

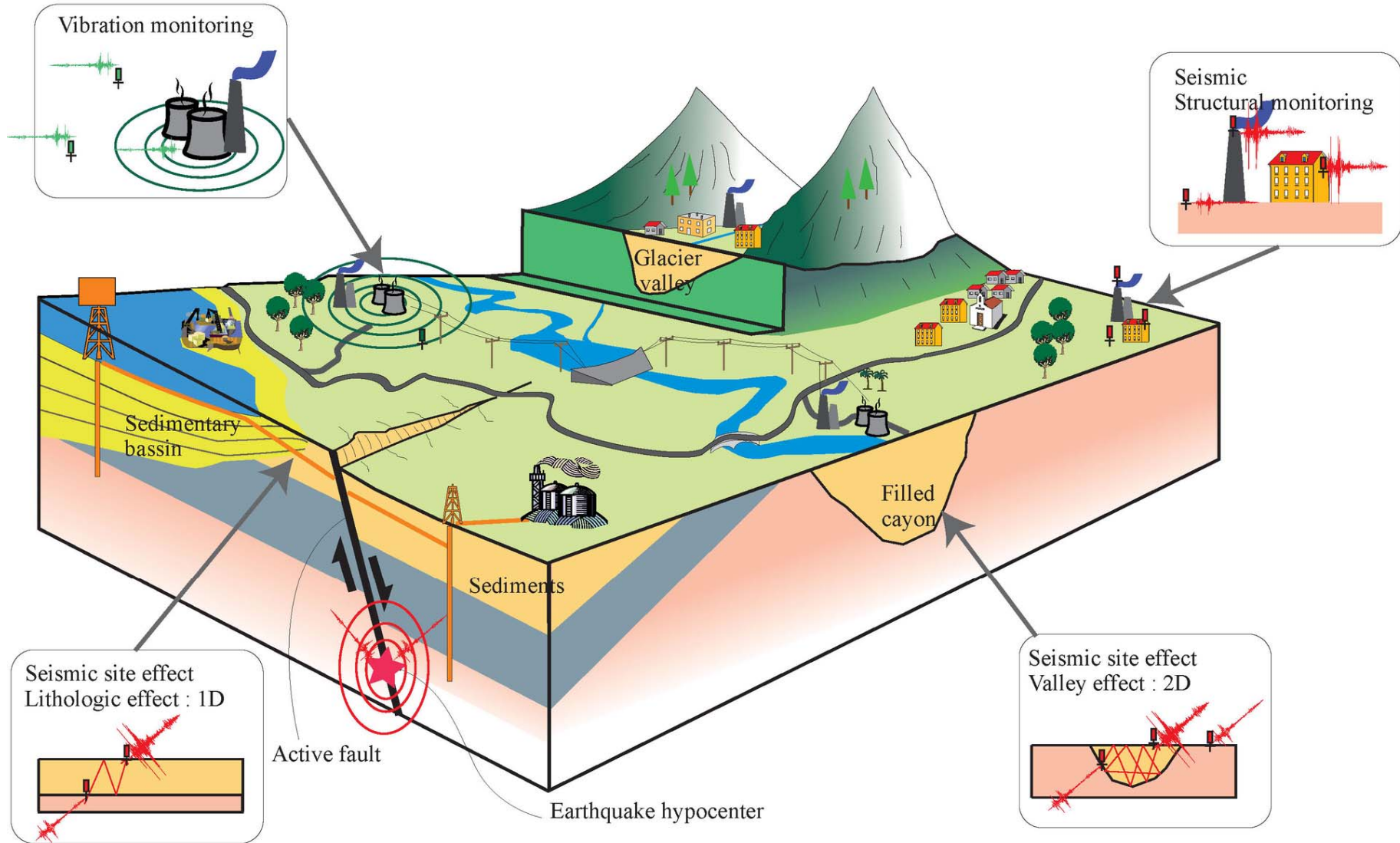


Meting en monitoring

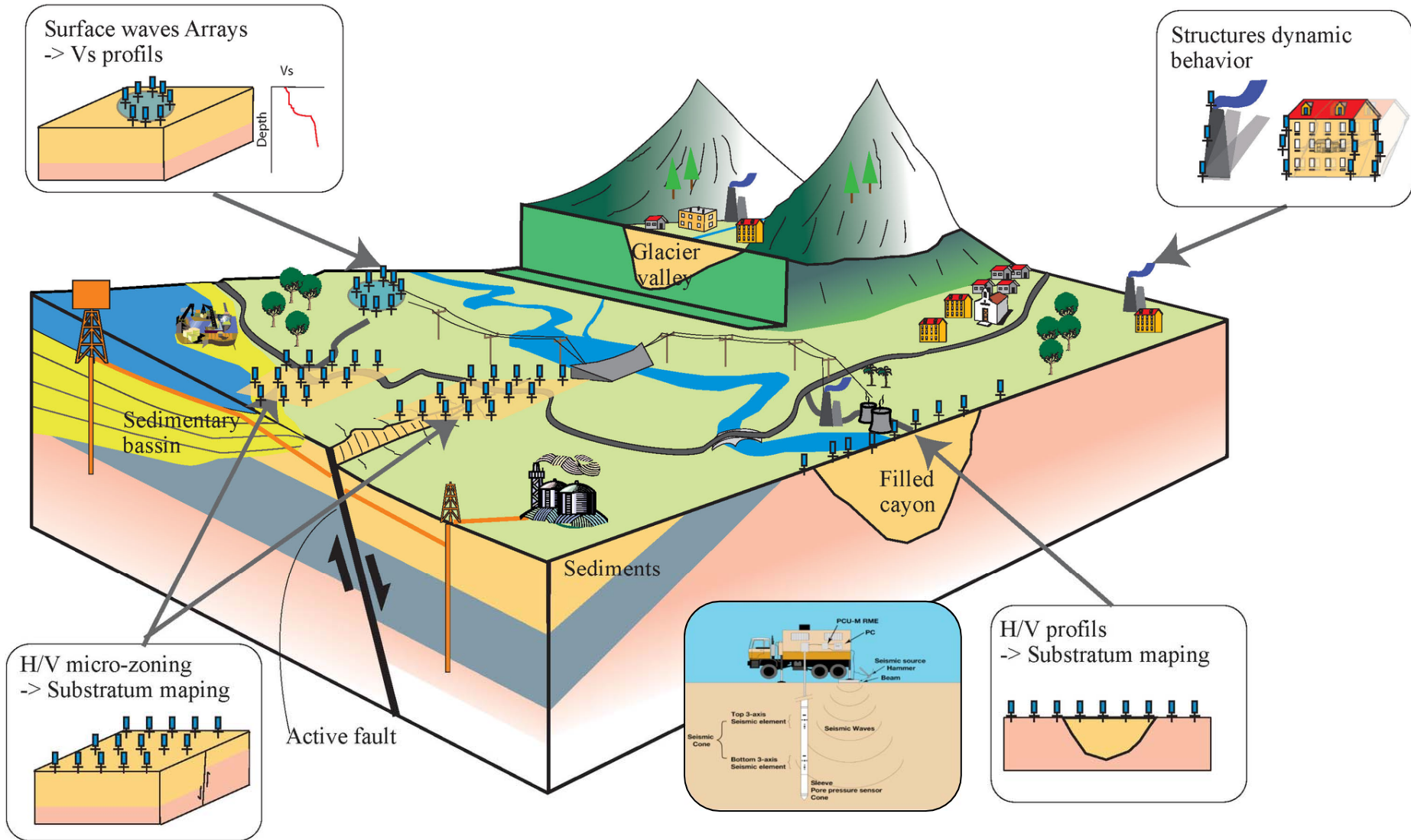
Klaas Siderius en Ben van der Kwaak

- Verschillende soorten seismische metingen en monitoring
- Aardbevingsmonitoring
- Ambient Vibrations
- Seismische sonderingen
- Dynamisch laboratoriumonderzoek

Aardbevingsmonitoring systemen



Geofysische metingen



Aardbevingsmonitoring systemen

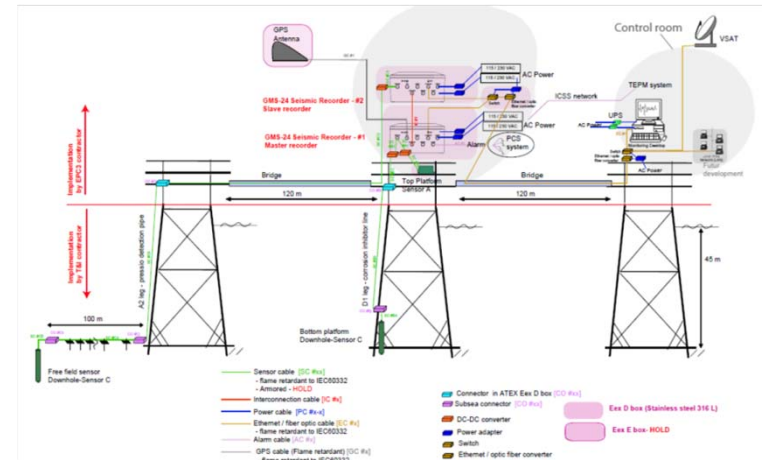
Permanente monitoring

Constructie

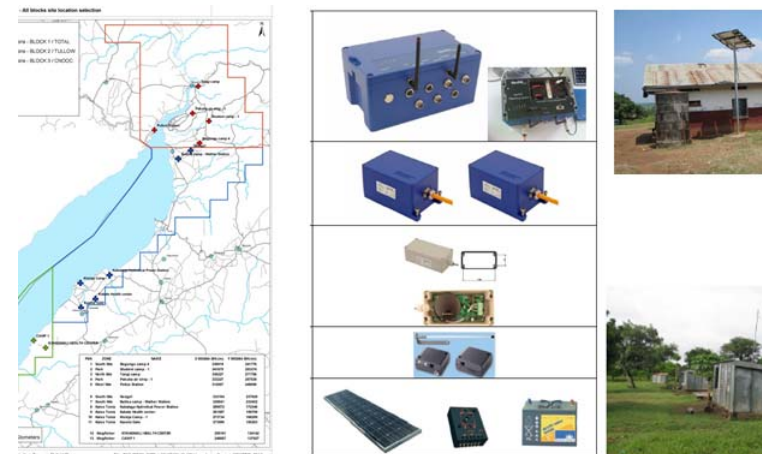
- Vaststellen belasting op constructie
- Overschrijden ontwerpwaarden
- Gedrag constructie

Regio

- Vaststellen seismische activiteit
- Eigenschappen van optredende aardbevingen
- Waarschuwingssystemen (safe shut down)



Offshore platform – Yadana (Myanmar)



Onshore olieveld Uganda

Ambient vibrations (achtergrondtrillingen)



Buildings
structures



Surface waves



Soil



Ambient Vibration experiment

Meting

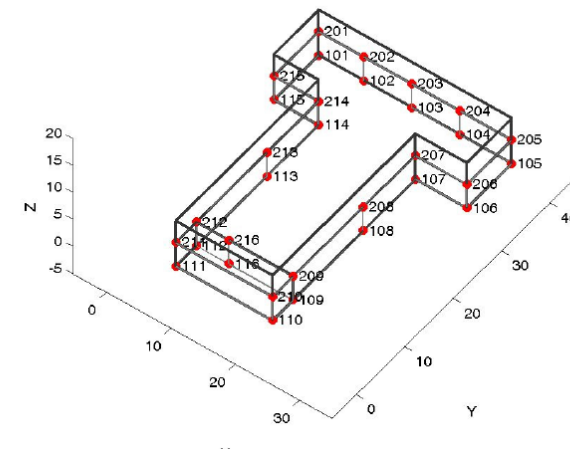
- Achtergrondtrillingen worden gemeten met zeer gevoelige sensoren
- Maken van geometrisch model van de constructie
- 1 sensor blijft op een vaste plaats, met de overige sensoren worden metingen verricht op de vooraf gedefinieerde punten
- Meting duurt ca. 1 dag



Zeer gevoelige sensoren

Resultaat

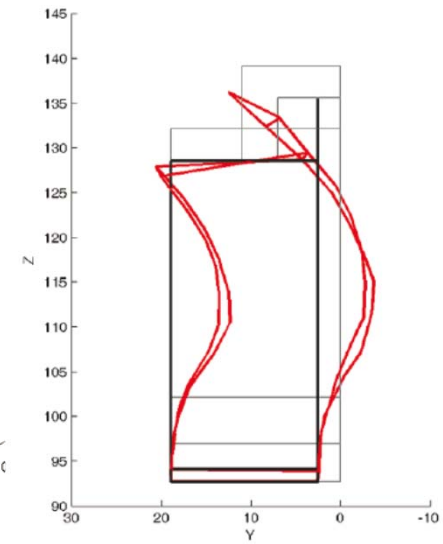
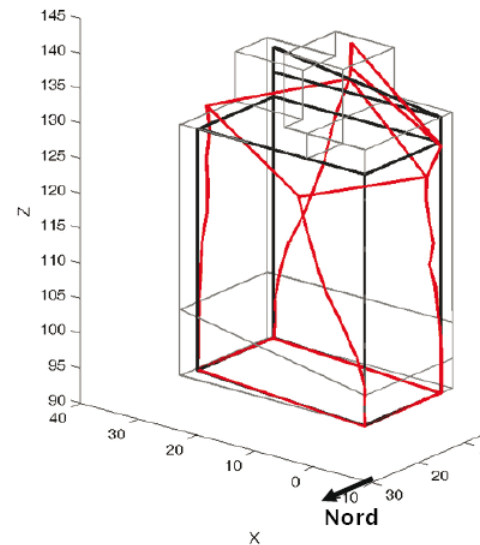
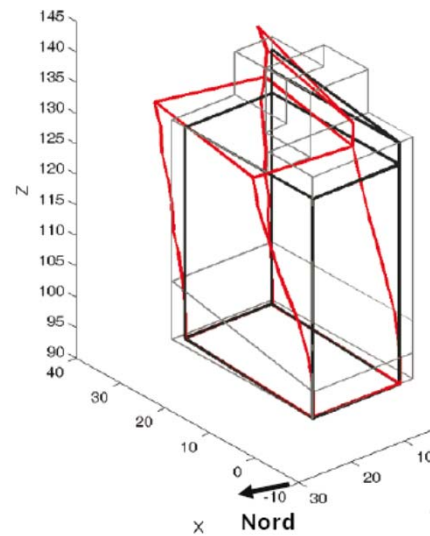
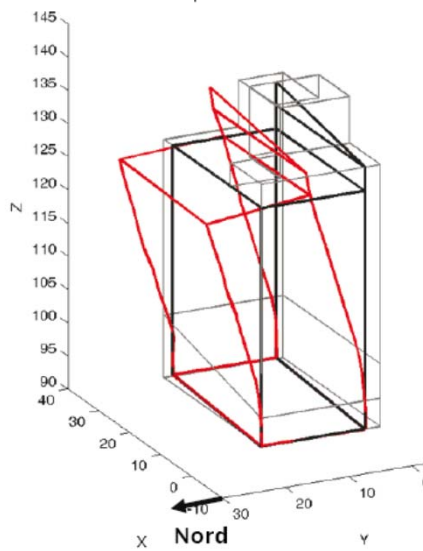
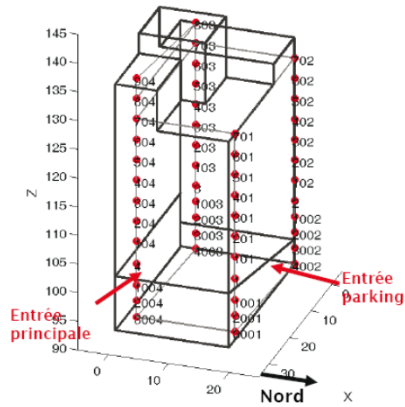
- Directe meting van dynamische eigenschappen op basis van achtergrond trillingen
- Eigenfrequenties (inclusief fundering), Modal shapes, damping
- Connecties met omliggende gebouwen
- Efficiënte dilatatie
- Stijve elementen identificeren
- Verandering in eigenschappen tussen 2 metingen



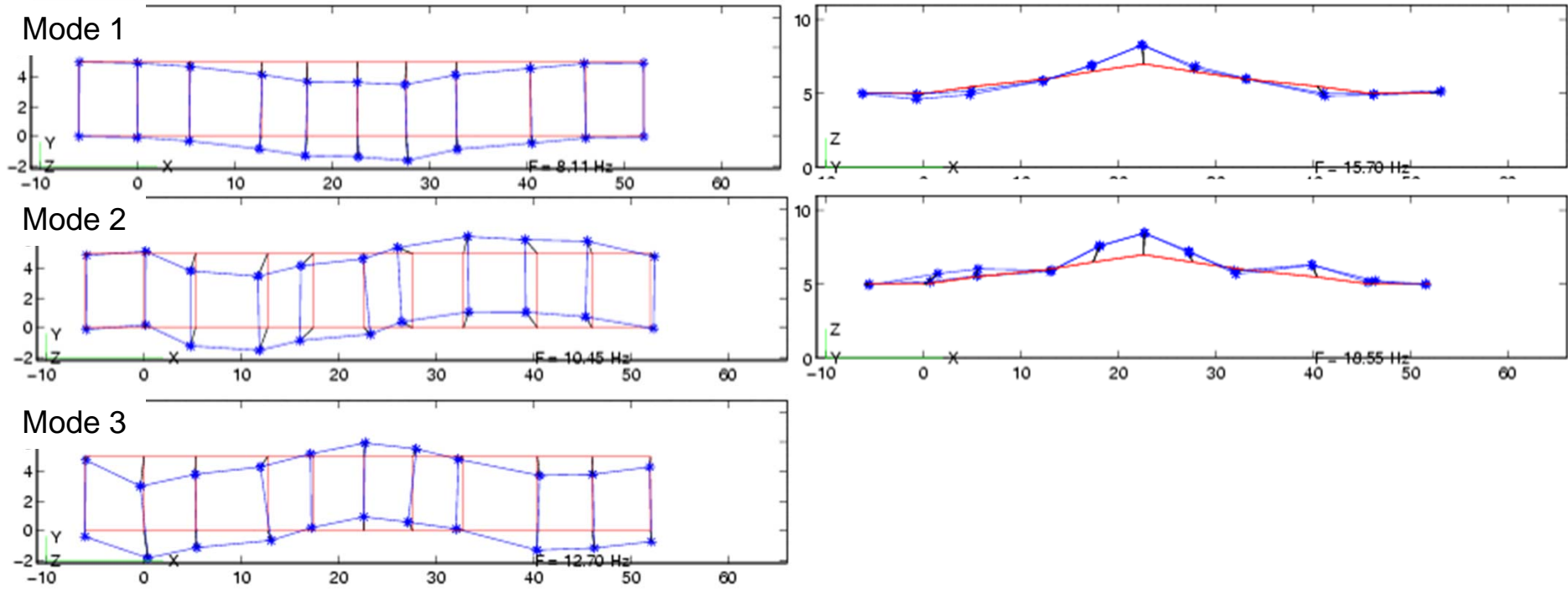
Geometrisch model van constructie

Dynamische eigenschappen bestaande constructies

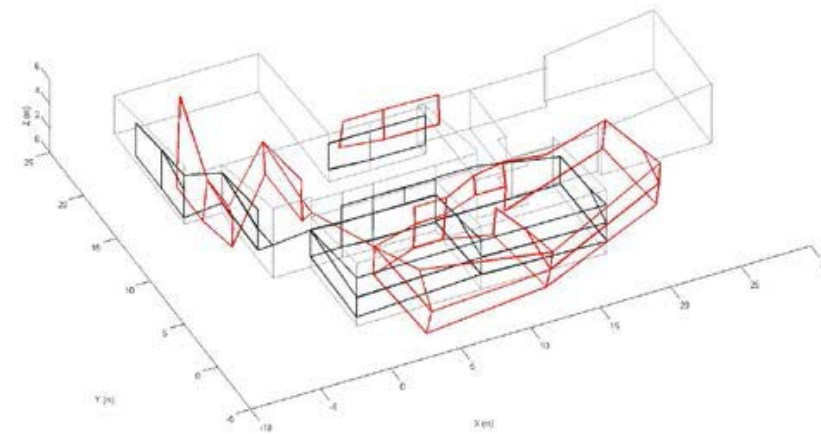
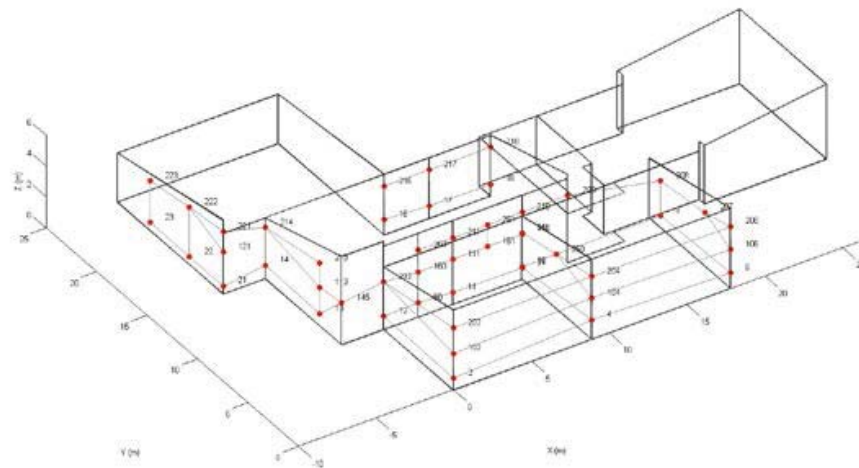
Port Au Prince - Haïti



Pont Julien - Sisteron



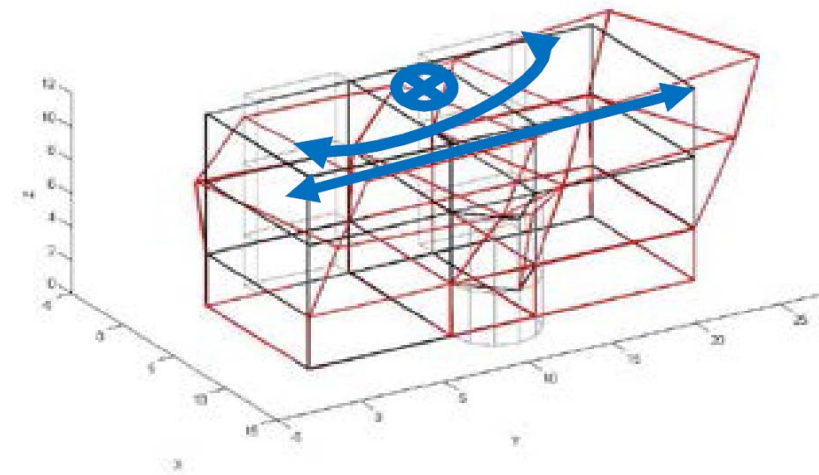
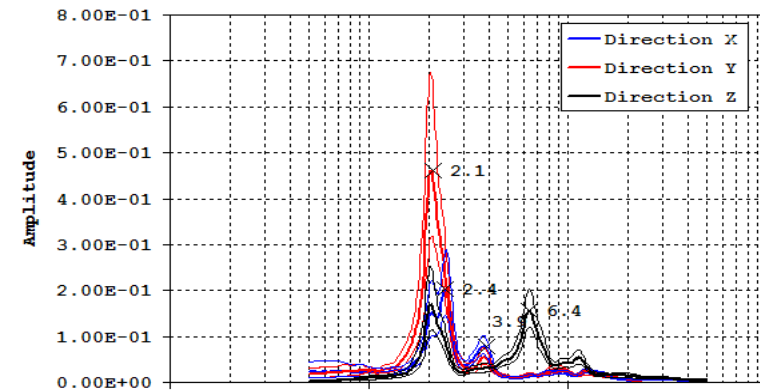
School in Ten Post, Groningen



Toepassing

- Input voor berekeningen
- Controle ontwerp (komt ontwerp eigenfrequentie overeen met werkelijke eigenfrequentie)
- Structural health monitoring

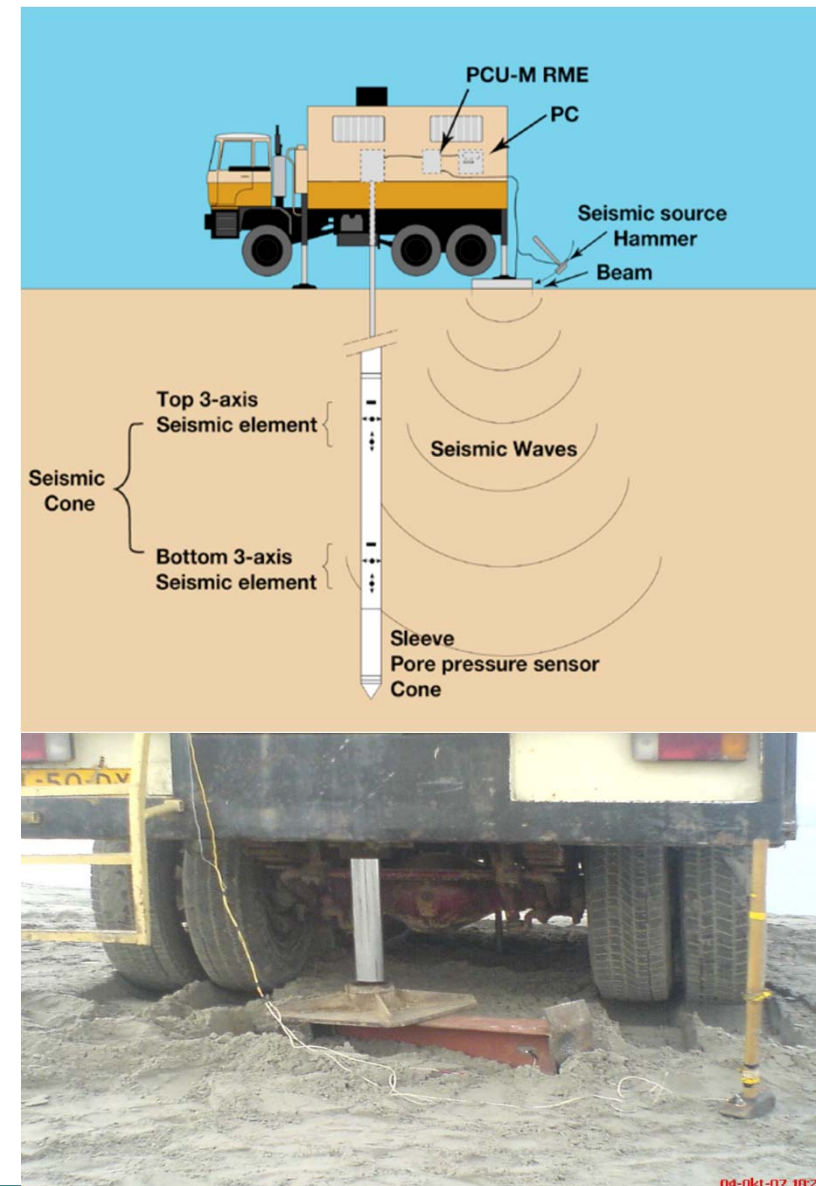
Amplitude spectrale
 Bât. : MOUNIER - Bulle B
 Fichier : 080715_0922_050.003
 Position : Toiture terrasse
 fo (Hz) : X: 2.4 / 3.9
 Y: 2.1 / 3.9
 Z: 2.1 / 6.4



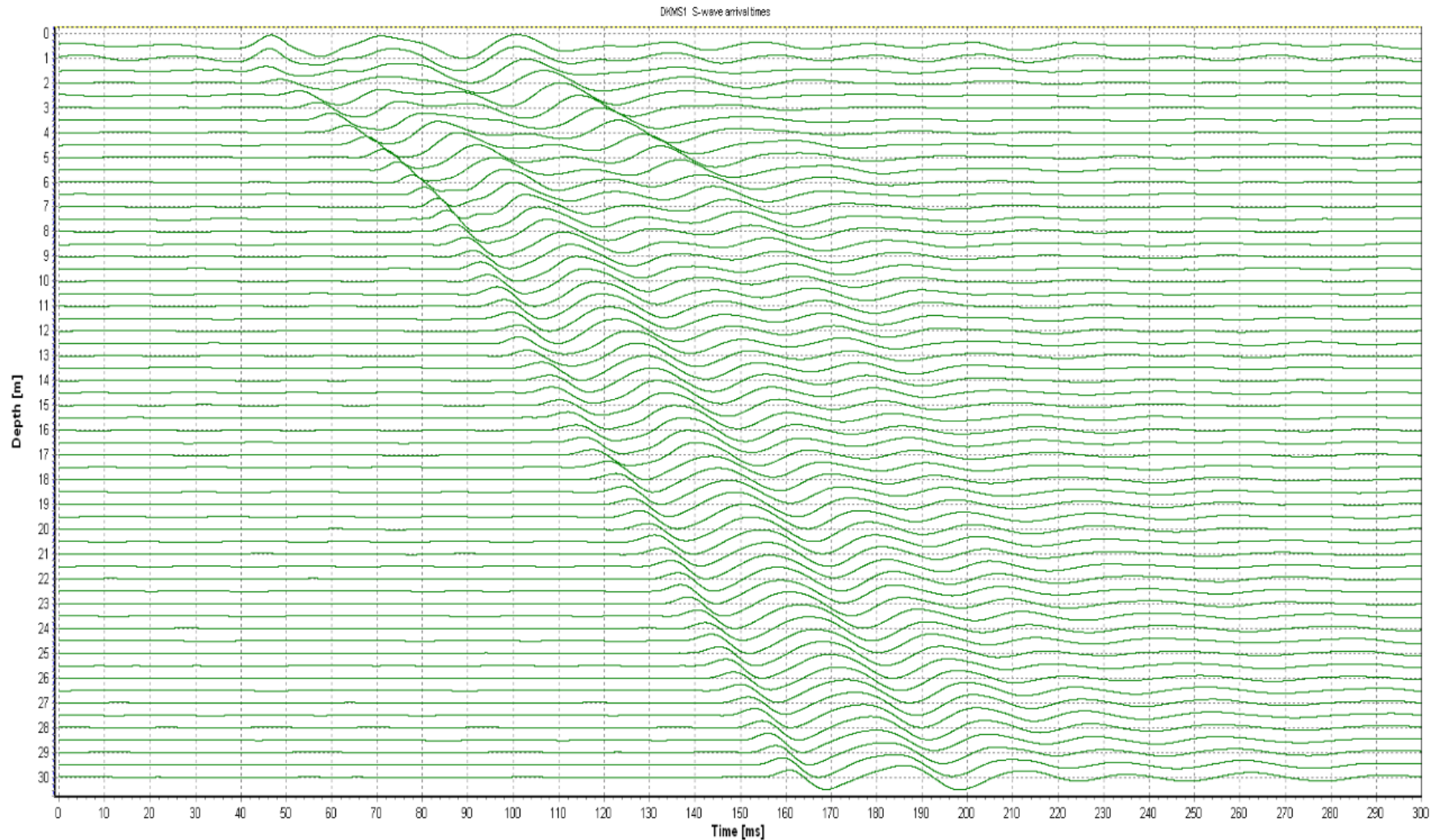
Seismische sonderingen

Bepaling van lokaal Vs-profiel en dynamische grondeigenschappen

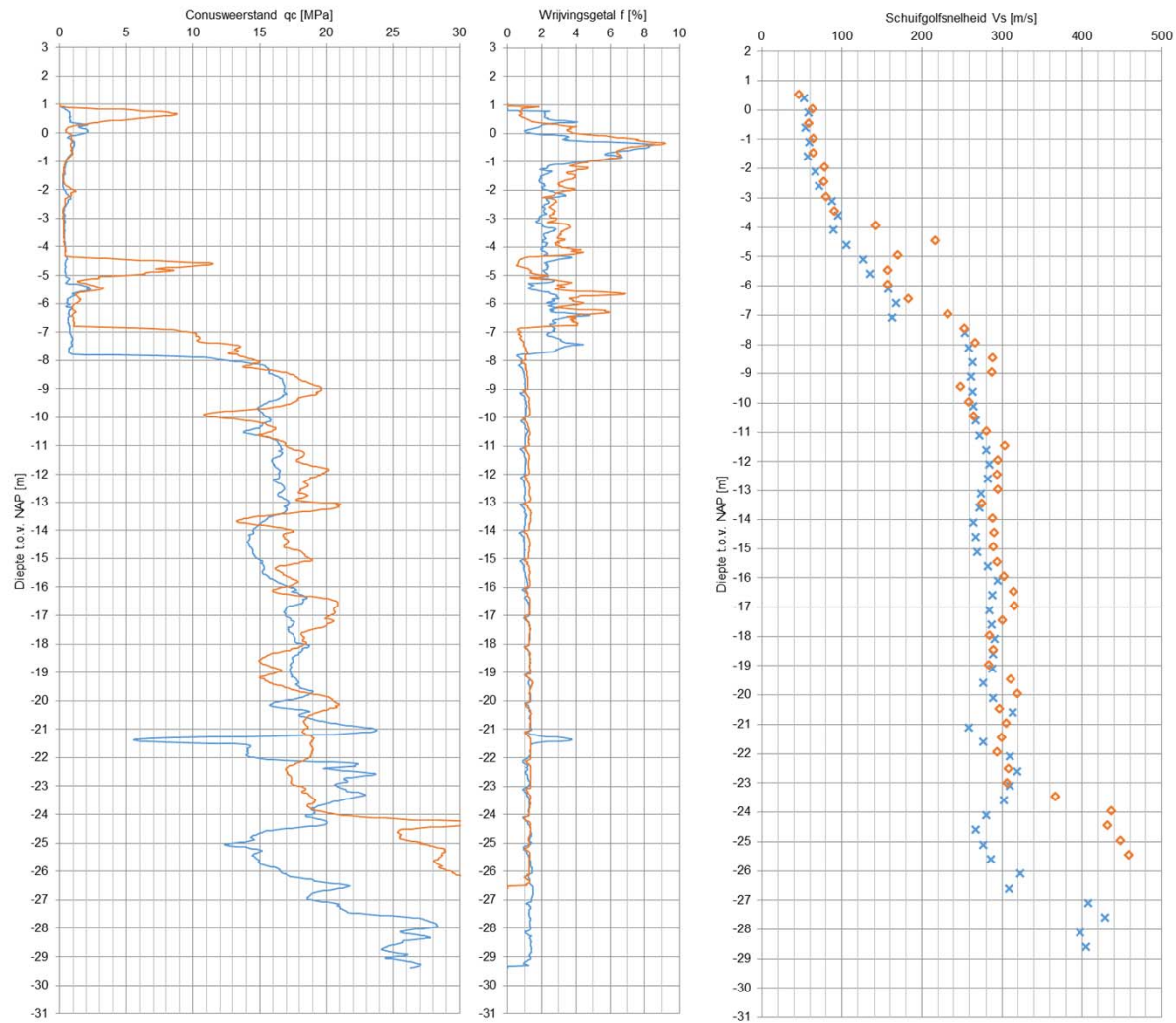
- In-situ metingen van de schuifgolfsnelheden
- Empirische correlaties tussen conusweerstand en schuifgolfsnelheid



- Resultaat van in-situ seismische sondering



Bepaling Vs; Gemeten schuifgolfsnelheden



Bepaling Vs profiel

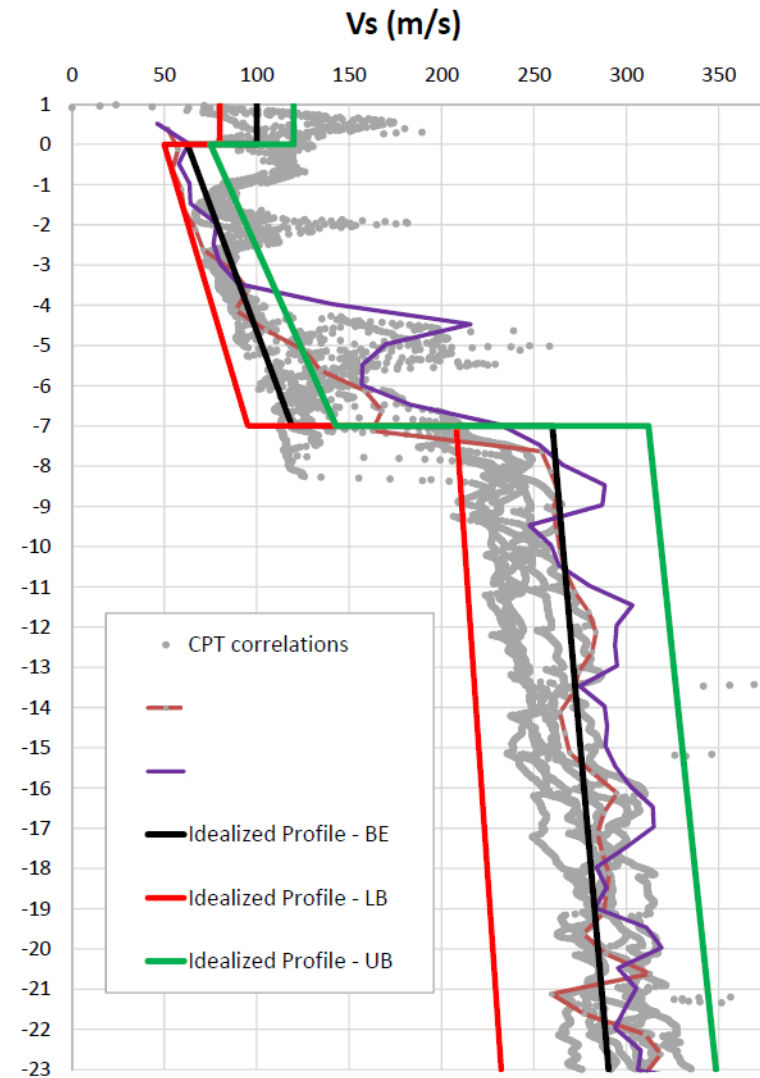
- Empirische correlaties tussen conusweerstand en schuifgolfsnelheid

Reference	Soil Type	Correlated Parameters	Correlations
Mayne and Rix (1995)	Clay	<ul style="list-style-type: none"> • Cone tip resistance, q_c 	$V_s = 1.75(q_c)^{0.627}$ where V_s is in m/s and q_c is in kPa
Rix and Stokoe (1991)	Quartz Sands	<ul style="list-style-type: none"> • Cone tip resistance, q_c • Effective vertical stress, σ'_v 	$G_{max} = 1634(q_c)^{0.26}(\sigma'_v)^{0.375}$ where G_{max} , q_c and σ'_v are in kPa; and $V_s = (G_{max}/\rho)^{0.5}$ in m/s
Andrus et al. (2007)	All	<ul style="list-style-type: none"> • Cone tip resistance corrected for pore pressure effects, q_t • Depth, z • Soil behavior type index, I_c • Age scaling factor (SF) 	$V_s = 2.62(q_t)^{0.395}(I_c)^{0.912}(z)^{0.124}SF$ where V_s is in m/s, q_t in kPa, I_c is dimensionless, z is in m, and SF = 1.12 for Pleistocene soils and 0.90 for Holocene soils;
Robertson (2009)	All	<ul style="list-style-type: none"> • Cone tip resistance corrected for pore pressure effects, q_t • Total stress, σ_v • Soil behavior type index, I_c 	$V_s = [10^{(0.55 I_c + 1.65)}(q_t - \sigma_v)/P_a]^{0.5}$ where V_s is in m/s, q_t and σ_v in kPa, I_c is dimensionless, and P_a is the atmospheric pressure

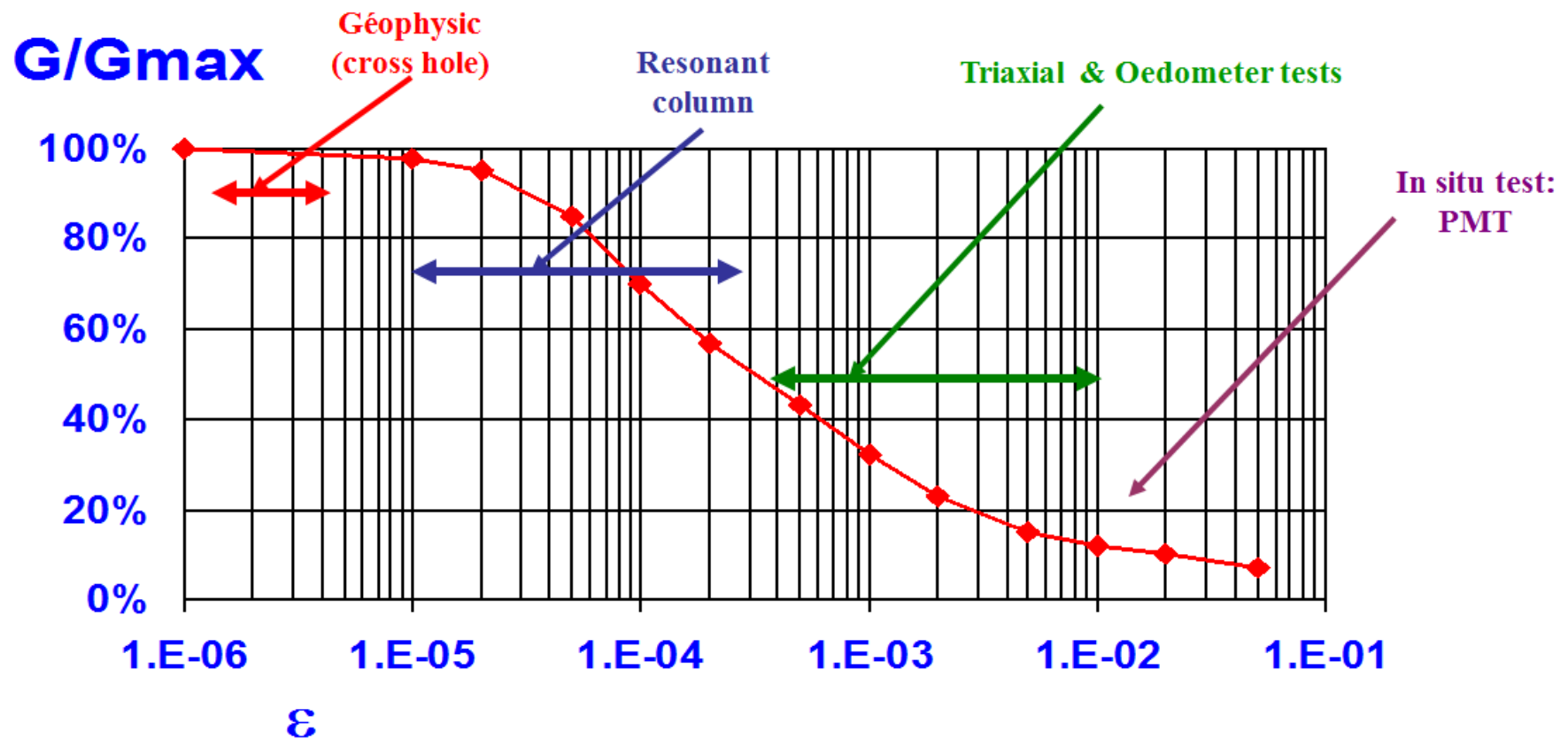
- Selectie van correlaties op basis van matching met uitgevoerde seismische sondering

Creëren schuifgolfsnelheid profiel

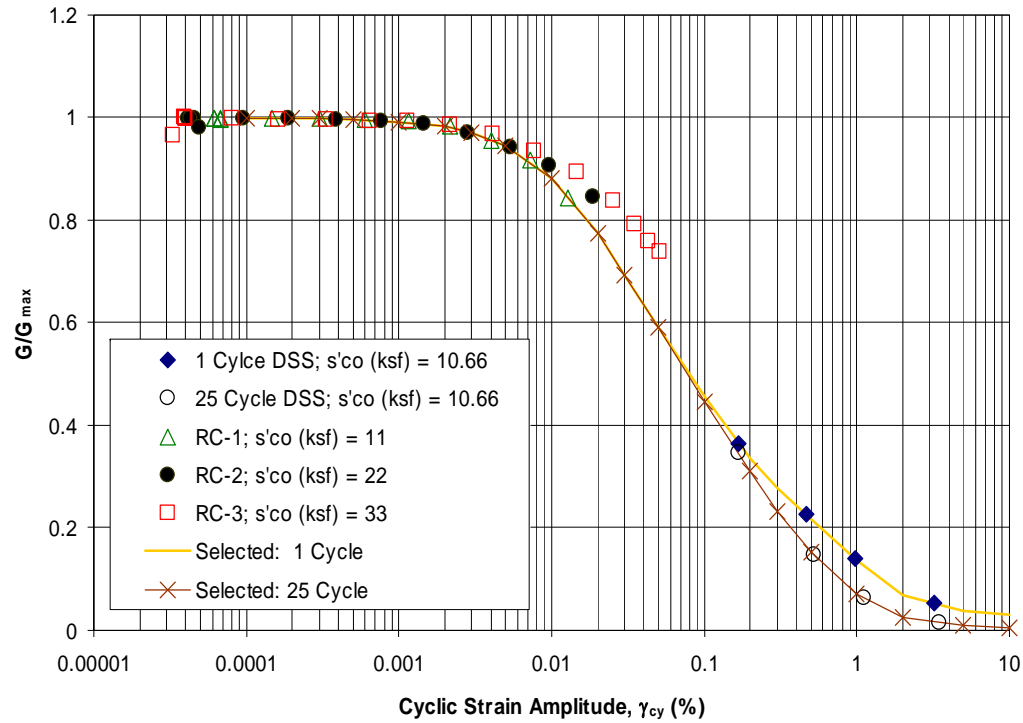
Bepaling boven en ondergrens op basis van variatie in schuifgolfsnelheid bepaald met correlaties en in-situ metingen



G/Gmax curves uit literatuur of bepalen aan de hand van laboratoriumonderzoek



Dynamische laboratoriumproeven



Cyclic Triaxial

Cyclic Direct Simple Shear

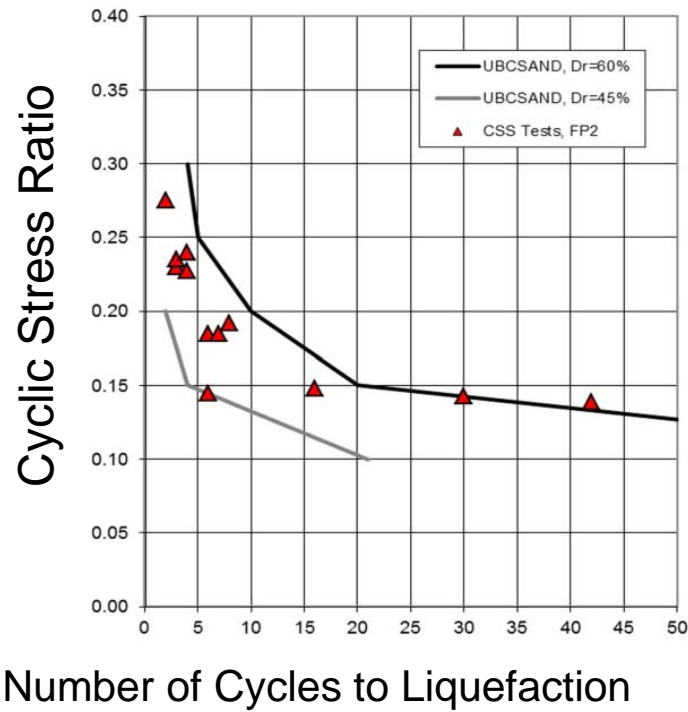
Resonant Column



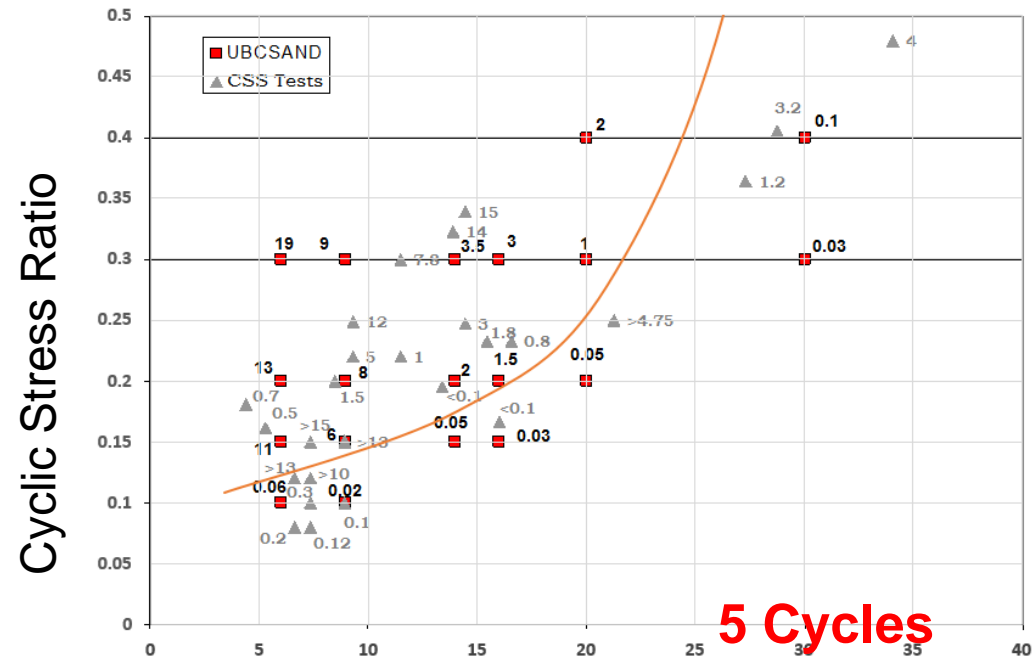
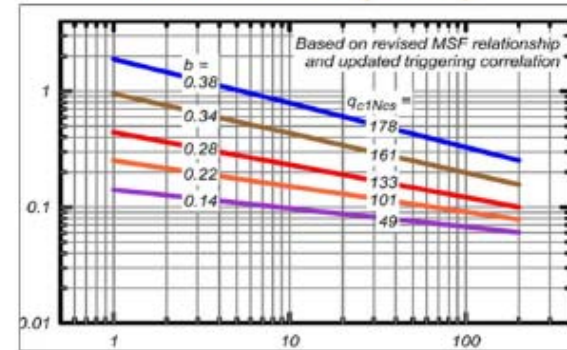
Post Liquefaction Shear Strain Accumulation

For Groningen sites check response at Small Number of Cycles!

Site-Specific Cyclic Simple Shear Tests



MSF from IB (2014)



5 Cycles

$N_{1,60}$



Vragen ?