Experiences from vibroexciter for big structures

Mats Hammarqvist

NGV 2022

efterklang:

PART OF AFRY

ACOUSTICS NOISE VIBRATION SOUND DESIGN

Also presented at SVIB 2022

NGV 2022

5th Nordic Ground Vibration Day

24 October 2022 • Aarhus • Denmark

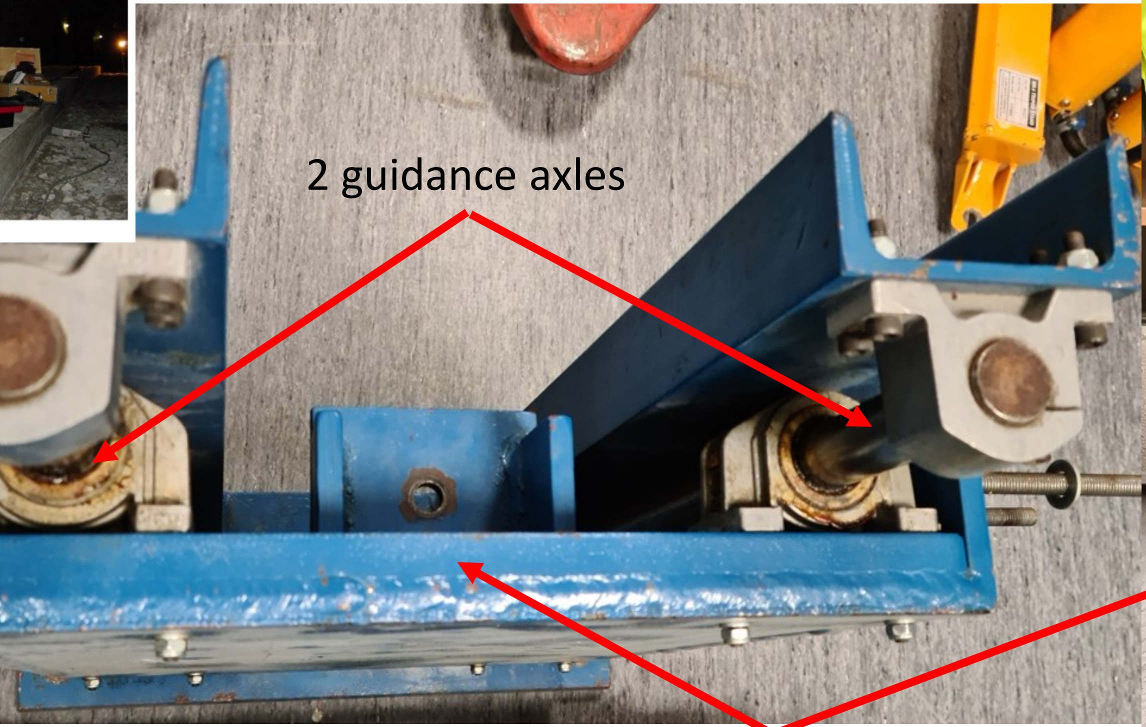
NGF 1950 SGY SGF JTI djf MARKVIB

Case Study 1: Train tunnel – structure borne sound

Case Study 2: Mobility of wooden building

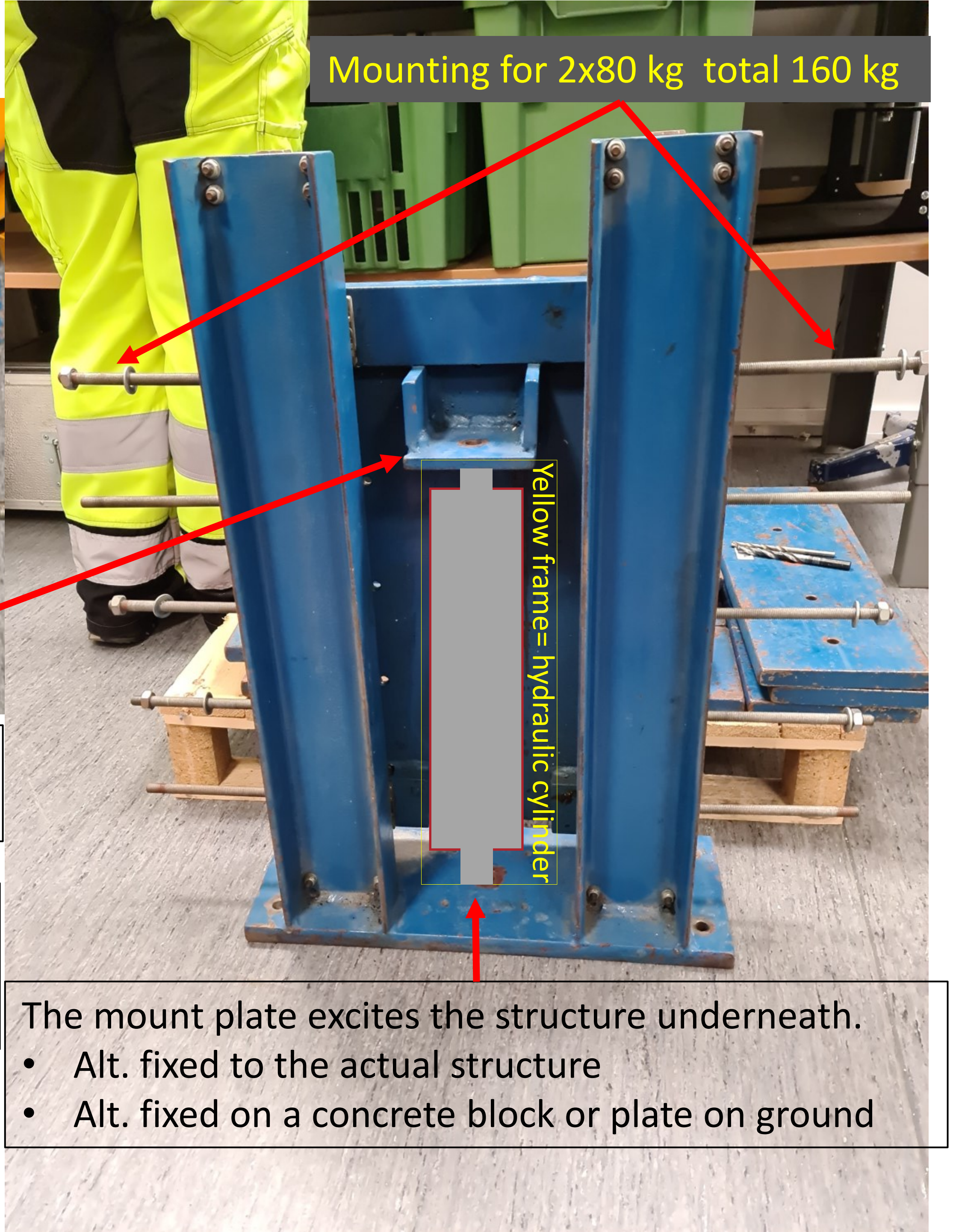
Case Study 3: Damping in a big machine foundation

Bild 4. Hydraulexciter under montering



Movable “sled” - weight moved by hydraulic cylinder.
Sled can be loaded with 2x6 steel plates

Principle: Hydraulic cylinder, with force transducer and translation sensor, vibrates ”movable sled” vertically which excites ”mounting plate”



The mount plate excites the structure underneath.

- Alt. fixed to the actual structure
- Alt. fixed on a concrete block or plate on ground

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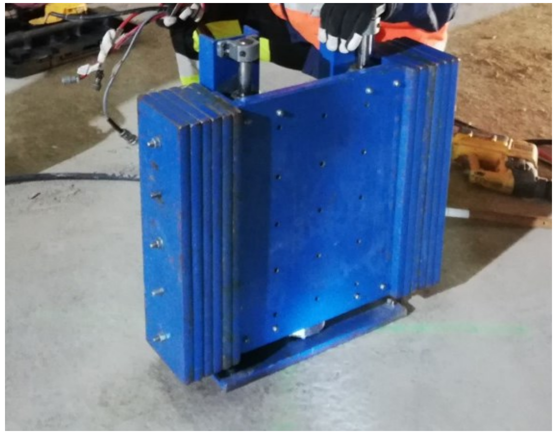
Servohydraulic mobile vibrationrigg

Force Cell – Force Transducer [+/- 10 kN]
LVDT – displacement sensors [+/-25 mm]

Movable sled mass: Approx. 160 kg (12 pc mountable weight plates)
Full weight vibroexciter: 237 kg

Excitation mount: 450 x 160 x 20 mm

Excitation force (stepped sinus, random) – chosen signal into Hydraulic Power Supply system



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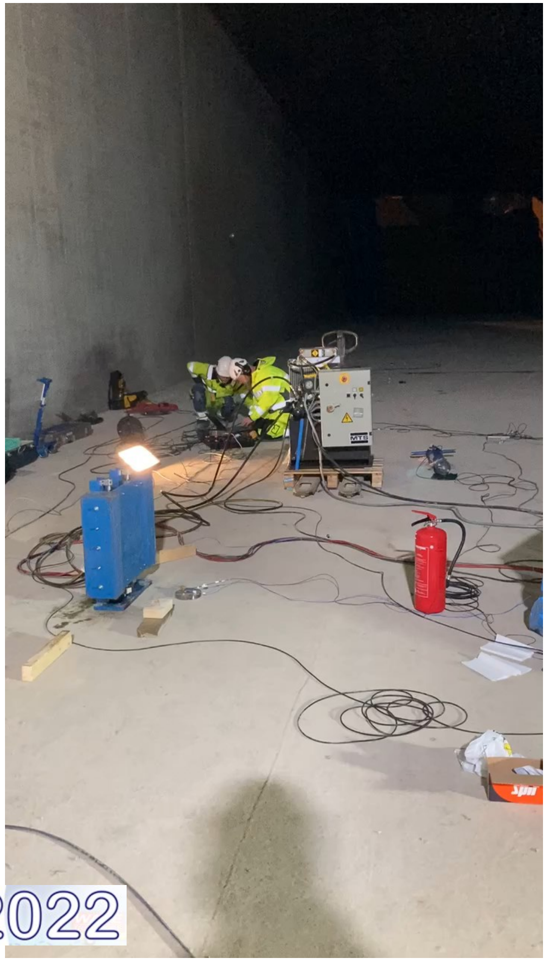
Dynamic stiffness in concrete tunnel - mobility Aim: data for elastic mat measures for structure borne sound

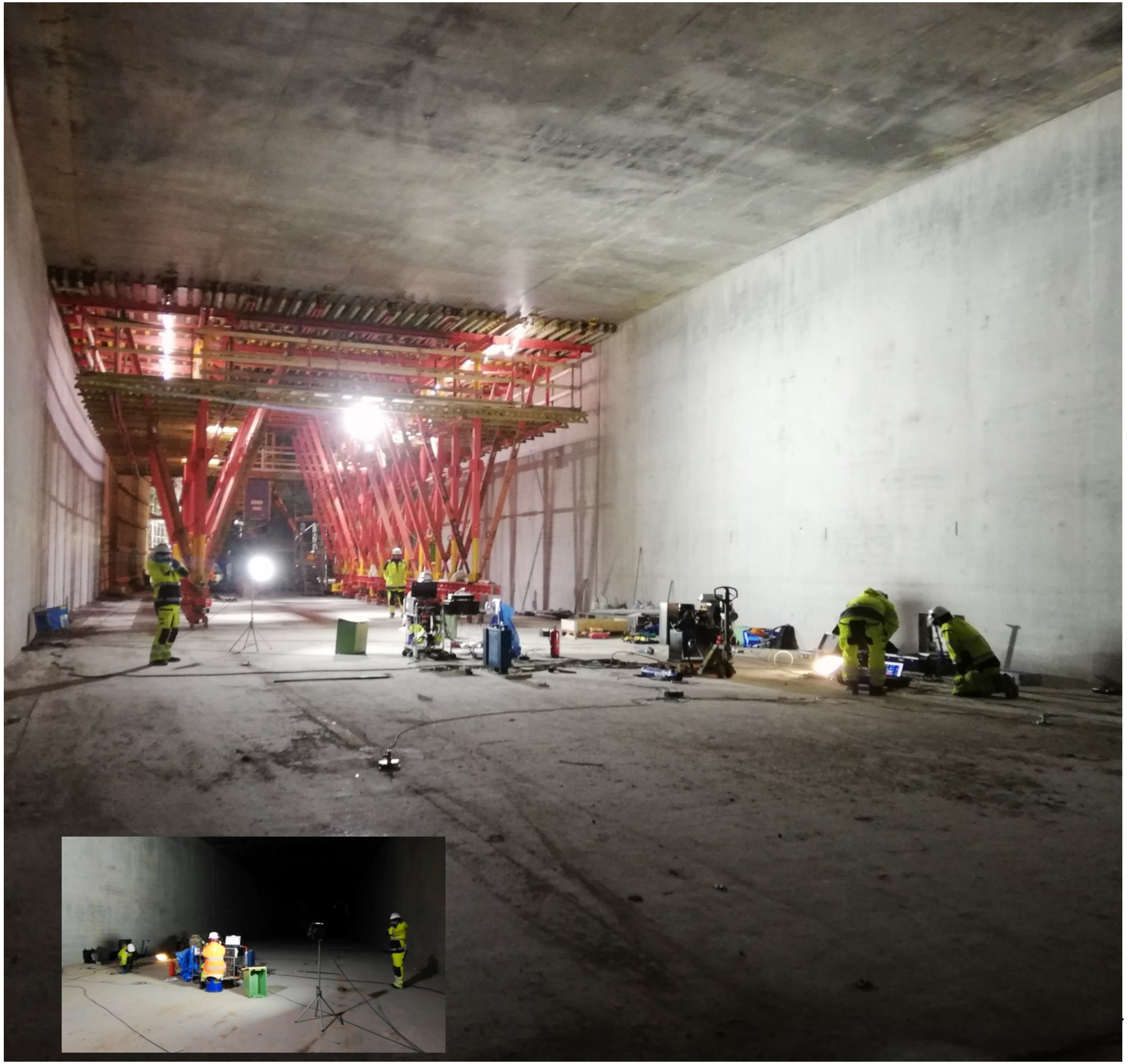
Measurement conducted: 2022-01-30

Personnel : Gustav Vågfelt, Mats Hammarqvist & Åsa Collet

Analyses: Åsa Collet

Case Study 1: Train tunnel





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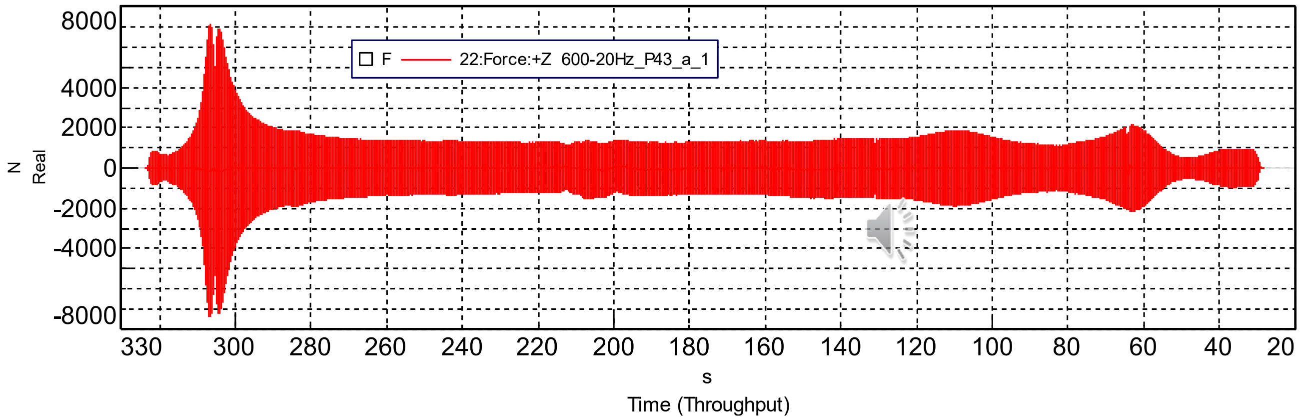
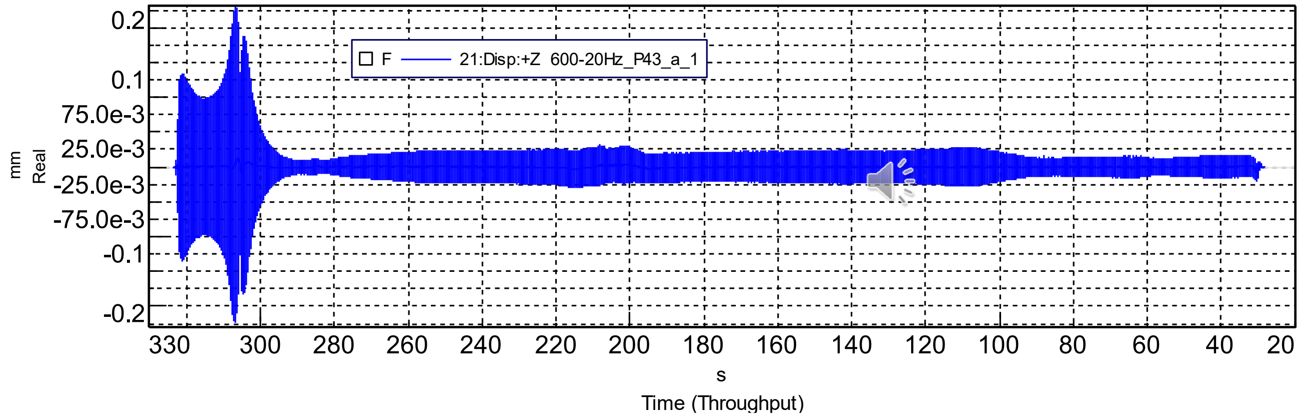
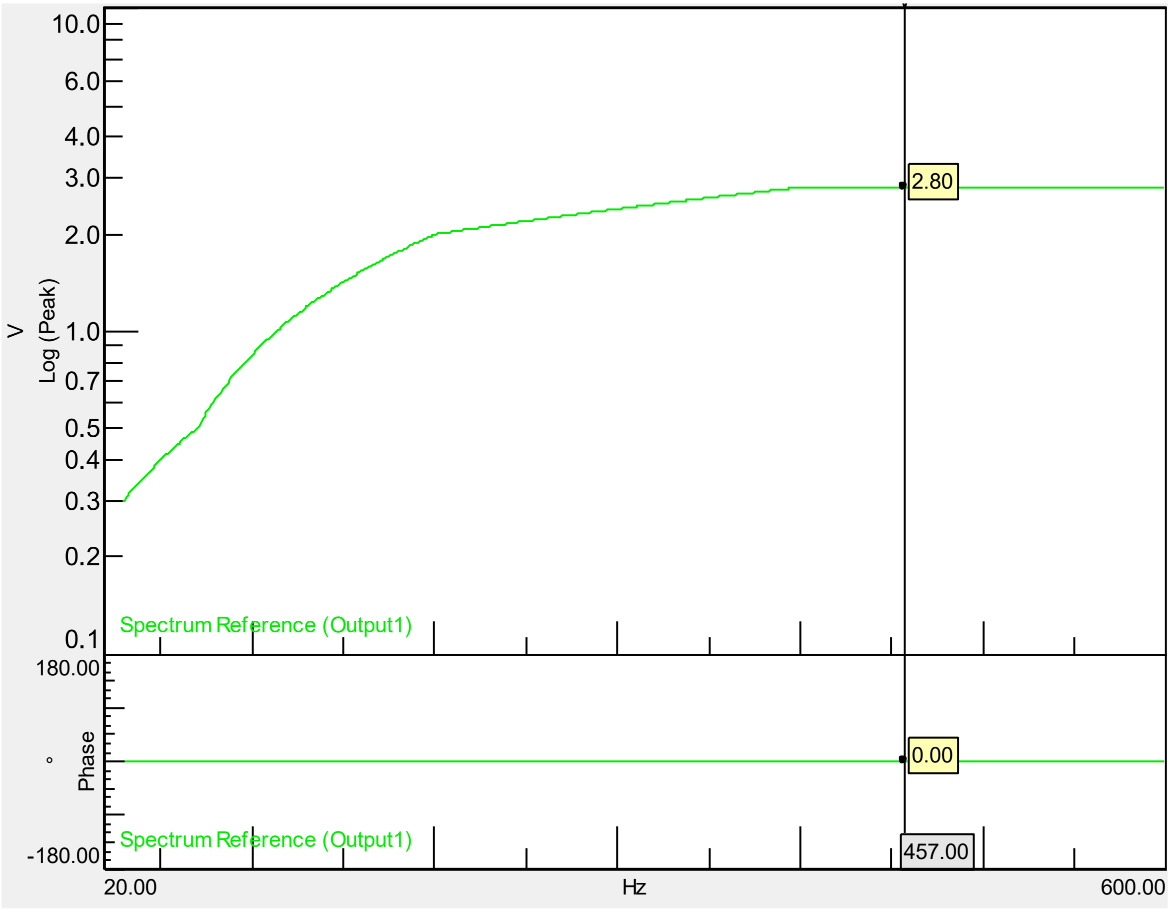
Time signal for Force [N] och Displacement [mm]

driving point sinus sweep f=20-600 Hz

Driving point, excitation on pile in train tunnel







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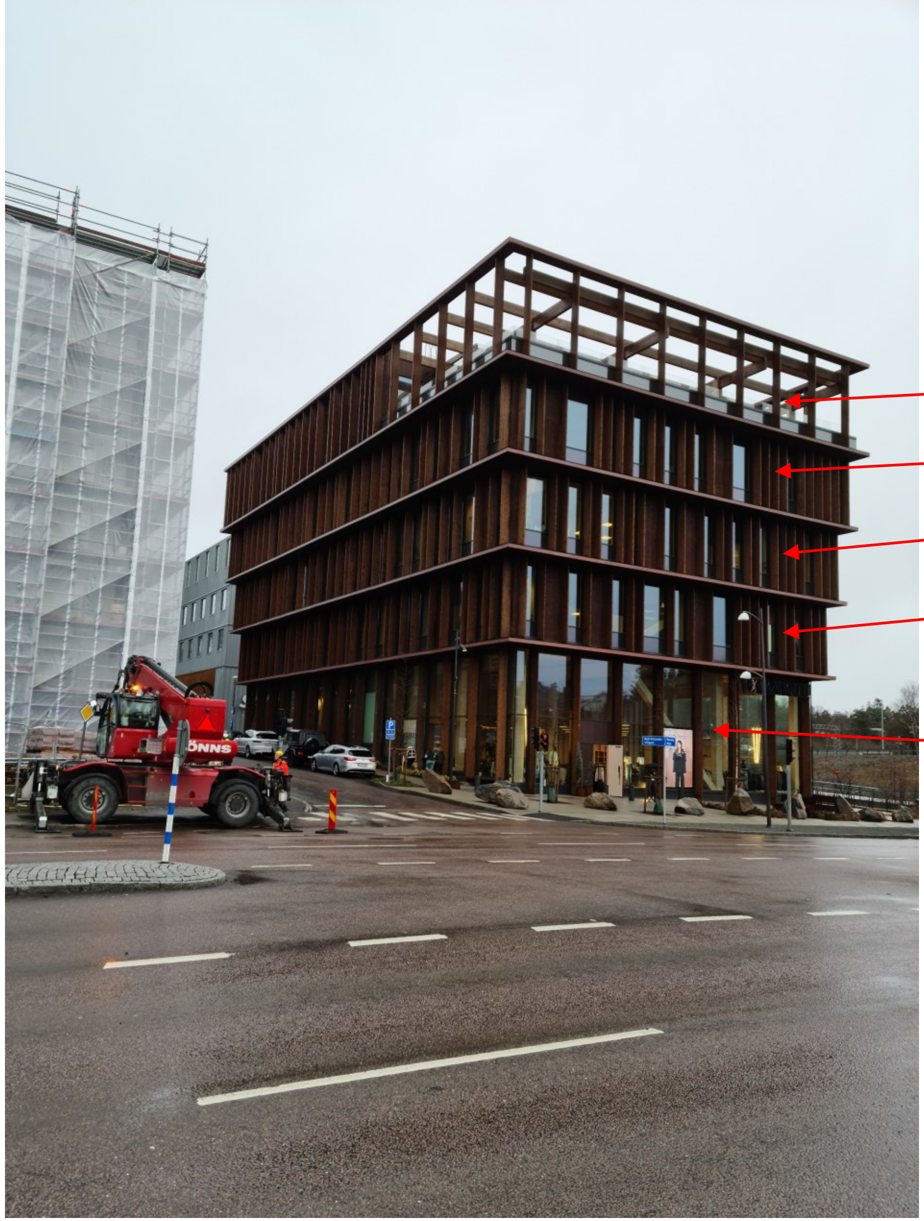
Transfer function ground to wooden house

Aim: Connection ground->building / building response

Measurements conducted: 2022-01-31

Personnel: Gustav Vågfelt, Karin Abrahamsson, Mats Hammarqvist & Åsa Collet

Analyses: Åsa Collet



Disposition of the house with sensors indoors

Plan 4: Offices + terrasse

Plan 3: Office with response points on flooring

Plan 2 : Offices

Plan 1 : Office with response points on flooring and wooden pilar. Concrete central stairway is instrumented (building core).

Entréplan, Shops/Commercial

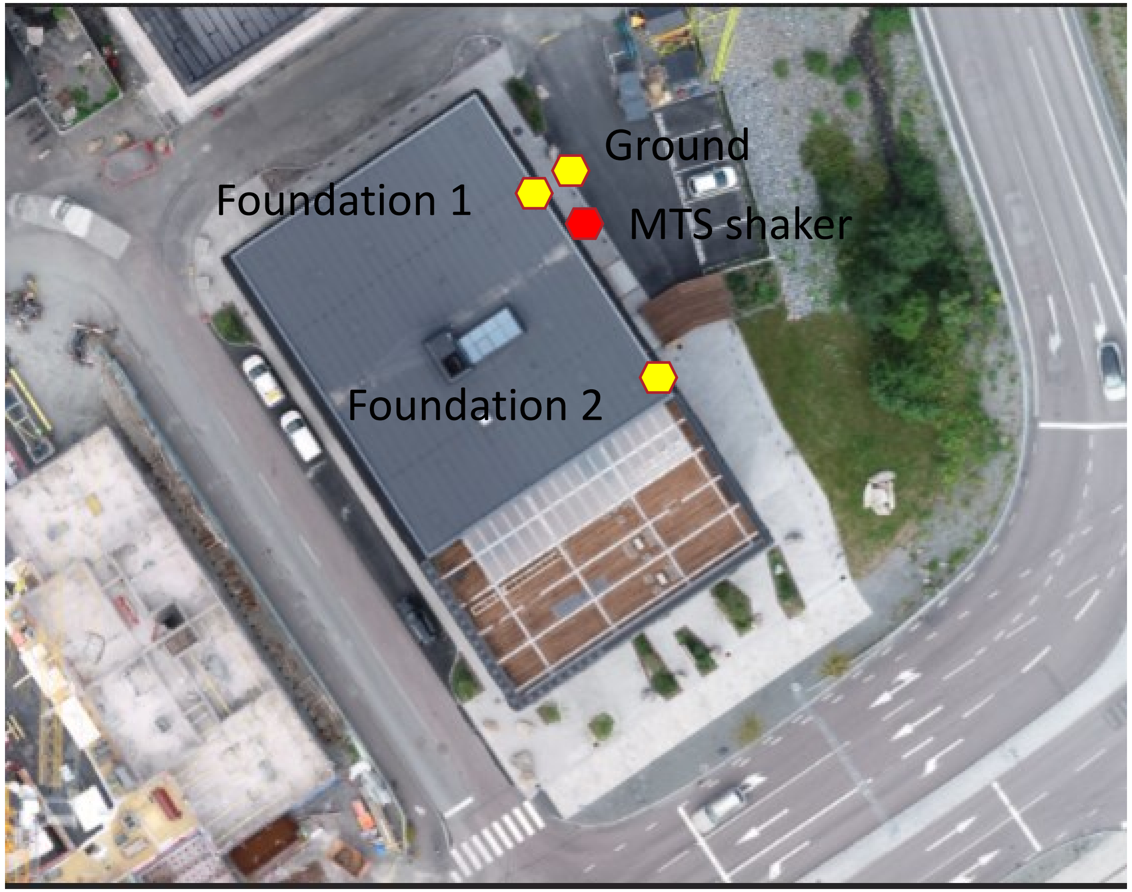
Cellar -1

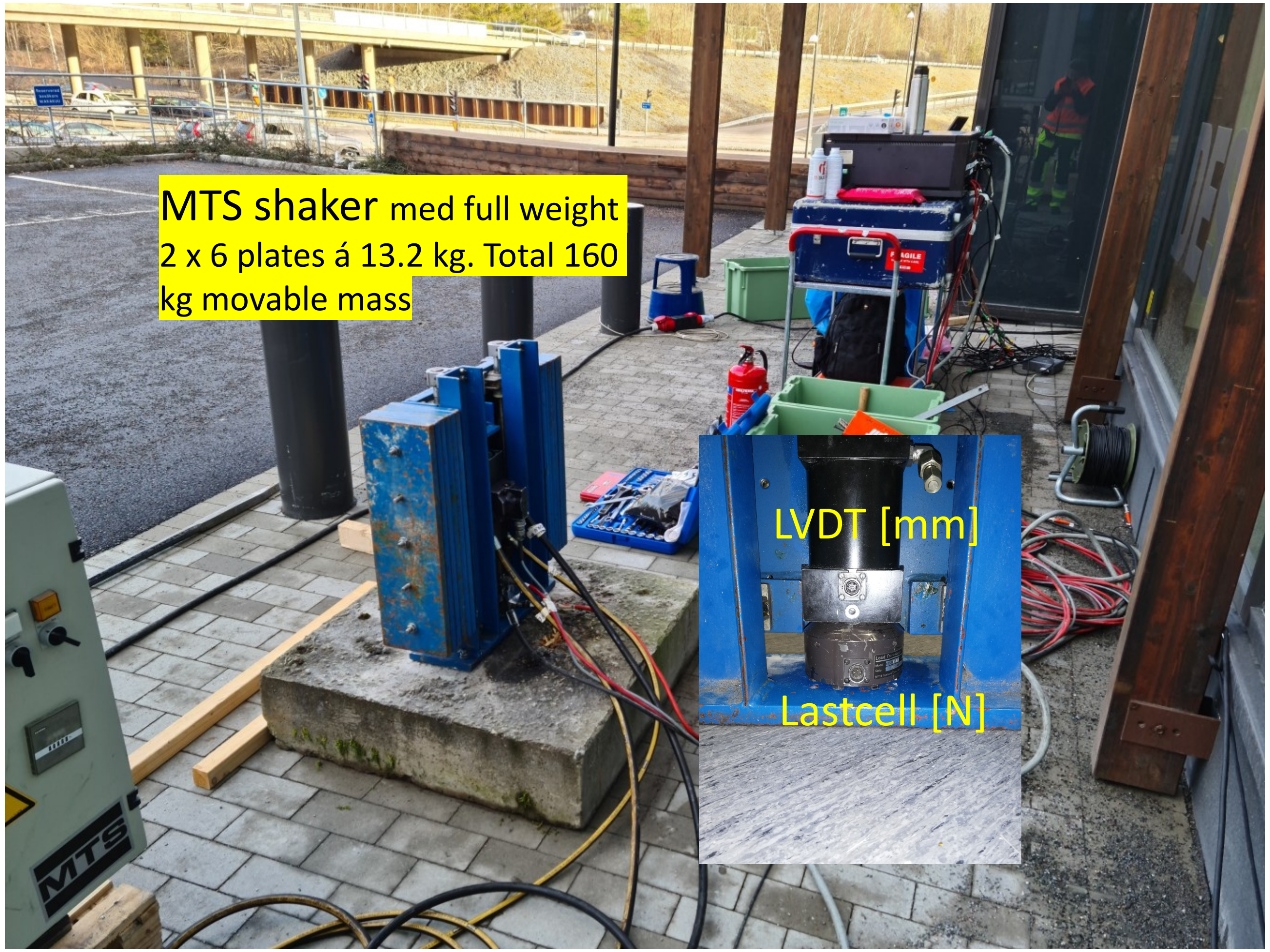
Cellar -2 (three-phase outlet ☺)

Givare som mäter utomhus:

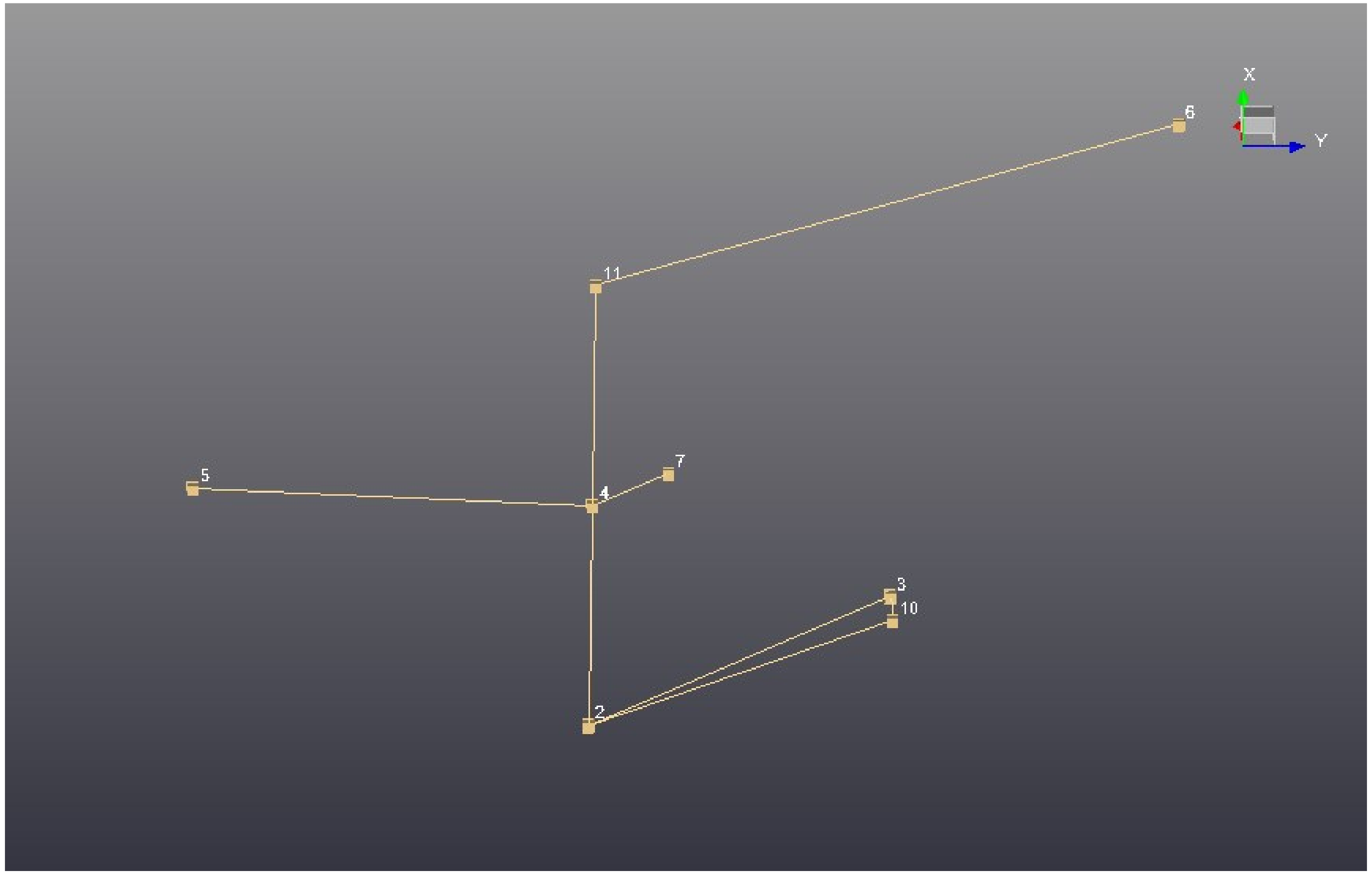
Drivpunkt vid MTS shaker: Displacement sensor [mm] + Force transducer [N]

Foundation 1:	3 pieces accelerometers [m/s2]
Foundation 2:	3 pieces accelerometers [m/s2]
Ground:	3 pieces accelerometers [m/s2]



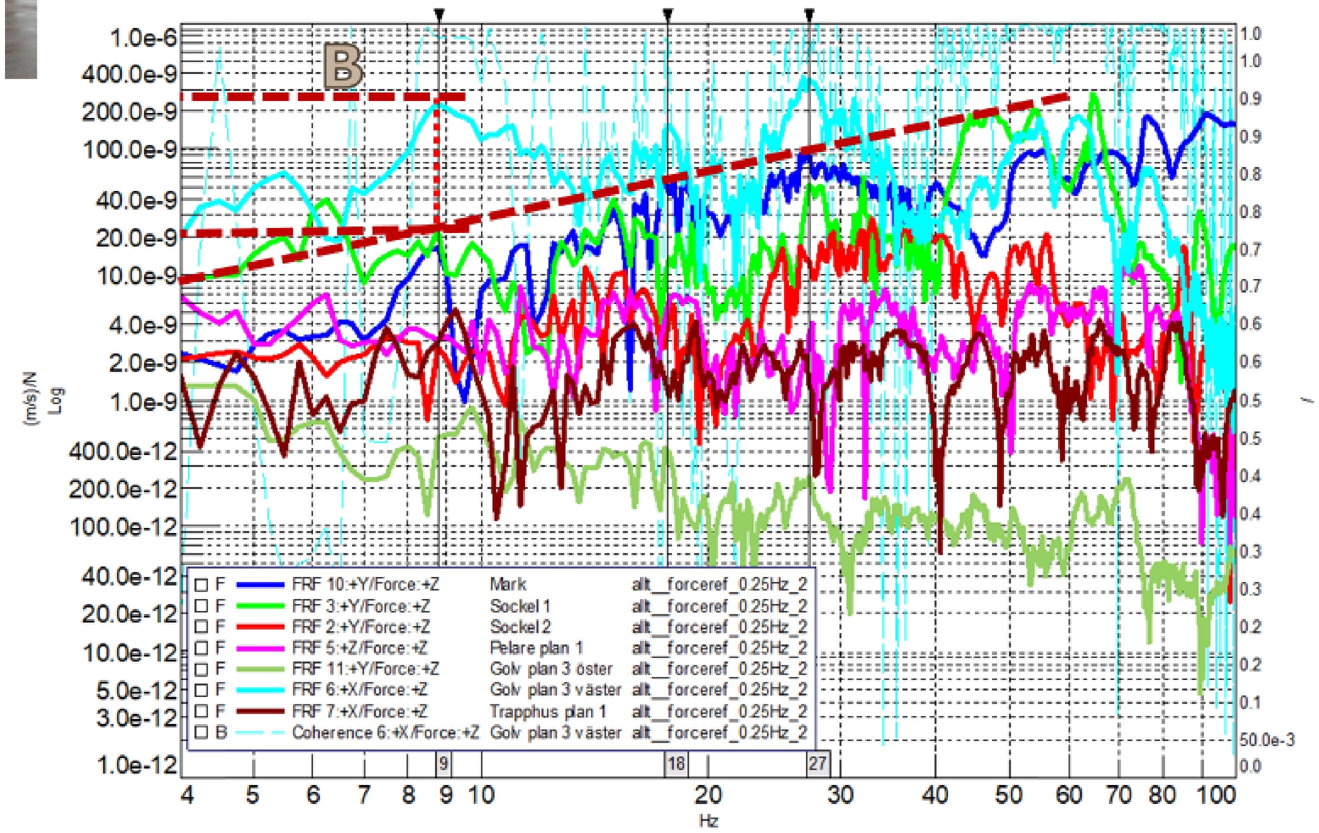


Wire model (ODS) animation at eigenfrequencies



5:	Pilar plan 1
4:	Flooring plan 1
2:	Foundation 2
3:	Foundation 1
10:	Ground
7:	Stairways plan 1
6:	Floor plan 3 west facade
11:	Flooring plan 3 east facade

Horisontella (längdsida hus) överföringsmobiliteter [(m/s)/N] med tillhörande koherens för golvgivare plan 3 väster, mätpostion 6



- Högst uppmätt mobilitet i horisontell led (längsled hus) för respons 6, Golv plan 1 väster, för alla mätpunkter och riktningar

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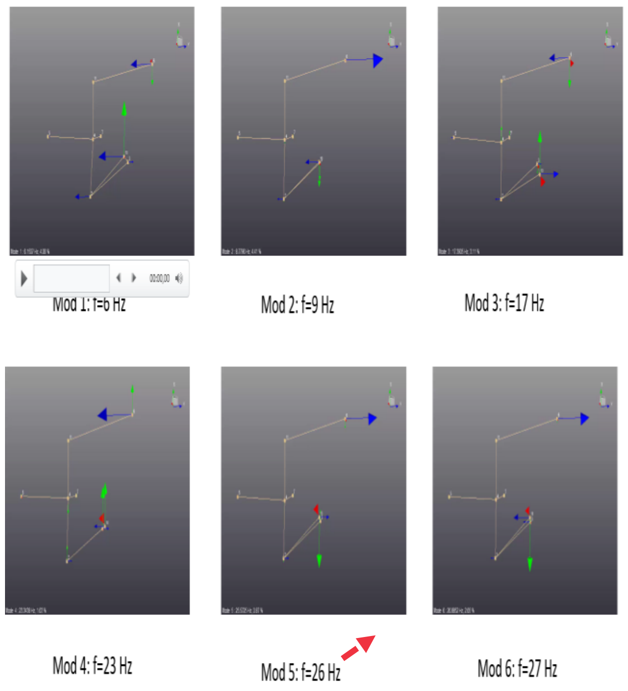
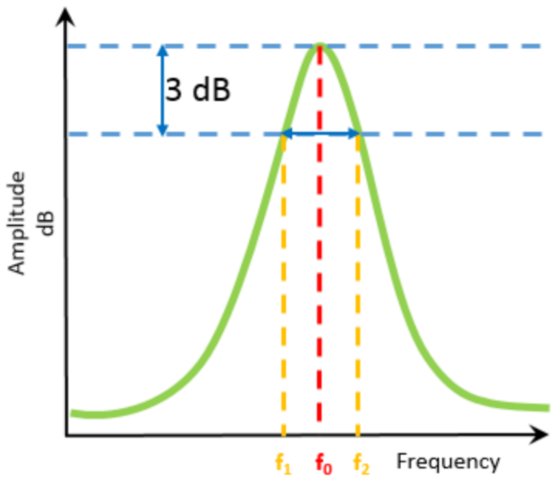
Figur Horisontell mobilitet i mätpunkter Nya Hovås (vertikal markposition som streckad linje). B motsvarar förstärkning till byggnad golv



Aim: To decide the damping in percent of critical damping % [%Cr] at the fundaments eigenfrequencies in situ

Definition different damping values.



$$Q = \frac{f_0}{f_2 - f_1}$$

Källa Siemens.

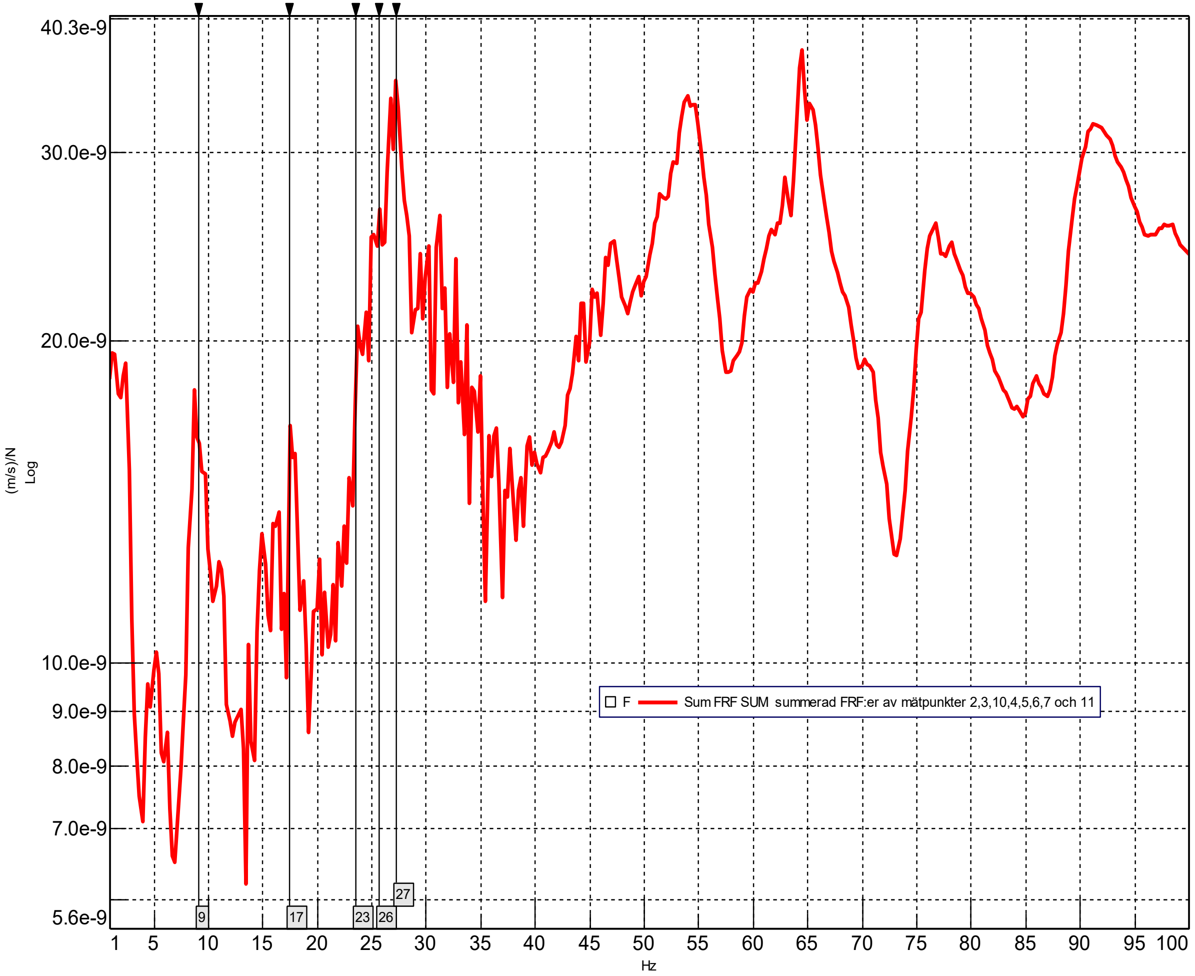
$$\eta = \frac{1}{Q} = 2\zeta = \frac{\%Cr}{50} = \tan\phi = \frac{\Delta\omega_{3dB}}{\omega_o}$$

η = loss factor
Q = damping factor or quality factor
ζ = damping ratio
$\%Cr$ = percent of critical damping ($\%Cr = 100\% x\zeta$)
ϕ = phase angle between cyclic stress and strain

Equation 1: Different damping quantities.

Identified eigenmodes from shaker test

Identified mode	Frecuency [Hz]	% of Critical damping	Ampification factor Q at resonance [-]
1	6.1	4.1	12
2	8.9	4.4	11
3	17	3.1	16
4	23	1.6	31
5	26	0.9	56
6	27	2.6	19
7	28	3.0	17
8	45	1.9	26
9	54	2.2	23
10	65	0.8	63
11	75	1.4	36
12	77	1.8	28
13	90	2.7	19



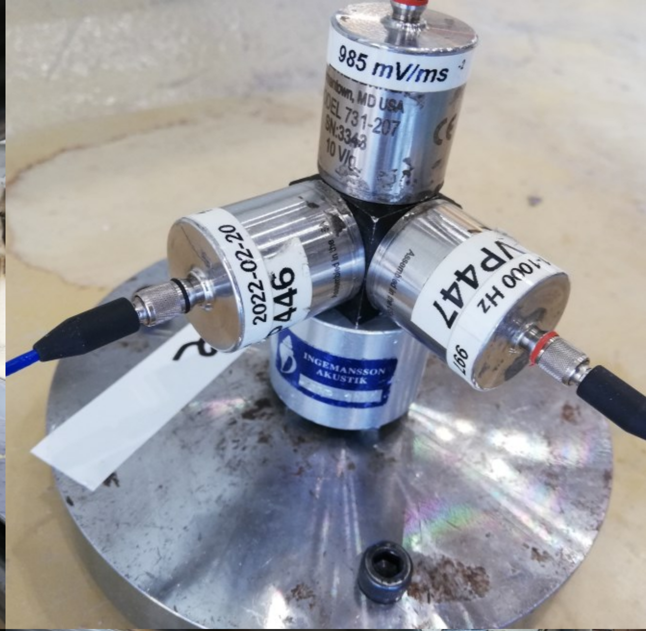
Rapport: 2022-09-07/Åsa Collet, Efterklang

Modal measurements of damping in machine foundation

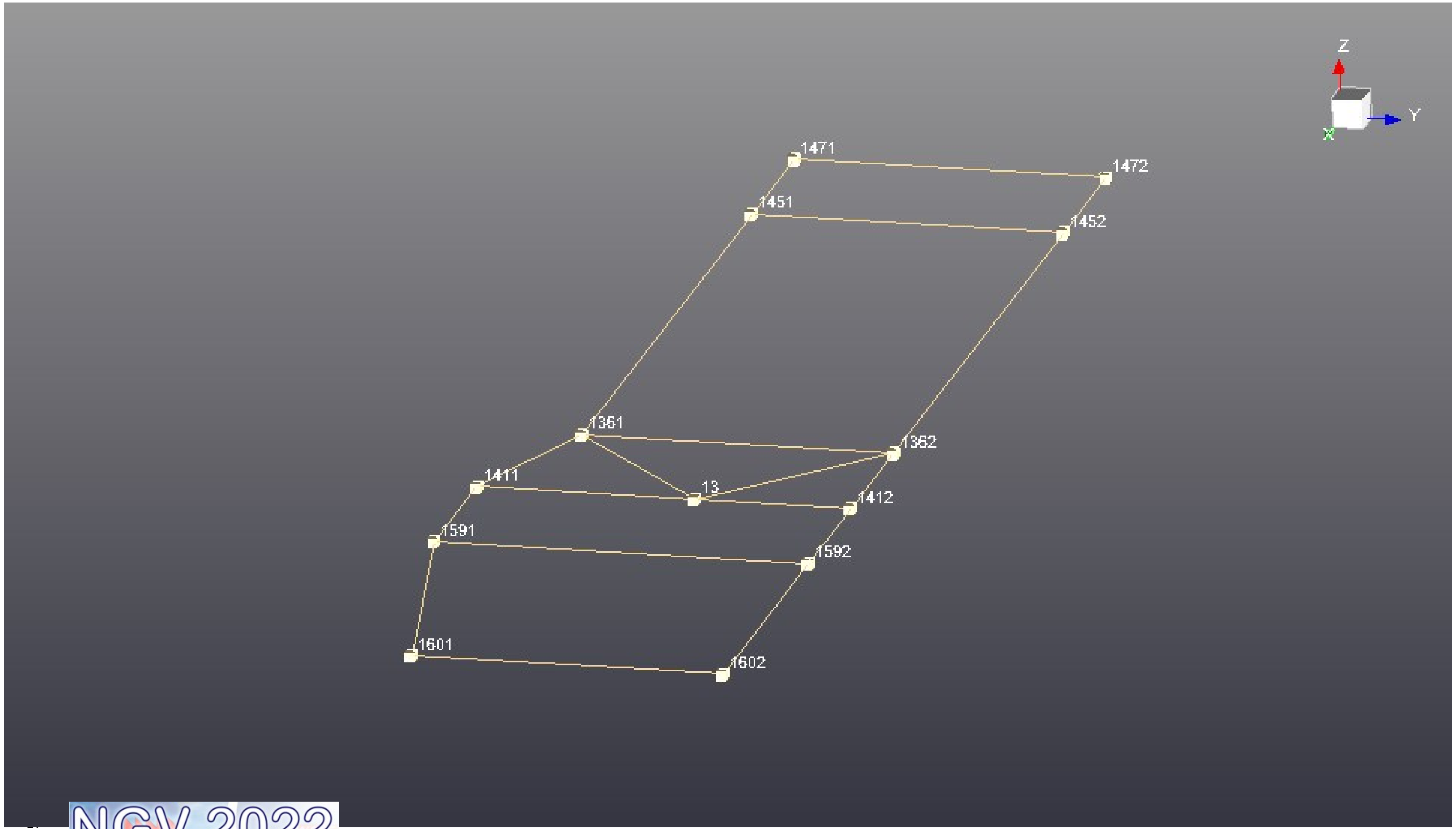
Measurement conducted: 2022-08-30
Personnel: Gustav Vågfelt & Åsa Collet
Analyses: Åsa Collet

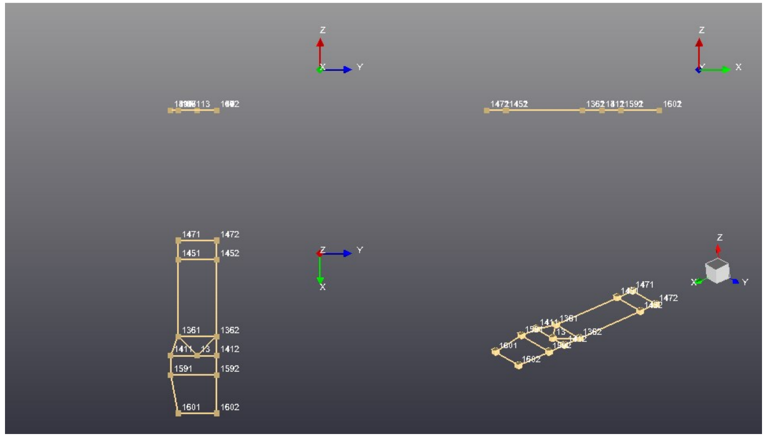
Results:

- Identified eigenfrequencies and damping
- Mobilities from measured transferfunction
- Timesignal displacement and force under sinus sweep
- Compliance with coherence in driving point
- Dynamic stiffness in driving point



Thread model of measured points in x, y och z
- Animation of eigenmodes shapes (mode shapes)





Different views