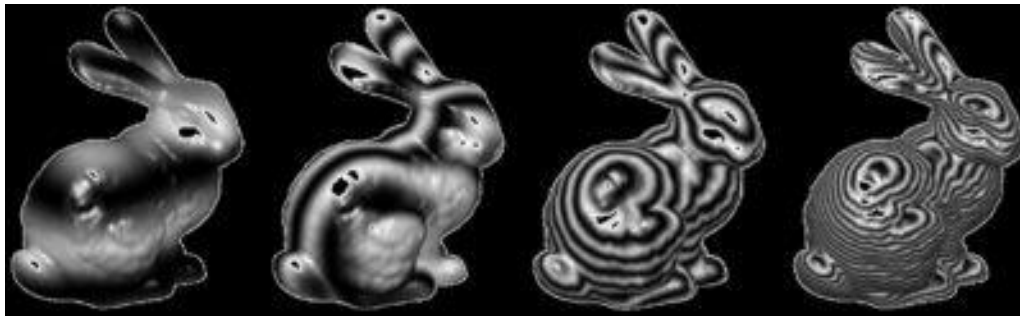
[Research.Consultant](#) with properties:

```
Year: 1967
Areas: {'Vibration' 'Acoustics' 'Policy'}
Company: {'Level.Tools' 'Koopman.com'}
Skills: {'Assembly' 'MATLAB' 'C++'}
Email: arnold.koopman@leveltools.nl
Previous: {'TNO' 'NS'}
```

Show [all properties](#)

# About Level.Tools

- part of Level Acoustics & Vibration B.V.
- based on TU/e campus
- spin-off from TU/e and TNO
- we are 4 people: us 2 plus 2 leading scientists in acoustics
- We aim to produce software tools and hardware tools
  - Lead users: engineers
  - End users: residents



# Timeline

La fenêtre



2005

lightweight  
junctions



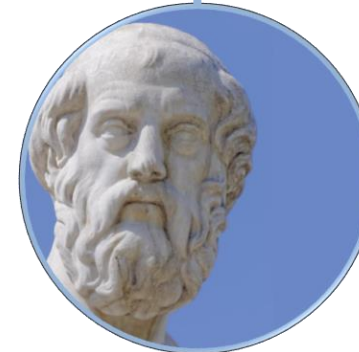
2007

Linea Nova



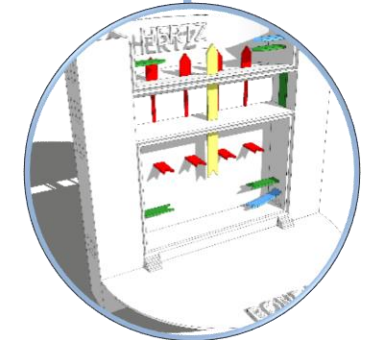
2009

SoViST.m



2013

Tivoli-Vredenburg



2015

- lightweight building
- sound isolation
- junction

- research project
- 7 years
- prediction of acoustics

- **vibration problem**
- included in research
- MATLAB/Comsol

- FEM/SEA are key prediction methods
- a tool to make that accessible

- **acoustics problem**
- avoided had SoViST existed in 2009

# Klassieke muziek komt in de knel

## Geluidstekken TivoliVredenburg probleem

**UTRECHT** | De geluidstekken van TivoliVredenburg nemen steeds grotere vormen aan. Vooral de programmering van klassieke muziek dreigt door de interne geluidstekken in de knel te komen.

PETER VAN DE VUSSE

Omdat ensembles en musici voor de kamermuziekzaal Hertz, waarin de dreunende housemuziek uit Ronda doorklinkt, ruim van tevoren moeten worden gecontracteerd, komt een gelijktijdig gebruik van de verschillende zalen in TivoliVredenburg vanaf het najaar in de knel.

Wethouder Victor Everhardt antwoordt dit op schriftelijke vragen

plaatst, óf een concert wordt geannuleerd. Wat de financiële schade is, kan hij nog niet zeggen.

Everhardt antwoordt verder dat, nadat er begin mei nieuwe geluidstekken zijn geconstateerd, de gemeente op 21 mei een bijeenkomst heeft belegd met topexperts op het gebied van akoestiek, waaronder Level Acoustics uit Eindhoven. Deze geluidstekken gaan

is duidelijk wat de oorzaak is van de geluidsoverlast, wie hiervoor aansprakelijk is en wat eventuele herstelkosten zijn. Het ingenieursbureau Royal HaskoningDHV voorzag de ontwerpers van akoestisch advies voor de constructie. De resultaten van het onderzoek worden medio september verwacht.

### Gezeur

Eind vorige week twitterde directeur Frans Vreeke over de geluidstek: 'gezeur over geluidstek in TivoliVredenburg is als klagen over die ene tegengoal bij 5-1 winst.'

Gisteren kwam verder naar buiten dat onderzoek in januari uit-



DEN

TIVOLI  
VREDEN  
BURG

TIVOLI  
VREDEN  
BURG

TIVOLI  
VREDEN  
BURG

TIVOLI  
VREDEN  
BURG

TIVOLI  
VREDE  
BURG

# TivoliVredenburg





# 5 concert halls under 1 roof



Background noise level: 20 dB(A)



Music sound level: 105 dB(A)

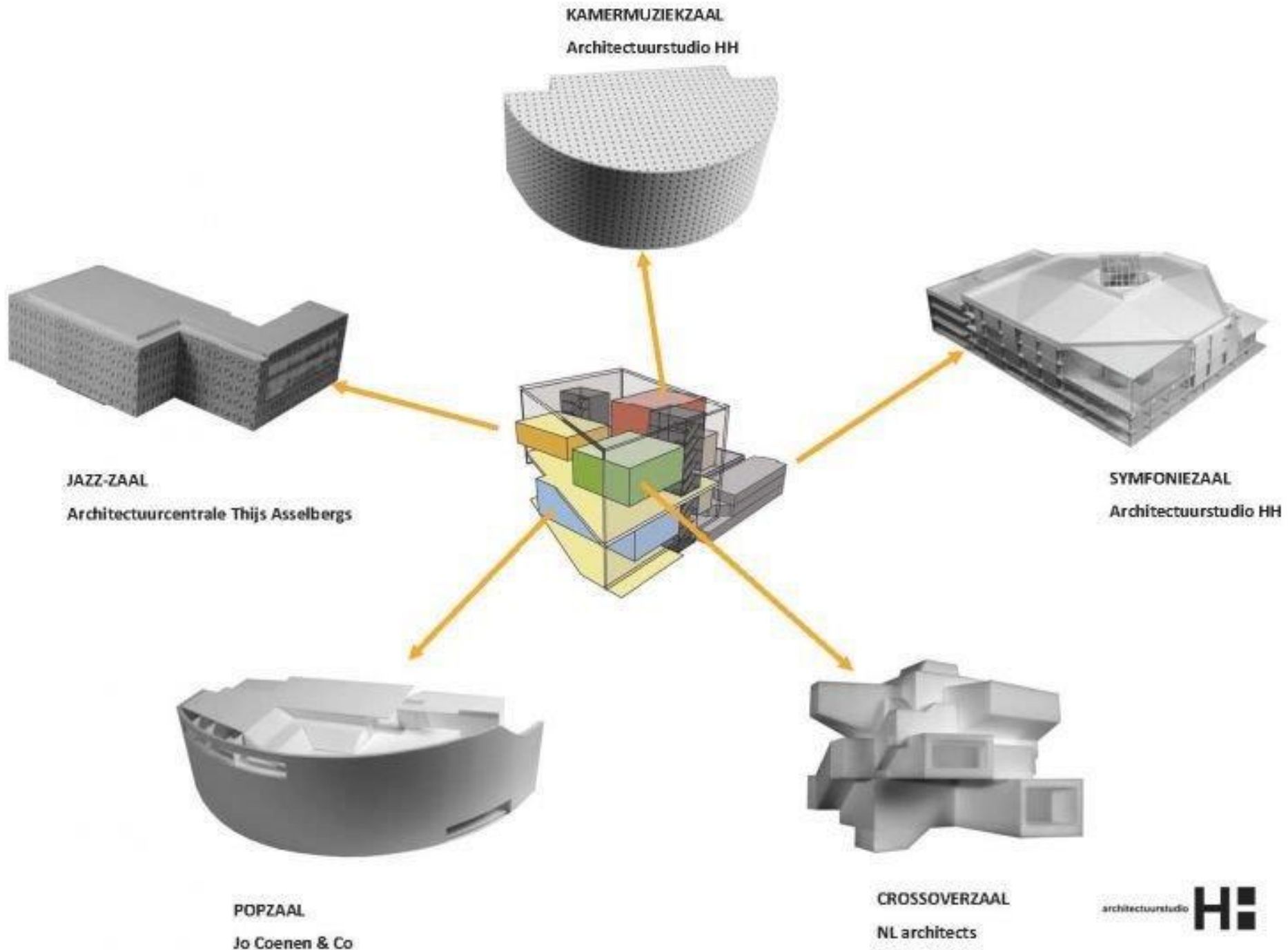




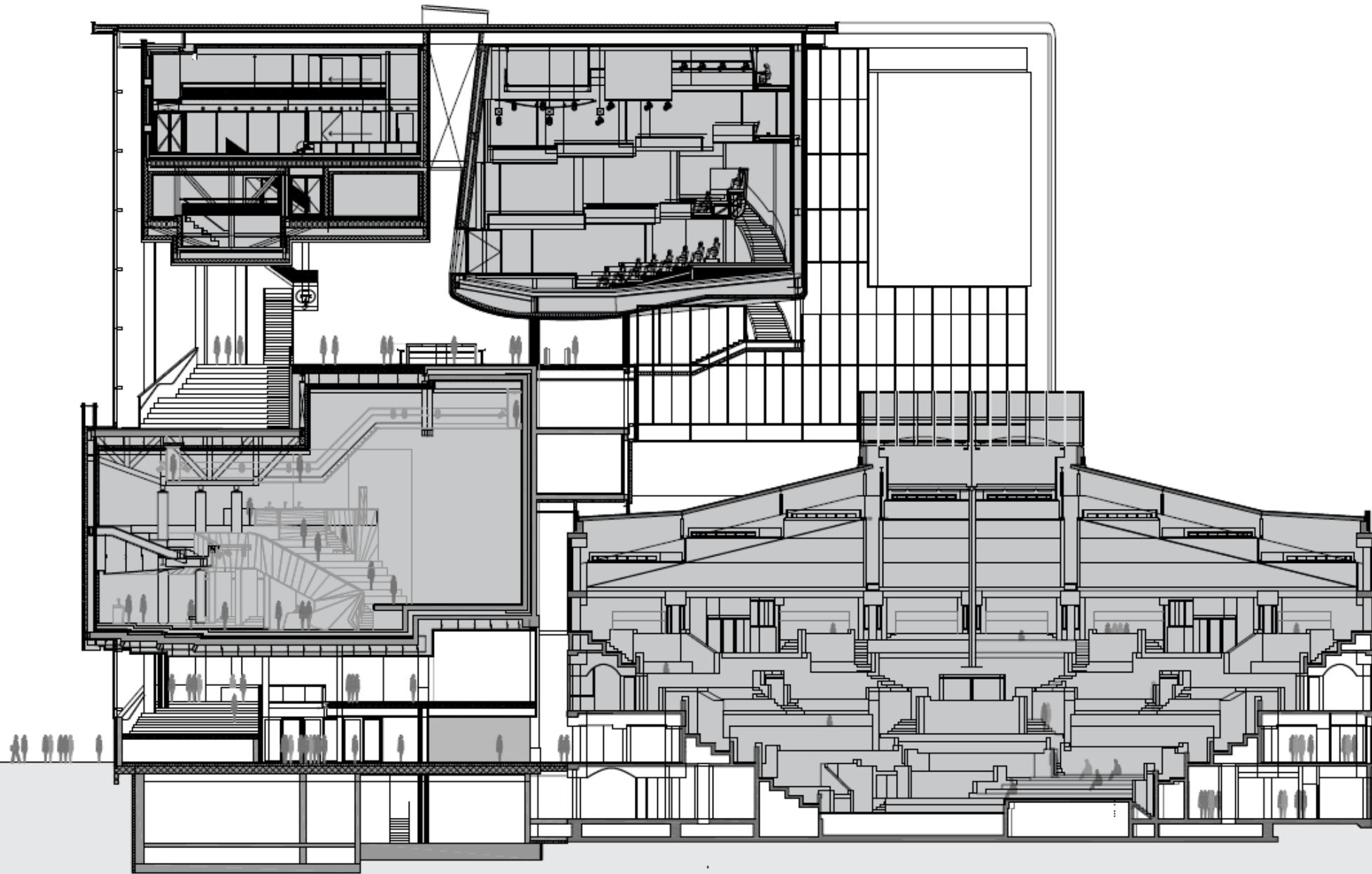
he  
mans

GUNCO  
R450  
6019

2





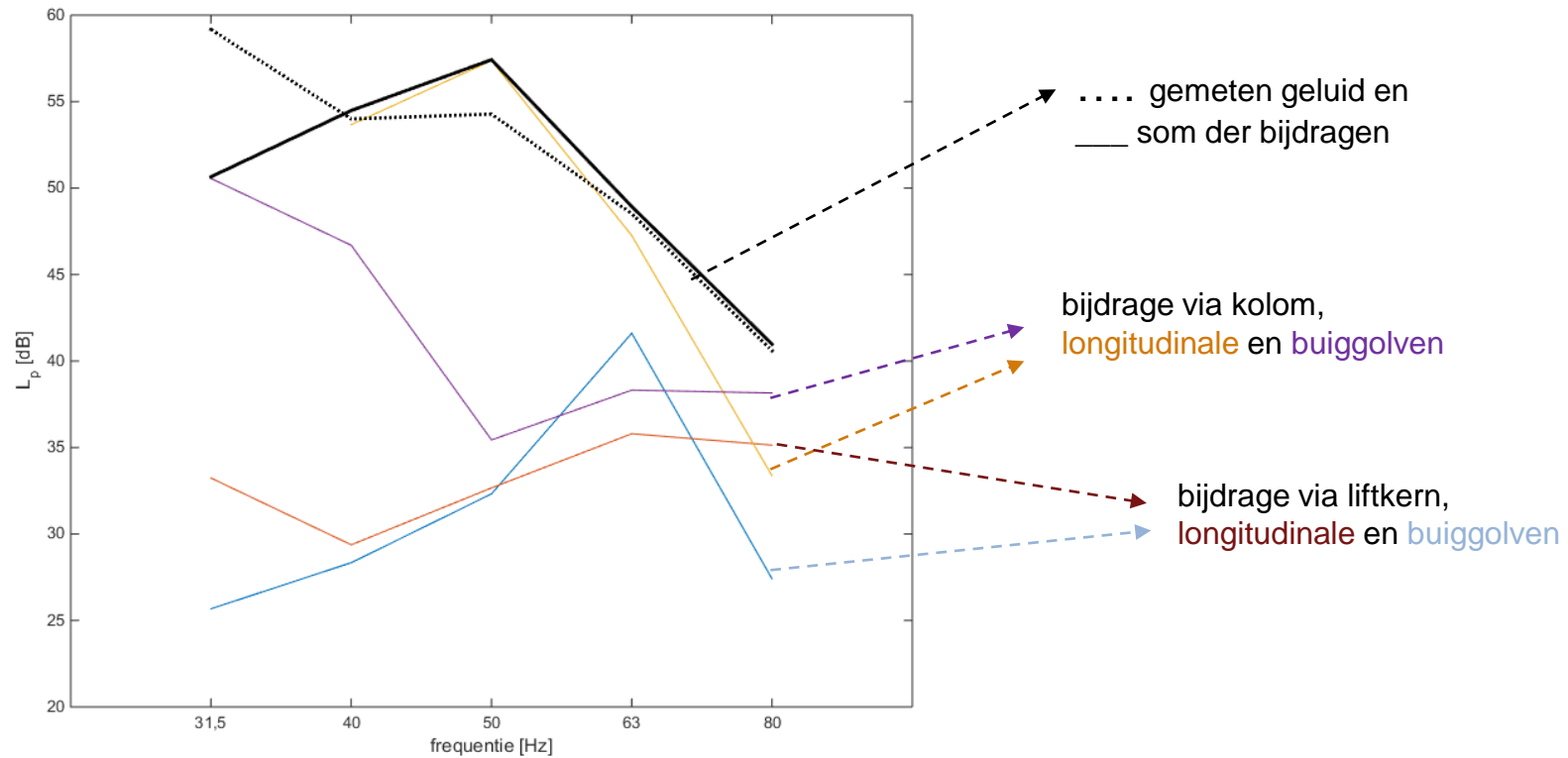


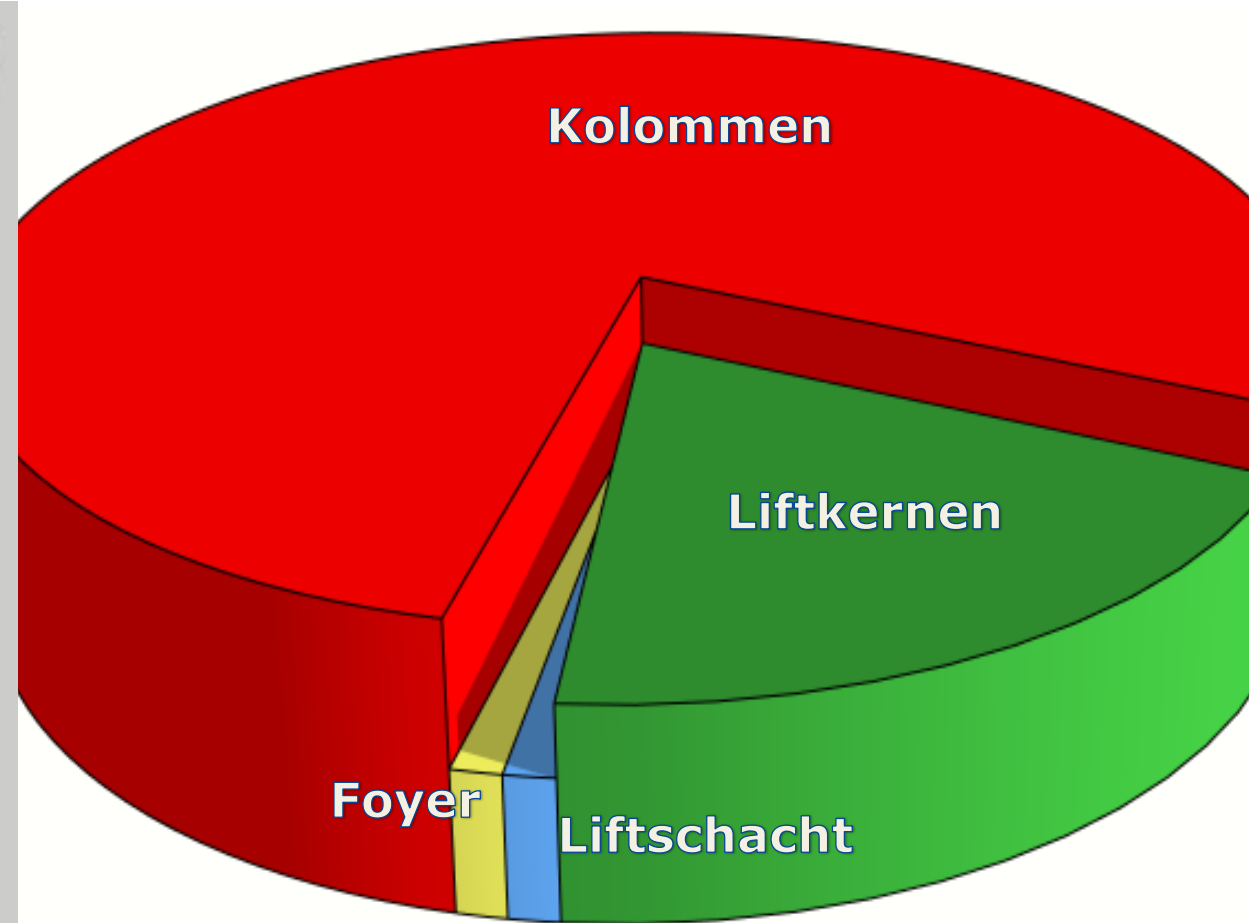
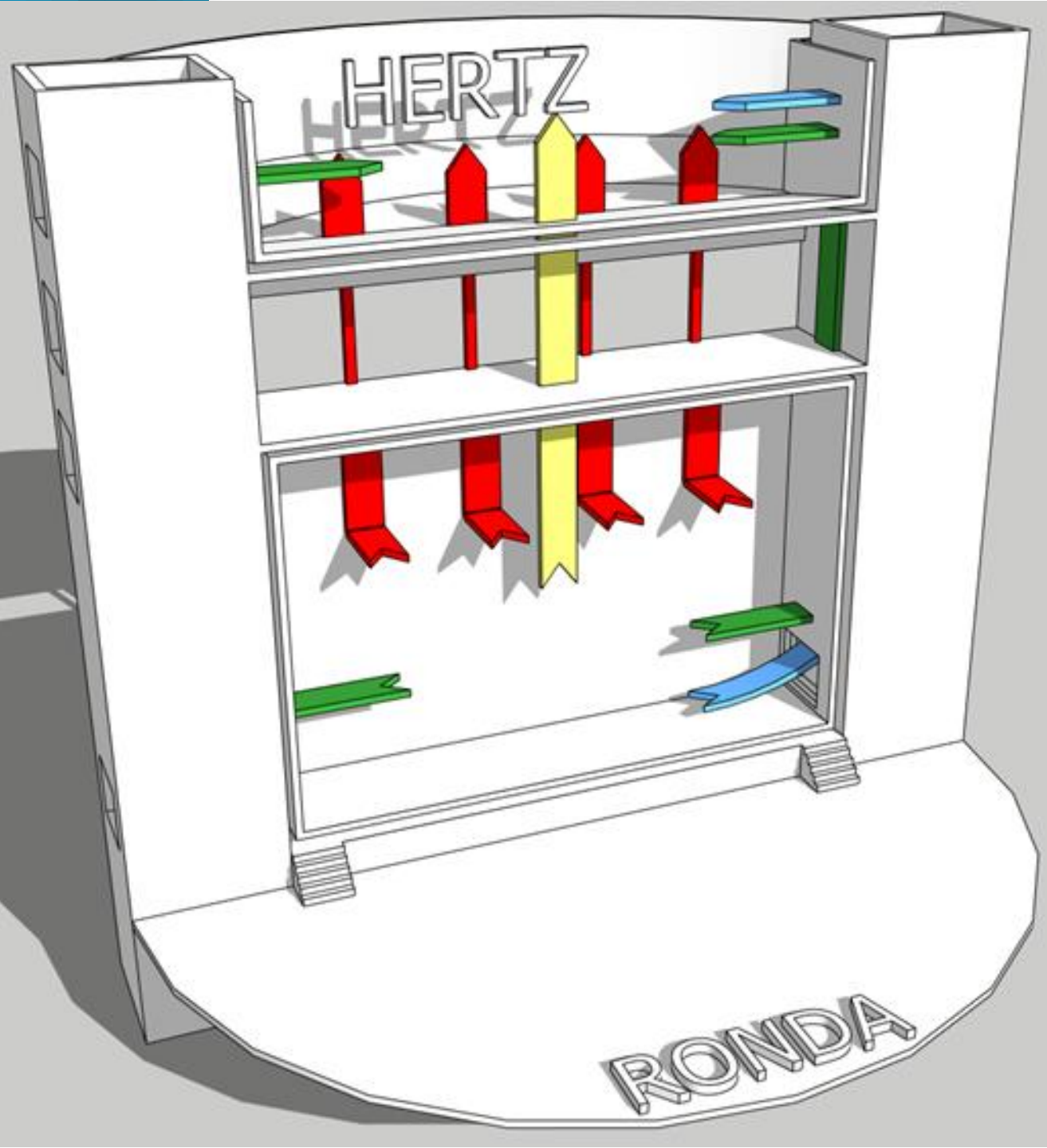


# Measurements & FEM modeling ...



# ... all postprocessed in MATLAB







# FEM model

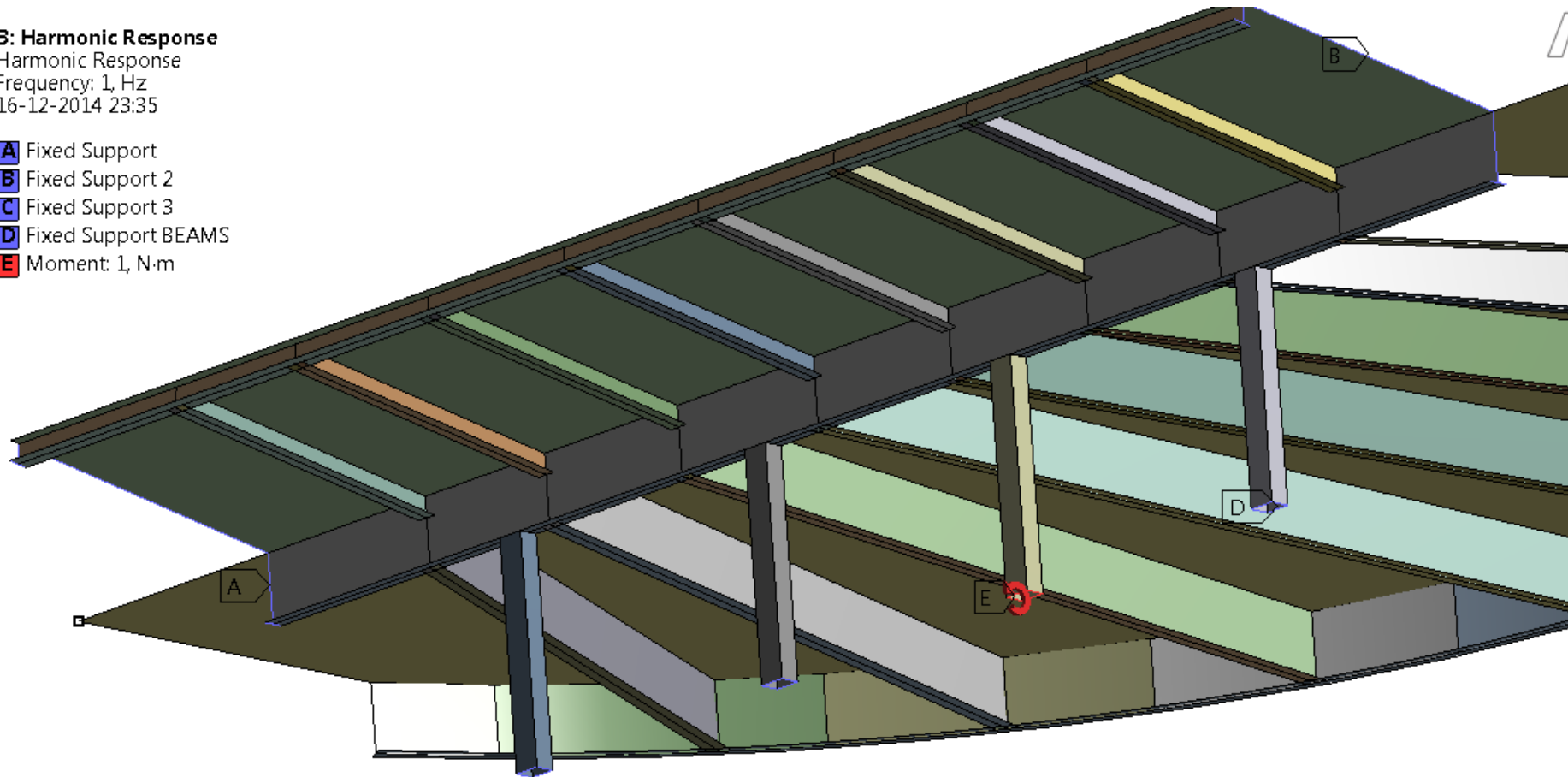
## B: Harmonic Response

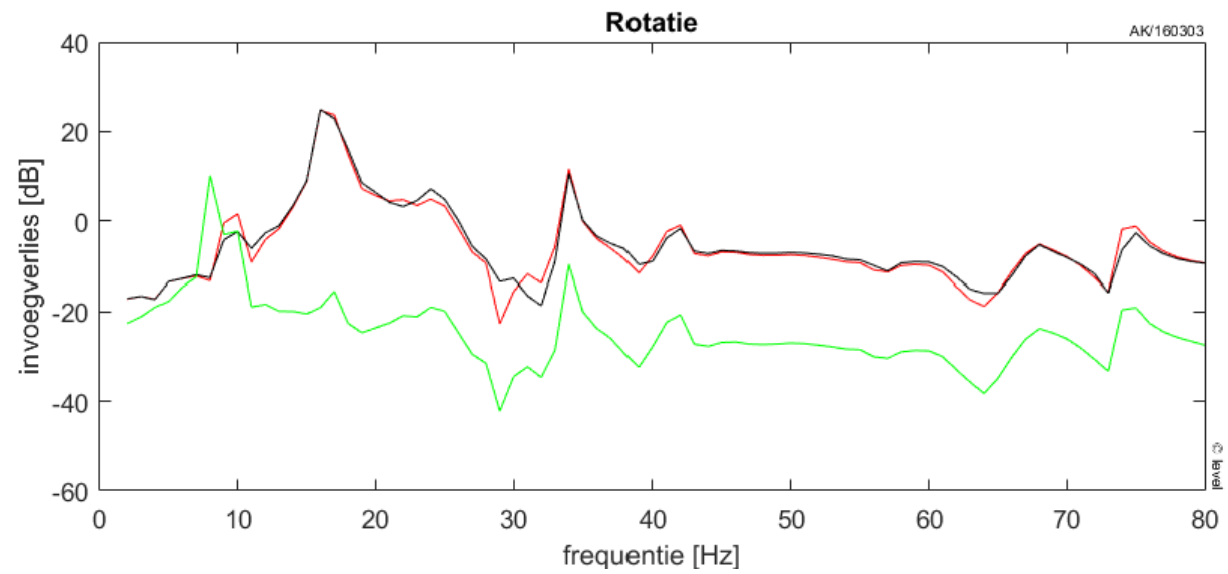
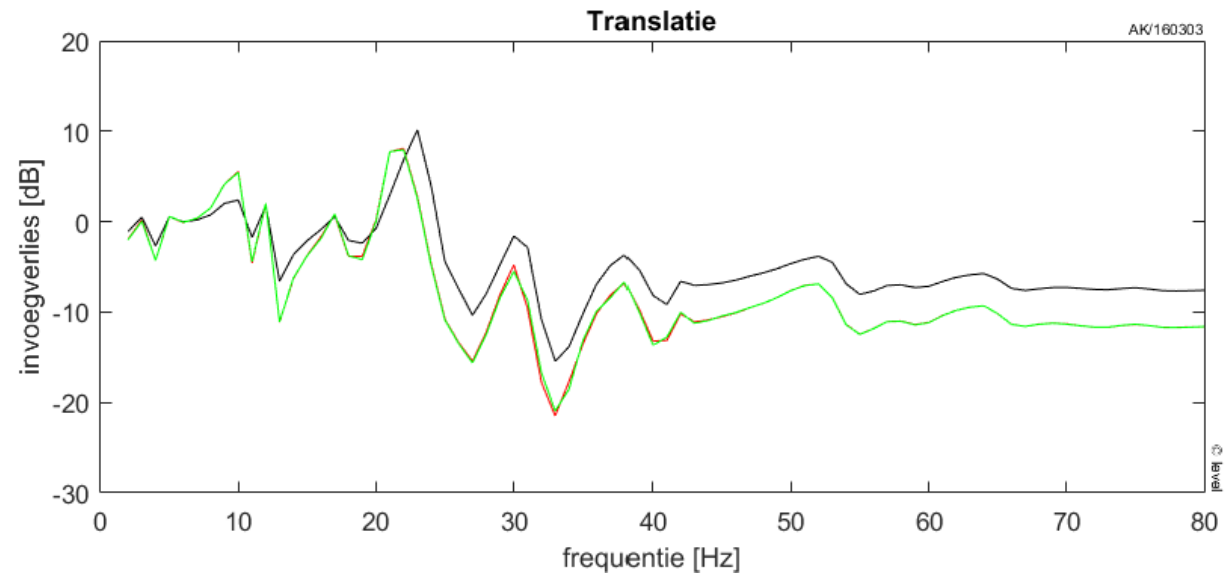
Harmonic Response

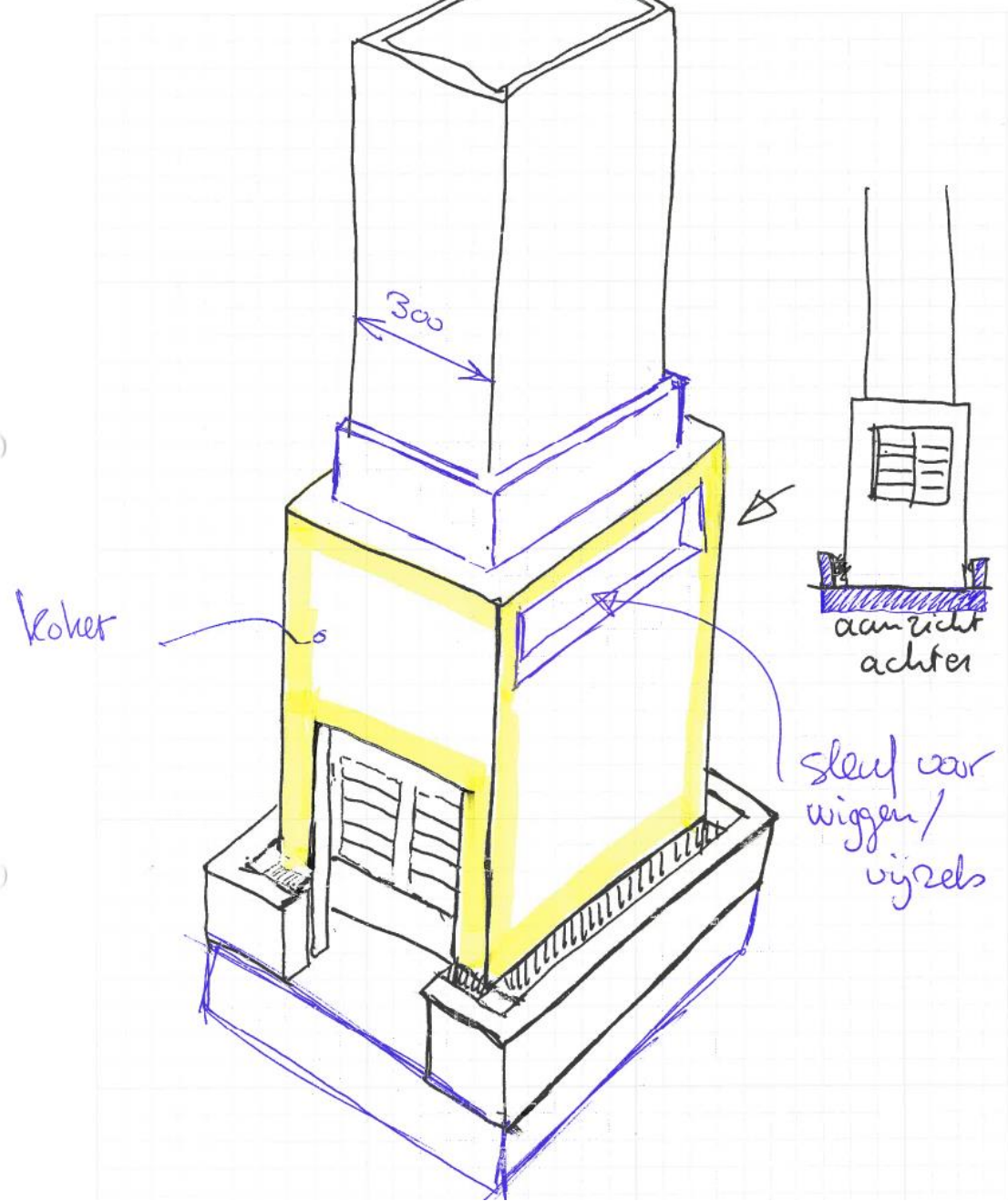
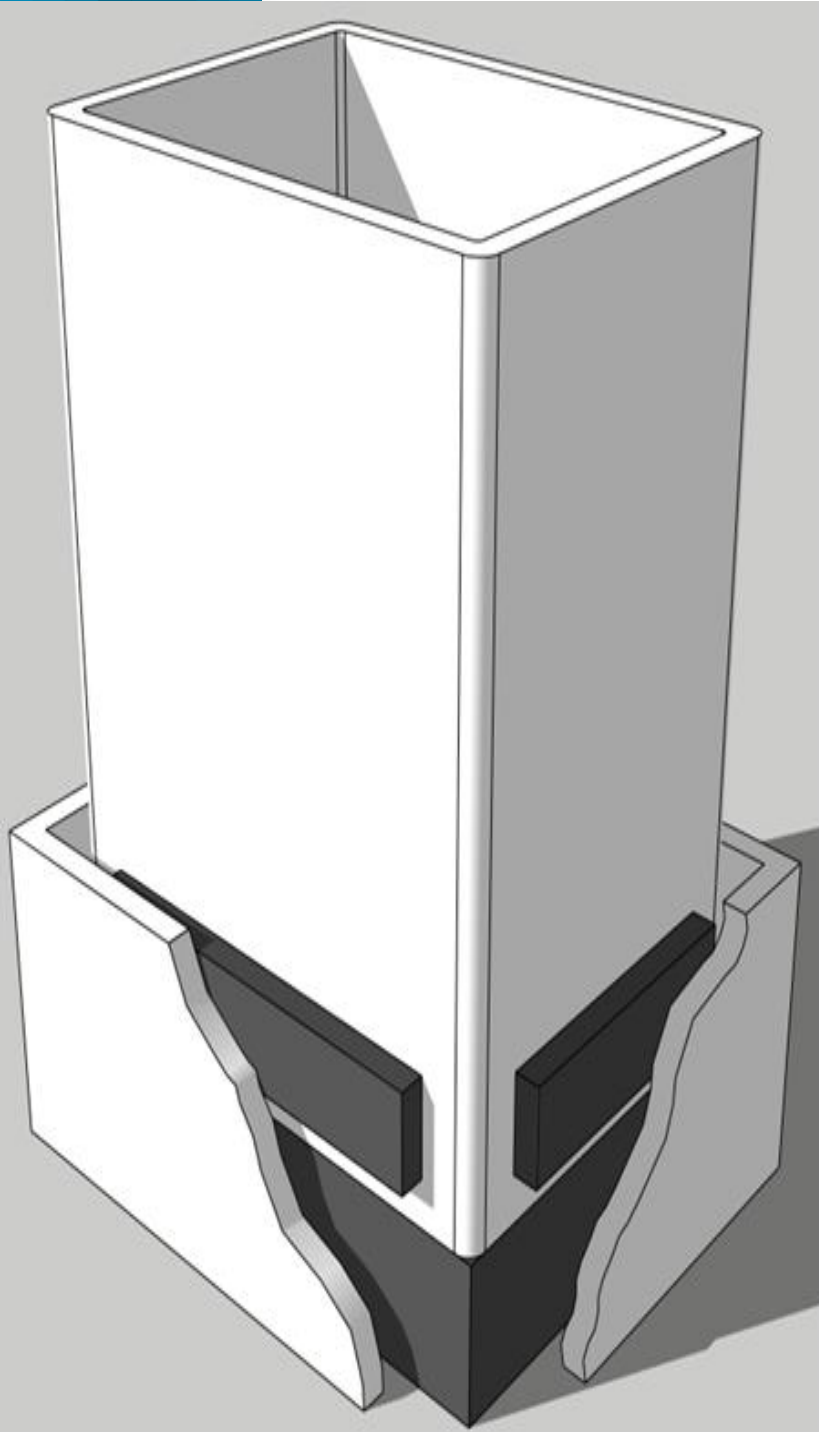
Frequency: 1, Hz

16-12-2014 23:35

- A** Fixed Support
- B** Fixed Support 2
- C** Fixed Support 3
- D** Fixed Support BEAMS
- E** Moment: 1, N-m





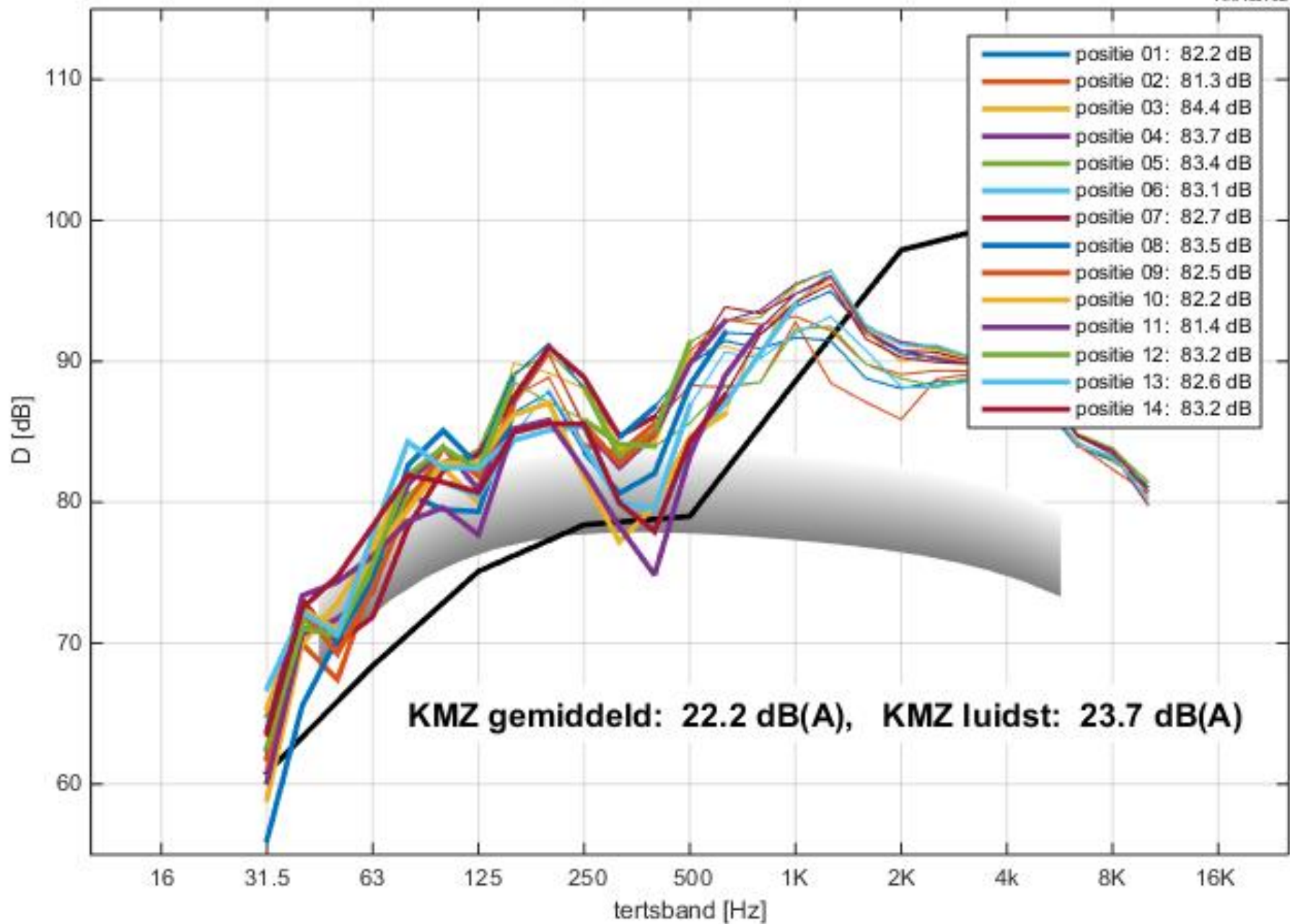






# Geluidisolatie PZ-KMZ

AK/180702



Level, Accoustics & Vibration







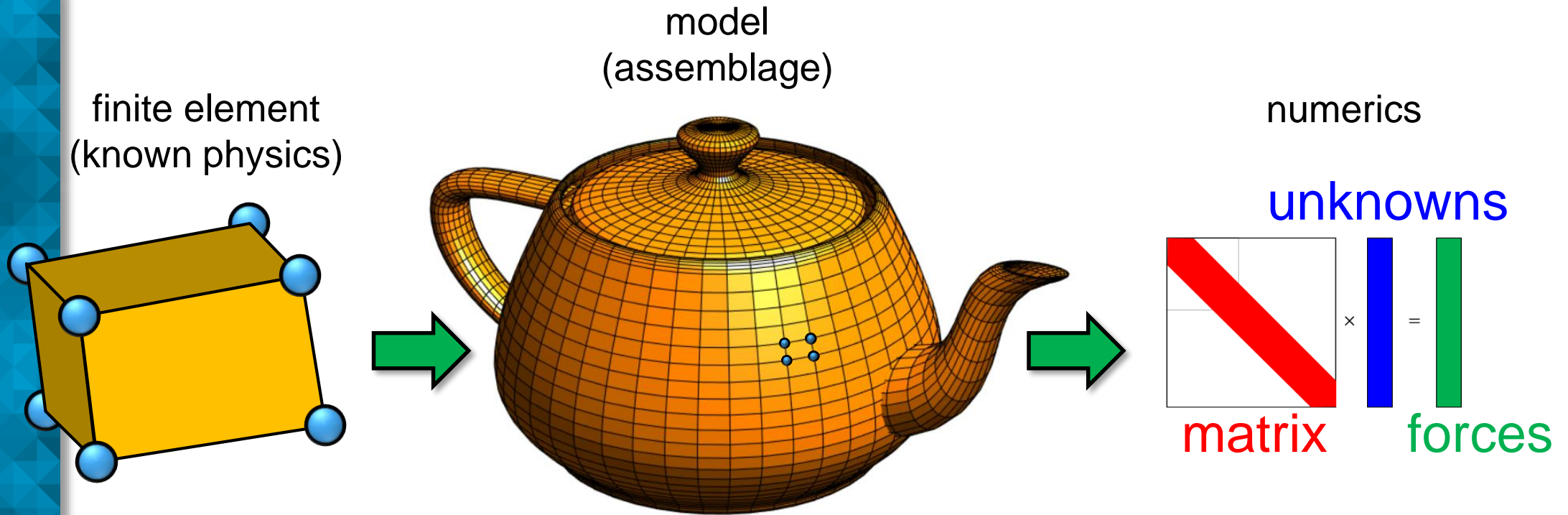




# Reasons to develop SoViST

- Not all building physicists have FEM/SEA software licenses and skills
- Existing FEM/SEA software is expensive
- Existing FEM/SEA software is by far more extensive than required
- Existing FEM/SEA software does not include required post-processing
  
- SoViST only includes what is necessary (FEM/SEA methods, Post-processing)
- SoViST makes the modelling decisions
  - It is possible due to the limited possibilities

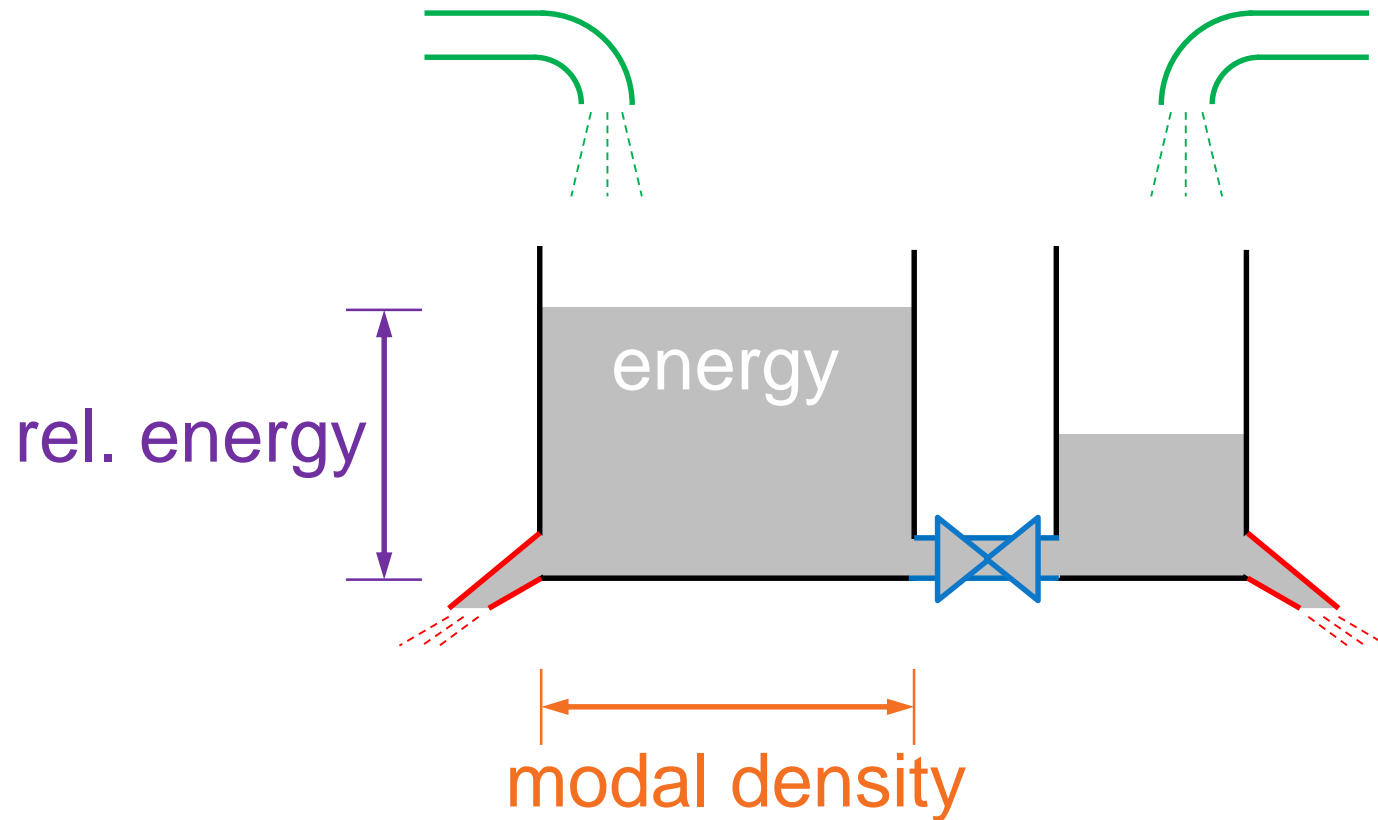
# FEM (Finite Element Method)



$$\begin{array}{l} \text{stiffness matrix} \\ \text{damping matrix} \\ \text{mass matrix} \end{array} \times \begin{array}{l} \text{displacements} \\ \text{velocities} \\ \text{accelerations} \end{array} = \begin{array}{l} \text{forces} \\ \text{forces} \\ \text{forces} \end{array}$$

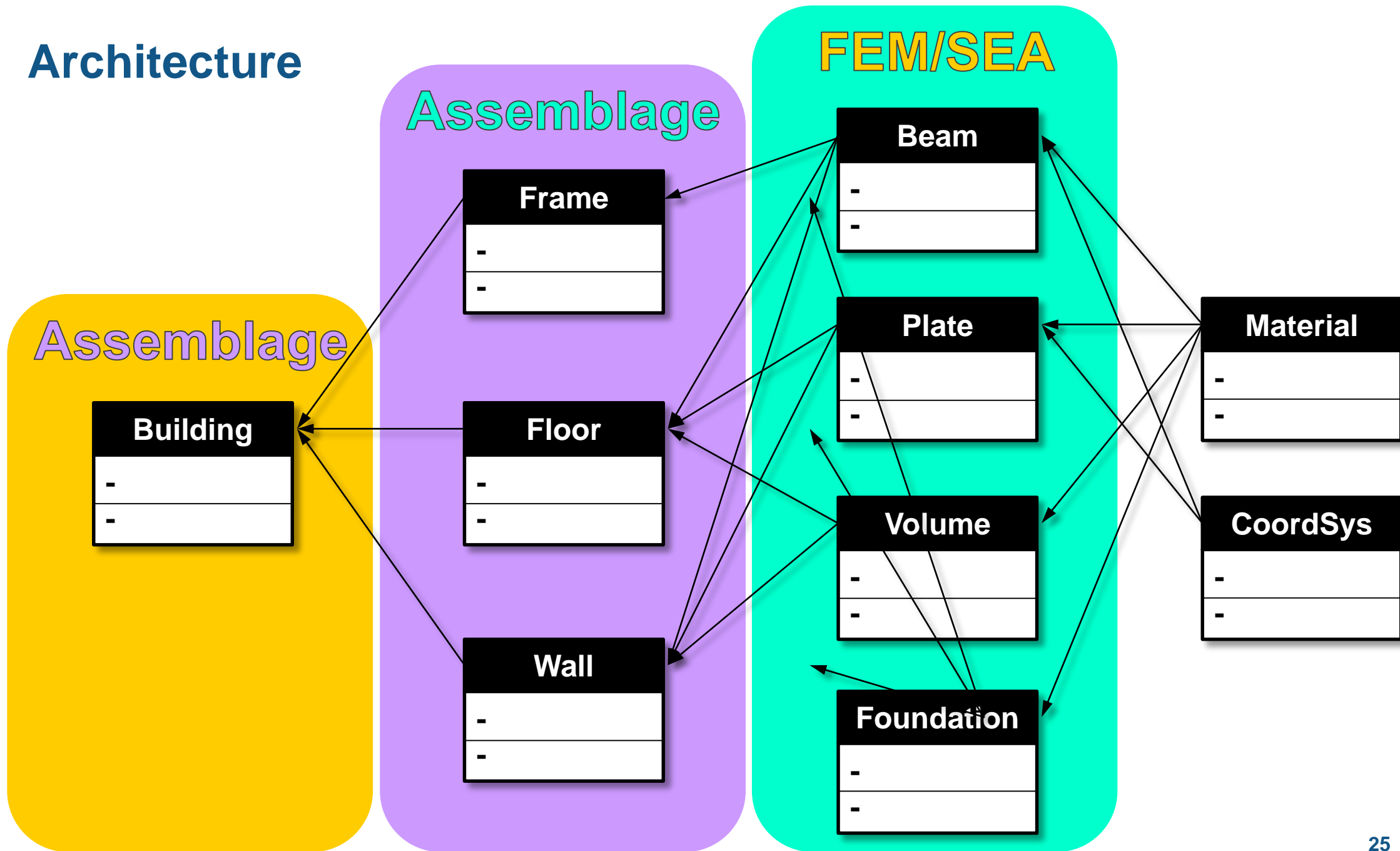


# SEA (Statistical Energy Analysis)



subsystem: wave type  
energy supply  
dissipation  
coupling loss factor

# Architecture



# SoViST (Sound and Vibration in Steel and Timber dwellings)

**Building**

**Evaluation**

**Graphical feedback**

**EVENTS**

**Inspect**

**MATLAB**

**MATLAB/JIDE**

**JIDE**

**level**  
.tools

Name	Description
Building	Building
System	
BuildingSystem	Steel frame
JunctionType	1
Dimensions	
LX	5
LY	5
LZ	2.6
Quantity	
NX	2
NY	1
NZ	2
Building Elements	
Floor	1. Vloer Type 1
Wall	1. Wand Type 1
Frame	
BeamX	1. HEA160
BeamAngleX	0.0
BeamY	1. HEA160
BeamAngleY	0.0
BeamZ	1. HEA160
BeamAngleZ	0.0
Visualisation	
FloorColor	
WallColor	
BeamXColor	
BeamYColor	
BeamZColor	
FrameColor	

```
07/06/2017 23:18:55 Starting HIVOSS calculations
|#####| Computing compliance
07/06/2017 23:19:08 Starting EN12354 calculations
|#####| Computing Kij
|#####| Computing Kij
07/06/2017 23:19:35 Done
```



## Concluding Remarks

- For a non-programmer there is no need to be afraid of MATLAB OOP
- Think of a good architecture to make the code recyclable
- Runtime library still feels as a drawback
- Therefore, since MATLAB OOP, we're also looking into other programming languages
- MATLAB will still be started every day on our laptops, as it is our engineering software of choice