

Het modelleren van fluid-structure interactie

28 juni 2012

Bianca Derkzen

Aanleiding



MASTER THESIS REPORT

SEISMIC ANALYSIS OF THE CONCRETE LPG TANK WITH FLUID-STRUCTURE INTERACTION



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May 2012

Doelstelling student en Pools universiteit:

- Ervaring opdoen met DIANA
- Vergelijking resultaten DIANA en ABAQUS

Het ontwerp dilemma

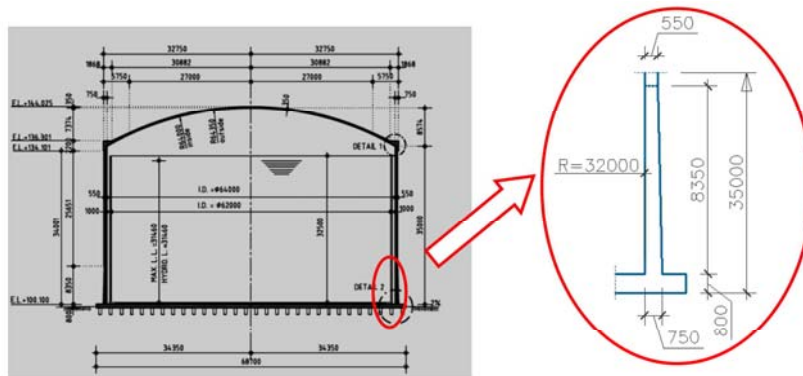


Figure 1.1. The LPG tank and detail of the tapered part of the wall. Source: (Toyo Kanetsu K.K., 2009).

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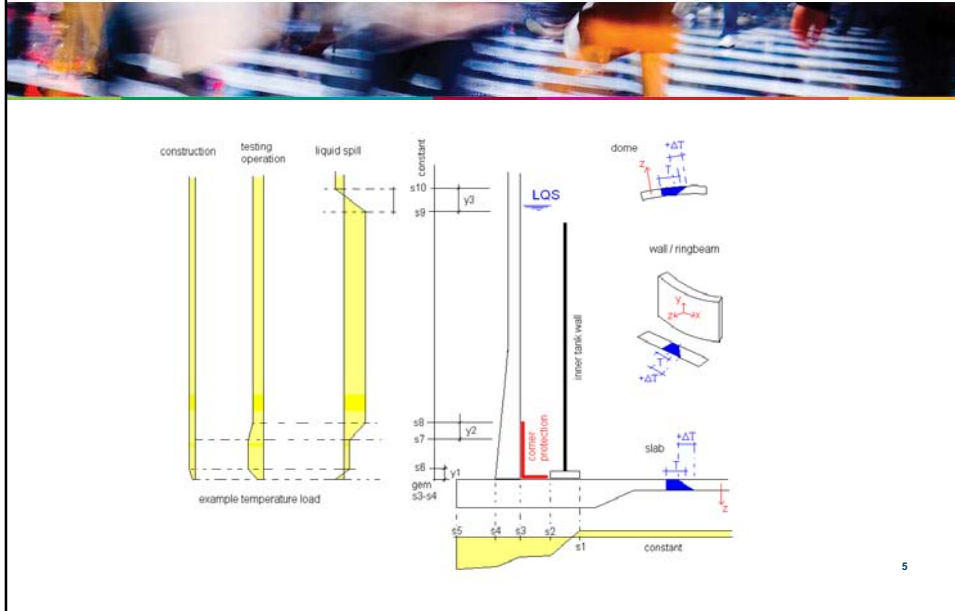
Kenmerken ontwerpproces



- Dimensies betonnen tankschil en afschatting hoeveelheden worden afgegeven in BID-design.
- Detailed design = ontwerp wapening en voorspanning m.b.v. 3D lineair-statisch DIANA model en post-processor.
- Complexiteit
 - Stijfheid fundering en damping
 - Temperatuurseffecten door cryogene vloeistof
 - Invloed aardbeving
 - Combinatie van effecten (aardbeving en "liquid spill")

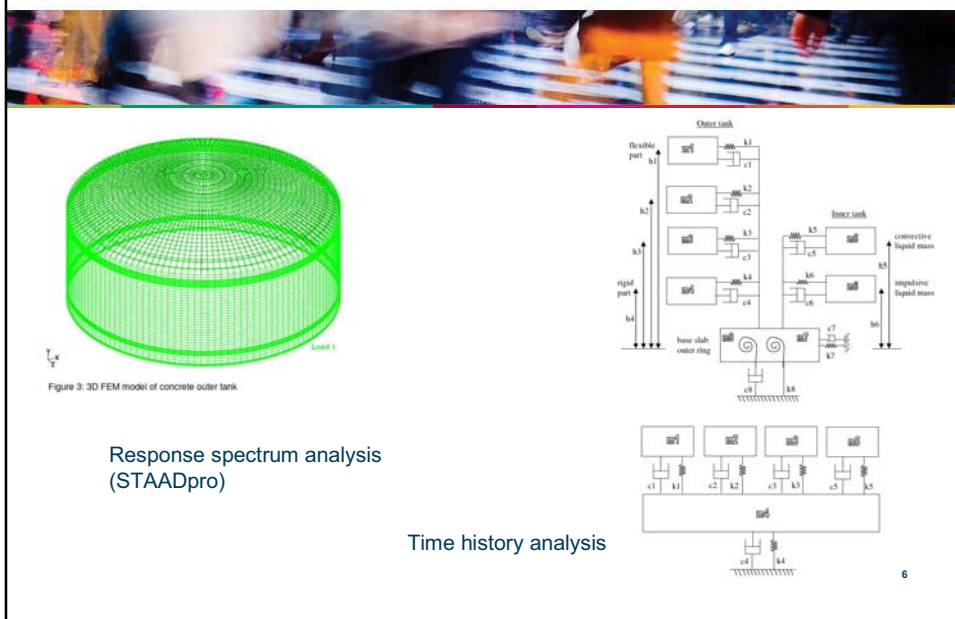
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Temperatuurbelasting



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Aardbeving



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Vertaling aardbeving

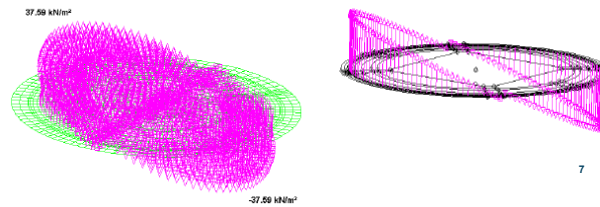
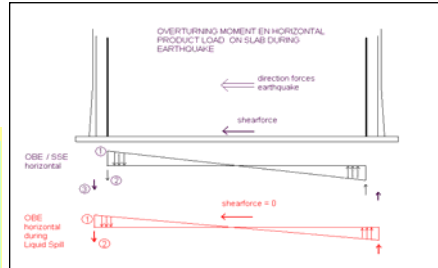


Structural part	Base shear [kN]	Overturning moment [kNm]
Outer tank wall & dome	35862	1540178
Inner tank	102412	3272203
Foundation	108509	3616553

lc 28: X EARTHQUAKE OBE horizontal load tank & product + overturning moment

lc29: Z

gravity load tank structure (incl. perm. load wall and dome)	4.527 %
extra contribution own weight slab/permanent loading slab	-13.688 %
<u>Horizontal force from product</u>	
shear force at base slab level of concrete outer tank	1022 ton
<u>Forces due to overturning moment</u>	
1. on inner tank bottom plate area	13.6 kN/m ²
2. on inner tank shell plate (inner tank wall)	127.2 kN/m
3. on concrete shell (outer tank wall)	-17.8 kN/m



Overturning moment / sloshing

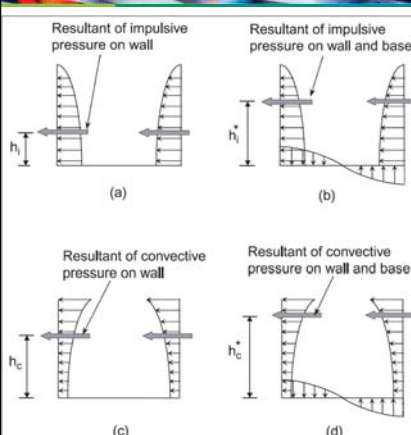


FIG. 1. QUALITATIVE DESCRIPTION OF HYDRODYNAMIC PRESSURE DISTRIBUTION ON TANK WALL AND BASE

Journal of Structural Engineering
Vol. 32, No.4, October-November 2005 pp. 297-310

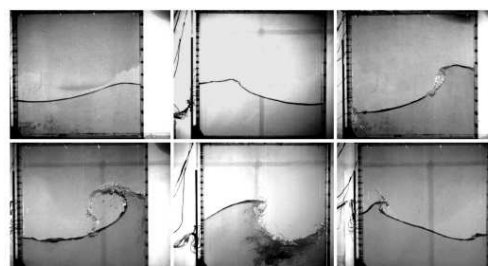


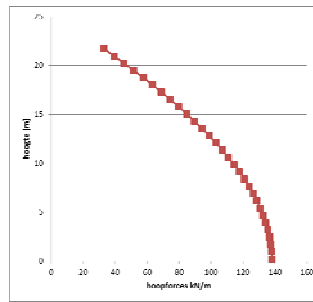
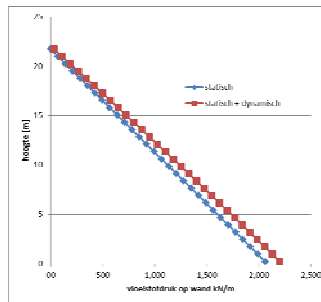
Figure 7.2. Snapshots of the water in the 2D tank during the experimental test. From left to right: at the first picture with smooth free-surface. Next photos with wave with increasing nonlinearities. (Colagrossi, Palladino, Greco, Lugni i Fallesen, 2005)

Hoopforces



EARTHQUAKE OBE LQS hoop forces (horizontal load)

Maximum height liquid (100%)	21.92 m
density factor	0.569
Seismic Data:	
ZIC ₁	0.08290 * g
ZIC ₂	0.02680 * g



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Fluid-Structure interaction DIANA

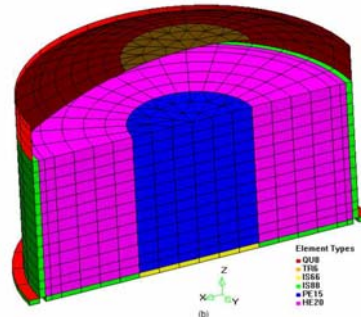
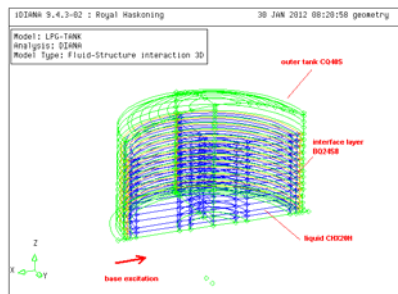
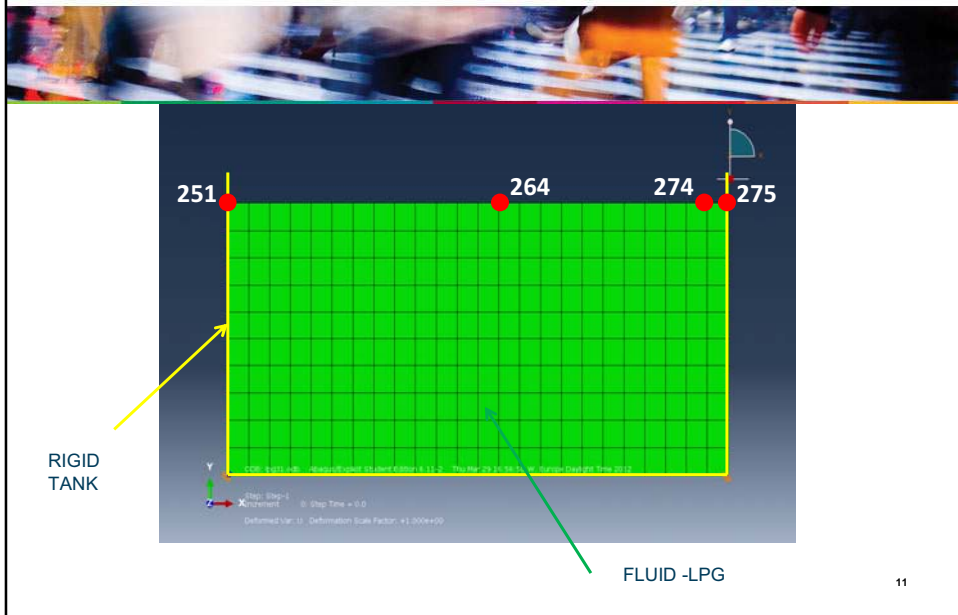


Figure 1 – Model after the corrections: a) geometry; b) mesh

Numerically, in DIANA, sloshing can't be included directly. Or?

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2D model of tank in ABAQUS 6.11.



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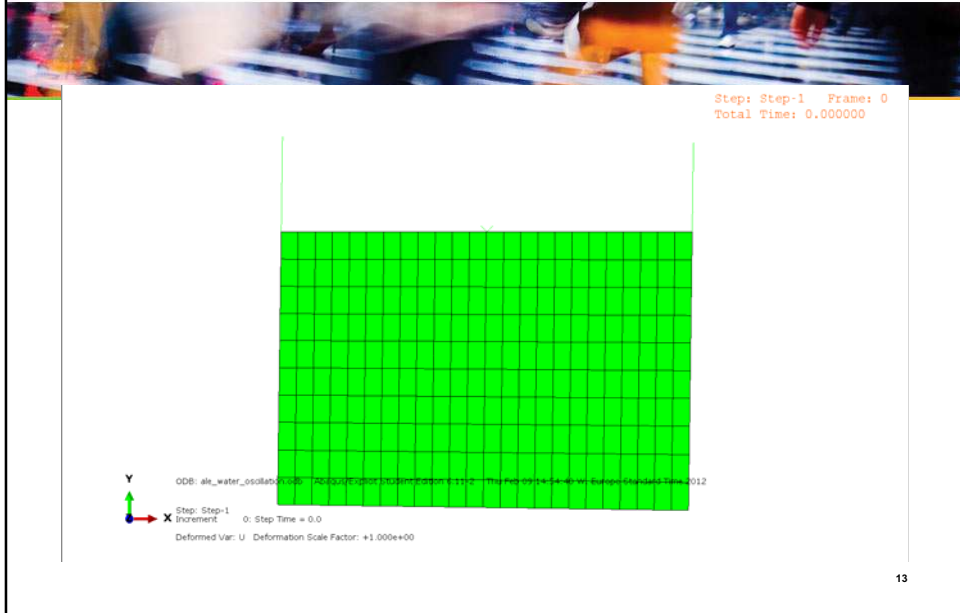
Analyse methode



- Smoothed particle hydrodynamic analysis
 - Meshless
 - fully Lagrangian (nodes are fixed within the material)
- Eulerian analysis
 - nodes are fixed in space, and material flows through elements that do not deform
 - Eulerian-Lagrangian contact
- Explicit dynamic analysis
 - automatic ALE adaptive meshing

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Sloshing

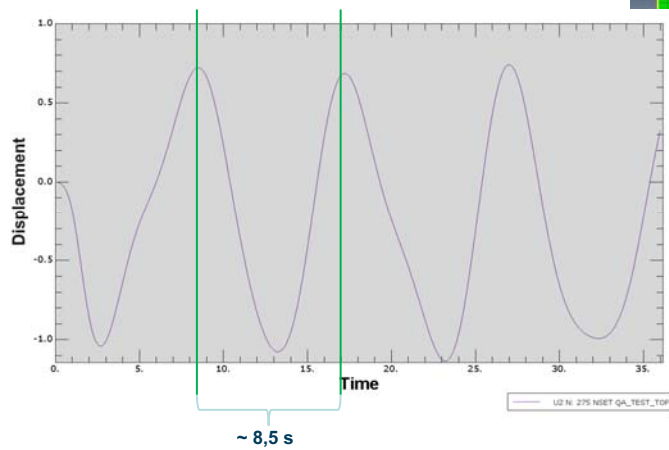
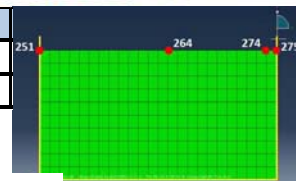


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BDE1

Period of sloshing

Sloshing mode:	Housner	Ibrahim	ACI 350.3	API 620	Eurocode 8
Period [s]	8,709	8,592	8,595	8,694	8,624
Wave height [m]	-	-	-	0,204	0,241



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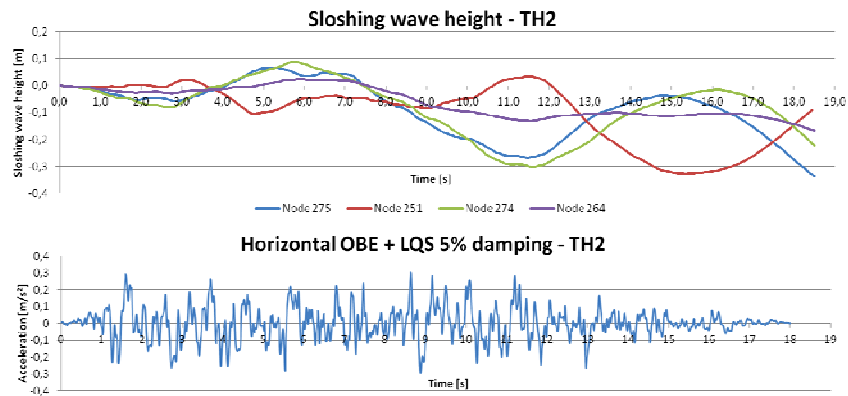
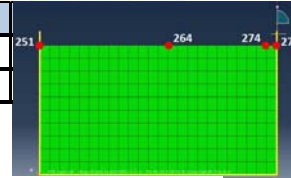
Dia 14

BDE1 Nice!

Derkzen, B.G.L. (Bianca); 12-4-2012

Sloshing wave height

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Hydrostatic pressure in LPG tank

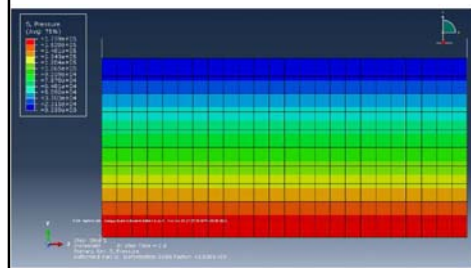


Figure 9.8. Hydrostatic pressure in the tank. Time step: 0.0s.

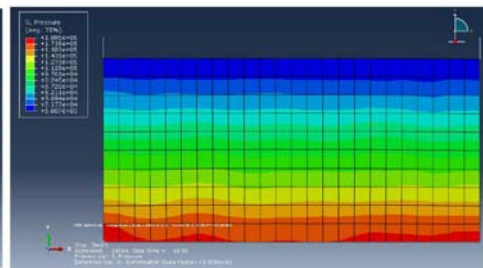


Figure 9.9. Fluid pressure in the tank during the earthquake. Time step: 18.5s.

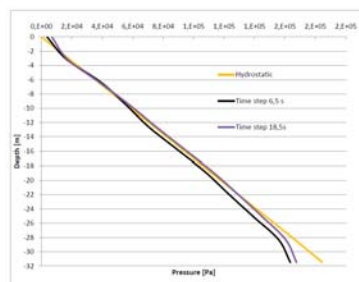


Figure 9.10. Pressure on the right wall during the TH2 earthquake record. Alepo.

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