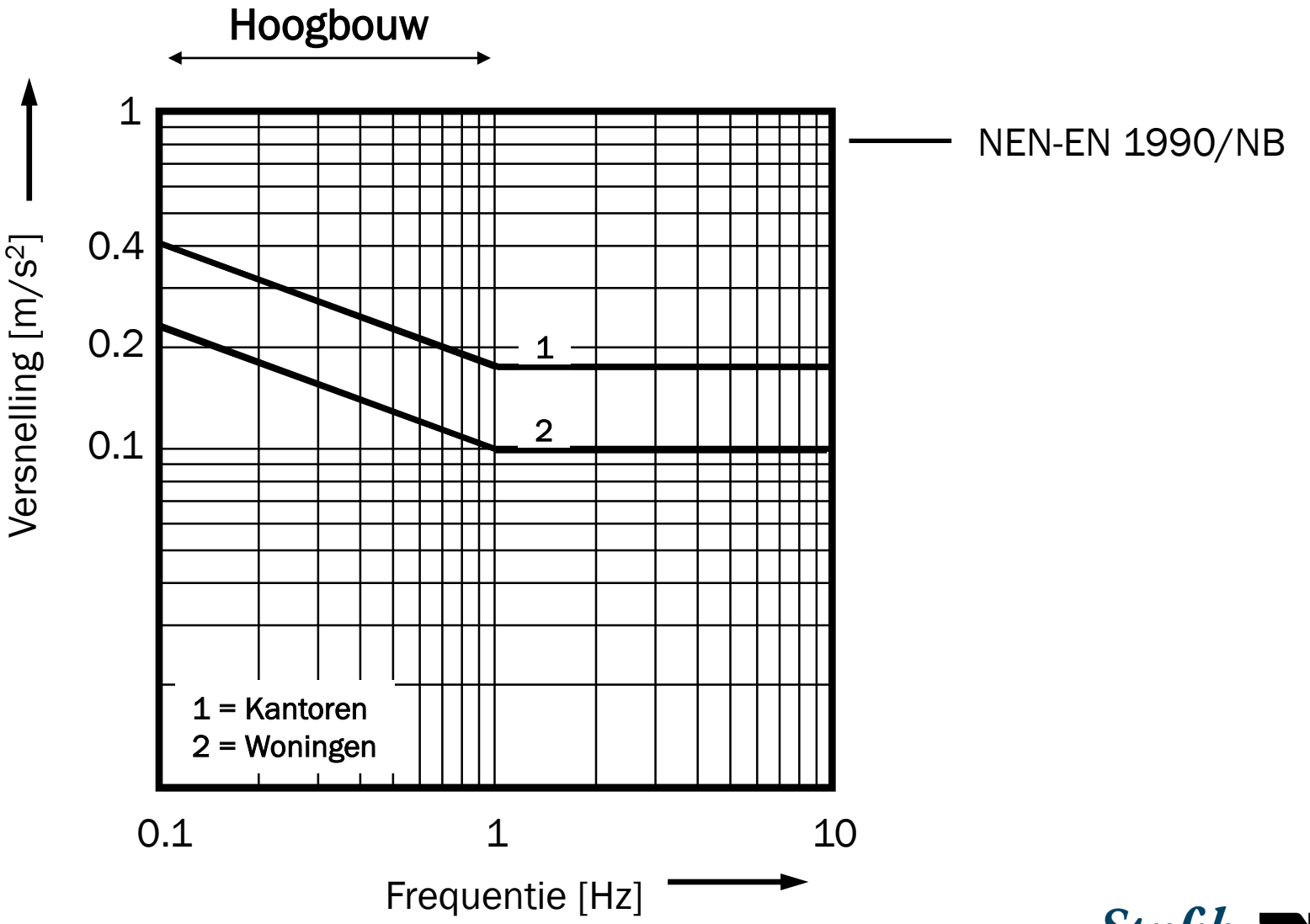
HIVIBE: MONITORING WINDTRILLINGEN HOOGBOUW

OKKE BRONKHORST

TNO, STRUCTURAL DYNAMICS, DELFT

TRILLINGSCOMFORT HOOGBOUW

COMFORT CRITERIA



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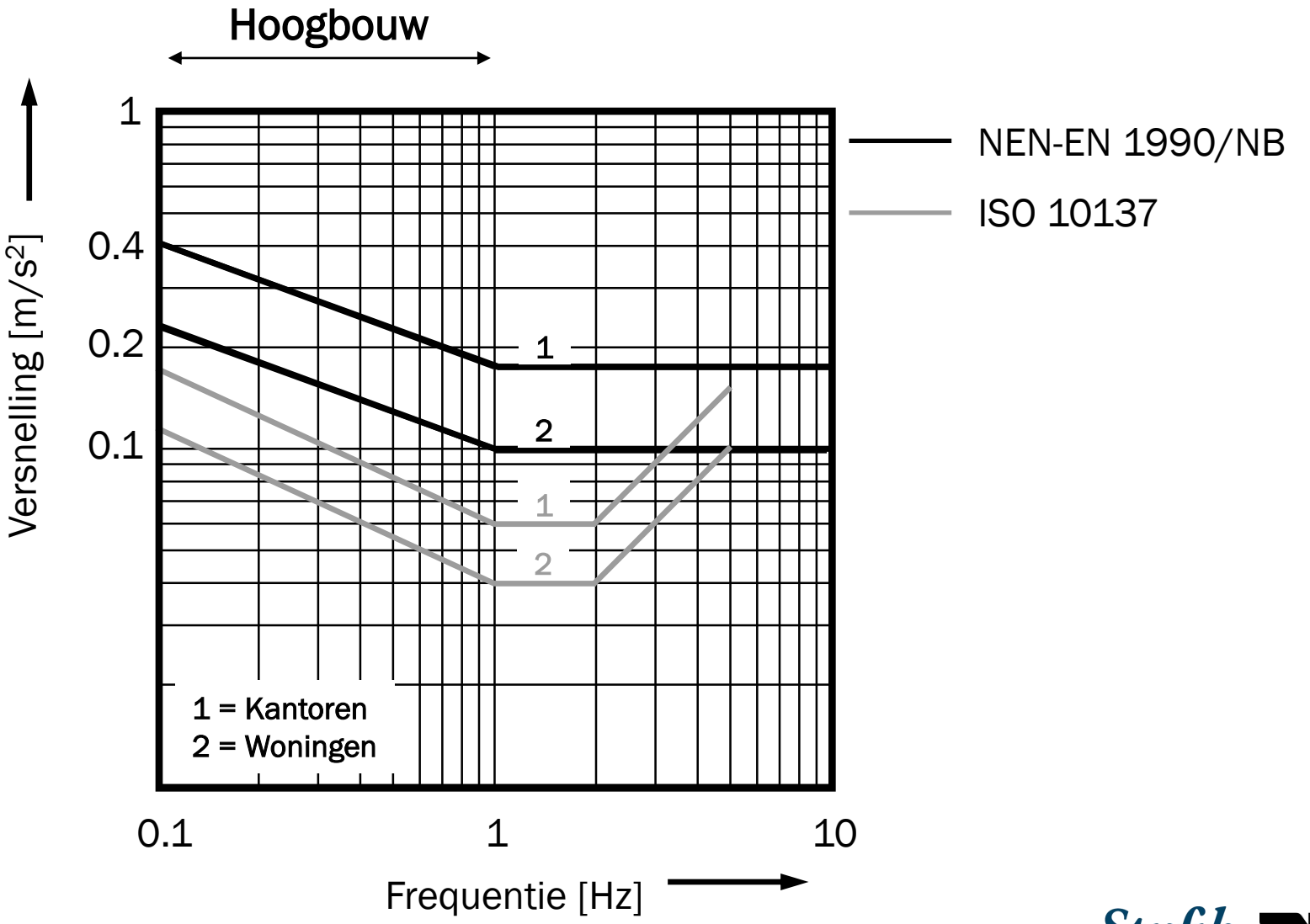
TRILLINGSCOMFORT HOOGBOUW

COMFORT CRITERIA



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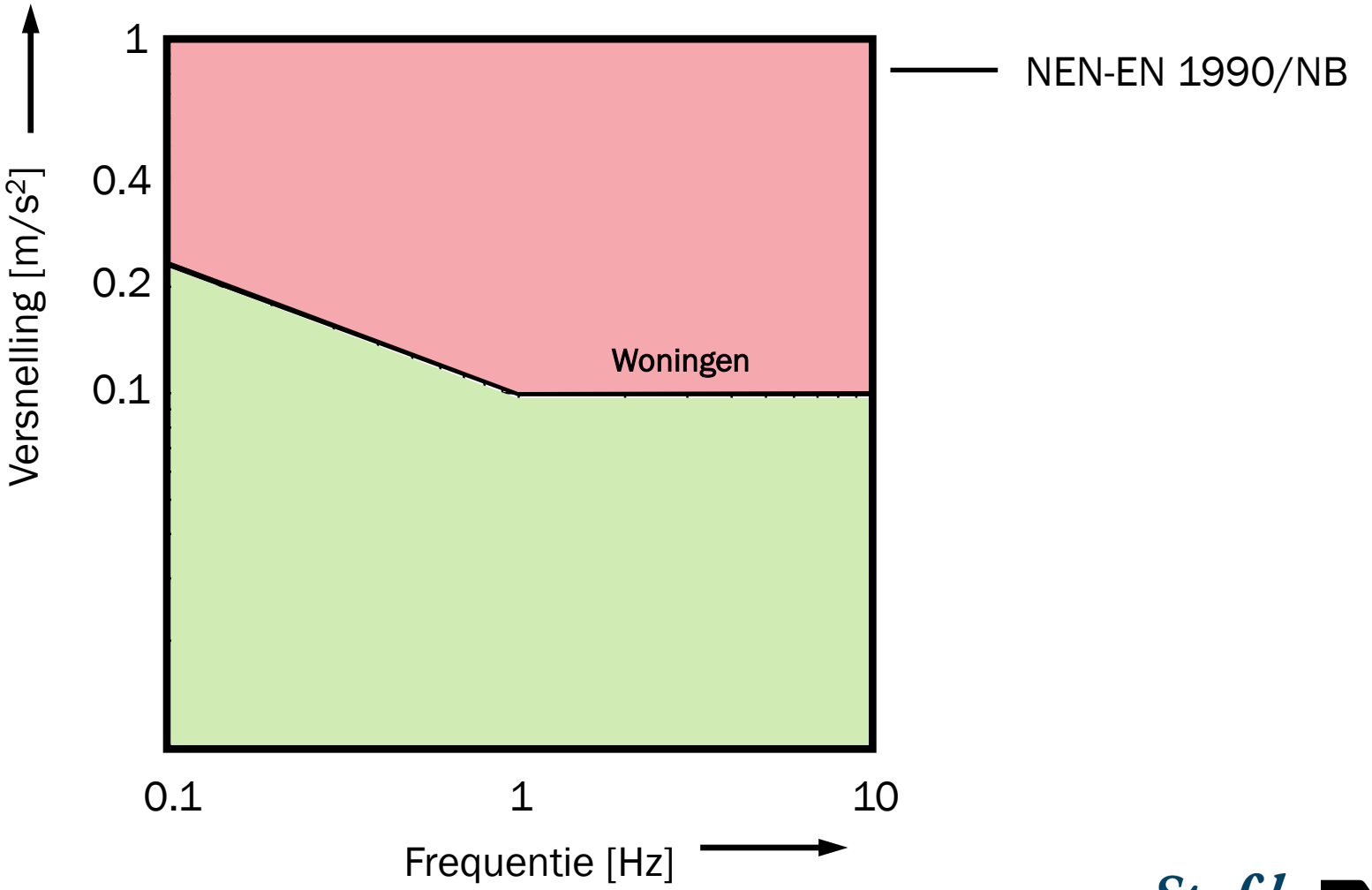
TRILLINGSCOMFORT HOOGBOUW

COMFORT CRITERIA



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TRILLINGSCOMFORT HOOGBOUW

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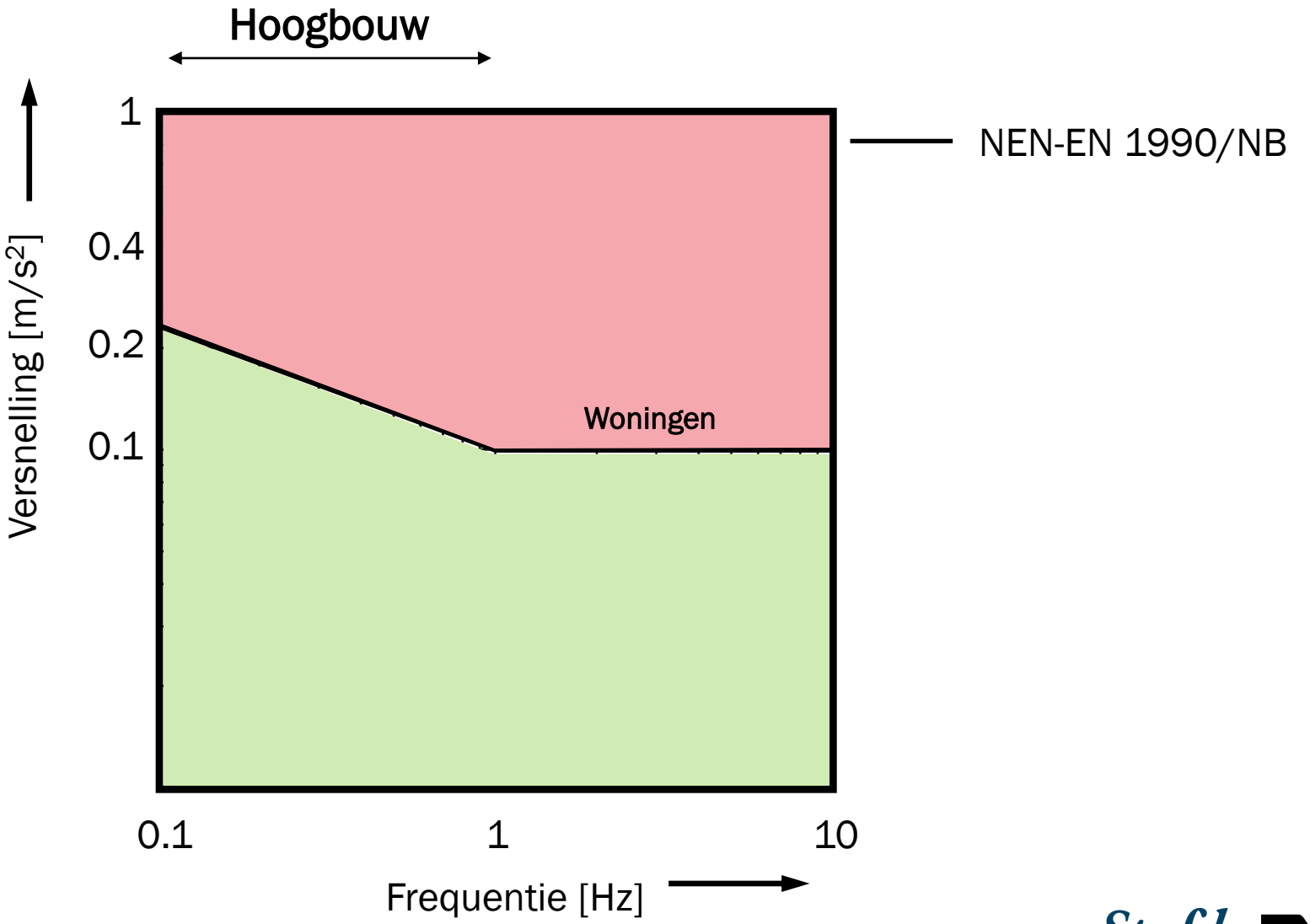

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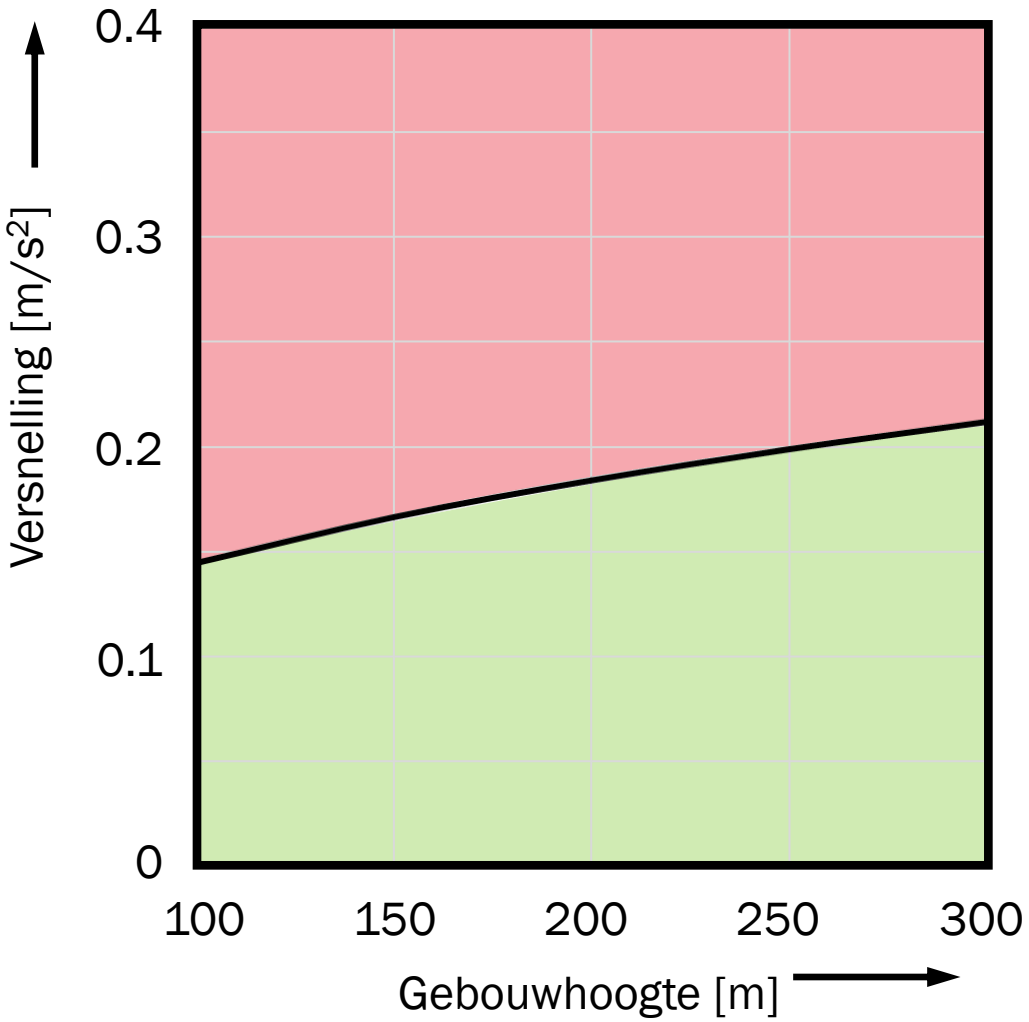
TRILLINGSCOMFORT HOOGBOUW

COMFORT CRITERIUM MET HOOGTE



NEN-EN 1990/NB (wonen)

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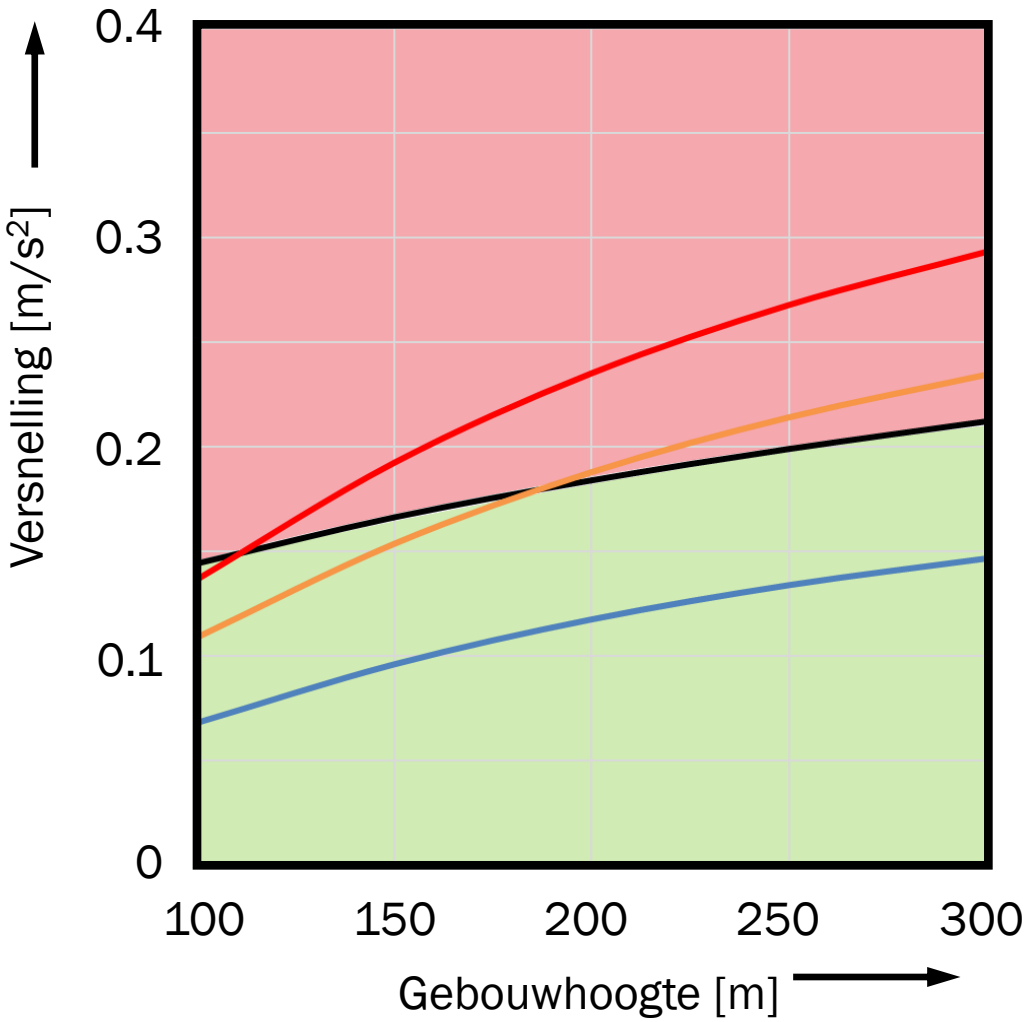
TRILLINGSCOMFORT HOOGBOUW

ONTWERPGRENZEN IN ZICHT



Licht stalen gebouw

Licht betonnen gebouw

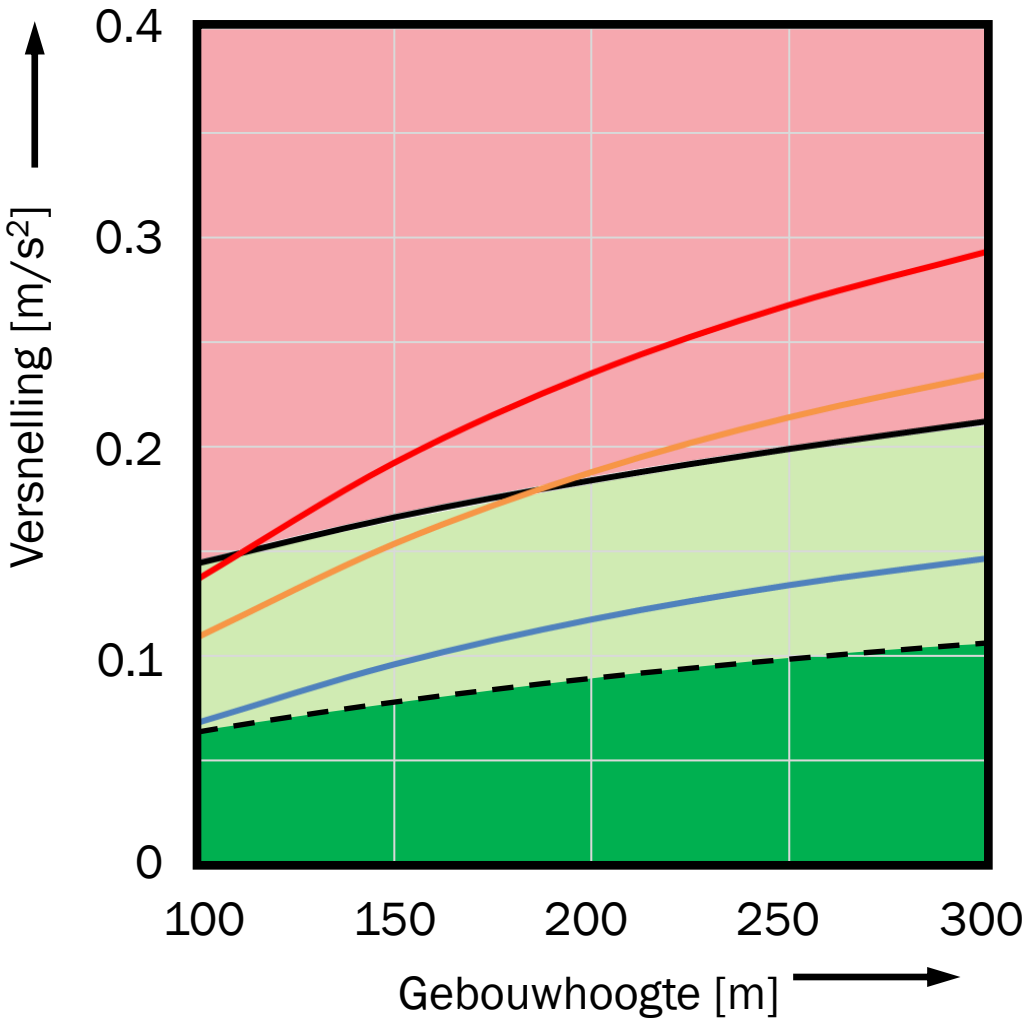
NEN-EN 1990/NB (wonen)

Zwaar betonnen gebouw

Stufib TNO innovation for life

TRILLINGSCOMFORT HOOGBOUW

ONTWERPGRENZEN IN ZICHT



Licht stalen gebouw

Licht betonnen gebouw

NEN-EN 1990/NB (wonen)

Zwaar betonnen gebouw

ISO 10137 (wonen)

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DYNAMISCHE EIGENSCHAPPEN

EIGENFREQUENTIE

	Montevideo	JuBi	NEMC	Oval tower
Meting	0.41 Hz	0.46 Hz	0.53 Hz	0.40 Hz

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DYNAMISCHE EIGENSCHAPPEN

EIGENFREQUENTIE

	Montevideo	JuBi	NEMC	Oval tower
Meting	0.41 Hz	0.46 Hz	0.53 Hz	0.40 Hz
Ontwerp (NEN 6702)	0.19 Hz	0.27 Hz	0.27 Hz	0.33 Hz

DYNAMISCHE EIGENSCHAPPEN

DEMPING

	Montevideo	JuBi	NEMC	Oval tower
Meting	1.4 %	1.0 %	1.7 %	1.4 %
Ontwerp (NEN 6702)	1.0 %	1.0 %	1.0 %	1.0 %

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DYNAMISCHE EIGENSCHAPPEN

DEMPING

	Montevideo	JuBi	NEMC	Oval tower
Meting	1.4 %	1.0 %	1.7 %	1.4 %
Ontwerp (NEN 6702)	1.0 %	1.0 %	1.0 %	1.0 %
NEN-EN 1991-1-4	1.2 %	1.6 %	1.6 %	1.6 %

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HIVIBE

HIGH-RISE **VIB**RATIONS IN DELTA CITIES **E**XPLORED

- Doel
  - Betrouwbare voorspelling windtrillingen hoogbouw
- Beoogde resultaten
  - Rekenmethodes voor de dynamische respons
  - Monitoring programma hoge gebouwen

TNO innovation for life · Aronsohn · zonneveld ingenieurs · structure portante · FUGRO · abt · BESIX

SCIA A NEMETSCHEK COMPANY · GEOBEST · bam · IMd Raadgevende Ingenieurs · Stichting Kennisoverdracht Windtechnologie · PEUTZ · TKI Deltatechnologie

BETER VOORSPELLEN DYNAMISCH GEDRAG

ONDERWERPEN

- Onderschatting eigenfrequentie




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BETER VOORSPELLEN DYNAMISCH GEDRAG

ONDERWERPEN

- Onderschatting eigenfrequentie
- Invloed fundering op demping




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BETER VOORSPELLEN DYNAMISCH GEDRAG

ONDERWERPEN

- Onderschatting eigenfrequentie
- Invloed fundering op demping
- Invloed trillingsamplitude
- Langeduur gedrag dynamische eigenschappen




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BETER VOORSPELLEN DYNAMISCH GEDRAG

ONDERWERPEN

- Onderschatting eigenfrequentie
- Invloed fundering op demping
- Invloed trillingsamplitude
- Langeduur gedrag dynamische eigenschappen
- Invloed nabijgelegen gebouwen




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BETER VOORSPELLEN DYNAMISCH GEDRAG

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- Onderschatting eigenfrequentie
- Invloed fundering op demping
- Invloed trillingsamplitude
- Langeduur gedrag dynamische eigenschappen
- Invloed nabijgelegen gebouwen




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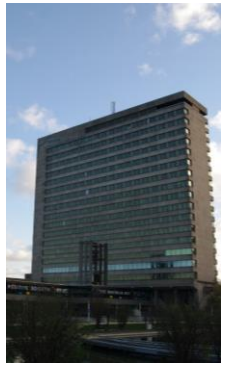
ONDERSCHATTING EIGENFREQUENTIE

METINGEN VS. BEREKENINGEN





	New Orleans	Zalmhaven	Tinbergen	JuBi toren	Erasmus MC
Meting	0.28 Hz	0.34 Hz	0.67 Hz	0.46 Hz	0.53 Hz
Berekening	0.23 Hz	0.24 Hz	-	0.34 Hz	0.27 Hz

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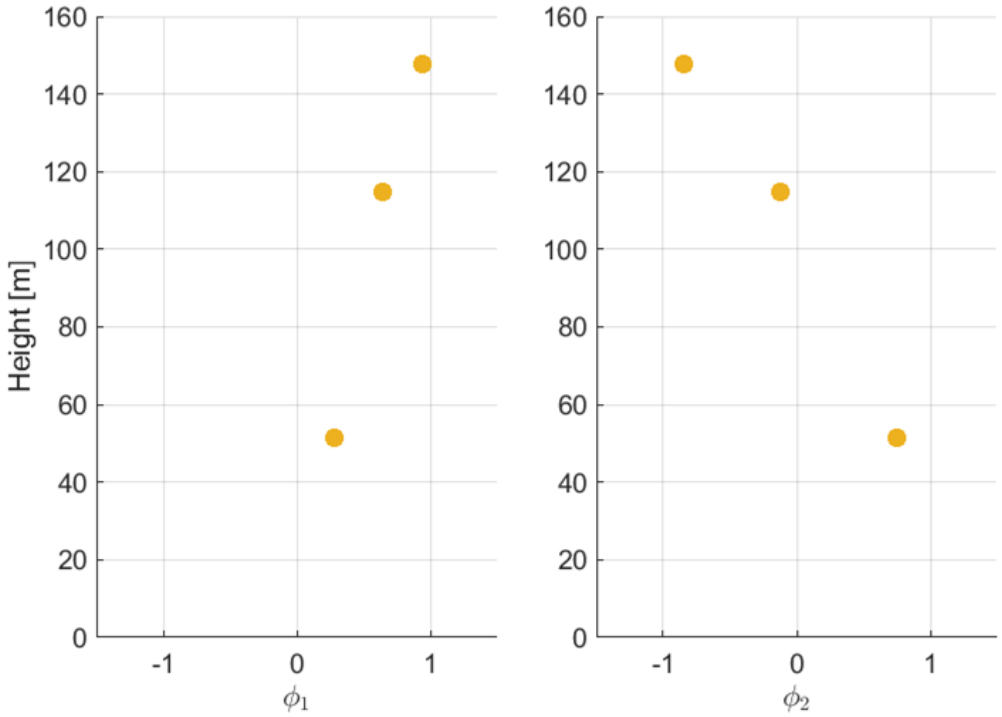
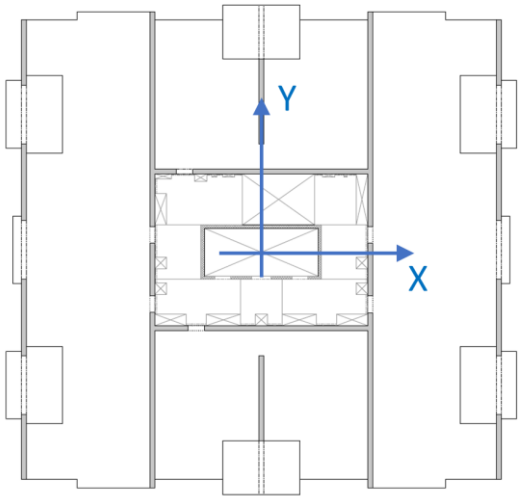
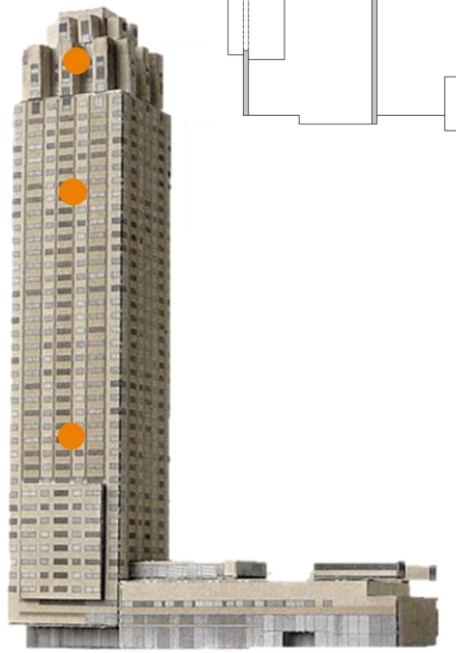
ONDERSCHATTING EIGENFREQUENTIE

GEMETEN TRILVORMEN NEW ORLEANS







	$f_{y,1}$	$f_{y,2}$
Meting	0.28 Hz	1.53 Hz

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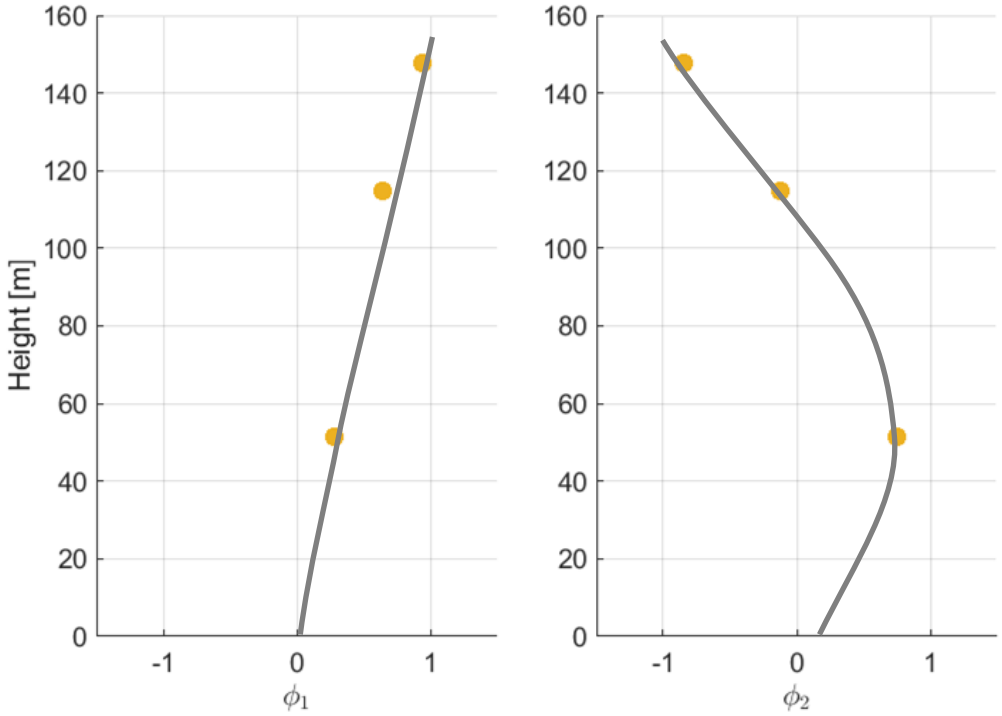
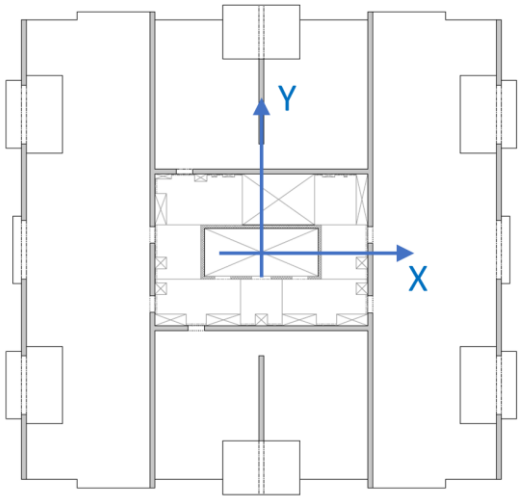
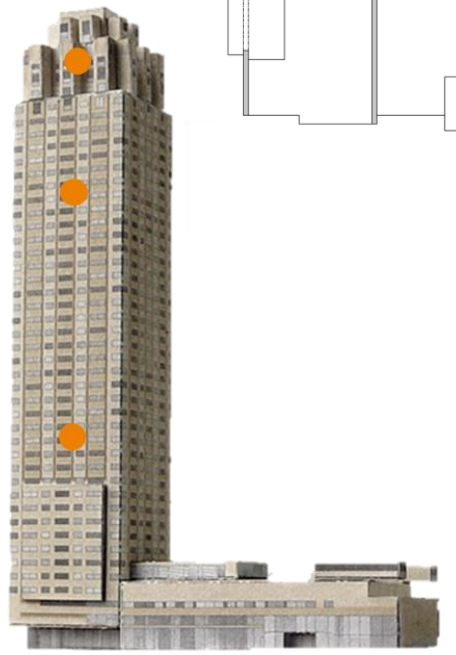
ONDERSCHATTING EIGENFREQUENTIE

BEREKENDE TRILVORMEN NEW ORLEANS







	$f_{y,1}$	$f_{y,2}$
Meting	0.28 Hz	1.53 Hz
Berekening	0.23 Hz	1.25 Hz

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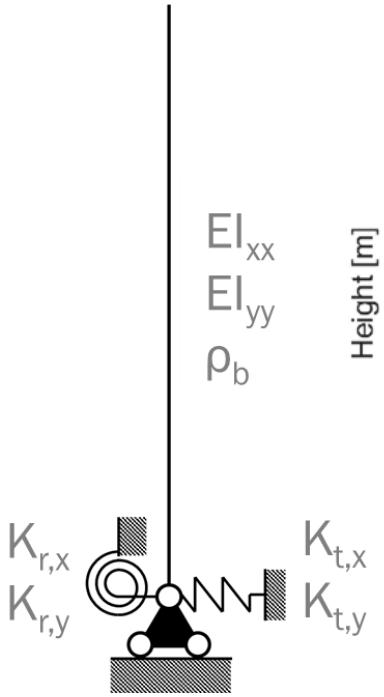
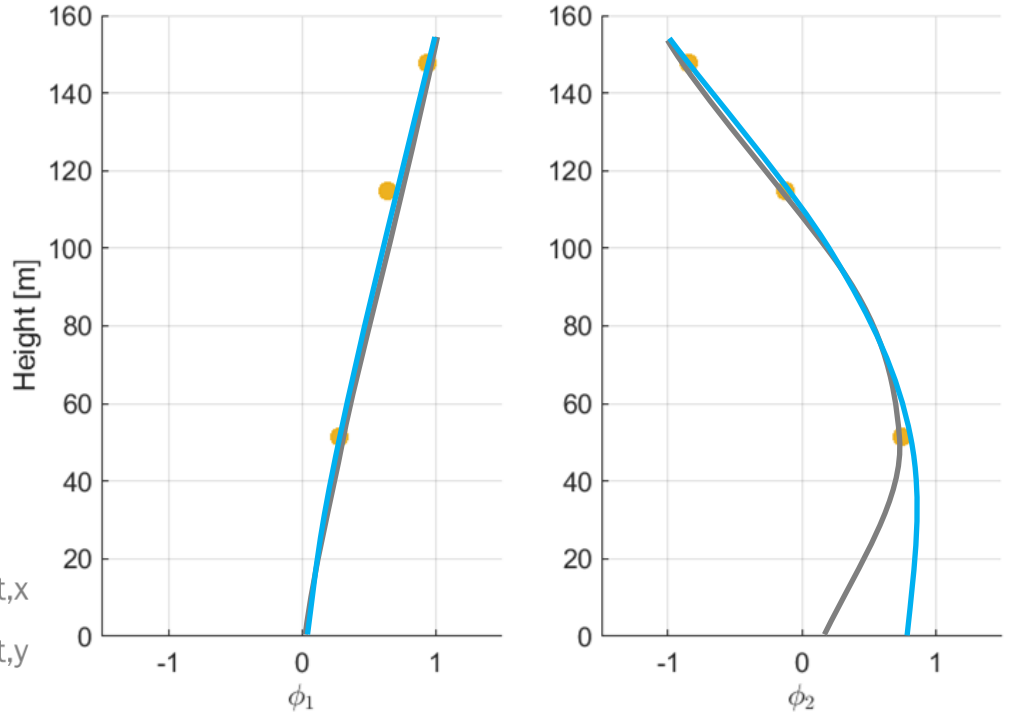
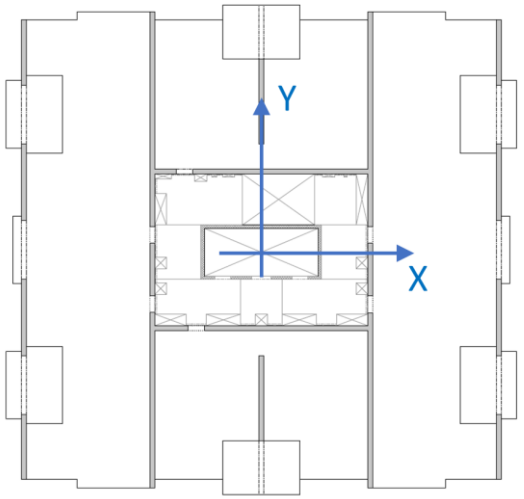
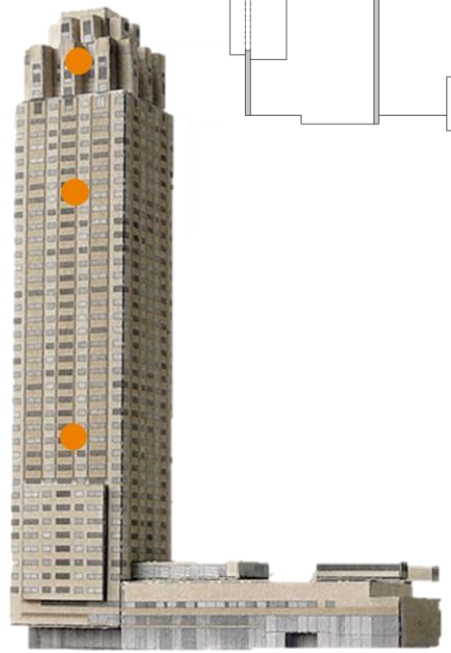
ONDERSCHATTING EIGENFREQUENTIE

GETUNEDE TRILVORMEN NEW ORLEANS







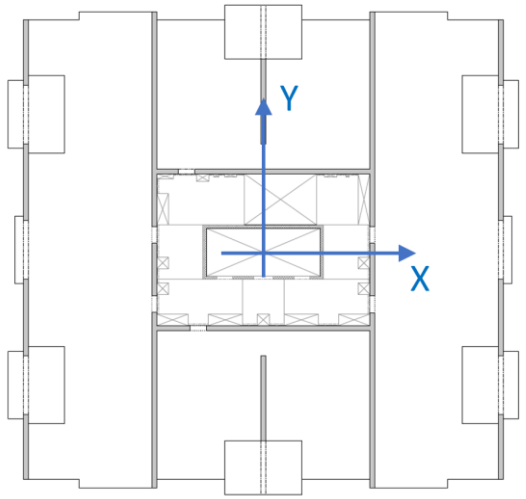


	$f_{y,1}$	$f_{y,2}$
Meting	0.28 Hz	1.53 Hz
Berekening	0.23 Hz	1.25 Hz
Optimalisatie	0.28 Hz	1.53 Hz

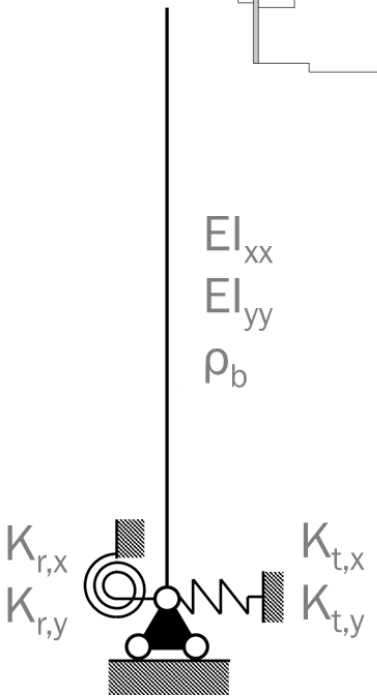
Stufib TNO innovation for life

ONDERSCHATTING EIGENFREQUENTIE

CONSTRUCTIEVE EIGENSCHAPPEN



Eigenschap	Meting	Berekening	Verhouding
ρ [kg/m^3]	469 (±35)	477	1.02
EI_{xx} [Nm^2]	9.70x10^{13} (±1.1x10^{13})	7.12x10^{13}	0.73
EI_{yy} [Nm^2]	6.51x10^{13} (±1.0x10^{13})	5.39x10^{13}	0.83
$K_{t,x}$ [N/m]	2.85x10^9 (±0.3x10^9)	3.11x10^9	1.09
$K_{t,y}$ [N/m]	2.20x10^9 (±0.2x10^9)	3.15x10^9	1.43
$K_{r,x}$ [Nm/rad]	3.07x10^{12} (±0.3x10^{13})	0.30x10^{12}	0.10
$K_{r,y}$ [Nm/rad]	11.1x10^{12} (-5+12x10^{12})	0.34x10^{12}	0.03



Stufib TNO innovation for life

ONDERSCHATTING EIGENFREQUENTIE

CONSTRUCTIEVE EIGENSCHAPPEN

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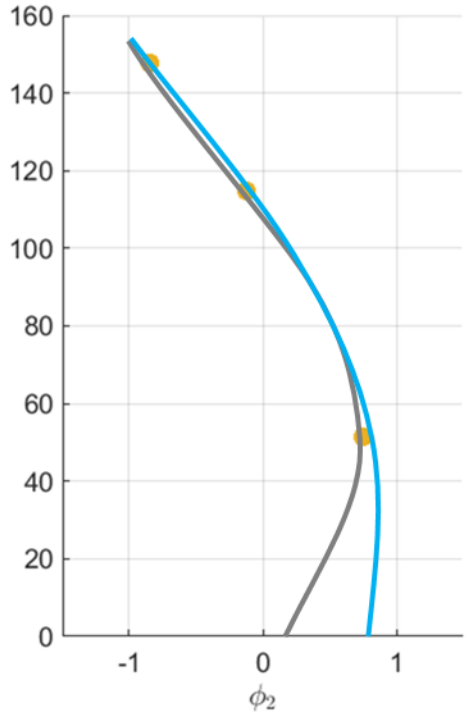

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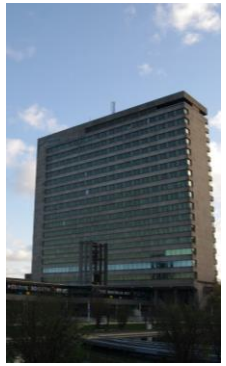
DEMPING

METINGEN VS. BEREKENINGEN





	New Orleans	Zalmhaven	Tinbergen	JuBi toren	Erasmus MC
Meting	0.8%	1.0%	1.0%	1.0 %	1.7 %
Berekening	1.6%	1.6%	1.6%	1.6%	1.6%

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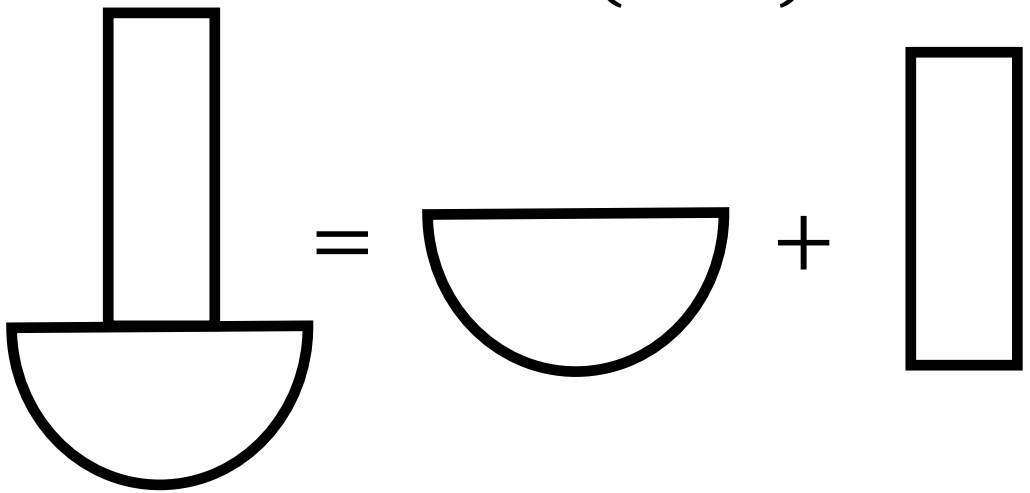
INVLOED FUNDERING OP DEMPING

DEMPINGSMODEL

$$D_t = D_f + \frac{1}{\left(\tilde{T}/T\right)^3} D_g$$



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C. Cruz, E. Miranda, Insights into damping ratios in buildings, Earthq. Engng. Struct. Dyn., p. 1-19, 2020.

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INVLOED FUNDERING OP DEMPING

VOORBEELD

- Woontoren New Orleans (D_t = 0.8%)
  - H x b x d: 155 m x 29 m x 29 m
  - ρ_b : 500 kg/m^3
  - ρ_s : 1955 kg/m^3
  - V_s : 325 m/s

Parameter	$f_e = 0{,}19$ Hz	$f_e = 0{,}30$ Hz
$D_g/(\tilde{T}/T)^3$	0,28 %	0,28 %
D_f	0,07 %	0,36 %
D_t	0,35 %	0,64 %

Stufib TNO innovation for life

INVLOED FUNDERING OP DEMPING

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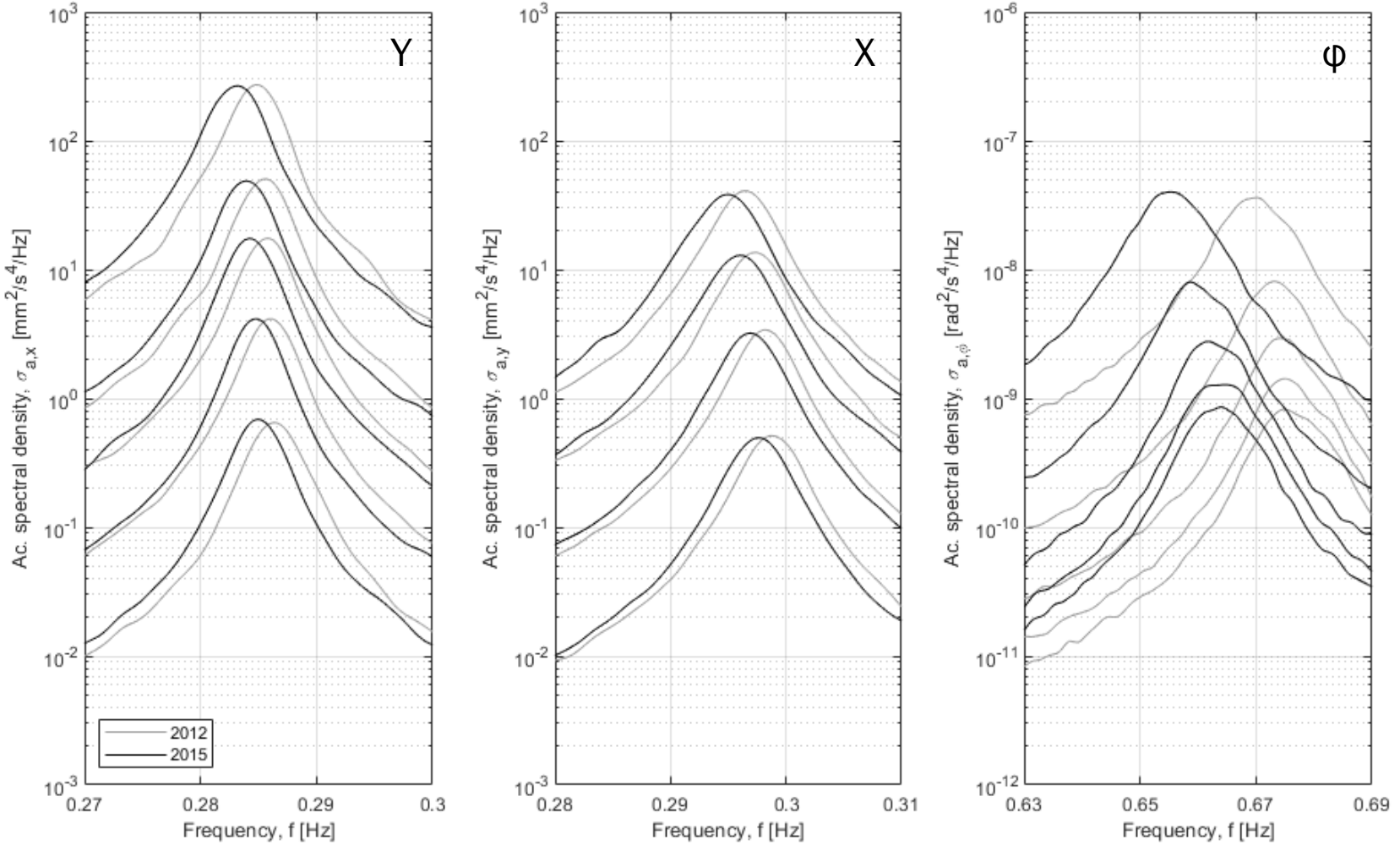
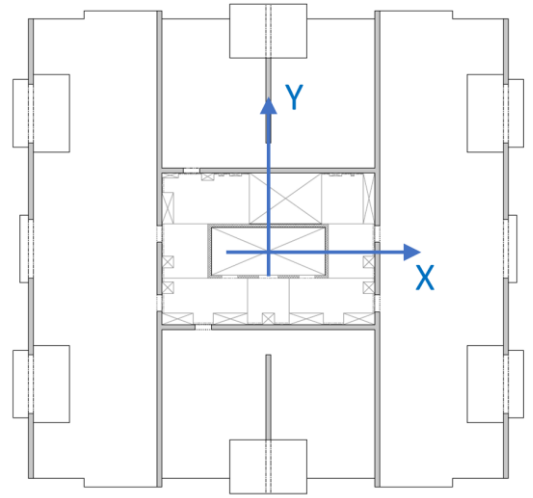
INVLOED AMPLITUDE EN TIJD

EIGENFREQUENTIE





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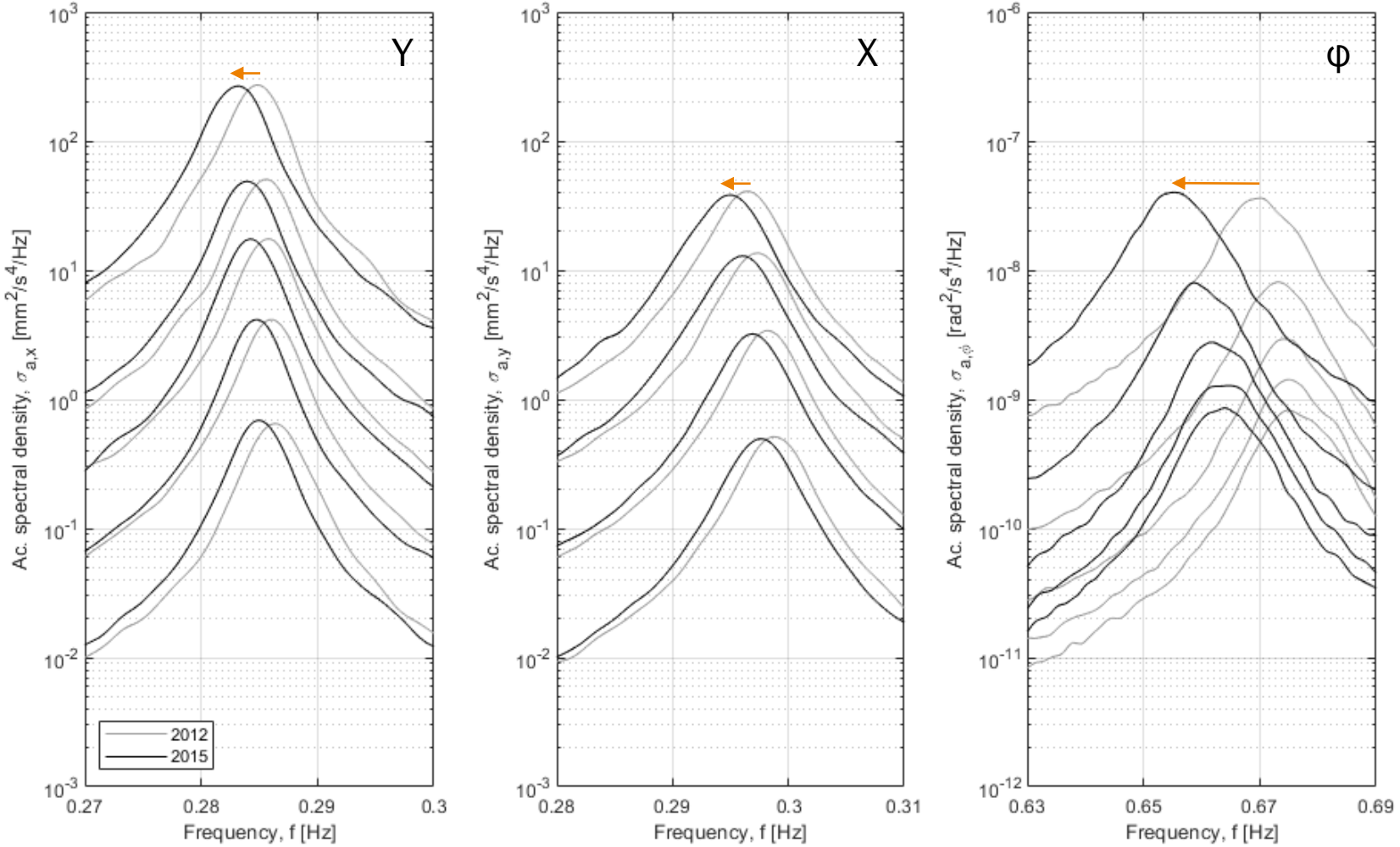
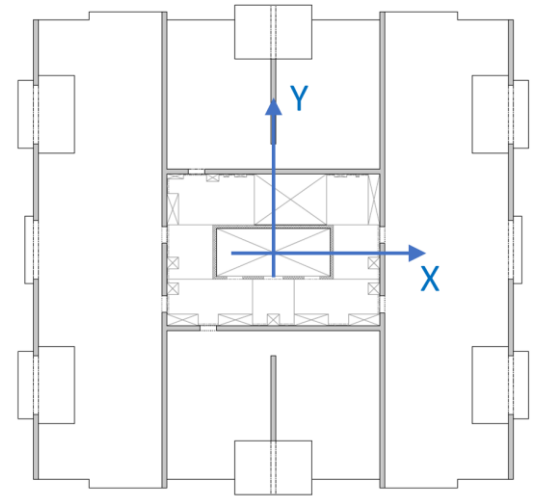
INVLOED AMPLITUDE EN TIJD

EIGENFREQUENTIE





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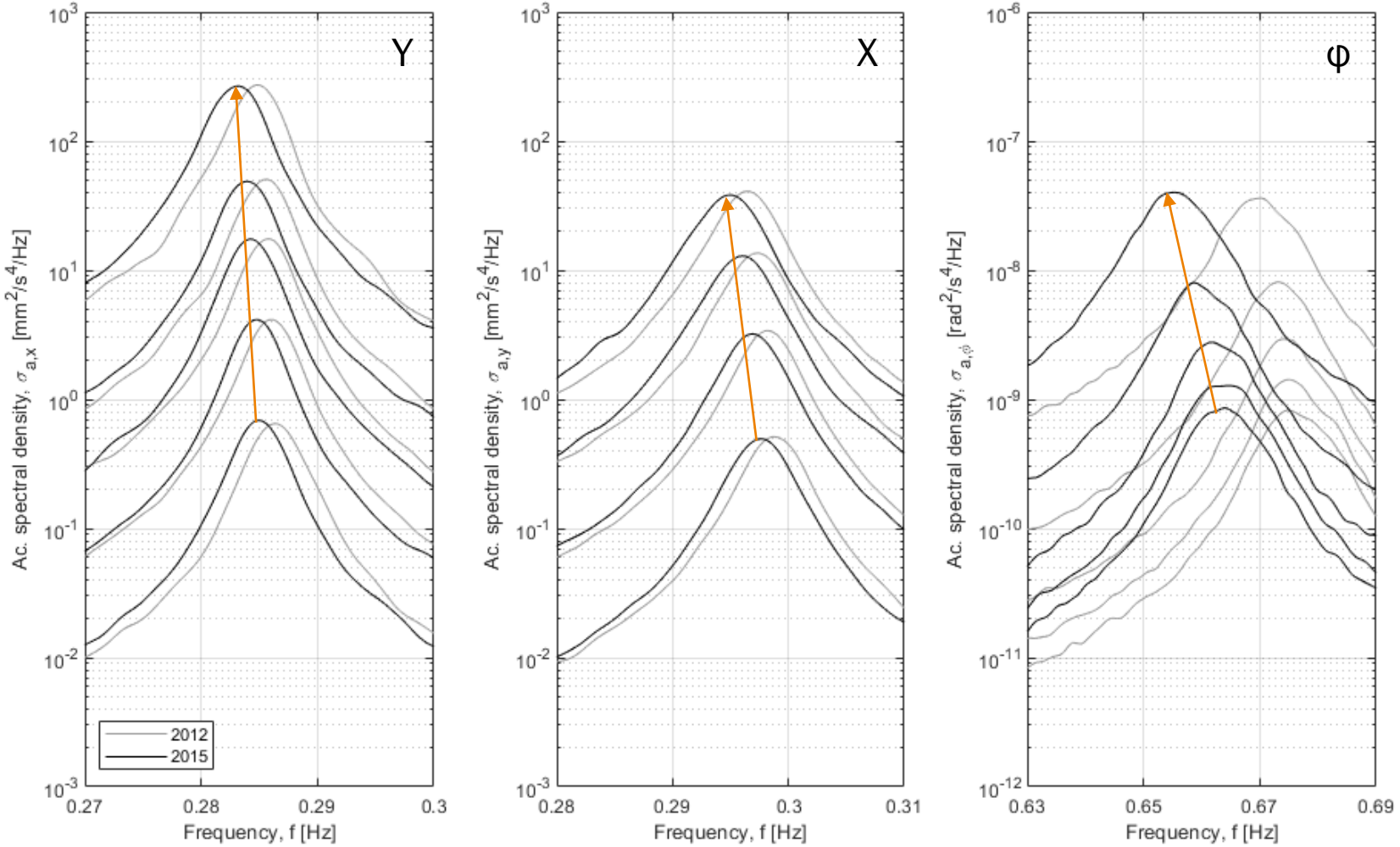
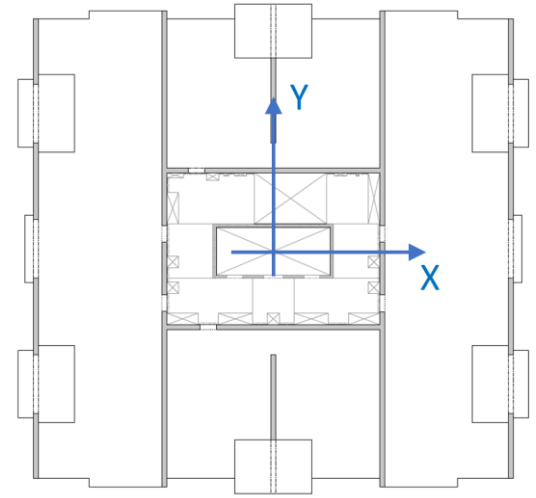
INVLOED AMPLITUDE EN TIJD

EIGENFREQUENTIE





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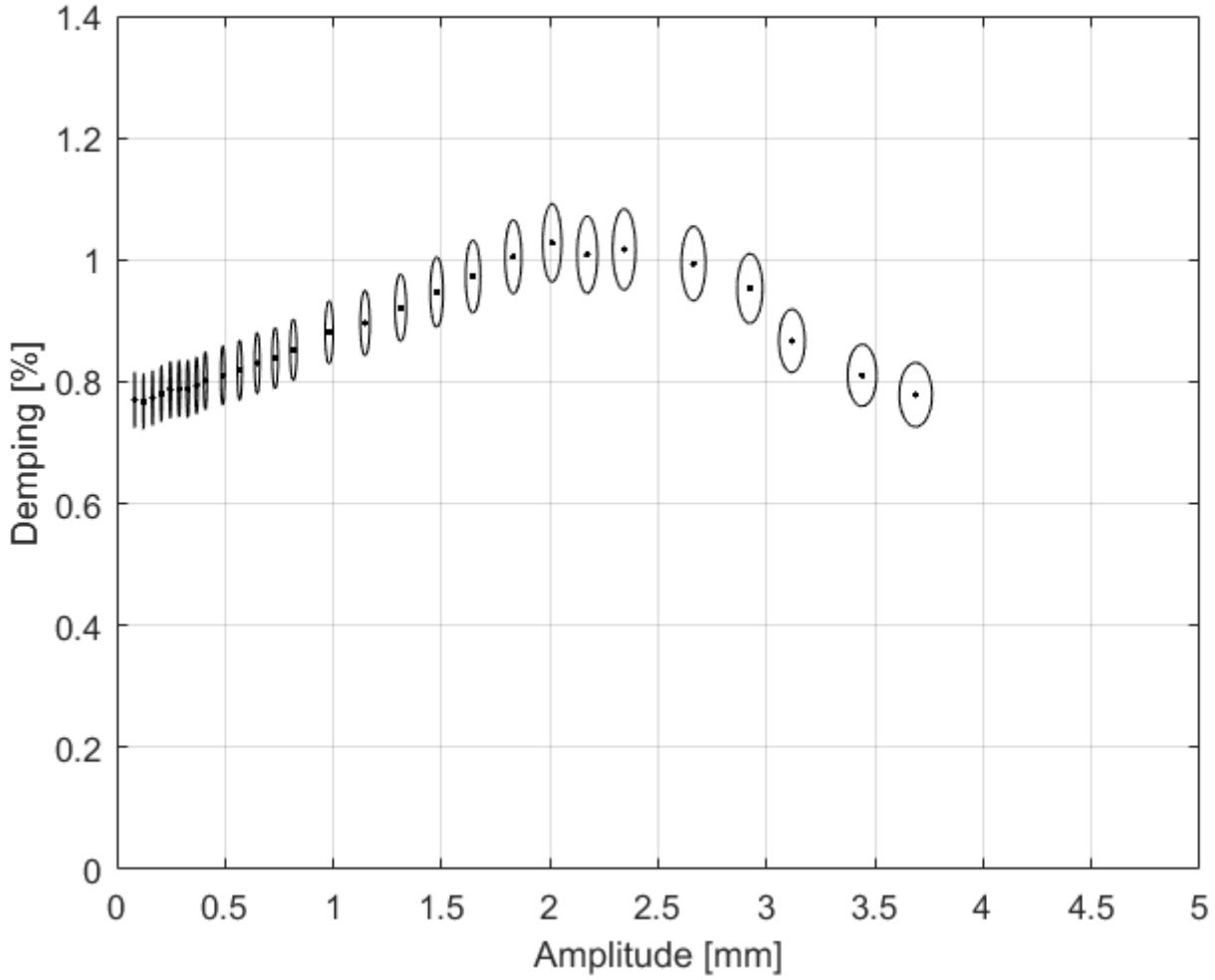
INVLOED AMPLITUDE EN TIJD

DEMPING



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AFSLUITING

- Betrouwbare voorspelling windtrillingen
- Inzicht in onderschatting eigenfrequentie
- Dempingsmodel voor invloed fundering
- Invloed amplitude en tijd op dynamische eigenschappen
- Meer langeduur monitoring nodig

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BEDANKT VOOR UW AANDACHT!

VRAGEN?

TNO innovation for life