

Facility Siting & Structural Resilience

*Safeguarding Occupied Buildings and Critical Assets in the Era
of Energy Transition and Emerging Threats*

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Blast

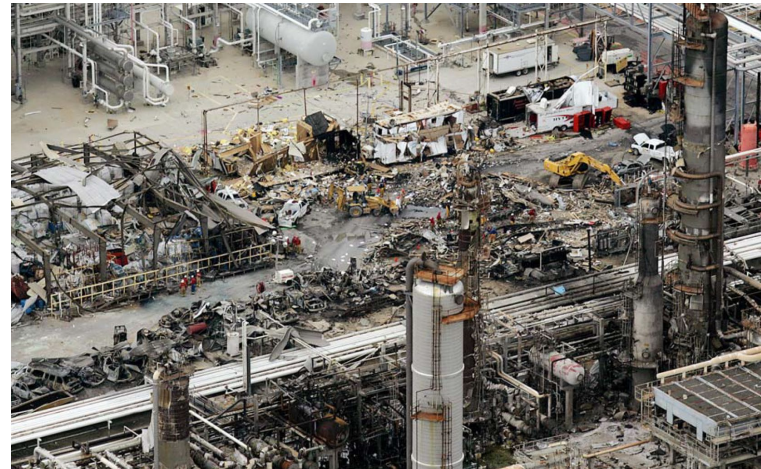
Setting the Scene

■ Incidents

- Flixborough (1974)
- Toulouse (2001)
- BP Texas (2005)
- Beirut (2020)

■ Intentional Bombings

- Madrid Train (2004)
- Aleppo Government Areas (2016)
- Brussels Metro & Airport (2016)
- Manchester Arena (2017)



Setting the Scene

- Redevelopment of industrial areas/sites to optimize land use and/or develop new business possibilities
- Improvements in (availability of) digital techniques
- Complex building environment
 - Increased number of high-rise buildings
 - Multiple functions in one building
 - Transformation of buildings
- Changes in Dutch legislation (Omgevingswet)
 - Possibilities for specific structural requirements for buildings near chemical plants
- Introduction of “new” security issues
 - Drone attacks

Upcoming Challenges and Opportunities

New activities
Site master planning

Energy transition /
changing markets

Buildings near
industrial sites

Building
requirements/measures

Industrial
buildings

Consequence
Classes

Detailed analysis /
new methods

External threats

Security &
terrorism

Impact on
constructions

Structural
Assessments

Site master planning

- Developing scenarios for future development
 - Expansion of existing plant
 - Adding supporting assets
 - New activities
- Determining related hazards
 - Quantifying potential effects
 - Exploring potential variations/uncertainties in early design stages
- Defining exclusion zones for new developments
- Optimizing plant layout using facility siting criteria

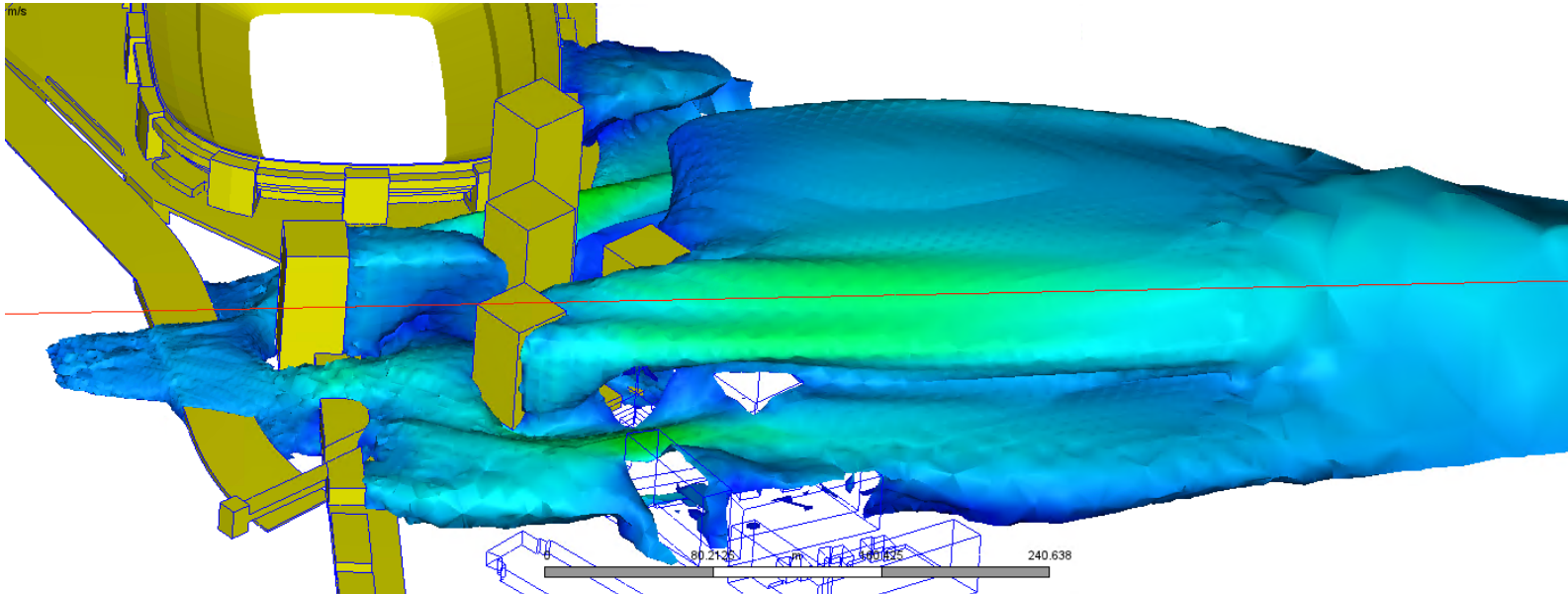


Consequence Classes

- Three levels of consequence classes (NEN-EN-1990)
 - Defining the requirements for design, construction and asset management
- Buildings with hazardous substances / processes in general CC3
- Demonstrate that a lower CC provides sufficient protection
 - The structure or parts of the structure
- The argumentation can include:
 - Existing studies
 - Detailed effect calculations
 - Structural assessment

Effects of incidents in the vicinity

- Toxic Cloud Dispersion
- Rupture of railway carriage with ammonia
- Dispersion of ammonia vapor cloud towards the city



Explosions on Site

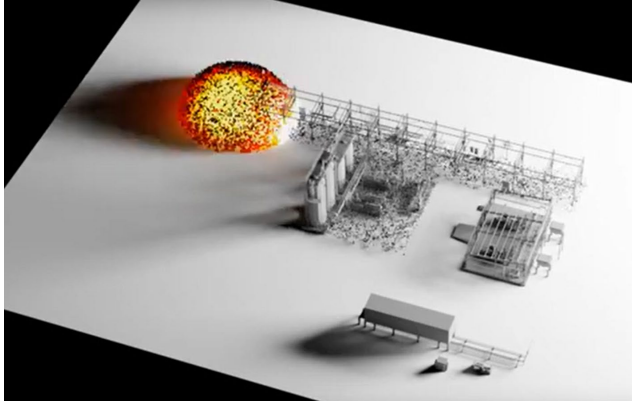
- Accidental or Intentional
- Importance of differences between deflagration and detonation effects for the assessments



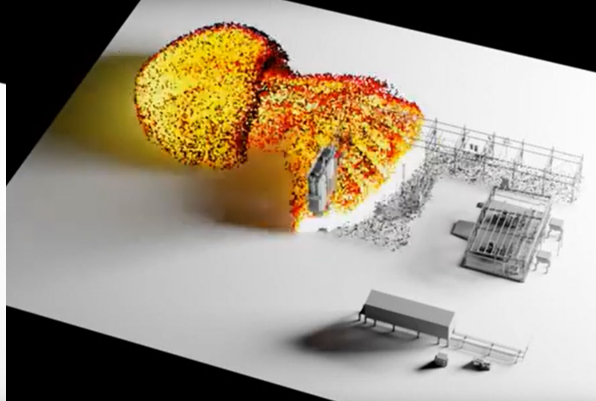
More detailed analysis

- Computational Fluid Dynamics
 - Vapor Cloud Explosion
 - Dealing with uncertainties (Monte Carlo Simulations)

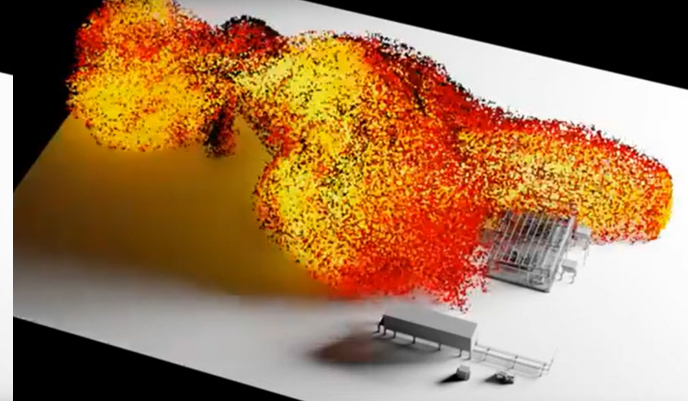
Vapour Cloud Explosions (VCE) simulated using Viper::Blast



Vapour Cloud Explosions (VCE) simulated using Viper::Blast

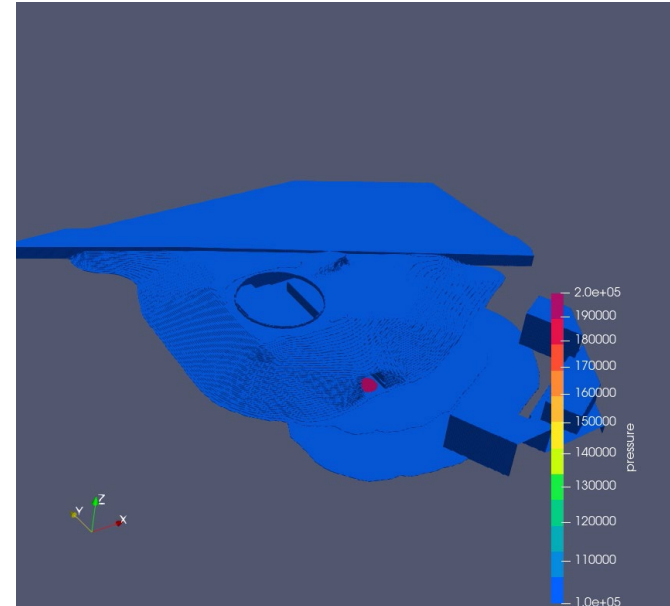
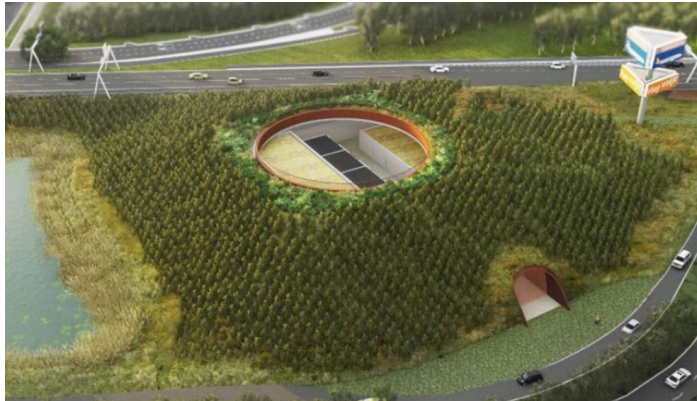


Vapour Cloud Explosions (VCE) simulated using Viper::Blast



External Security Threats

- Terrorism
- Critical Infrastructure
 - Embassies, Nuclear Reactors, Electrical Installations, Airports, Government Buildings, Stations
 - Drone threats
 - Oil & Gas, Chemical???



Structural Assessment (1)

- Interaction between Shockwave and Building
- Methods
 - Simple: Building Equivalent Static
 - More Complex: Component at SDOF level
 - Most Complex: Nonlinear Time History + CFD

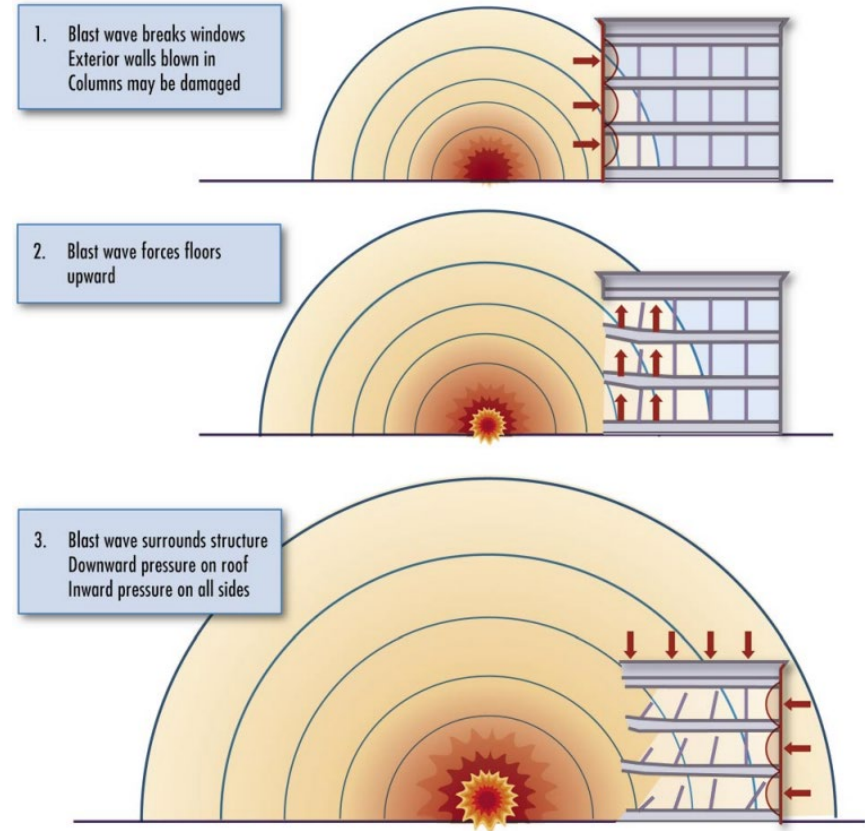
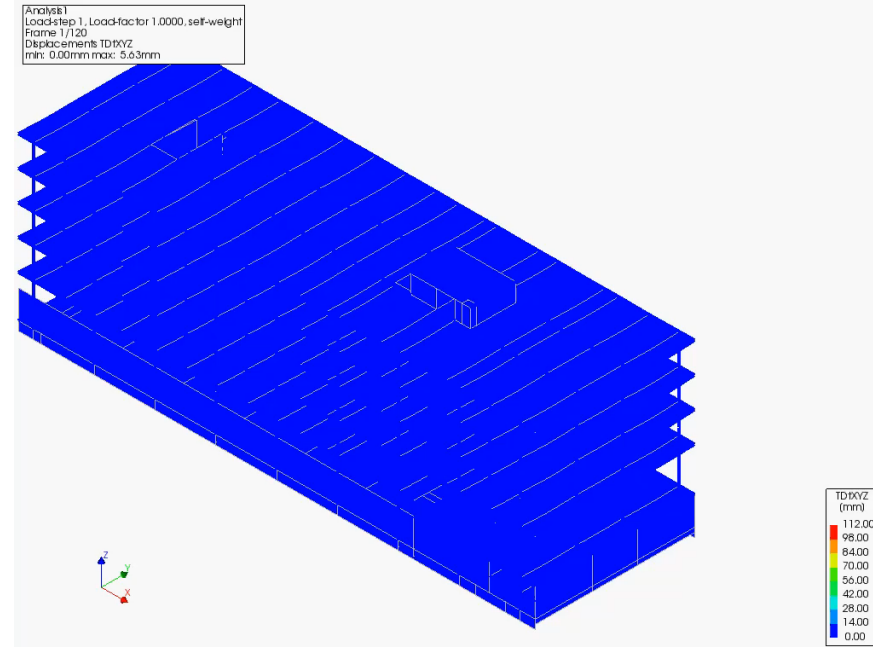
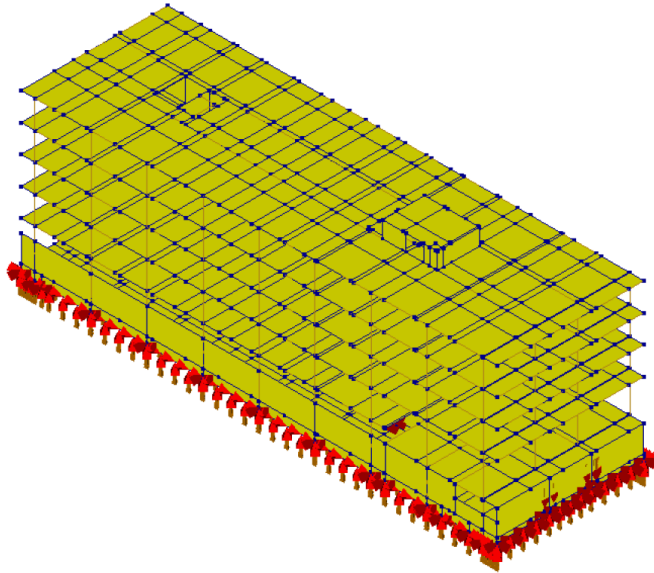


Figure 4-4 Blast pressure effects on a structure

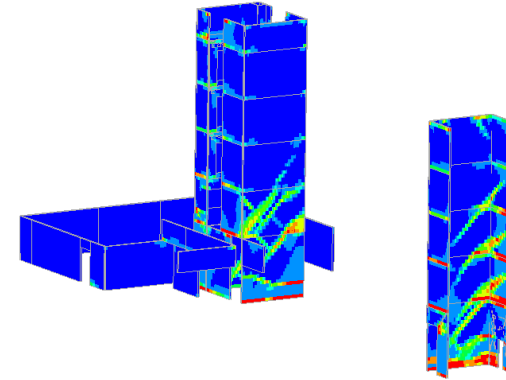
Structural Assessment (2)

- Nonlinear Time History
- Office Building

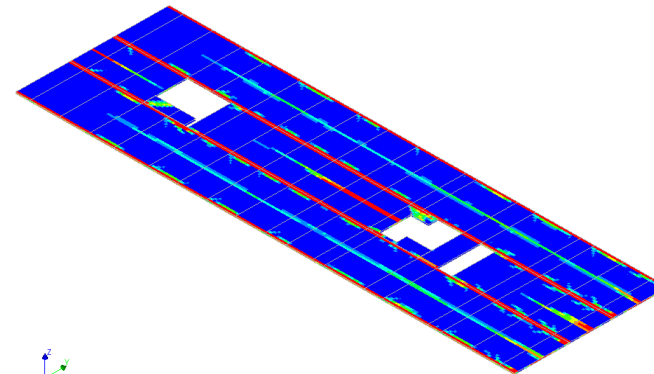


Structural Damage

- Survivability
- Acceptable Damage Levels
 - Collapse
 - Near Collapse
 - Significant (Repairable) Damage
 - No Damage
- Ductility of building (parts)
- Strengthening
- Provide information on response spectrum for equipment design



Analysis1
Extreme maximum up to Time-step 370
Reinforcement Cauchy Total Stresses SYY
min: -4.46N/mm² max: 555.57N/mm²



Wrap Up

- Changing markets and changes in the external context require the exploration of changes to activities on site
 - Try to incorporate HSE and facility siting perspectives in site master planning (strategic level)
 - Revisit facility siting studies for emerging threats or new hazards
 - Use structural assessments to provide solid insights in effects on constructions
 - Prepare for discussions on consequence classes of structures
 - Make use of (digital) techniques (e.g. parametric modelling, Monte Carlo simulations) to deal with uncertainty in the design or context

Include HSE and process safety in site master planning and use structural assessments for the critical assets on site to ensure a safe outlook for future operations

Q&A