

Machine-Induced Vibrations
MACHINE FOUNDATIONS




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Why do we need machine foundations?



Response from ChatGPT:

Machine foundations are needed to keep heavy machinery stable, safe, and accurate in operation  . Here's why they matter:


 **1. Vibration Control** Machines like compressors, turbines, generators, CNC machines, and large motors create vibrations. A proper foundation absorbs and dampens these vibrations to:

- Prevent damage to the machine
- Avoid transmitting vibrations to nearby equipment or structures
- Maintain precision and performance

Why do we need machine foundations?

  **2. Load Distribution** Foundations spread the machine's weight evenly into the ground so the soil isn't overstressed. This prevents:

- Settlement
- Tilting
- Misalignment

 **3. Alignment & Accuracy** Many machines need extremely precise alignment to function correctly. A rigid, stable foundation ensures:

- Proper shaft alignment
- Smooth operation
- Reduced wear and tear

Why do we need machine foundations?

🔒 **4. Safety** Stable foundations help avoid:

- Machine movement during operation
- Structural failure
- Accidents due to vibration or imbalance

🔧 **5. Anchorage & Fixity**

They provide a secure base to anchor bolts and supports, ensuring the machine doesn't shift or rotate under dynamic loads.

Why do we need machine foundations?

✂ **6. Durability & Reliability** Good foundations extend the lifespan of expensive machinery by minimizing:

- Fatigue
- Cracking
- Loosening of components

If you want, I can also explain the types of machine foundations, how they're designed, or how to choose one for a specific machine 😊.

Case Study: 17 MW Steam Turbine

Discussions based on two assessment criteria: **30 mm** and **± 20%**

5. FOUNDATION BOLTS (WITH NUTS, WASHERS & KEEP PLATES) FOR TURBINE & GENERATOR ARE IN 'AST' SCOPE OF SUPPLY, & ARE BEING SUPPLIED TO SUIT THE SLAB THICKNESS.
6. DYNAMIC FORCES GIVEN IN THE TABLE ARE THE UNBALANCE FORCES AT OPERATING SPEED.
7. MAXIMUM PERMISSIBLE AMPLITUDE OF VIBRATION ON TOP OF DECK IS 30 MICRONS.
8. TG SLAB BELOW TURBINE BASE PLATE WILL BE SUBJECTED TO AN EVEN TEMPERATURE OF MAX. 80°C. TEMPERATURE DIFFERENCE BETWEEN TOP & BOTTOM DECK SHALL BE CONSIDERED WITH AMBIENT TEMP. AT TG DECK BOTTOM
9. WEIGHT OF HEAVIEST SINGLE PIECE IS 12.8 TONS, ON OPERATING FLOOR.
10. CURB ANGLES TO BE PROVIDED ALL AROUND THE SLAB, FOUNDATION COLUMN, FOR TOP & BOTTOM CUTOUTS
11. NATURAL VERTICAL & HORIZONTAL FREQUENCIES & CORRESPONDING VERTICAL & HORIZONTAL AMPLITUDES FOR DESIGNED FOUNDATION SHOULD NOT FALL WITHIN 20% OF THE SPEED OF EITHER TURBINE OR GENERATOR. IT SHOULD BE WITHIN LIMIT OF IS -2974 PART III 1975.
12. THE DESIGN CALCULATIONS AND ALL NECESSARY SAFETY MARGINS TO BE CONSIDERED FOR THE CONSTRUCTION OF FOUNDATION, IS THE RESPONSIBILITY OF CIVIL DESIGNER.
13. T.O.C : TOP OF CONCRETE & T.O.G : TOP OF GROUTING
14. DIMENSION MARKED (*) TO BE CONFIRMED BY CUSTOMER AFTER CIVIL DESIGN
15. (**) MARKED DETAILS SHALL BE CONFIRMED AFTER RECEIPT OF VENDOR DRAWING.

Key Figures

Table Foundation:

Toptable: 5.0 x 12.0 x 1.4 m

Columns: 0.8 x 0.8 x 7.1 m

Baseplate: 5.0 x 12.0 x 1.2 m

Operational Speeds:

Turbine: 7'446 rpm (=124 Hz)

Generator: 1'500 rpm (= 25 Hz)

Rotating Masses:

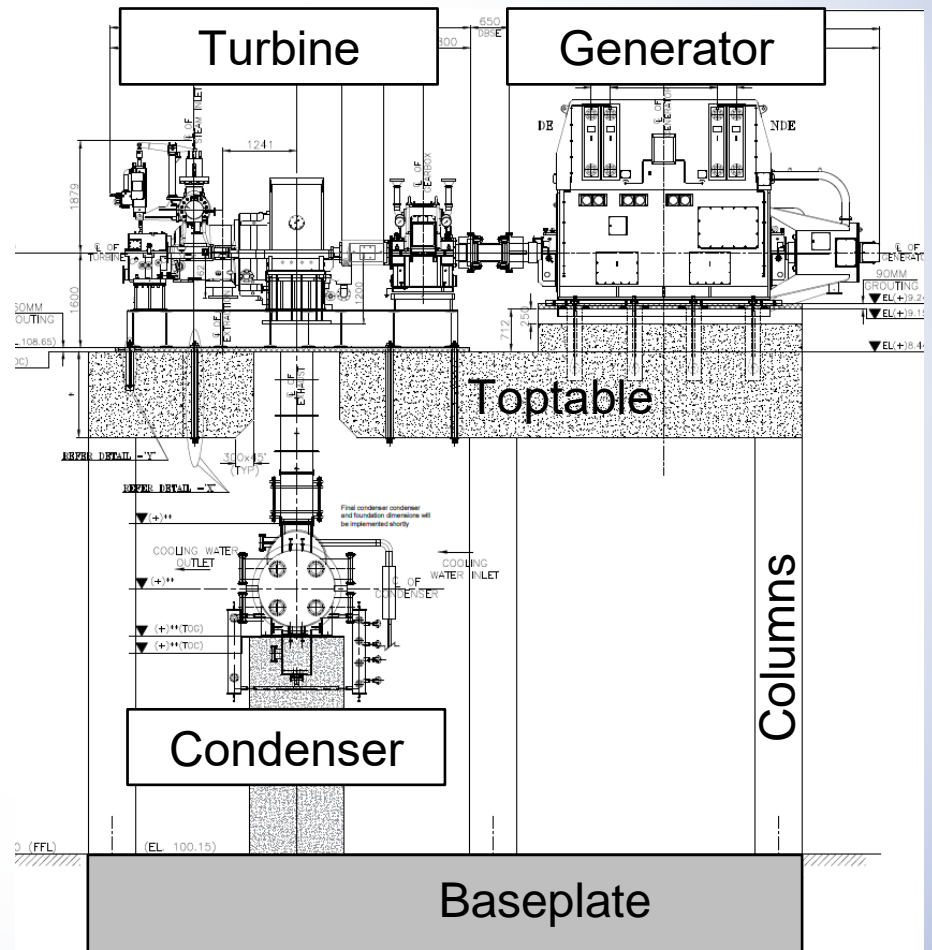
Turbine: 3.3 t

Generator: 12.9 t

Machine Masses:

Turbine: 59 t

Generator: 47 t



Allowable Vibrations

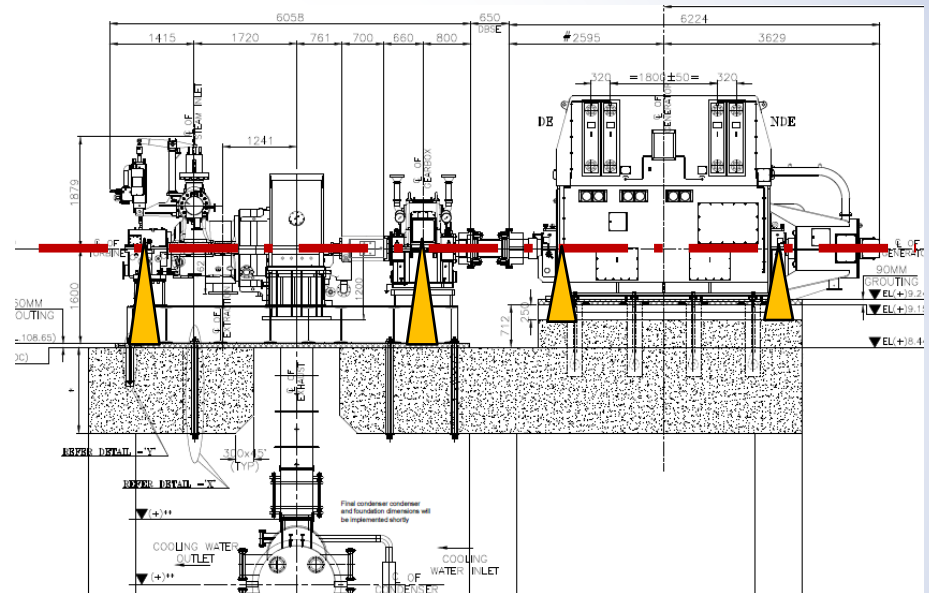
Ensuring reliable machine operation, low wear and tear.

According to the machine manufacturer's specifications, the **permissible vibration amplitude** on the foundation table is **30 μm** .

Usually, allowable vibrations amplitudes are defined in [mm/s]

→ Forced vibrations for normal operation caused by rotor unbalance

→ Excitation at the bearings



ISO 20816-1 - Machine Vibration

Mechanical vibration — Measurement and evaluation of machine vibration Part 1: General guidelines

Velocity Severity	Velocity Range Limits and Machine Classes					
			Large Machines			
mm/s RMS	Small Machines Class I	Medium Machines Class II	Rigid Supports Class III	Less Rigid Supports Class IV		
0,28	Good	Good	Good	Good		
0,45						
0,71						
1,12	satisfactory	satisfactory	satisfactory	satisfactory		
1,80	unsatisfactory (alert)					
2,80	Unacceptable (danger)	unsatisfactory (alert)	unsatisfactory (alert)	satisfactory		
4,50		Unacceptable (danger)	Unacceptable (danger)	unsatisfactory (alert)		
7,10				Unacceptable (danger)	Unacceptable (danger)	
11,20		Unacceptable (danger)	Unacceptable (danger)	Unacceptable (danger)	Unacceptable (danger)	
18,00					Unacceptable (danger)	Unacceptable (danger)
28,00	Unacceptable (danger)					
45,00	Unacceptable (danger)	Unacceptable (danger)	Unacceptable (danger)	Unacceptable (danger)		

Conversion of s_{\max} to v_{rms} (harmonic vibration): $v_{\text{rms}} = 2 \cdot \pi \cdot f \cdot s_{\max} \cdot 0.707$

→ Case Study (Generator): $v_{\text{rms}} = 2 \cdot \pi \cdot 25 \cdot 0.03 \cdot 0.707 = 3.33 \text{ mm/s}$

Balancing Quality G

The balance quality G is a quality characteristic that enables rotors to be compared in terms of their balance.

$$G = e \cdot \Omega \quad [\text{mm/s}]$$

Eccentricity x angular velocity (of the rotating part)

Reference to centrifugal force: $F = m \cdot e \cdot \Omega^2 = m \cdot \Omega \cdot G$

Distinguish between the state immediately after commissioning and in the final state / worn out condition (usually one level worse).

ISO 21940-11 - Balancing Quality

Mechanical vibration — Rotor balancing —

Part 11: Procedures and tolerances for rotors with rigid behaviour

Balancing grade	Rotor types / examples of components
G 2.5	Medium and large electric motors and generators, compressors, computer drives, gas and steam turbines, machine tools, general mechanical engineering
G 6.3	Small electric motors and generators, pulleys, flywheels, fans, pumps, centrifuges, water turbines, rollers for paper and printing machines, parts of process engineering, general mechanical engineering
G 16	Drive shafts (propeller shafts, cardan shafts) with special requirements, parts of crushing and agricultural machinery
G 40	Car components: wheels, rims, wheel sets, drive shafts and crankshafts

Unbalance of the Generator

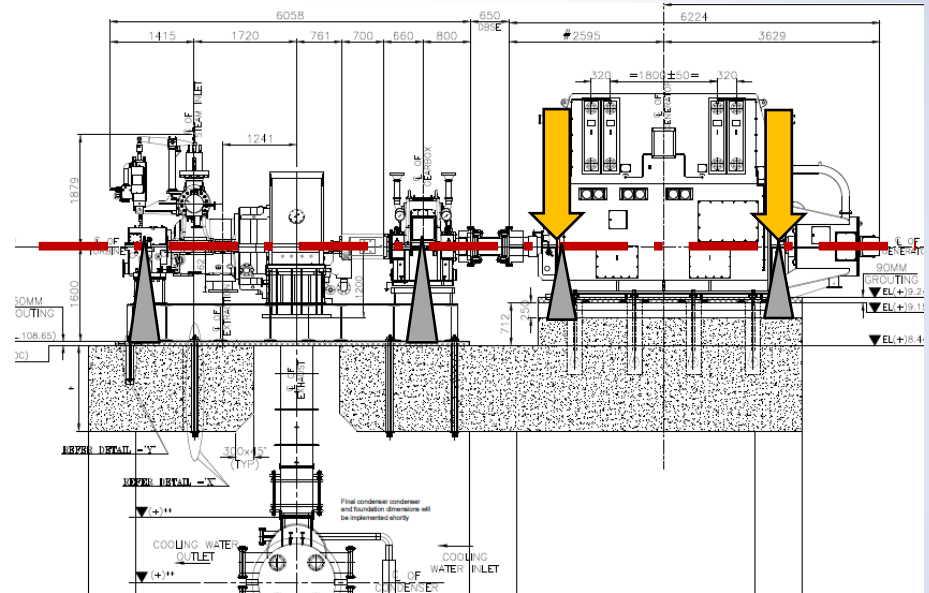
Balancing Quality: G 6.3
(worn out condition)

Rotormasse: 12.9 t

$$F = m \cdot e \cdot \Omega^2 = m \cdot \Omega \cdot G$$
$$= m \cdot 2 \cdot \pi \cdot f \cdot G = 12.8 \text{ kN}$$

Load Case:

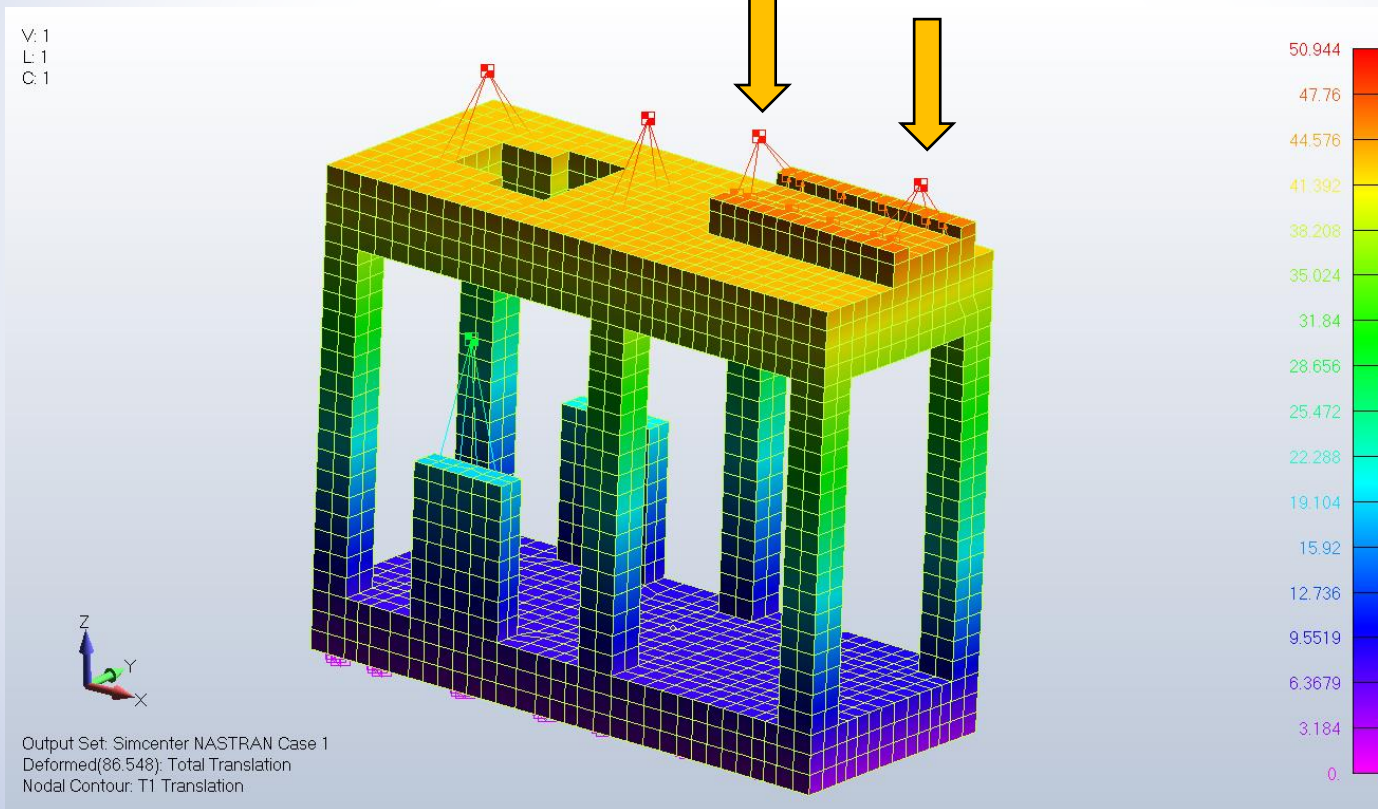
- Unbalance Vertical
- In phase on two bearings
- 2x 6.4 kN



Unbalance Generator: Amplitudes

Static Deflection:

$$s_{\max} = 51 \mu\text{m}$$



Unbalance Generator: Amplitudes

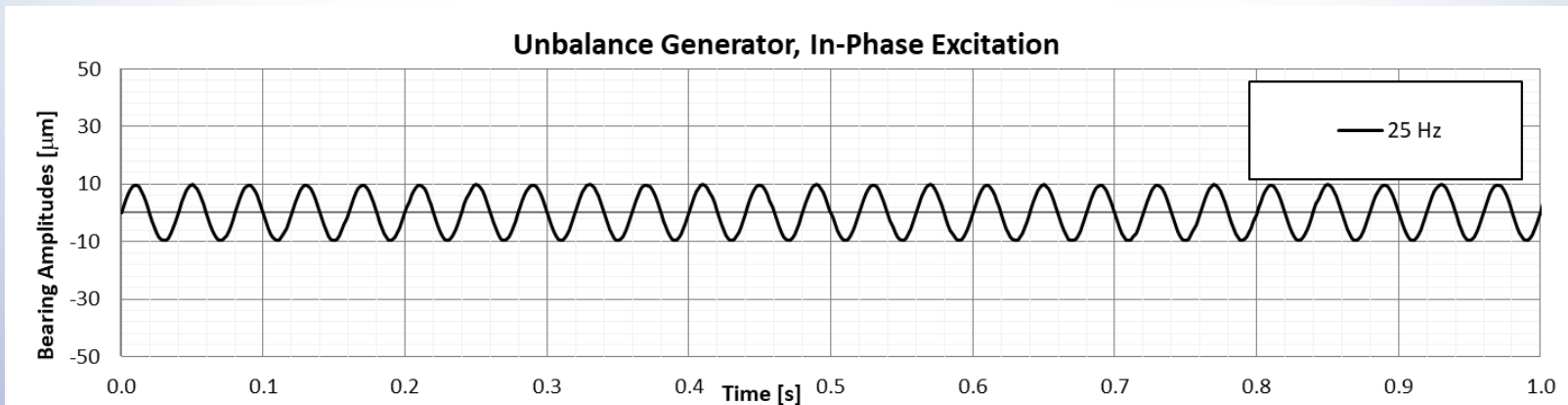
Static Deflection:

$$s_{\max} = 51 \mu\text{m}$$

Dynamic Amplitude (@ 25 Hz):

$$s_{\max} = 9.7 \mu\text{m}$$

$$v_{\max} = 1.5 \text{ mm/s}$$



Unbalance Generator: Amplitudes

Static Deflection:

$$s_{\max} = 51 \mu\text{m}$$

Dynamic Amplitude (@ 25 Hz):

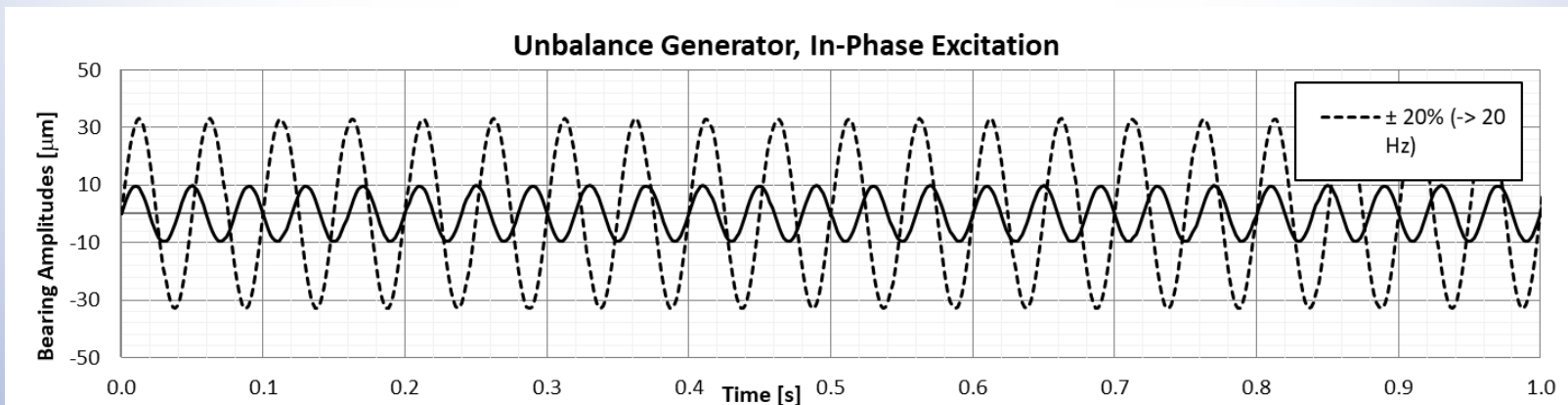
$$s_{\max} = 9.7 \mu\text{m}$$

$$v_{\max} = 1.5 \text{ mm/s}$$

Max. Dynamic Amplitude (@ 25 Hz \pm 20%):

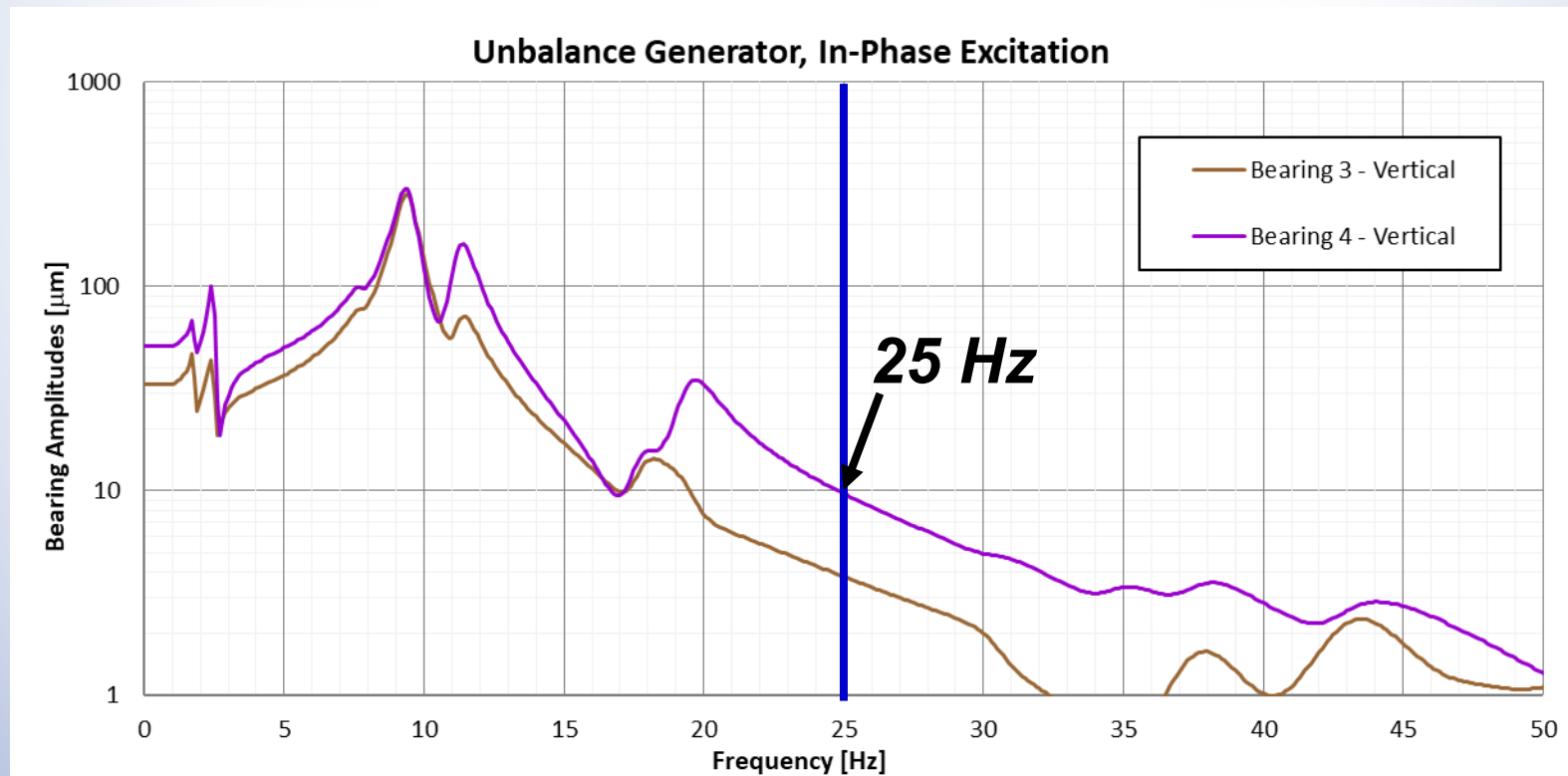
$$s_{\max} = 33 \mu\text{m}$$

$$v_{\max} = 5.2 \text{ mm/s}$$



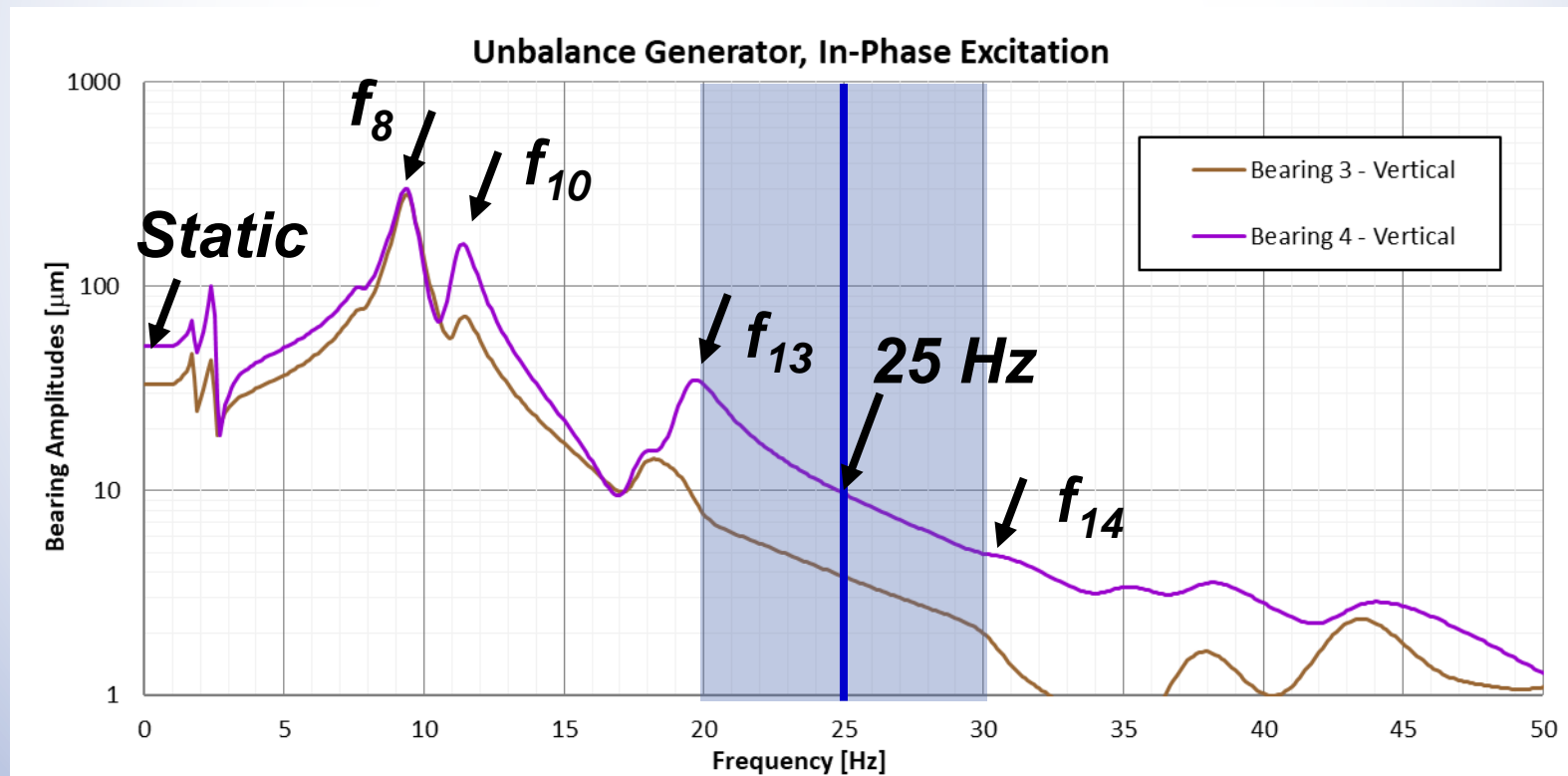
Sweep Calculations

The response of the foundation to excitation at the bearings is analysed using so-called Sweep Calculations. The calculation procedure is to sweep harmonic unit loads over the relevant frequency range.

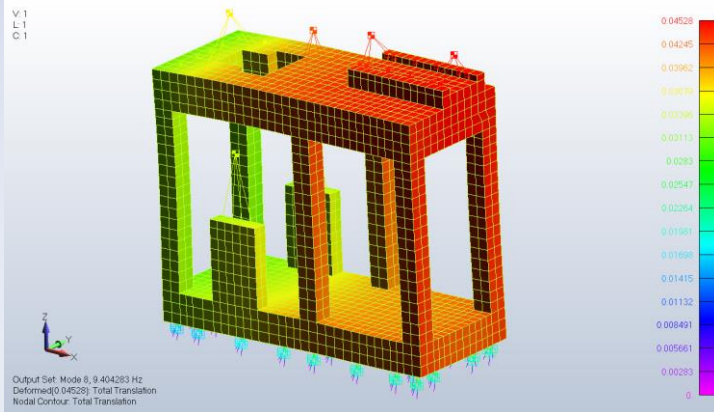


Sweep Calculations

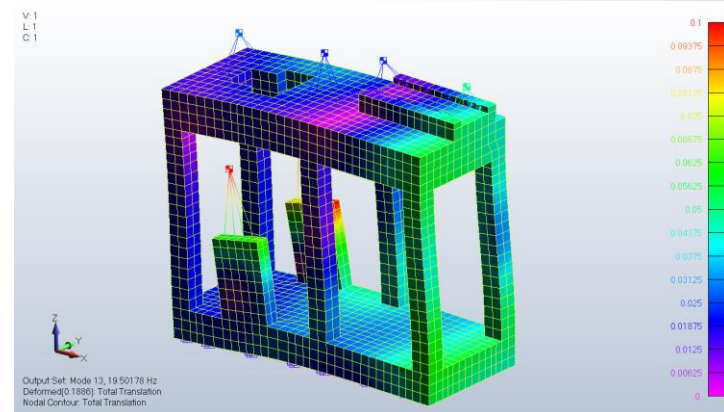
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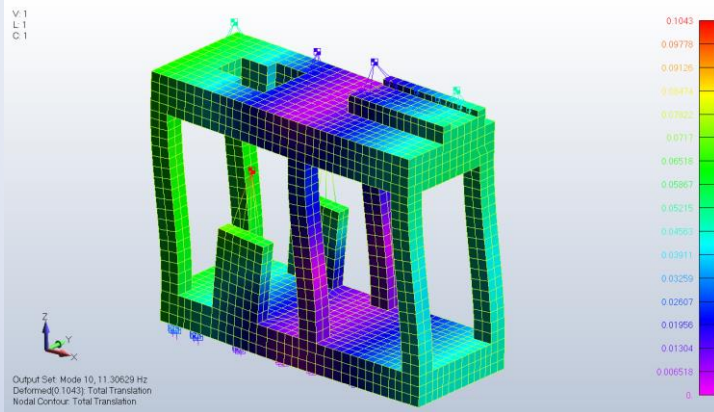
Structural Modes / Eigenfrequencies



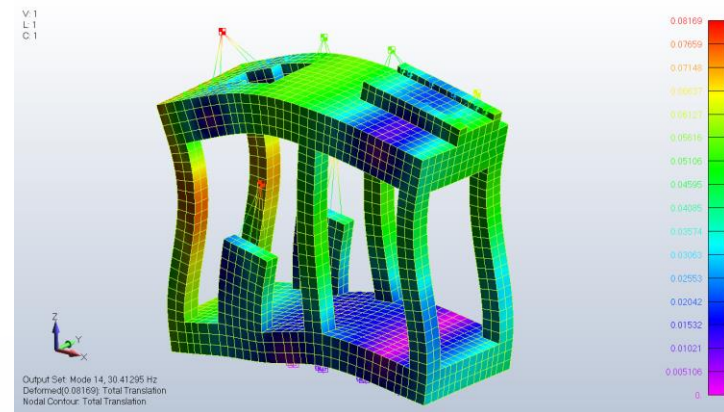
$$f_8 = 9.4 \text{ Hz}$$



$$f_{10} = 11.3 \text{ Hz}$$



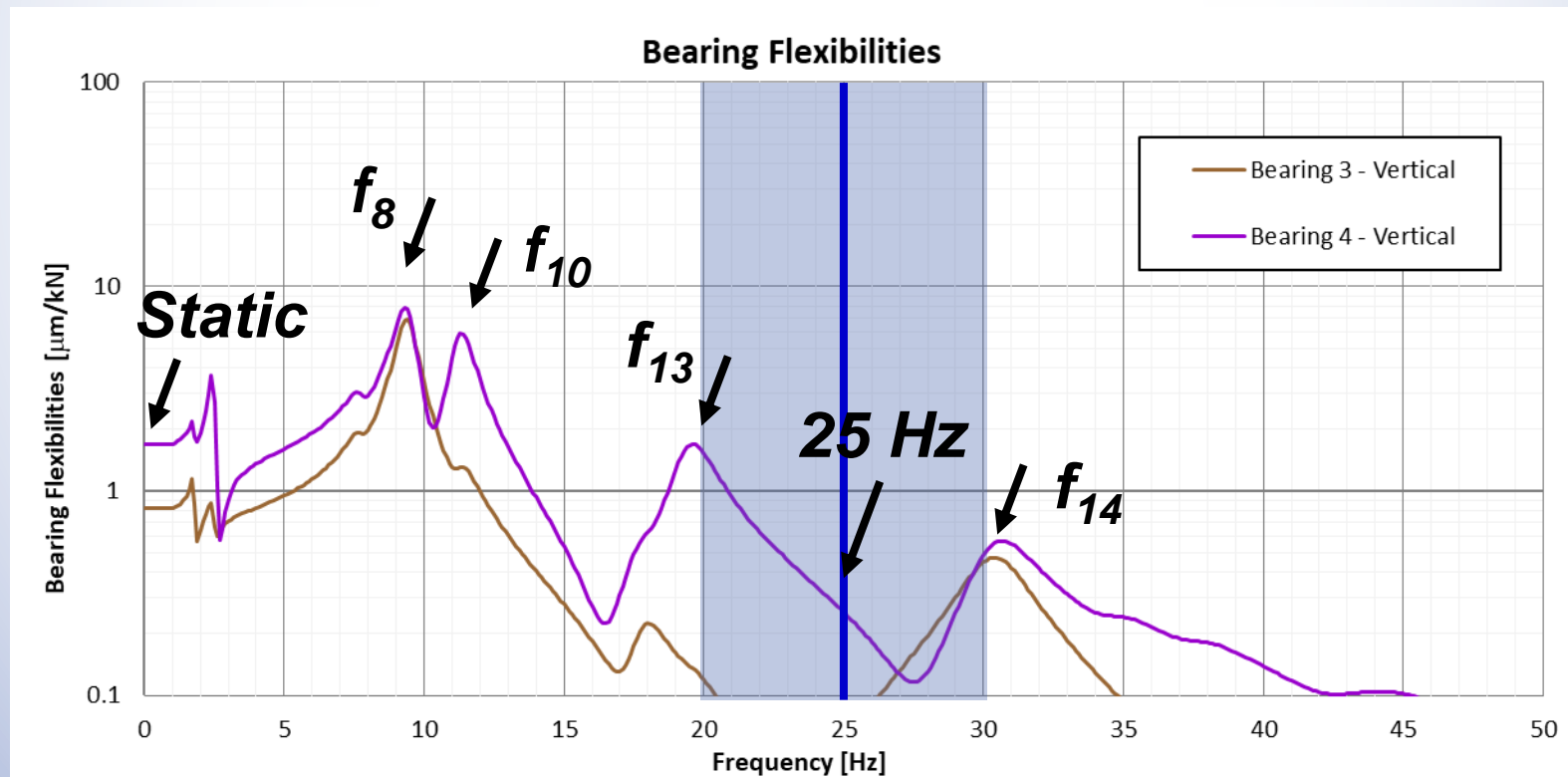
$$f_{13} = 19.5 \text{ Hz}$$



$$f_{14} = 30.4 \text{ Hz}$$

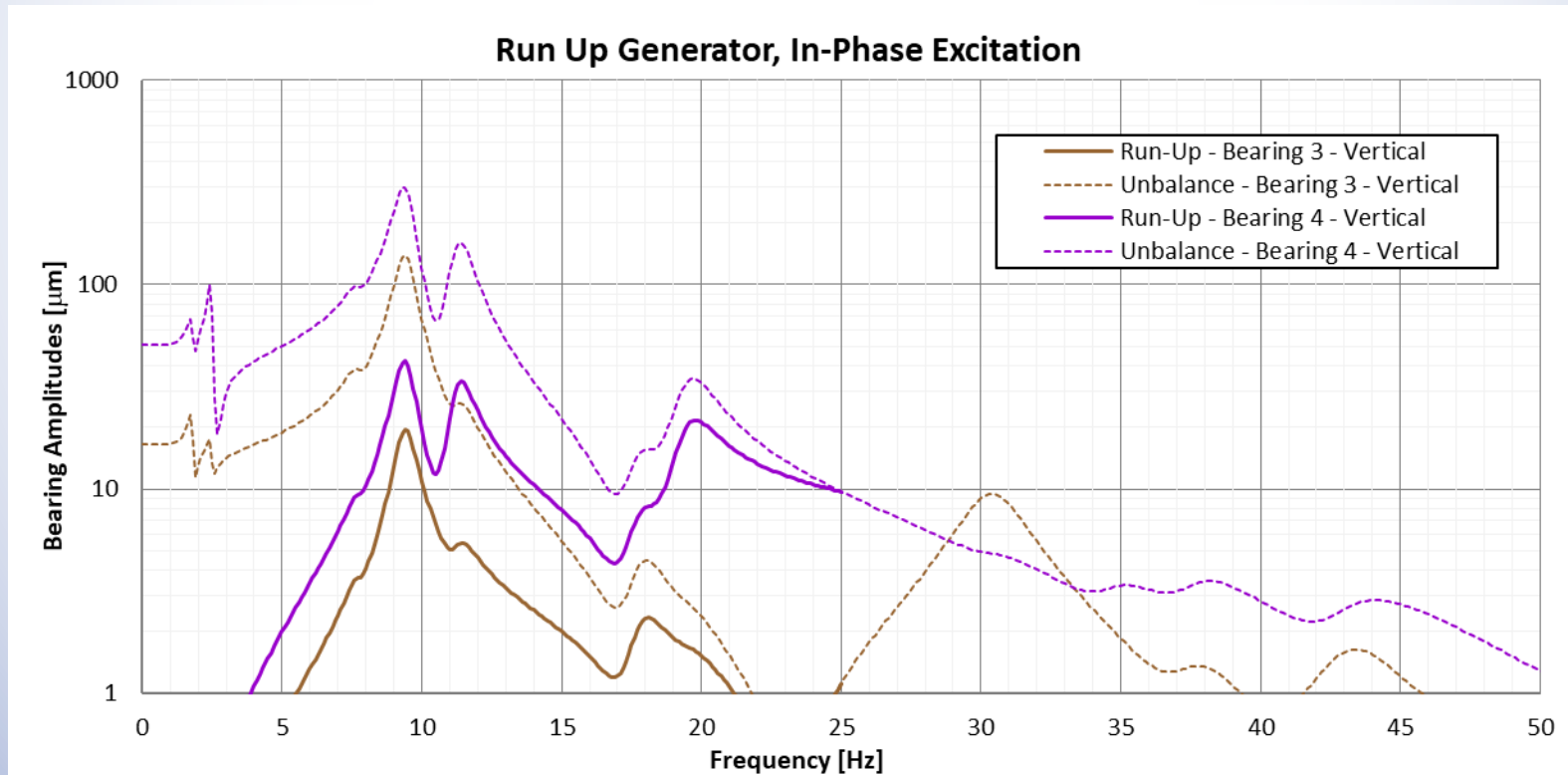
Bearing Flexibility

Sweep Calculations at each bearing to recognise the influence of the fundamental natural frequencies and to identify critical local structural eigenfrequencies.



Run Up / Shut Down

$$F = m \cdot e \cdot \Omega^2$$



Motion Amplification Camera

- High-speed camera + image processing software
- Light-based: Changes in brightness



Foundation Types

Slabs: For common workshops, base plates preferred

(Rigid) Blocks: Heavy inertia mass needed

Frames / Tables: Space needed below the machine

Decoupled Blocks or Tables: Low tuned systems, control of the dynamic behaviour, alignment possible

Machine Types:

- Rotating parts, oscillating parts, impacting parts
- harmonic, periodical, transient or stochastic excitation

Tables / Frames

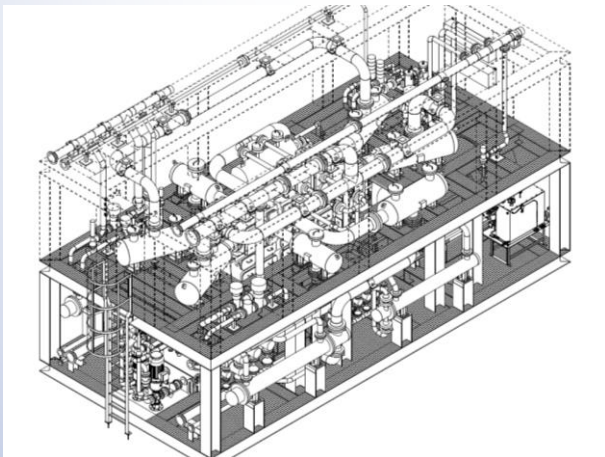


Turbo Generator

Blocks



Compressor



Compressor



Coal Mill

Slabs



Production Line

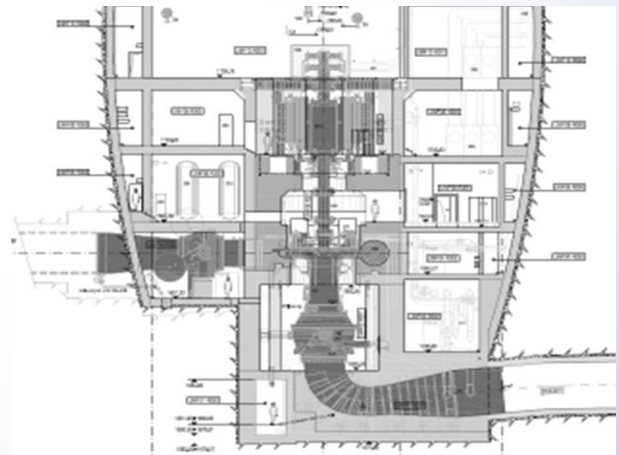


Workshop (test plate)

Various



Fan (Cement Mill)



Pump-Storage Power Plant

Mounting / Tuning

Spring Mounted Foundations:

*Very low tuned, dynamical decoupled
(e.g. supported by “soft” spring elements)*

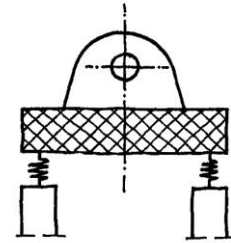
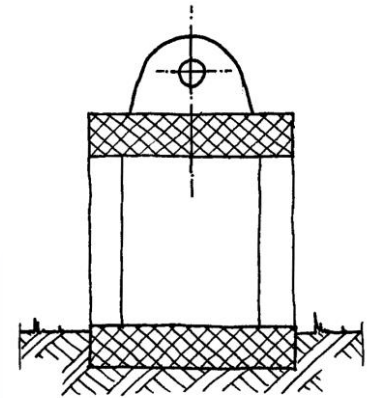


Table Mounted Foundations:

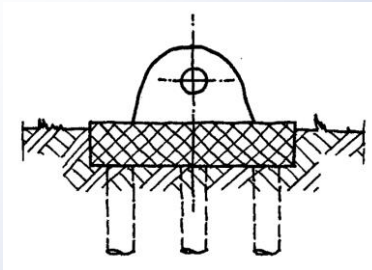
*Low tuned (e.g. supported by “elastic”,
slender columns)*

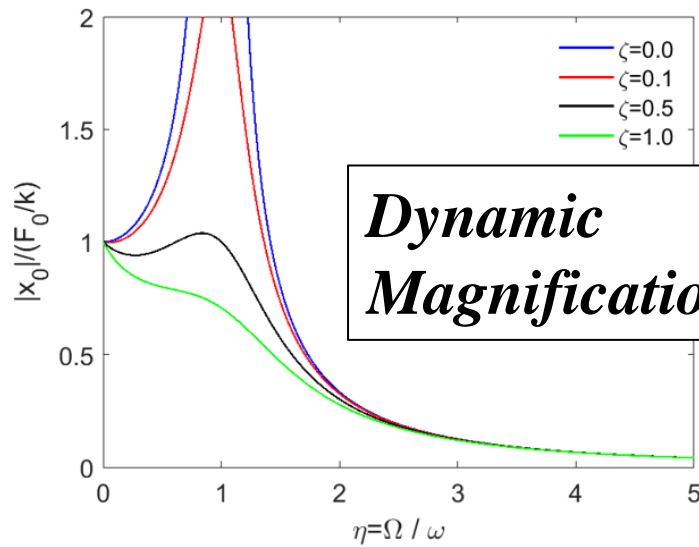
*High tuned (e.g. supported by “rigid”
columns)*



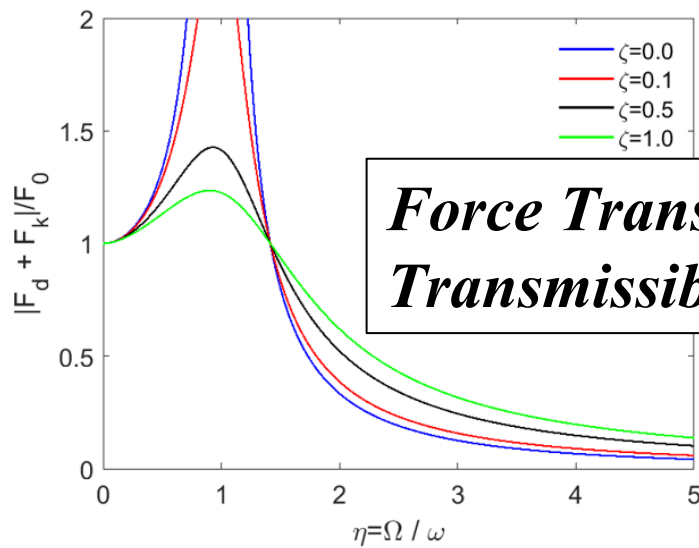
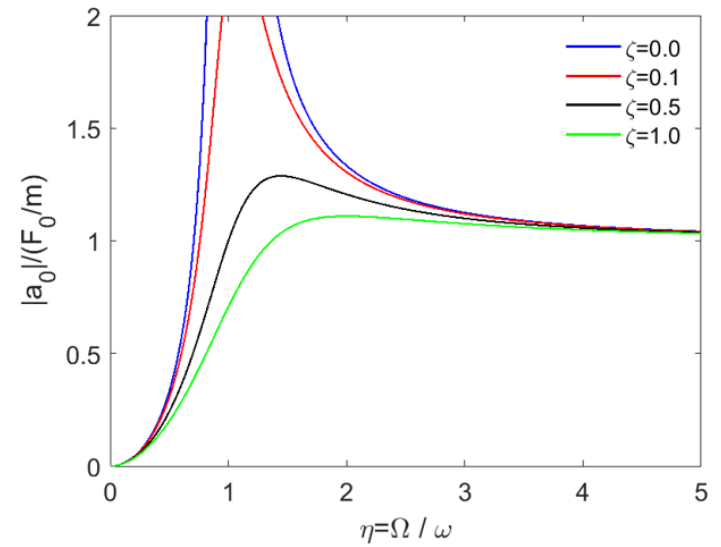
Raft Foundations:

*Soil mounted foundations,
if needed on piles*

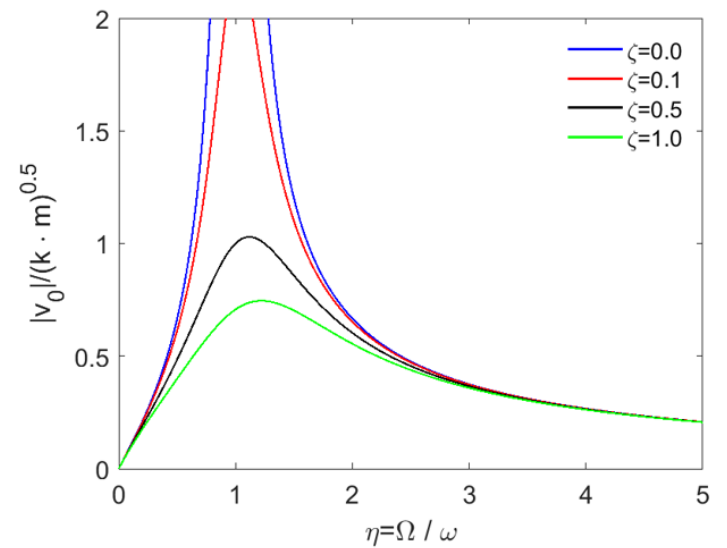




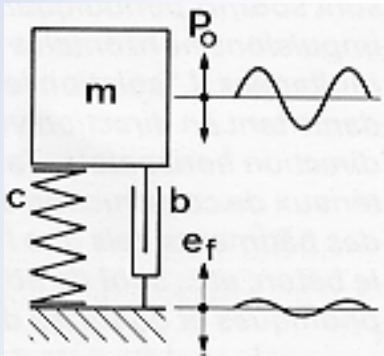
*Dynamic
Magnification*



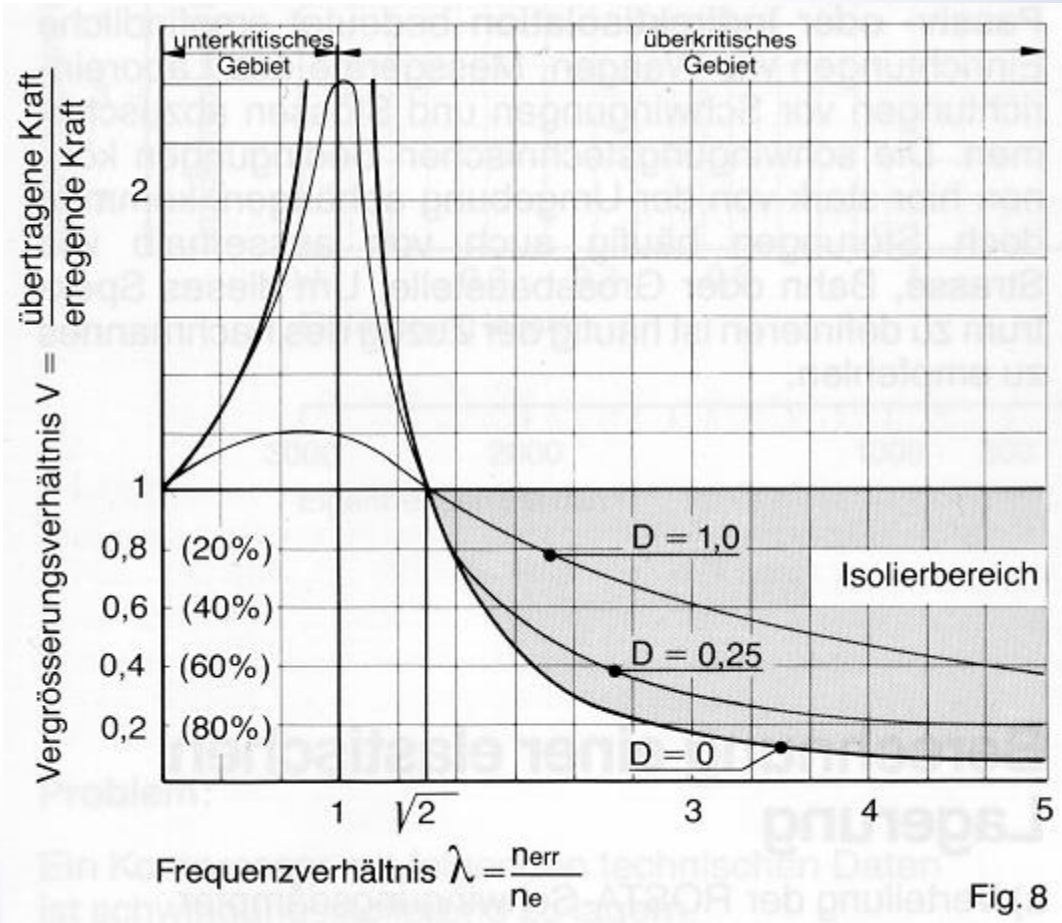
*Force Transfer /
Transmissibility*



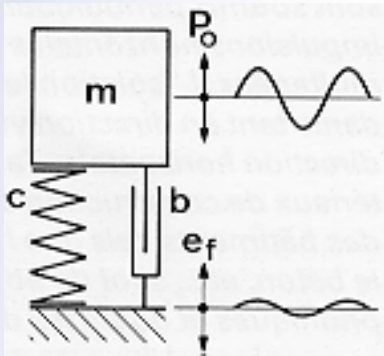
Design: Avoiding Resonances



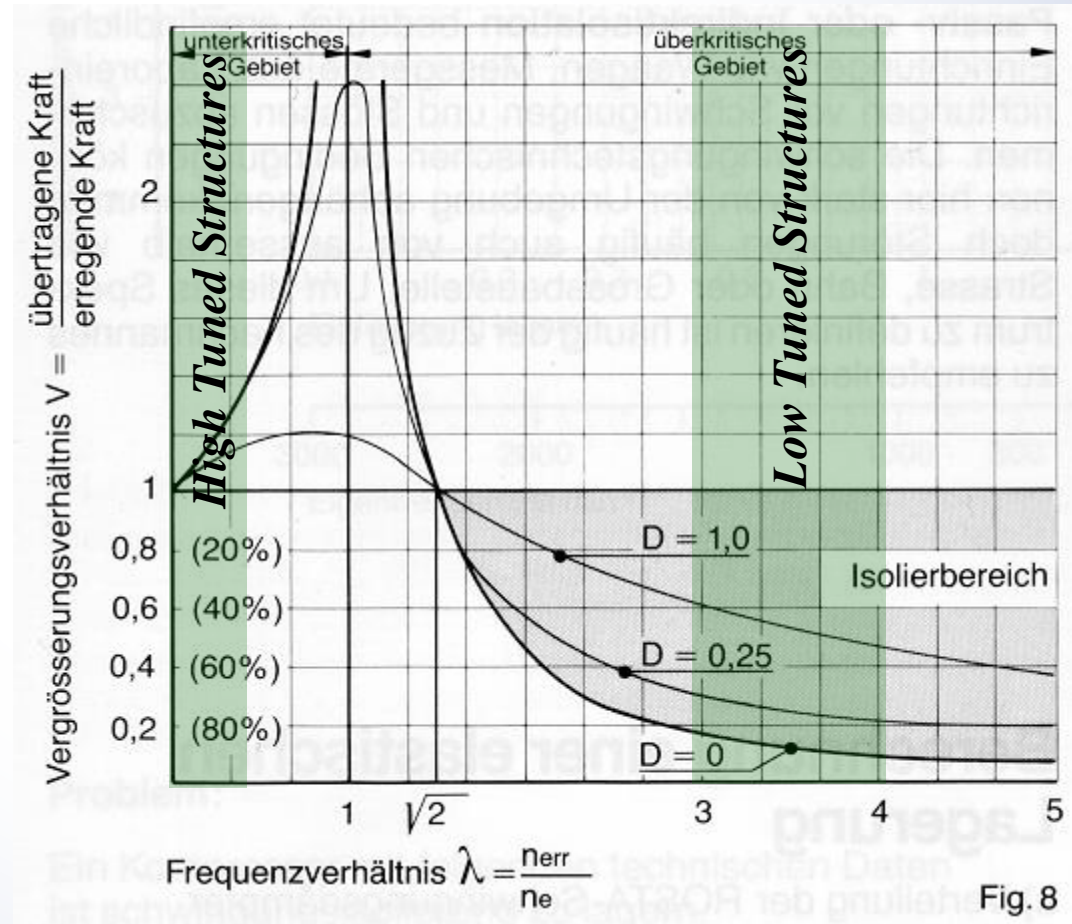
Spring-Mass-System



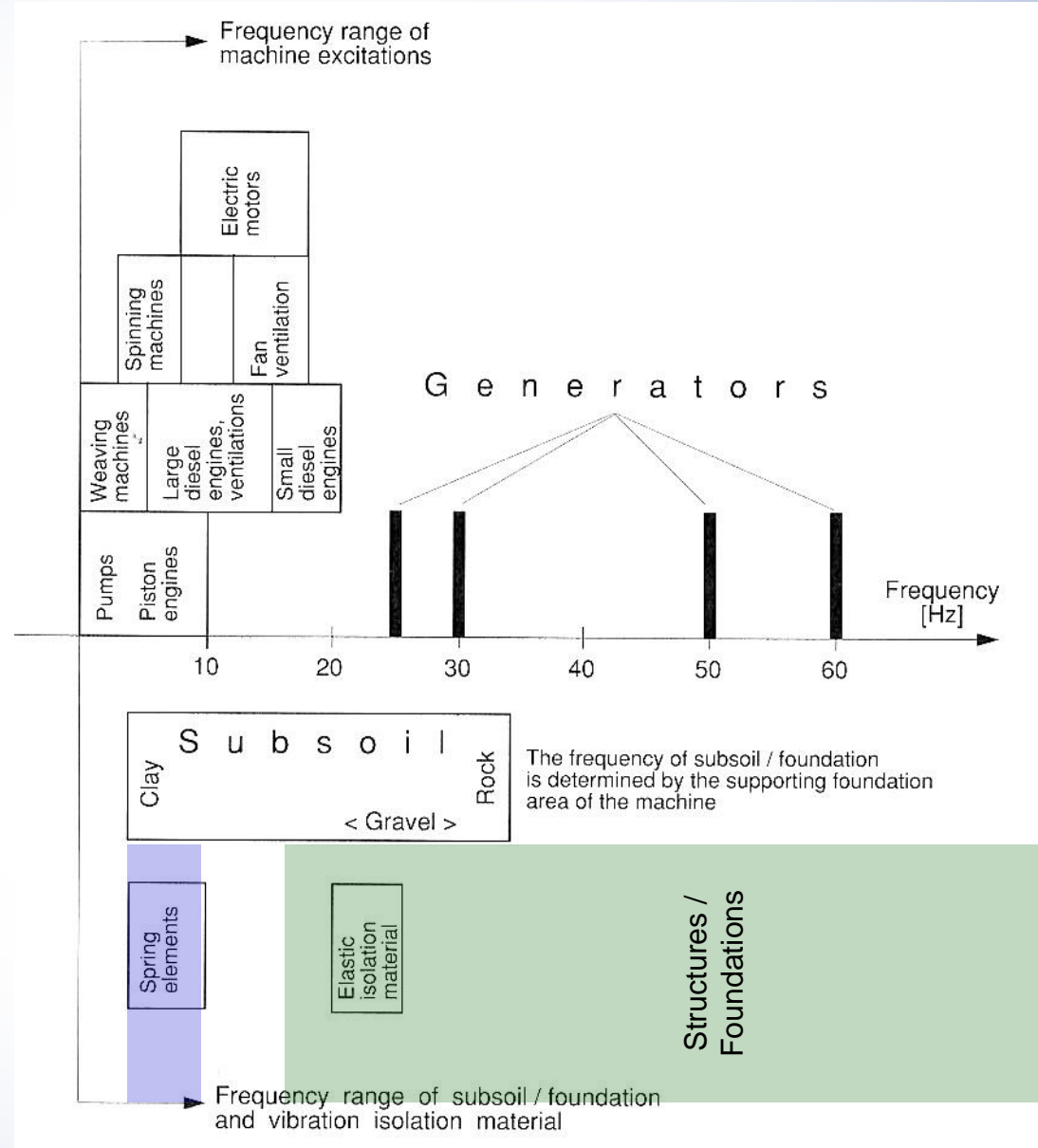
Tuning / Vibration Isolation



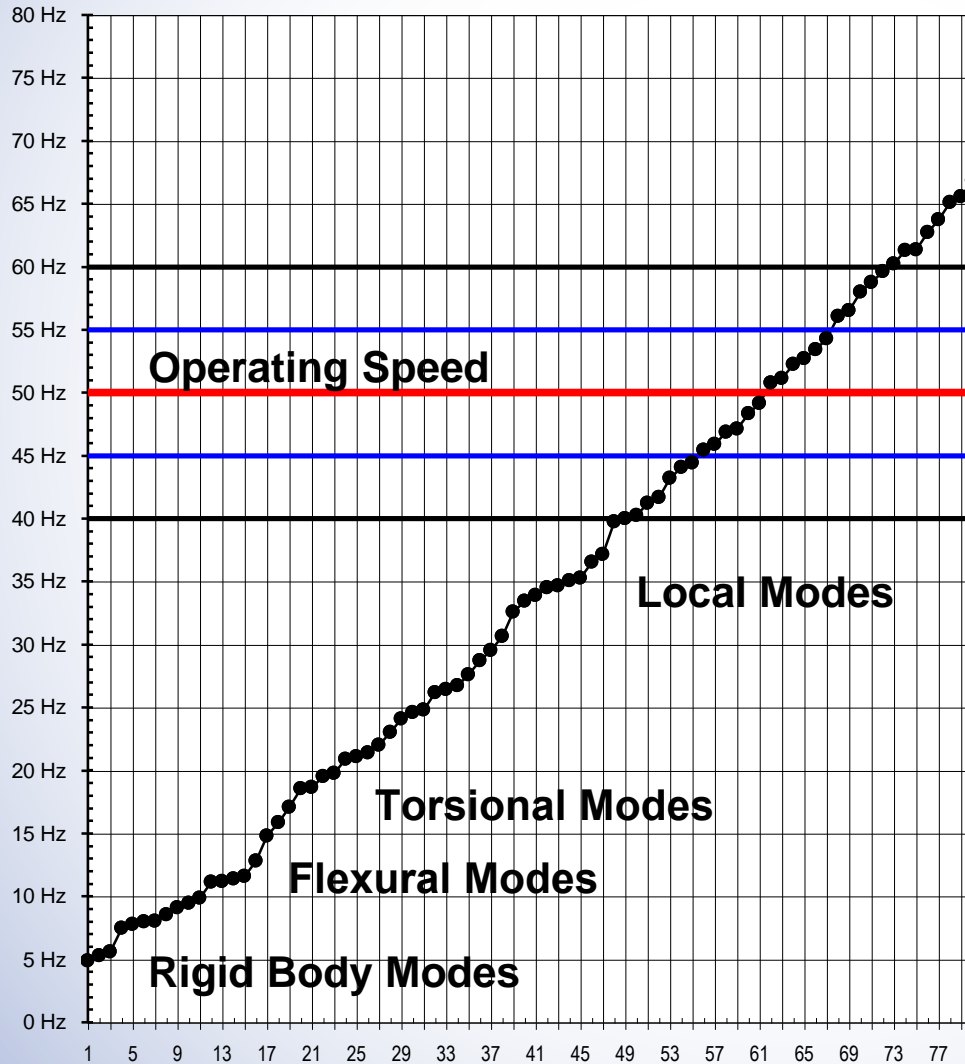
Spring-Mass-System



Operation Frequency vs. Mounting System

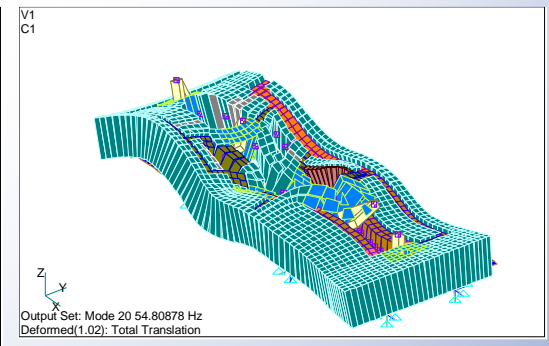
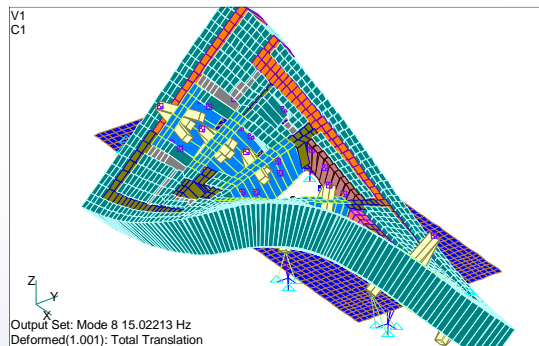
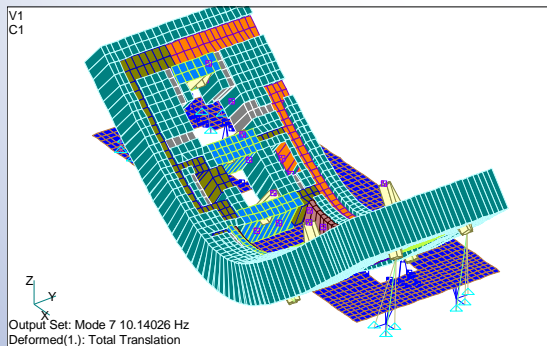
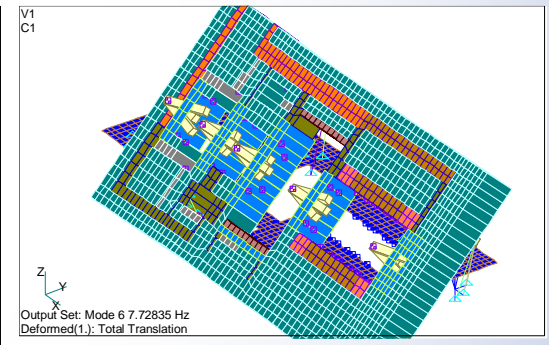
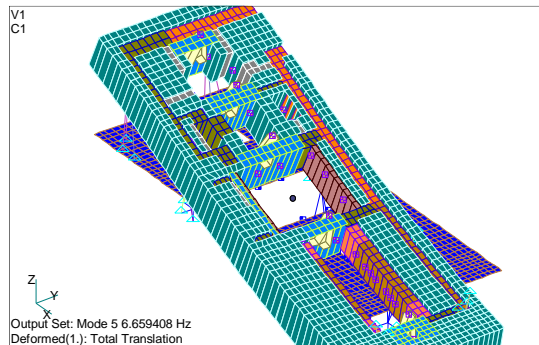
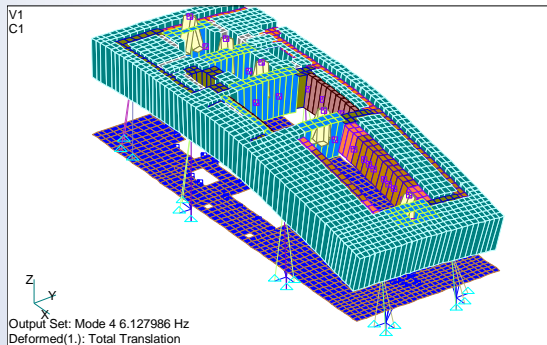
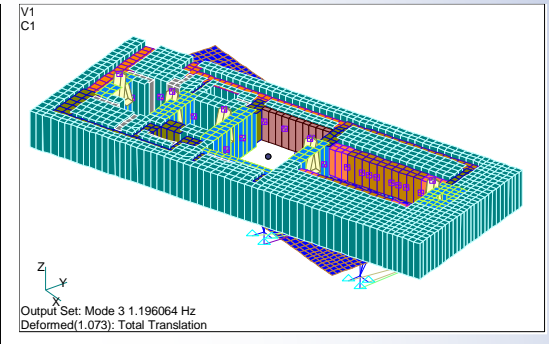
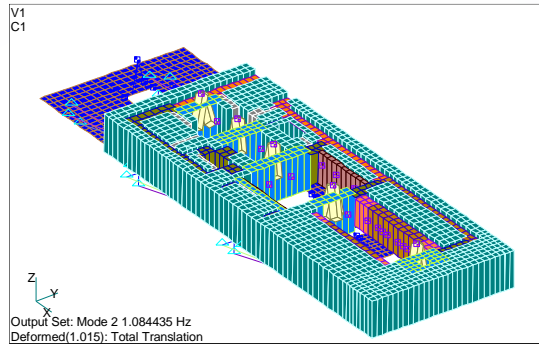
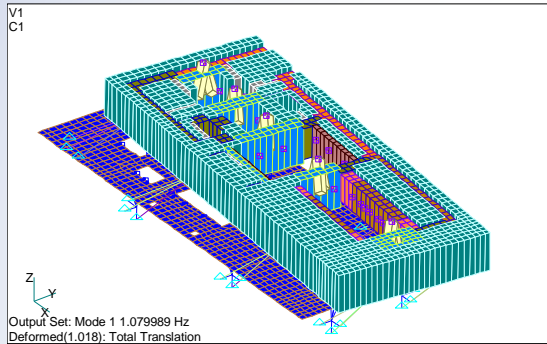


Structural Eigenfrequencies

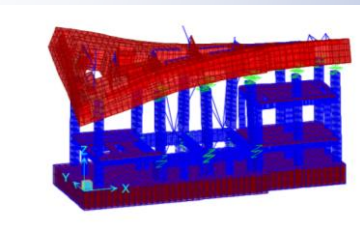
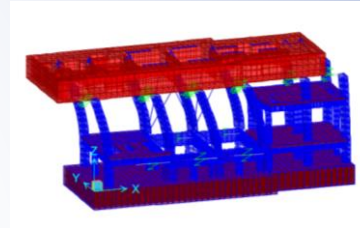
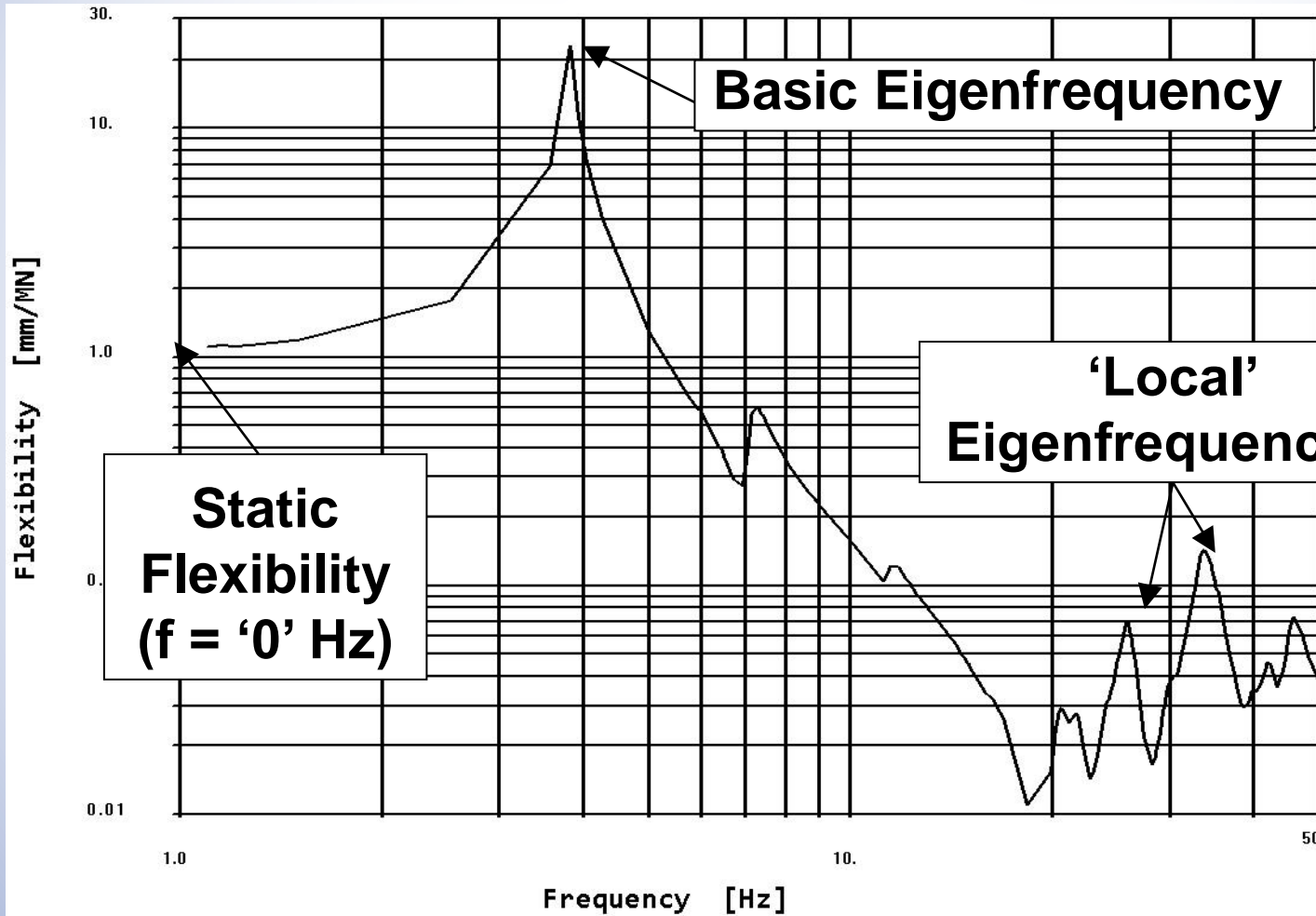


MODE	NATURAL FREQUENCY	PERIOD	PARTICIPATION FACTORS		
			X1	X2	X3
1	4.9	0.2041	519.6	39412.6	1.1
2	5.3	0.1901	54113.6	1791.3	13.6
3	5.6	0.1787	2345.8	12369.9	2.2
4	7.5	0.1342	285.1	36.3	7409.0
5	7.8	0.1288	335.2	9.1	13512.6
6	8.0	0.1255	1047.9	373.8	207.1
7	8.1	0.1242	129.8	4132.7	88.1
8	8.5	0.1171	260.1	15.7	35691.0
9	9.1	0.1100	14.9	0.0	5.9
10	9.5	0.1057	5.4	1087.6	40.1
11	9.9	0.1012	3.9	3.5	1399.3
12	11.1	0.0898	0.0	4.7	0.0
13	11.2	0.0892	51.3	0.0	196.1
14	11.4	0.0878	0.0	0.0	0.3
15	11.6	0.0864	0.8	221.3	5.5
16	12.8	0.0781	2.7	11.4	1.4
17	14.8	0.0677	308.6	0.0	151.6
18	15.8	0.0631	7.5	0.2	5.6
19	17.1	0.0585	0.3	0.6	2.2
20	18.5	0.0539	0.1	0.0	0.0
21	18.7	0.0536	0.1	0.0	0.0
22	19.5	0.0513	17.1	0.0	11.9
23	19.8	0.0505	2.8	0.0	78.7
24	20.9	0.0478	17.7	0.0	51.7
25	21.1	0.0475	5.0	0.3	15.0
26	21.4	0.0468	2.8	1.1	222.6
27	22.0	0.0455	0.7	1.0	159.2
28	23.0	0.0434	0.0	0.9	3.7
29	24.1	0.0415	2.3	1.4	49.2
30	24.6	0.0406	0.0	4.0	56.3
31	24.8	0.0403	0.1	0.8	1.8
32	26.2	0.0382	2.4	0.1	4.6
33	26.4	0.0378	0.5	0.4	72.1
34	26.7	0.0374	0.1	5.9	6.3
35	27.6	0.0362	0.7	0.0	0.4
36	28.7	0.0348	0.1	0.3	5.3
37	29.5	0.0339	0.1	0.5	0.0
38	30.6	0.0326	1.6	0.0	1.9
39	32.6	0.0307	0.5	1.3	0.2
40	33.4	0.0299	0.2	0.6	3.3
41	33.9	0.0295	0.0	0.0	0.0
42	34.5	0.0290	0.2	0.6	0.8
43	34.7	0.0289	0.2	0.1	0.0
44	35.1	0.0285	0.3	0.0	1.3
45	35.3	0.0283	0.1	0.8	0.0
46	36.5	0.0274	0.0	0.0	0.0
47	37.2	0.0269	0.6	0.0	0.2
48	39.7	0.0252	0.1	0.1	0.2
49	40.0	0.0250	0.3	0.1	0.0
50	40.3	0.0248	0.0	0.1	0.6
51	41.2	0.0243	0.1	0.0	0.1
52	41.7	0.0240	0.1	0.2	1.7
53	43.2	0.0231	0.0	0.0	0.0
54	44.1	0.0227	0.0	0.0	0.0
55	44.4	0.0225	0.0	0.0	0.0
56	45.5	0.0220	0.0	0.4	0.1
57	45.9	0.0218	0.0	0.6	0.1
58	46.8	0.0213	0.0	0.2	0.0
59	47.1	0.0212	0.2	0.1	0.5
60	48.3	0.0207	0.5	0.1	0.1
61	49.2	0.0203	0.9	0.1	0.0
62	50.8	0.0197	0.2	0.0	2.0
63	51.1	0.0196	0.0	0.0	0.2
64	52.2	0.0191	0.0	0.0	0.2
65	52.7	0.0190	0.0	0.0	0.3
66	53.4	0.0187	1.1	0.1	0.0
67	54.3	0.0184	0.0	0.0	0.0
68	56.0	0.0178	0.0	0.0	0.1
69	56.5	0.0177	0.4	0.0	0.0
70	58.0	0.0172	0.0	0.0	0.0
71	58.8	0.0170	0.0	0.0	0.0
72	59.6	0.0168	0.0	0.0	0.0

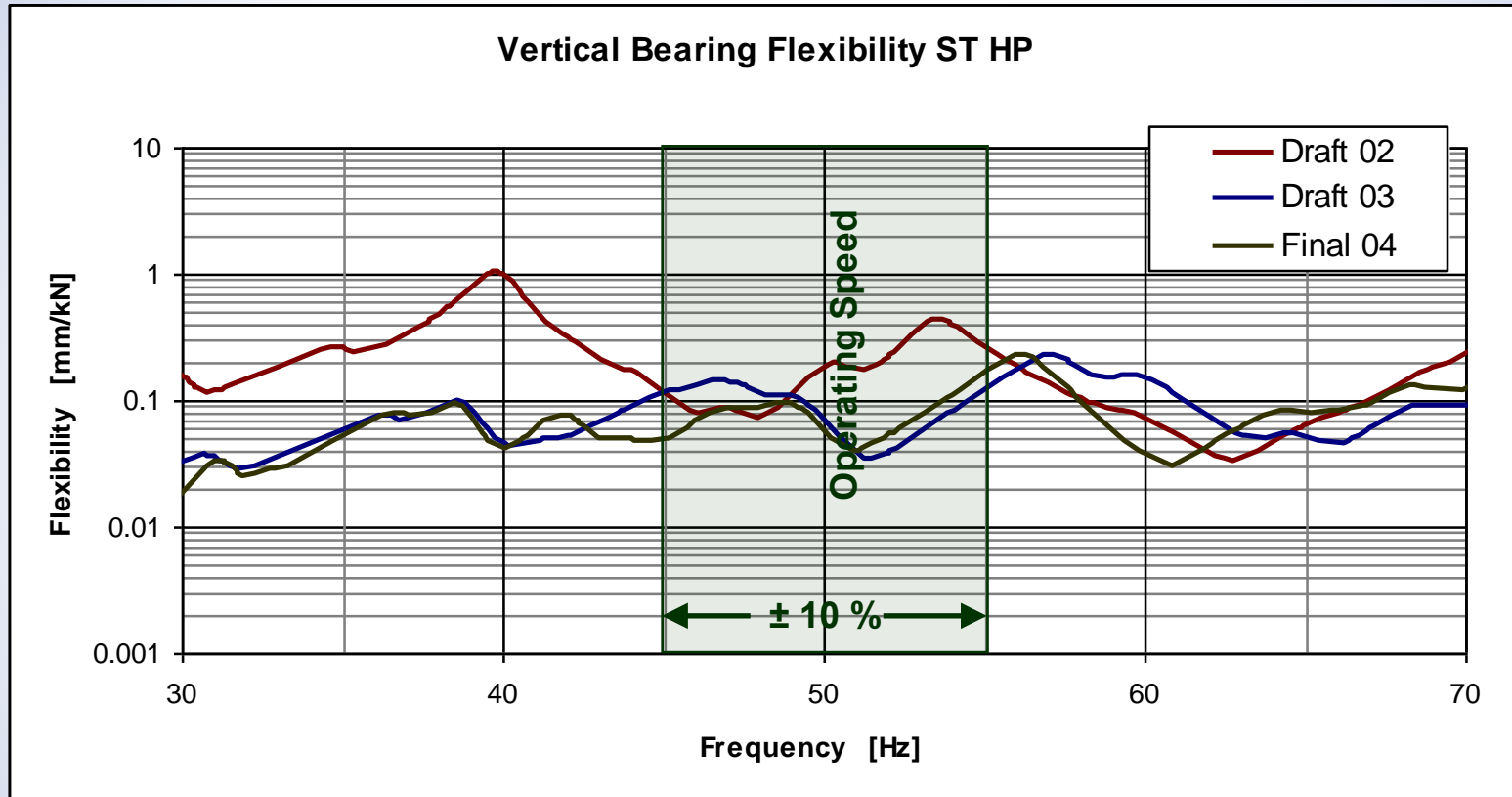
Eigenmodes “Toptable on Springs”



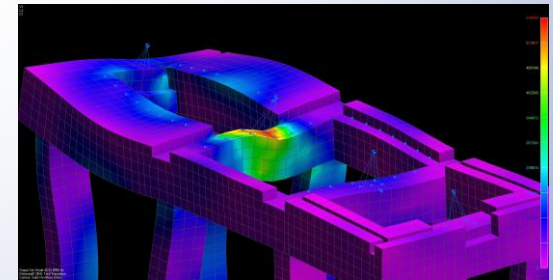
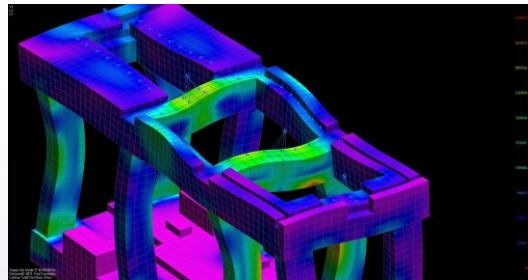
(Dynamic) Bearing Flexibility



Frequency Tuning of the Foundation Structure



-> **Avoiding local resonances / critical eigenfrequencies next to the operation speed**



Requirements

- **Fundamental eigenfrequencies not near the range of the operational speed.**
 - low tuned systems (eigenmodes < operational speed)
 - heavy mass on soft support
- **Forced vibrations of the foundation within the limits defined by codes or machine manufacturer.**
 - high stiffness and heavy mass
- **The design of the foundation structure has to include all sections forces like bending, distortional moments, shear forces and axial stresses for operational, accidental and seismic states**
 - material strength and thickness (inner lever arm)

Foundation Requirements (Cont.)

- **The overall stiffness of the foundation structure has to limit the deflections of the rotor shaft axis for the operational states, respectively the bearing flexibility. Limits defined by codes or machine manufacturer.**
 - high foundation stiffness to prevent deflections, twisting and warping
 - avoiding local resonances
- **The sensitivity to differential settlements has to be minimised.** → high stiffness required
- **Temperature effects has to be minimised.**
 - et al. high thermal inertia (= mass of concrete) required.

Foundation Requirements (Cont.)

- **Vibration isolation** has to guaranty that external vibrations will not affect / reduce the functional efficiency of the machine. On the other hand, the vibrations caused by the machine itself has to be absorbed mostly by the foundation itself so that no uncontrolled vibration propagation will affect adjoined structures / machines.
 - low tuned systems, high structural masses (= fundamental eigenmodes low below the operational speed).
- **Additional space for secondary elements** below and around has to be provided by the foundation (pipes, oil channels, condenser, etc).
 - limited maximum dimension of the foundation
 - restricted size and position of the columns

Further Considerations

- Allowable operational deflections:

"Misalignment Tolerance Matrix MTM,, relative or absolute bearing deflections or curvature of the rotor axis. -> „No“ deflections allowed.

- Differential subsoil settlements:

Difficult to predict, additional stiffness capacities of the foundation

- High accidental load cases

Blade loss (acc. DIN 4024 „Machine Foundations“: up to 18 times the rotor weight – static equivalent), short circuit, deflagration, etc.

In general: A foundation has to be stiff, heavy and softly supported!

Standard Design Checks (TG-Found.)

Dynamic Calculations:

- Natural Frequencies
- Flexibility of Bearing Supports
- Normal Operation (Unbalance)

Quasi-static Calculations:

- Strength Design
- Deflections: Rotor Curvature, Differential Rotation of Shaft and Bearing, Displacements
- Support Reactions
- Settlements
- Crack Width

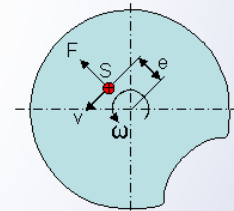
Main Machine Forces / Load Cases

Load Combination	Loading Case
N°	Load Combination
ULTIMATE LIMIT STATE	
1001	Operating State
1002	Unbalance Turbine Vertical
1003	Unbalance Turbine Vertical
1004	Unbalance Turbine Horizontal
1005	Unbalance Turbine Horizontal
1006	Generator Short Circuit
1007	Generator Short Circuit
1008	Vacuum Break
1009	Earthquake Longitudinal
1010	Earthquake Longitudinal
1011	Earthquake Transversal
1012	Earthquake Transversal
1013	Earthquake Vertical
1014	Earthquake Vertical
SERVICEABILITY LIMIT STATE	
Relative Deflections	
1015	Operating State
1016	Operating State + Therm. Ext.
Spring Supports	
1017	Machine Weight
1018	Dead Load
Operating	
1019	Operating State

Main parameter: Operational Speed(s)

ULS:

- Governing: Accidental States
- In general: Equivalent static forces
- Blade Loss
(up to 18x rotor weight)
acting at the bearings
- Generator Short Circuit
- Vacuum Break



Comment: Seismic Design regarding “Safe Operation Earthquake” and “Safe Shutdown Earthquake”

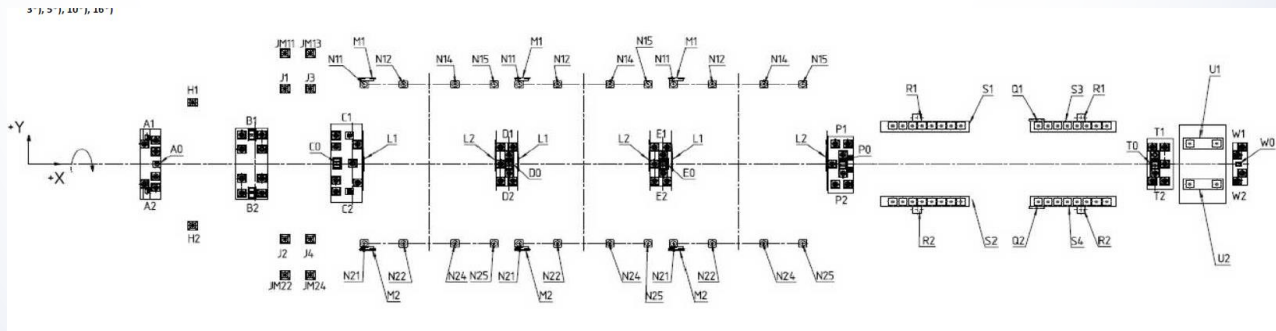
Machine-Foundation Interaction

In general, the machine is only considered as mass for the foundation design, where a distinction is made between rotor and casing. This means that mainly the casing stiffness and the impact of the rotor are neglected.

Rotor:



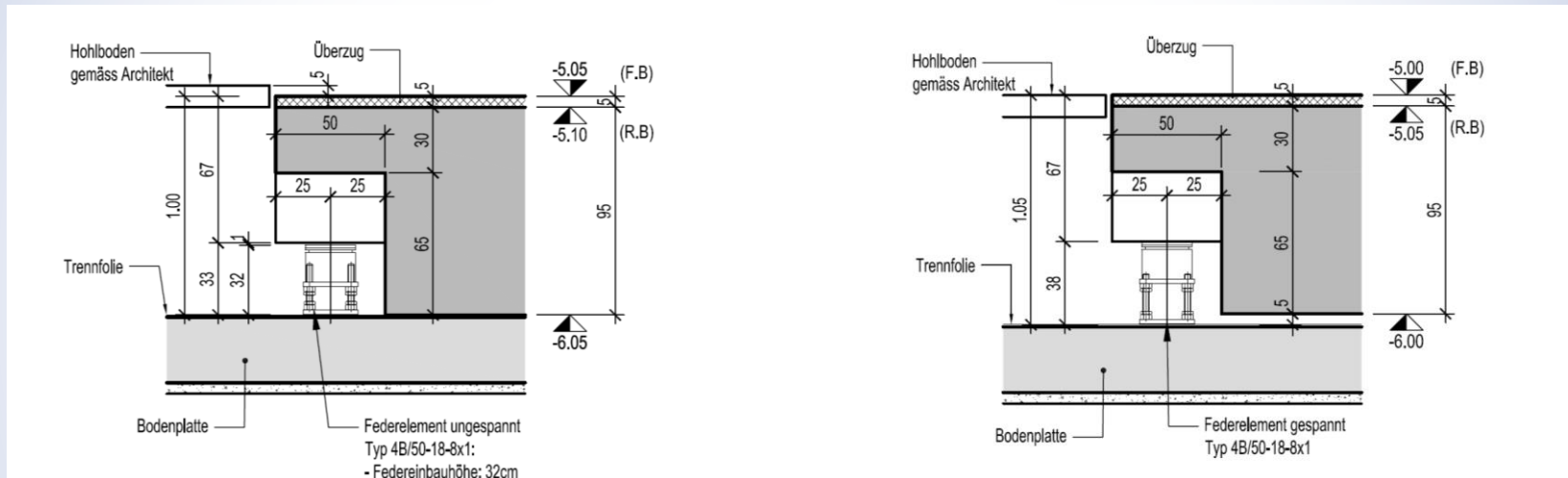
Casing:



Machine and foundation uncertainties: Sweep calculations

Construction Process

Spring Mounted Foundation: Loading procedure? Lifting?



Concreting of the foundation directly onto the floor / separating layer

Final state after lifting of the foundation

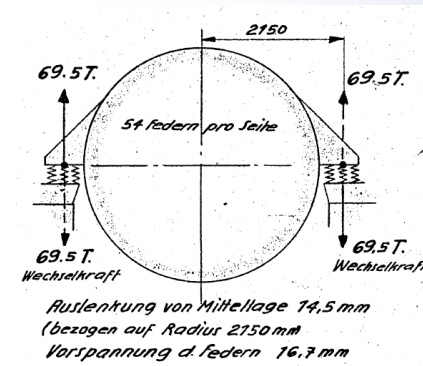
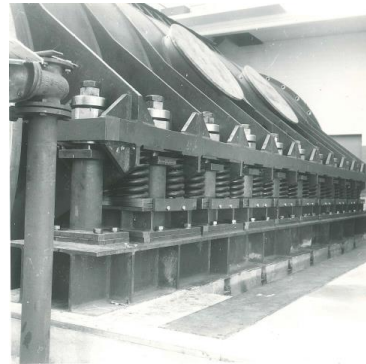
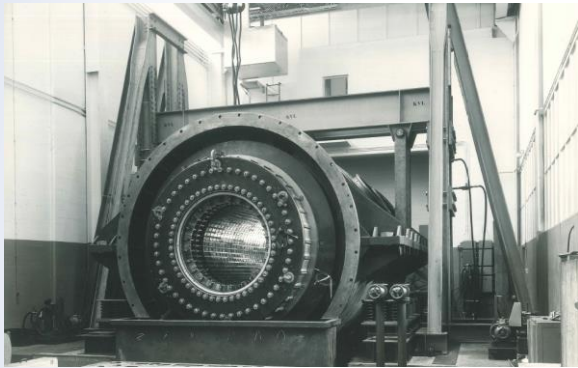
- *Excavation work, construction of a floor slab.*
- *Placement of the separation layer.*
- *Placement of formwork steel, embedded steel parts, anchor boxes, etc.*
- *Concreting of the entire foundation.*
- *Placing of the spring supports by the contractor.*
- *Installation of the machine.*
- *Loading of the spring supports and lifting of the foundation, fine adjustment*

Selected Case I:

Short Circuit Generator

Short-circuit generator replacement

Change: Tests at 60 Hz also to be considered



The bearing system has to be checked:

- Springs of the stator to be tested
- Verifications of the elastic bearing system

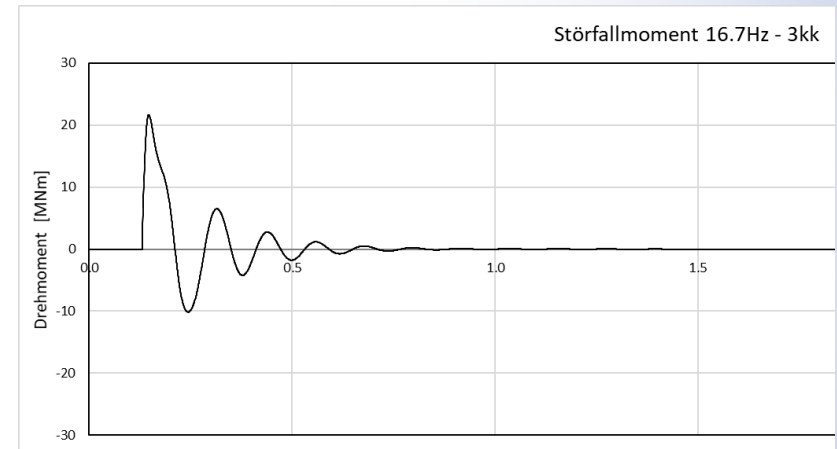
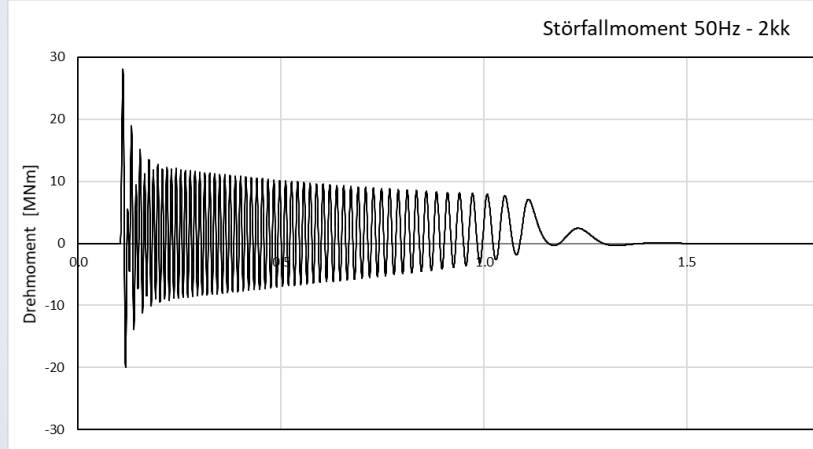
Testing frequencies: 16.7 Hz, 50 Hz and 60 Hz (incl. "2f oscillations")

Selected Case I:

Short Circuit Loads

Accidents on purpose: Testing of electrical devices / components

Loading examples (time history plots):



Several loading situations to be checked:

- decreasing (amplitudes)
- frequency drops
- impulse-like loading

Selected Case I:

Specialities / Comments

Low tuned system: Rotational eigenfrequency around 6.1 Hz

But: Natural frequency of the (helical compression) spring itself was critical. At 104 Hz (measured value), the spring fundamental frequency is within a critical range with regard to the planned 60 Hz tests: Run-through at the drop in speed of the "2f excitation frequency".

Conclusions: A minimal effect of the falling speed and the excitation of the spring fundamental frequency is to be expected. However, the critical range is passed through relatively quickly and a strong / significant amplification is not to be expected. The effect is therefore negligible for the design of the springs (e.g. regarding superimposed stress changes).

Selected Case II:

‘Reconstruction Toptable’



Lost steel formwork / new spring mounted toptable on existing substructure

Selected Case II:

Specialities / Comments

Before: High tuned structure

After: Low tuned structure

- Substructure to be designed for static loads only, governing dynamic forces only within the toptable

Lost steel formwork, to reduce overall construction time

These Days: More retrofits than new ones (in western country)

-> foundation assessments and adjustments

Machine-Induced Vibrations
MACHINE FOUNDATIONS

**Thank you for your
attention!**

Pascal Fleischer, TROMBIK Ingenieure AG

EPFL, Civil – Dynamics of Structures

(Criteria in favour to a spring mounted foundation)

Spring Mounted vs. Conventional

- ***Vibrational isolation:*** *The passive vibration isolation protects the T/G-Set against vibrations coming from the surrounding area and the active vibration isolation absorbs the vibrations caused by the T/G-Set, resp. prevents the vibrations from being spread out into the surrounding area.*
- ***Low tuned systems:*** *Separating the frequencies by (low) tuning of the foundation is the most effective measure against machine-induced vibrations and to avoid any state of resonance. For conventional STP the obtainable basic natural frequencies are not very low, as the supporting columns cannot be constructed infinitely slender (due to structural and constructive requirements) and often a spring mounted STP is the only solution to have the control on the (basic) eigenfrequencies.*

(Criteria in favour to a spring mounted foundation)

Spring Mounted vs. Conventional

- ***Geotechnical situation:*** *STG are very sensitive against (differential) settlements of the subsoil; settlements directly affect the shaft alignment and depend mainly on the subsoil classification and material parameters, position of different subsoil-layers, groundwater level and the baseplate itself - for conventional STP massive baseplates (with or without piles) are necessary. Spring mounted STP are considerably less sensitive to such differential settlements of the substructure due to the built-in elastic bedding conditions for the toptable. If a reduction of the total mass is required to reduce the soil pressures / soil settlements (when piles not possible or not effective) or the soil is sensitive to dynamic stresses (alternating stresses) a spring mounted STP has to be chosen. A complete separation between foundation structure and surrounding structures is strictly required for conventional STP due to vibration transmission aspects; if the groundwater level lies within or above the foundation additional measures has to be taken into account in regard to the watertightness.*

(Criteria in favour to a spring mounted foundation)

Spring Mounted vs. Conventional

- ***Height level adjustments of the toptable:*** *By major adjustments on the spring supports a close to the origin foundation elevation can be reached: Readjusting of normal long time deformations of the reinforced concrete foundation table (creeping / shrinkage of the concrete or settlements), which can affect the machine operation (misalignment of the machine shaft line).*
- ***Bill of Quantity (Concrete & Reinforcement):*** *Overall size and weight of spring mounted foundations are considerably smaller compared with conventional foundations: Slender columns and thin baseplate (less excavation work), resp. columns and baseplate can be part of / can be integrated into the building. Further on a shorter construction time of the base plate can be expected.*
- ***Seismicity / Base Isolation:*** *Protection of the T/G-Set against earthquake forces by a very low tuned system. Horizontal stiffness for the decoupled toptable to be very low.*

(Criteria in favour to a spring mounted foundation)

Spring Mounted vs. Conventional

- ***Long-term behaviour:*** *As a more theoretical, but also very important factor it must be mentioned that due to the "soft" support of the T/G-Set the operating conditions are positively influenced. Long-time experience with spring mounted foundations show an optimum of performance and smooth running behaviour.*
- ***Dimensions of the substructure (only static loads):*** *The substructure is dynamically decoupled, therefore the substructure has only to be designed for static loading situations. This leads to slender columns and a thinner baseplate and allows more space for secondary equipment below the foundation table as condenser, pumps, pipes, etc.*
 - . ***usable space below the foundation table***
 - . ***New toptable on existing substructure***