The Determination of Ship Impact Loads on a Bridge Foundation

Client: Highways Department of the HKSAR

Consultant: Ove Arup & Partners Hong Kong Limited

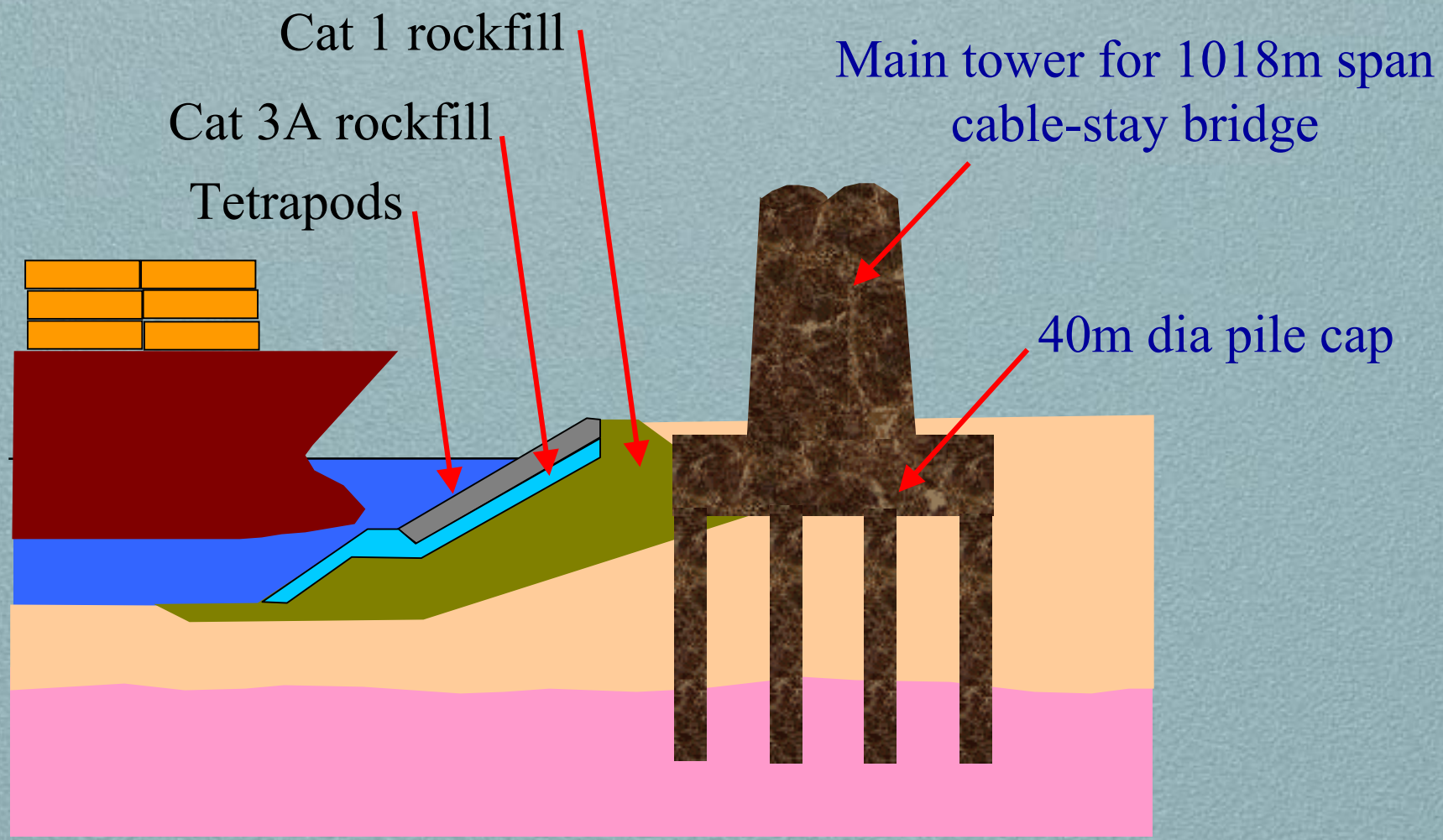
Daman D.M. Lee (Arup)

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Location of Main Tower Foundation

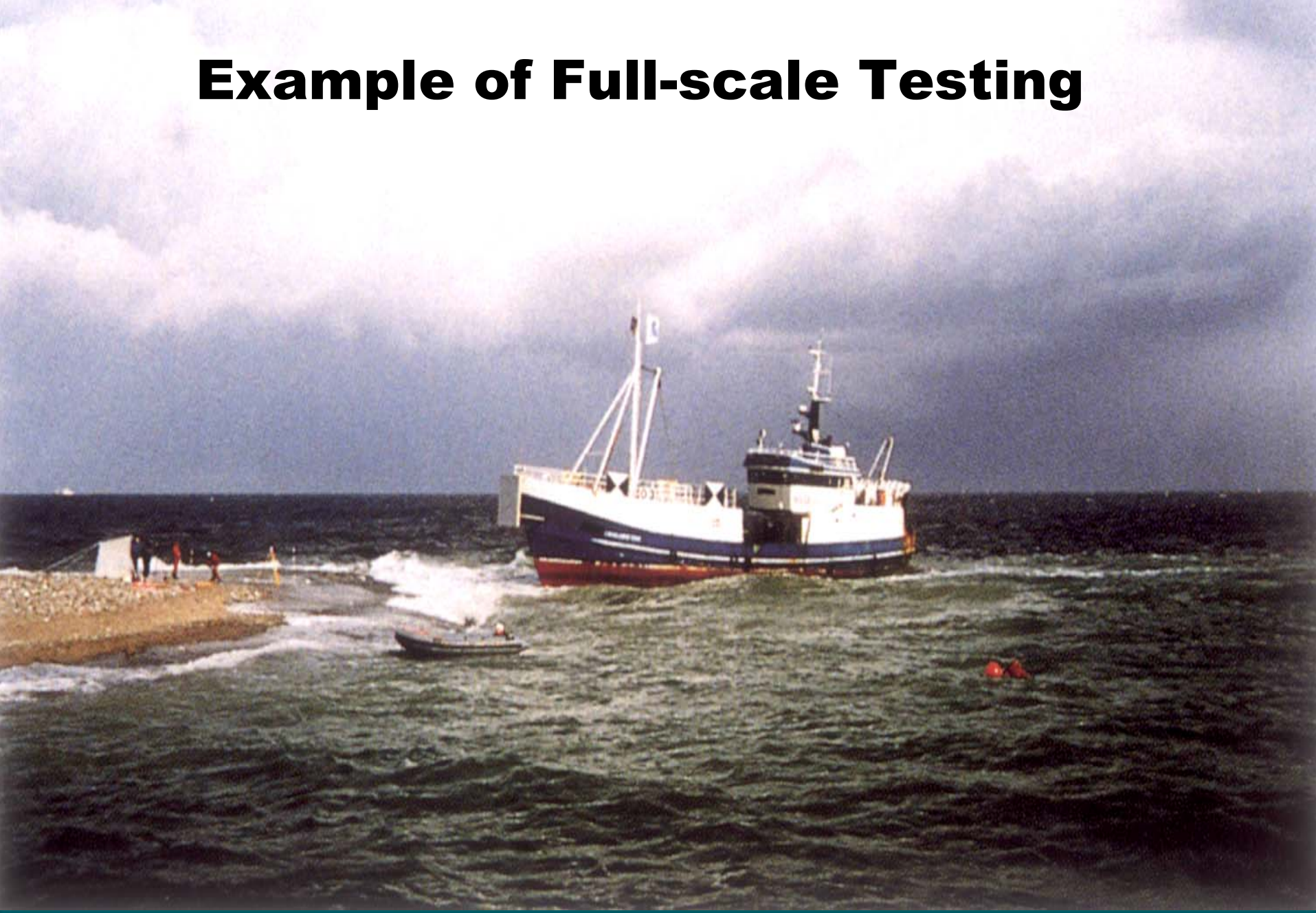


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Details of Design Impact Vessel

Displacement	:	155,000 (tonnes)
Length	:	347 (m)
Width	:	42.8 (m)
Draft	:	14.5 (m)
Impact speed	:	6 (knots)
		3.1(m/s)

Example of Full-scale Testing



NEED FOR CENTRIFUGE TESTING

- Not direct impact on foundation or pylon
- Uncertain load spread => over conservative design
- Numerical analyses - not a simple one

From Procurement To Completion

- Arup proposed testing in consultancy bid
- Highways Department appointed Arup in March 2001
- Prepared the Brief by end of March 2001
- Technical & fee proposals by 5 April 2001
- 12 Tests completed end of July 2001
- Total cost approx. HK$1million

GeoDelft Centrifuge

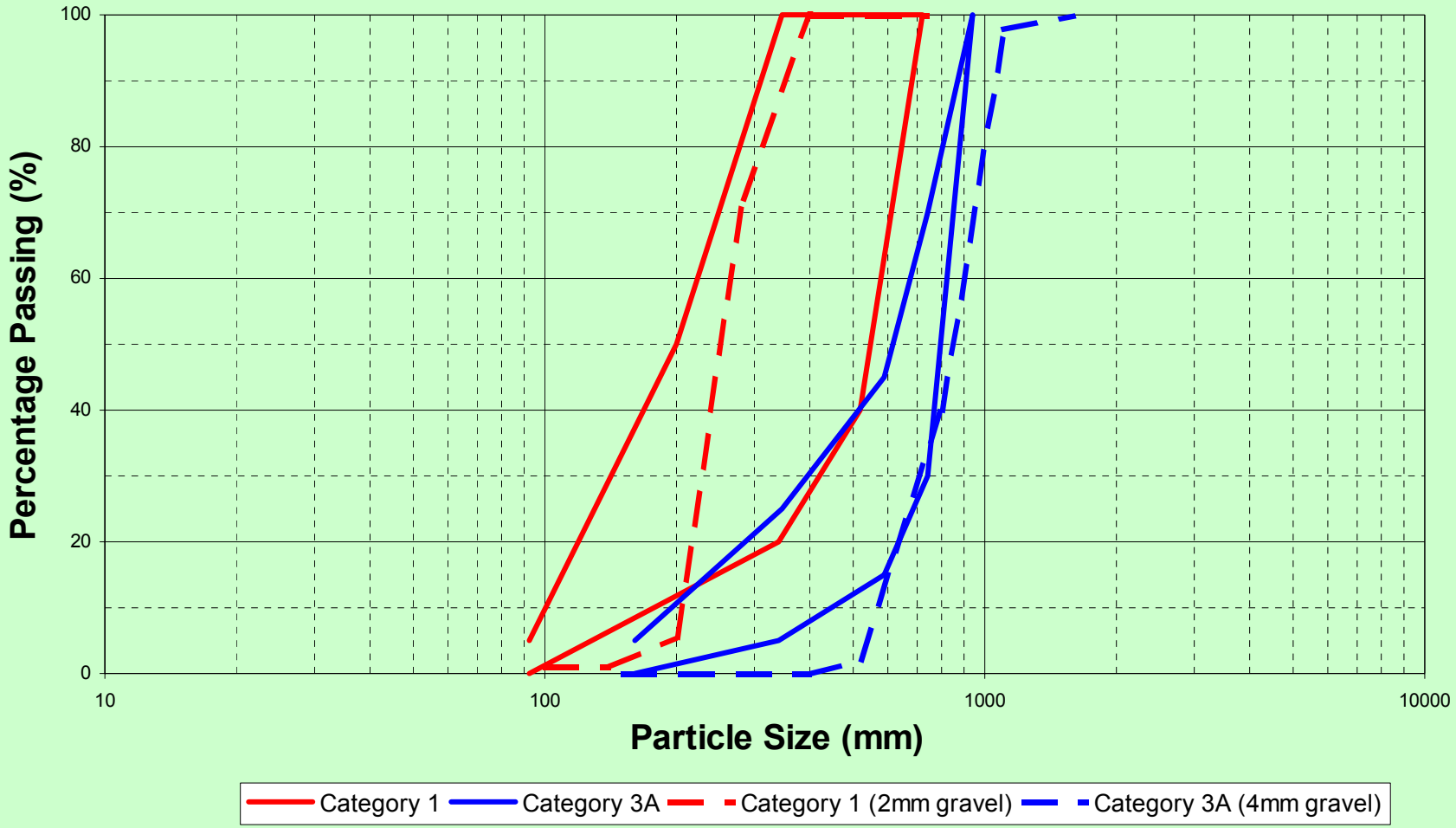


- 6m radius
- Up to 5,500 kg at 300g

Centrifuge Model

- Model size 1/200 of prototype
- Cylindrical strong box 600mm dia.
- Hull modelled as solid block
- Rockfills modelled by scaling
- Bow exact contour was modelled
- Scaled ship weights 20 kg

Modelling of the Rockfills



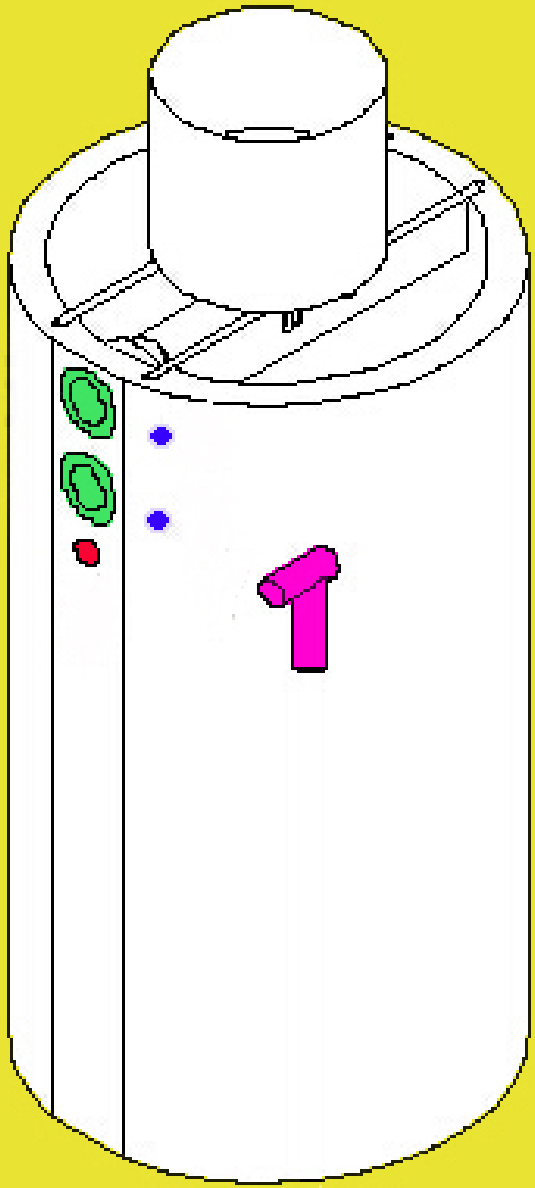
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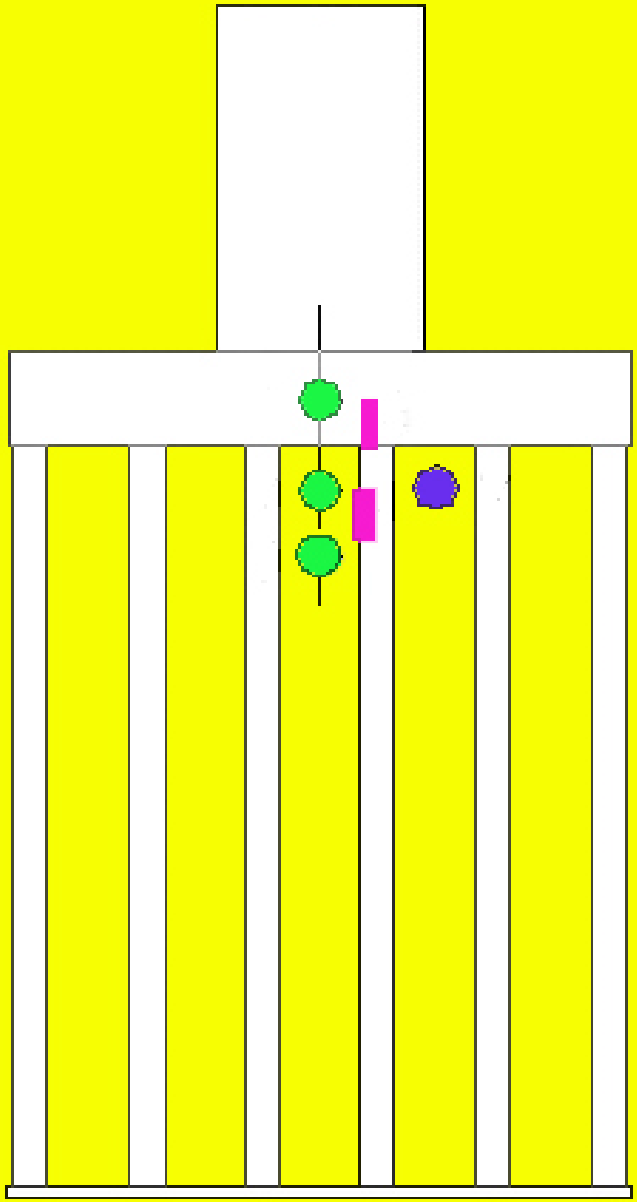


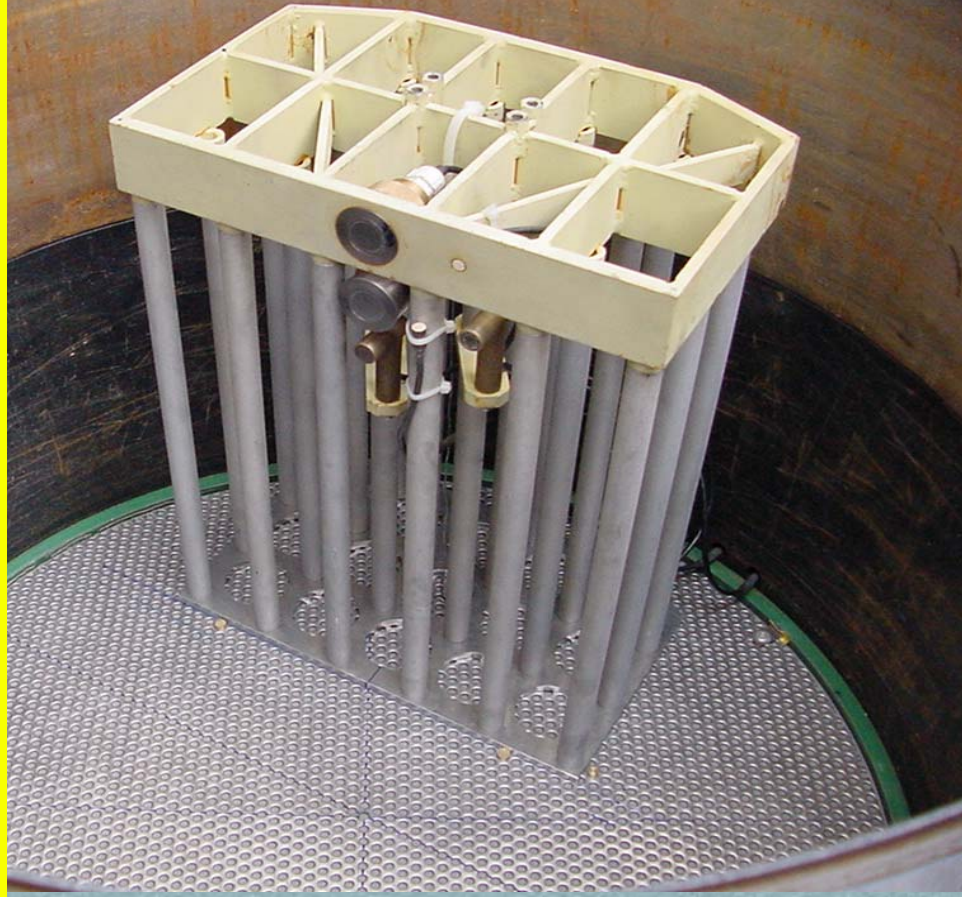


Circular Foundation (dia. ~40m)

Instruments used:

- Total pressure cells
- Pore pressure transducers





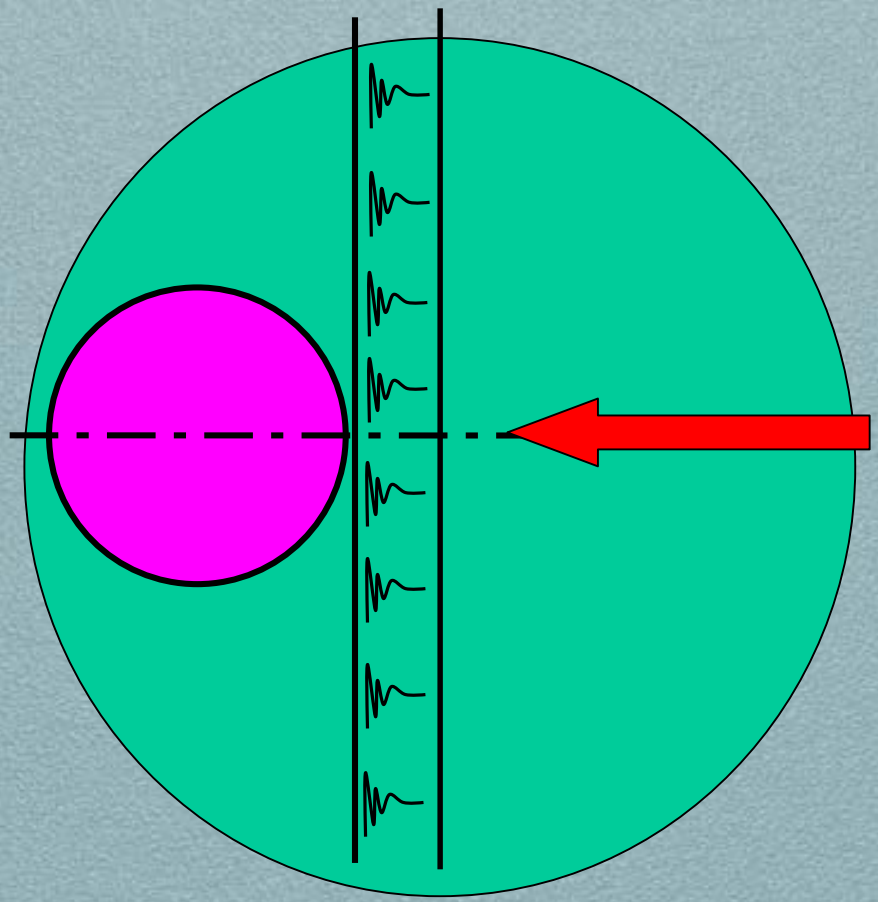
Large Dia. Bored Piles
(~ 24 no.)





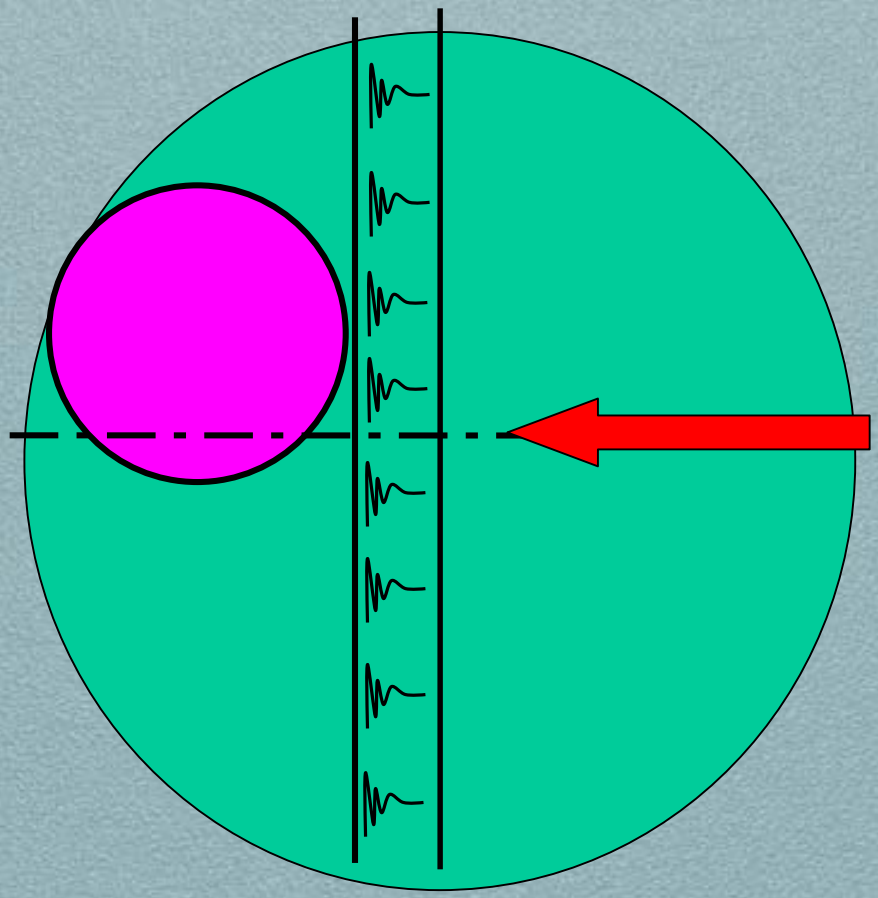


DIRECT IMPACT



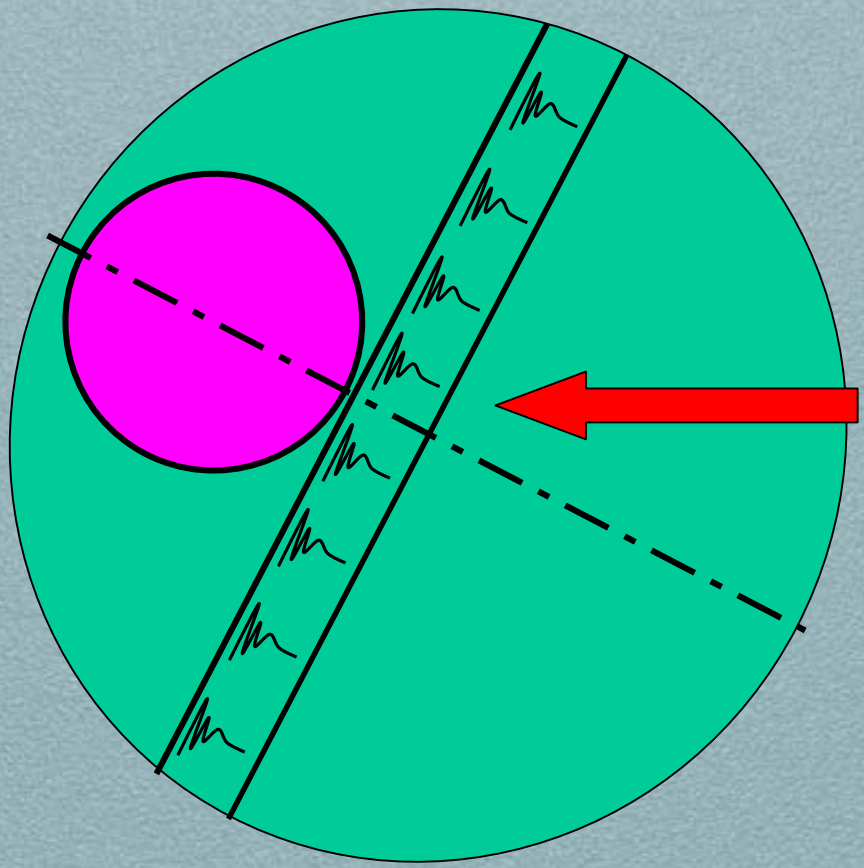
PLAN

OFFSET IMPACT



PLAN

ANGLED IMPACT



PLAN





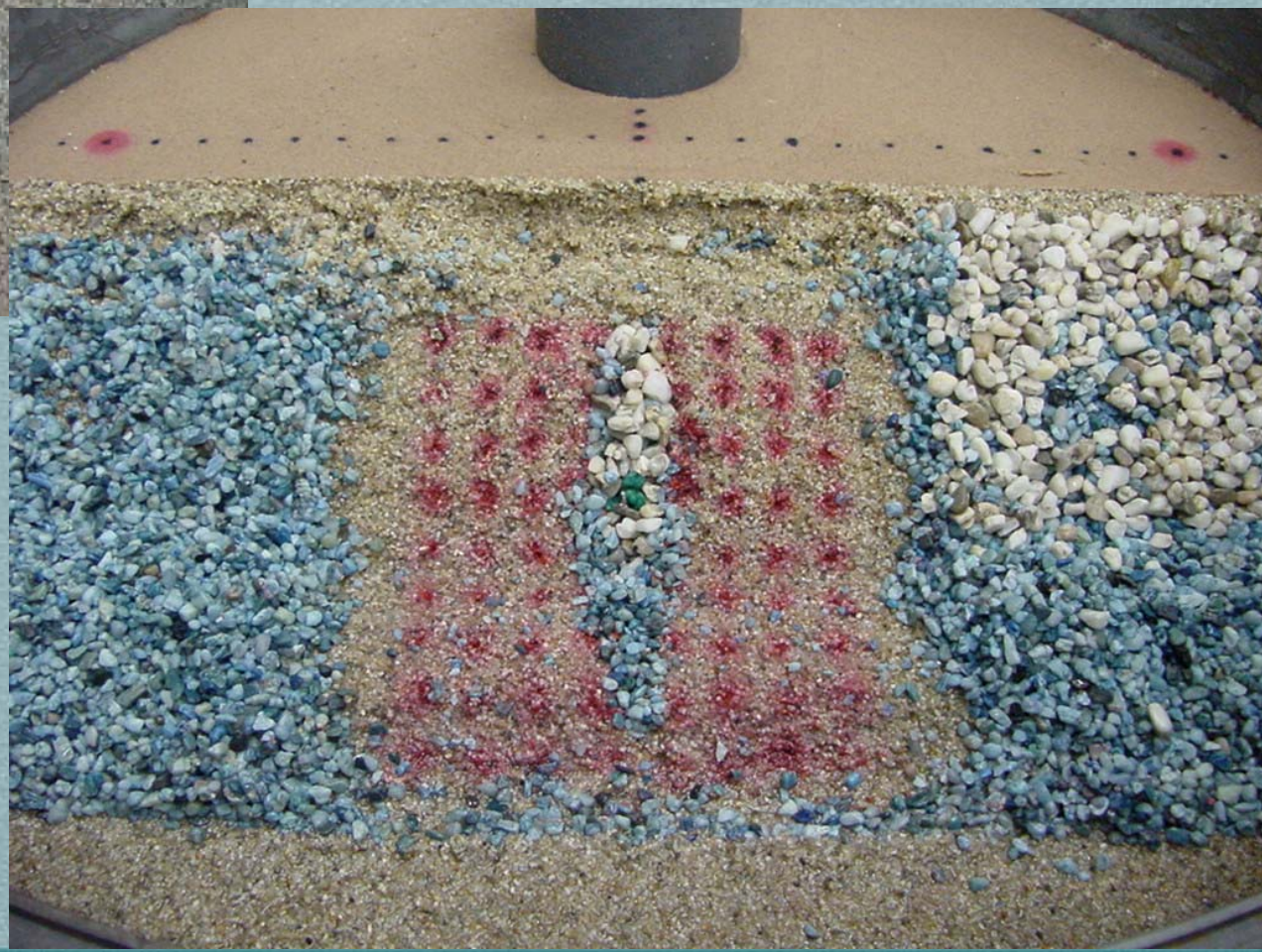
Taken during impact



Taken after test

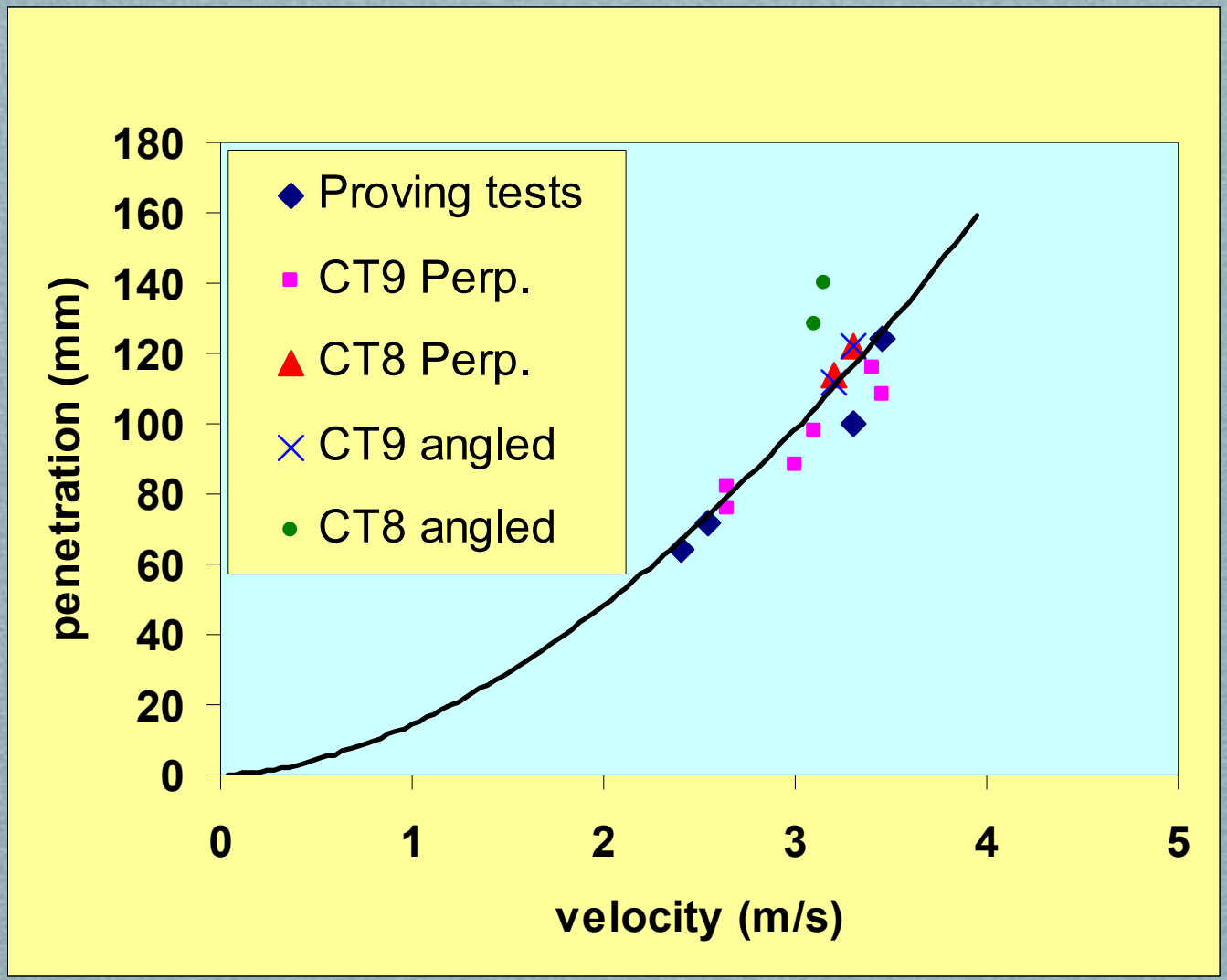


After test



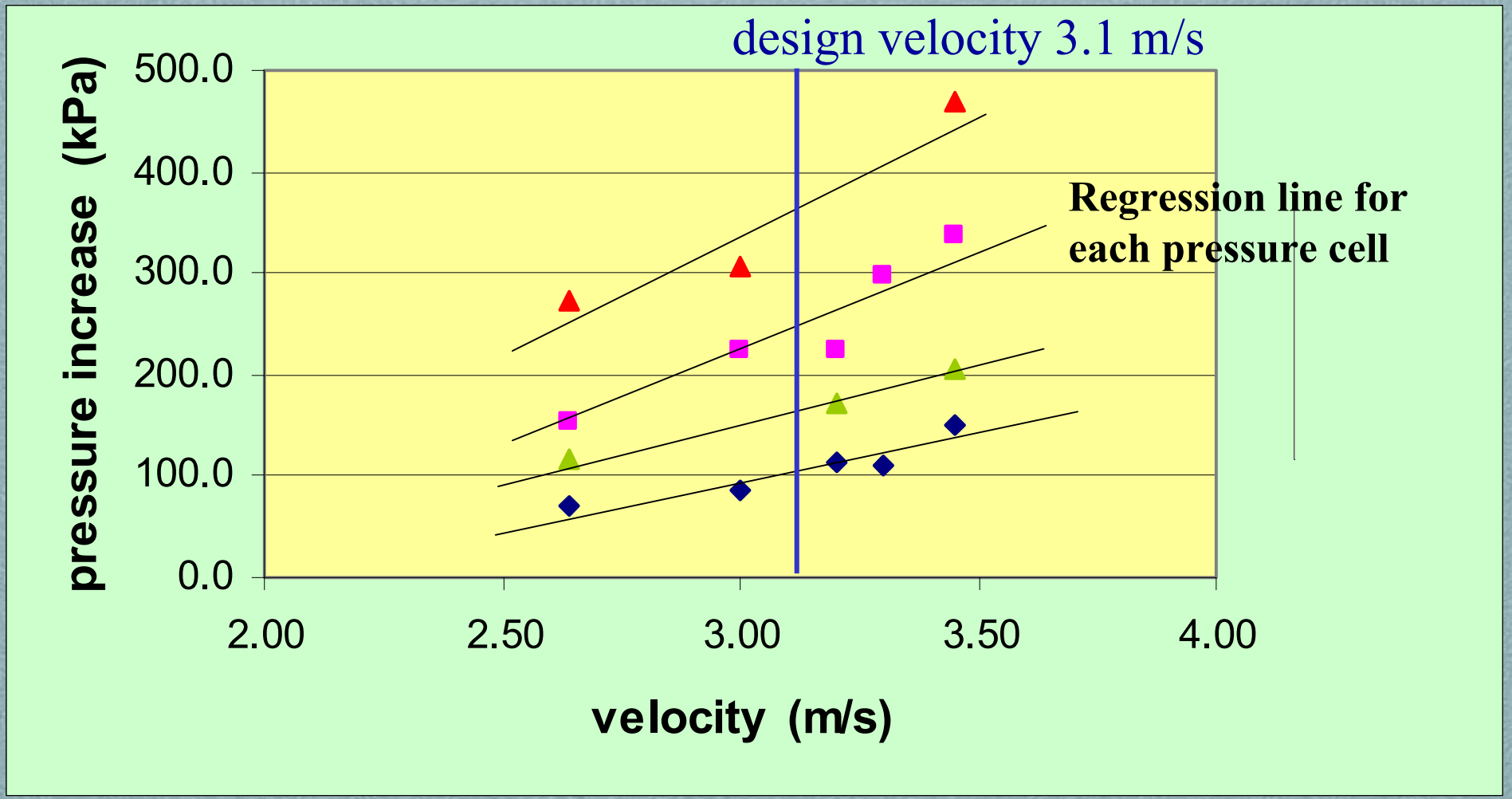
2mm gravel layer
(before test)

Relation of Impact Velocity vs Penetration



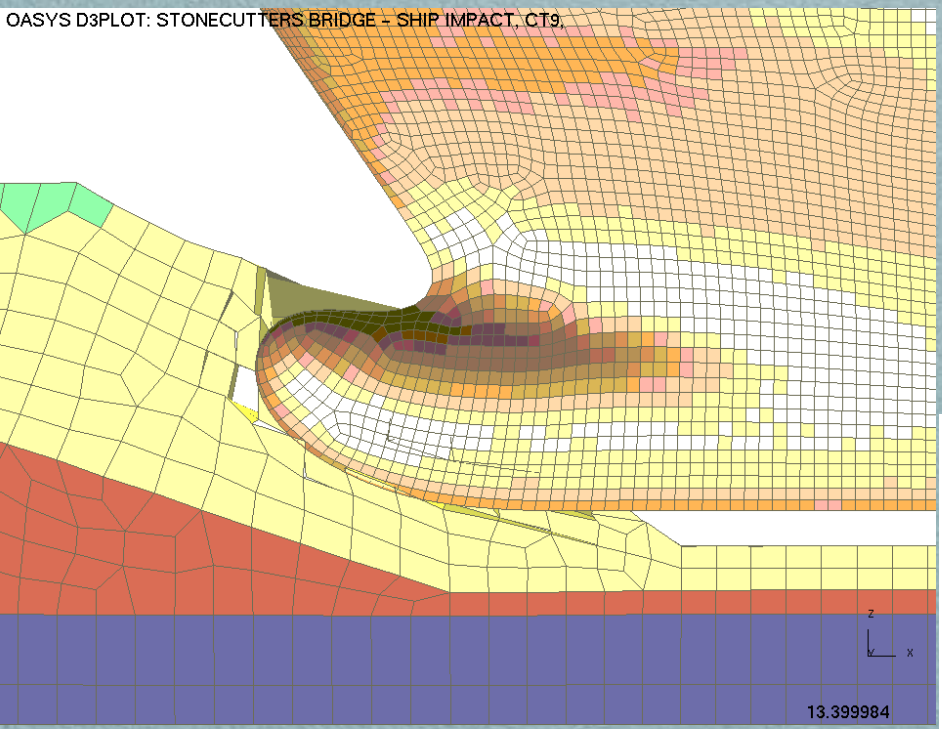
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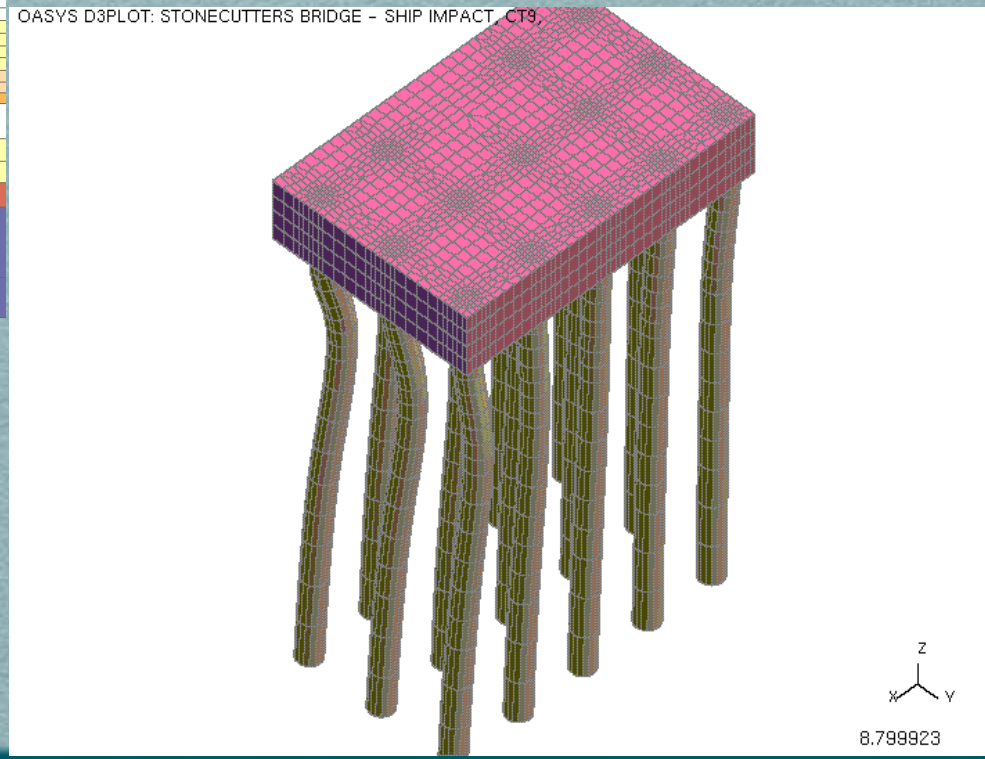
Determination Of Design Pressure



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Use of Centrifuge Test Results





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CONCLUSIONS

- The use of centrifuge tests was essential for this ship impact assessment of the bridge foundations
- Consistent ship penetrations were obtained
- Allowed direct measurements of pressure in soil
- Obtained time history impact force for design
- The tests are becoming more affordable
- Clients are willing to support R&D to achieve cost-effectiveness


Thank you