ORPHAN BREAKWATERS: COLLAPSE AND TRANSMISSION REDUCTION

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PhD study (Part-time) to identify when and how changes of knowledge and/or technology influenced survival (or failure) of (vertical) breakwaters (1670-1910).

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150 Celebrating engineering innovation from 1868 – 2018... and onwards

Contents

- Motivation for PhD study
- General chronology for PhD study period
- Port Logan, Portpatrick, Hartlepool and Greve du Lecque
- Outline design of the ‘failing wall’ experiments
- Progress and results of the ‘failing wall’ experiments
- Wave transmission and reflection results
- Summary of wave transmission results – improved guidance
- The codicil – that ‘but’!
- Who helped.

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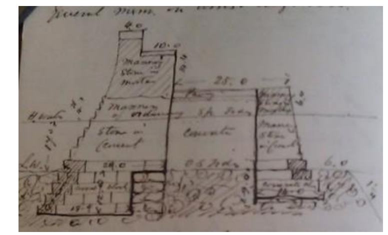
Old Breakwaters – fail or survive – why?

←Wick, failed 1870

→ Greve du Lecq, Jersey, after failure in 1895

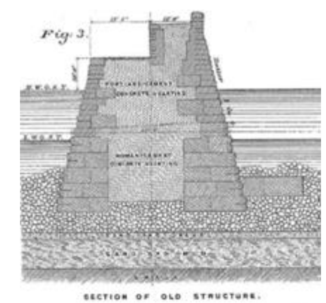
→ Alderney, will it fail (again) in 2019?

Part-time PhD study to identify when and how changes of knowledge and/or technology influenced survival (or failure) of (vertical) breakwaters (1670-1910):



- Literature review / analysis sites and technologies.
- Time map of development / availability of key technologies:
  - Diving
  - Concrete
  - Steam power
  - Design methods / knowledge

- Hydraulic model tests (summer 2015) to quantify onset of failure, and protection afforded by 'orphan' breakwaters.
- Case studies of selected failed and surviving examples.
- Development of generic advice for old vertical breakwaters or seawalls



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Cronology

1661 Start of breakwater at Tangiers (British outpost)
1676 Use of timber caissons at Tangiers
1683 Demolition / abandonment of Tangiers
1757 Smeaton lime / pozzolanic mortar used at Eddystone
1773 Steam engine fitted to lighter to dredge sand
1774 Smeaton started Aberdeen North Pier
1795 Boulton & Paul making steam engines
1803 Maiden voyage of *Charlotte Dundas*, steam powered tug
1813 Rennie used diving bell for breakwater foundations at Ramsgate
1824 Aspdin patented Portland Cement
1825 Stonehaven by Stephenson
1833 Cockenzie by Stephenson
1851 Alderney started; 1851 Great Exhibition showcases new technologies
1862 Messent makes 40t concrete blocks for Tyne piers
1871 Alderney complete
1872 Failure at Wick
1875 Dyce Cay placing concrete in 50t bulk bags at Aberdeen
1884 104t concrete bags placed at Newhaven
1892 Titan crane placing 50t concrete blocks at Peterhead
1909 Dover harbour completed

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The Orphan Breakwater problem – Port Logan

Port Logan, Rhinns of Galloway.

Failure of close fitting blockwork armour (low permeability) over ungrouted rock fill.

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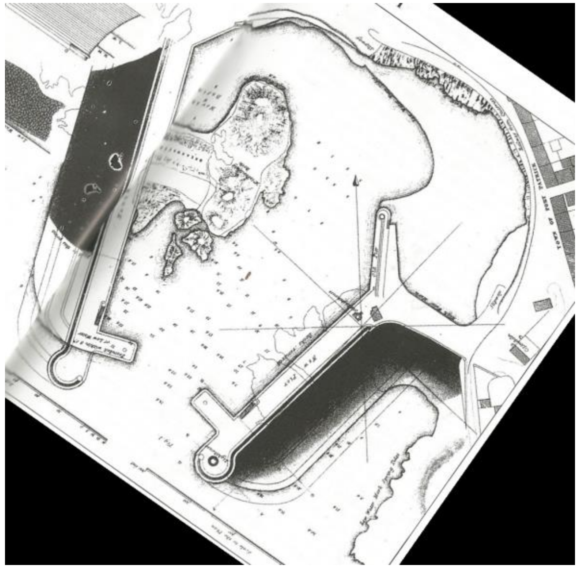
The Orphan Breakwater problem - Portpatrick

Coastal harbour for trade (mail packets). Wave protection by breakwaters, often rubble mounds to low-water, vertical walls of stone blocks, rubble fill. 100-150 years later, little or no income to maintain / repair breakwaters. But areas protected used for commercial or residential purposes –significantly increased risk of flooding.



←Portpatrick – Rennie's plan of 1819

→ Portpatrick, 2016, courtesy Bing Maps

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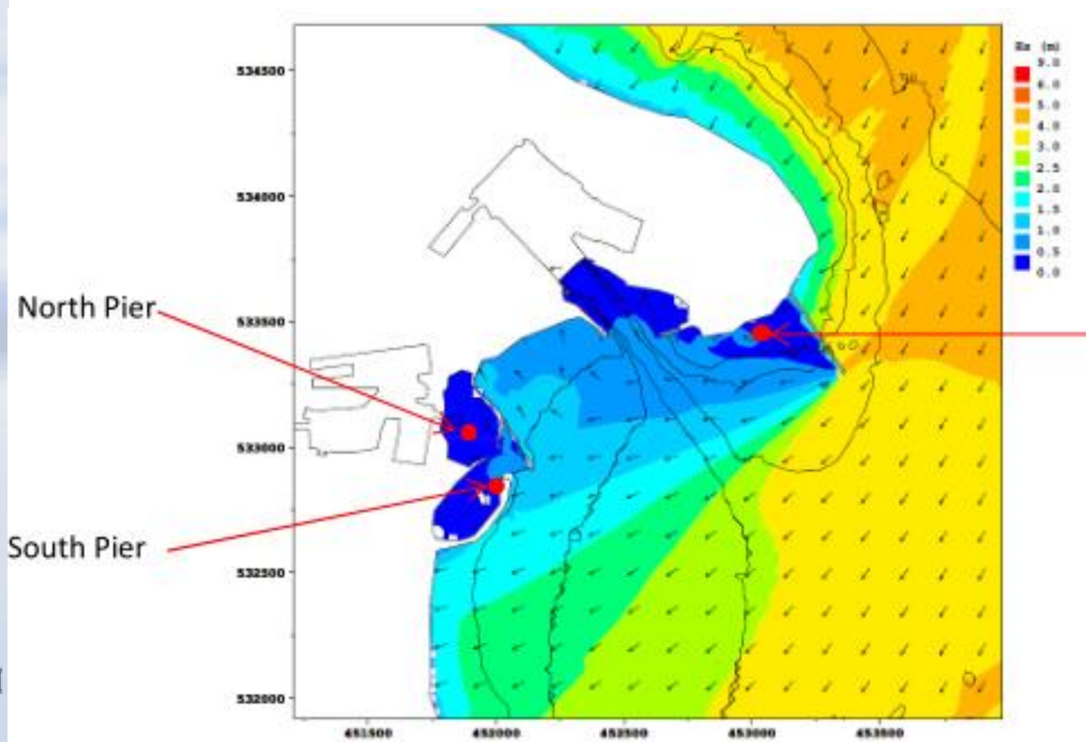
The Orphan Breakwater problem - Hartlepool

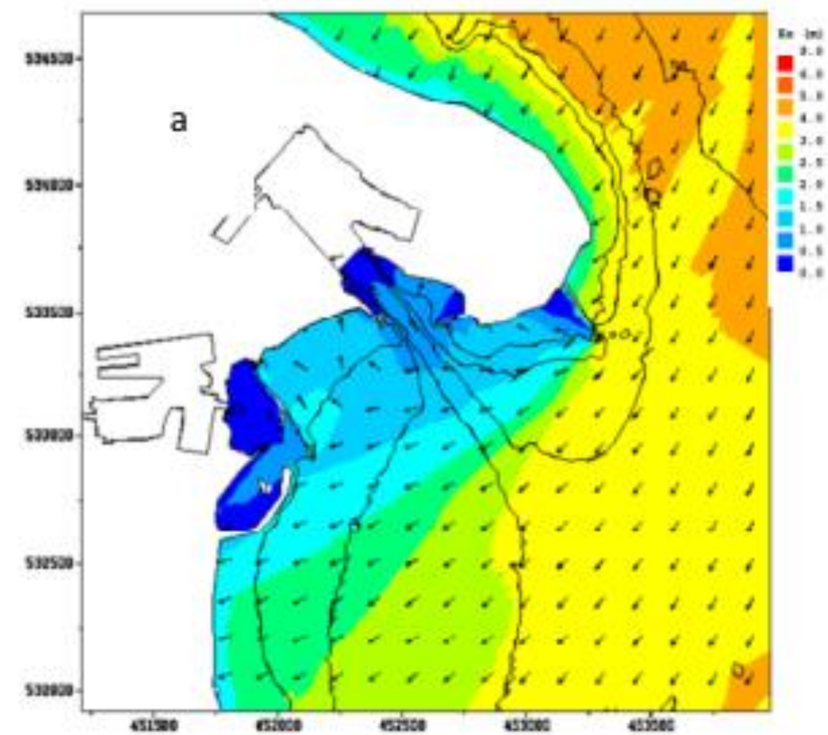
£22 million extra required over the next 100 years to maintain ‘protected’ frontages if Heugh Breakwater collapses.
The Port is important for the local economy and the Heugh Breakwater is important to maintain access to the Port.

Simulations of wave penetration for ‘present ‘and ‘failed breakwater’ case:

← Hartlepool, present configuration

→ Hartlepool – removal of 1/3 of Heugh breakwater





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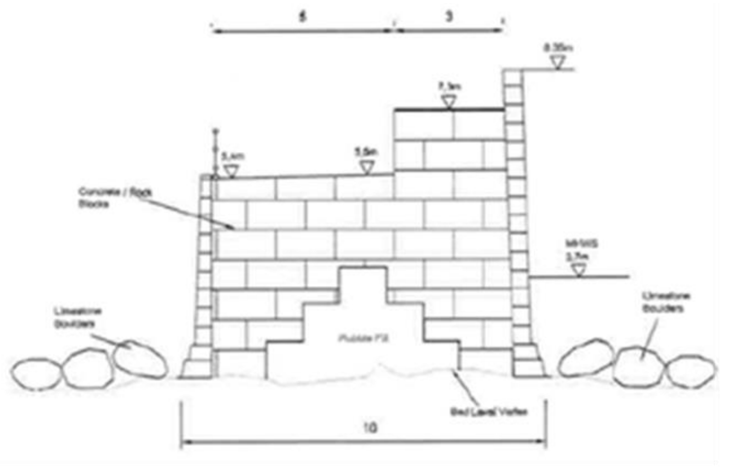
The Orphan Breakwater problem – design of model tests



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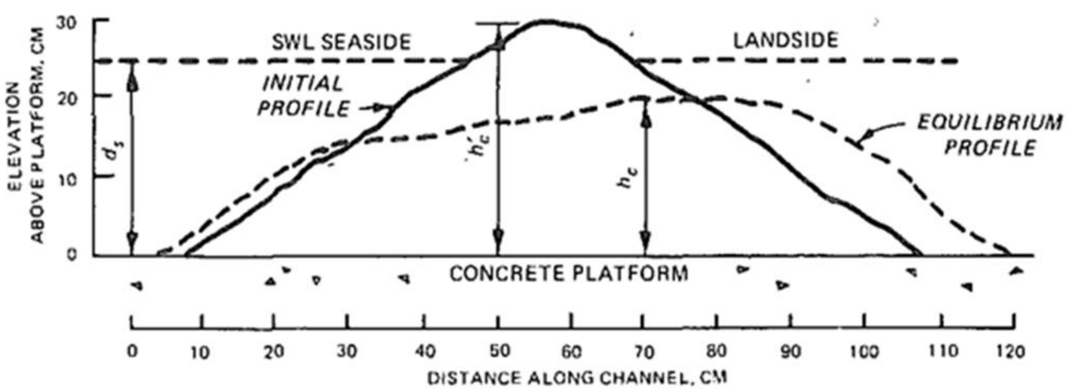
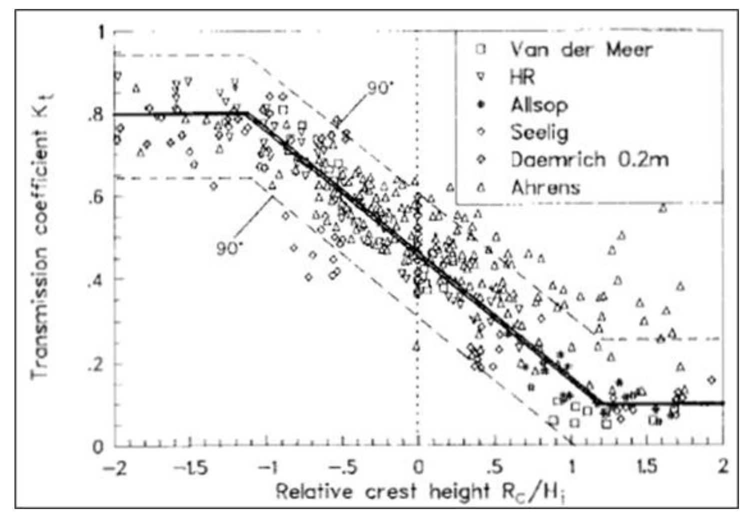
The Orphan Breakwater problem – design of model tests

Initial study at Plymouth by Elysia Ward.



Expected results, crest recession and wave transmission.



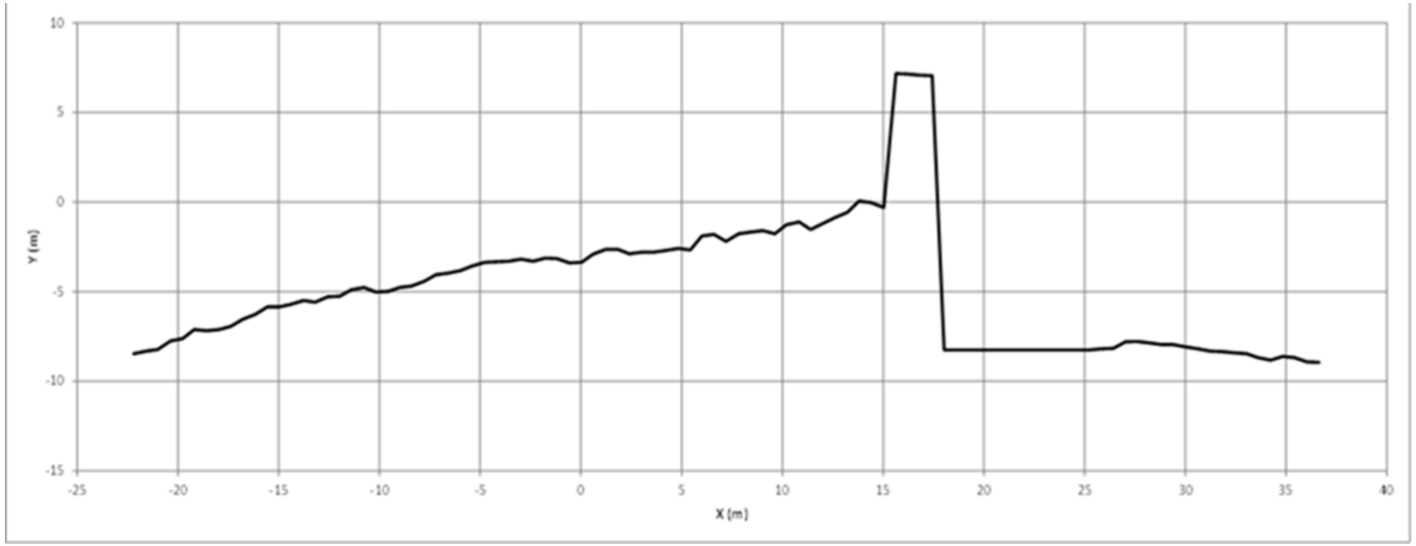


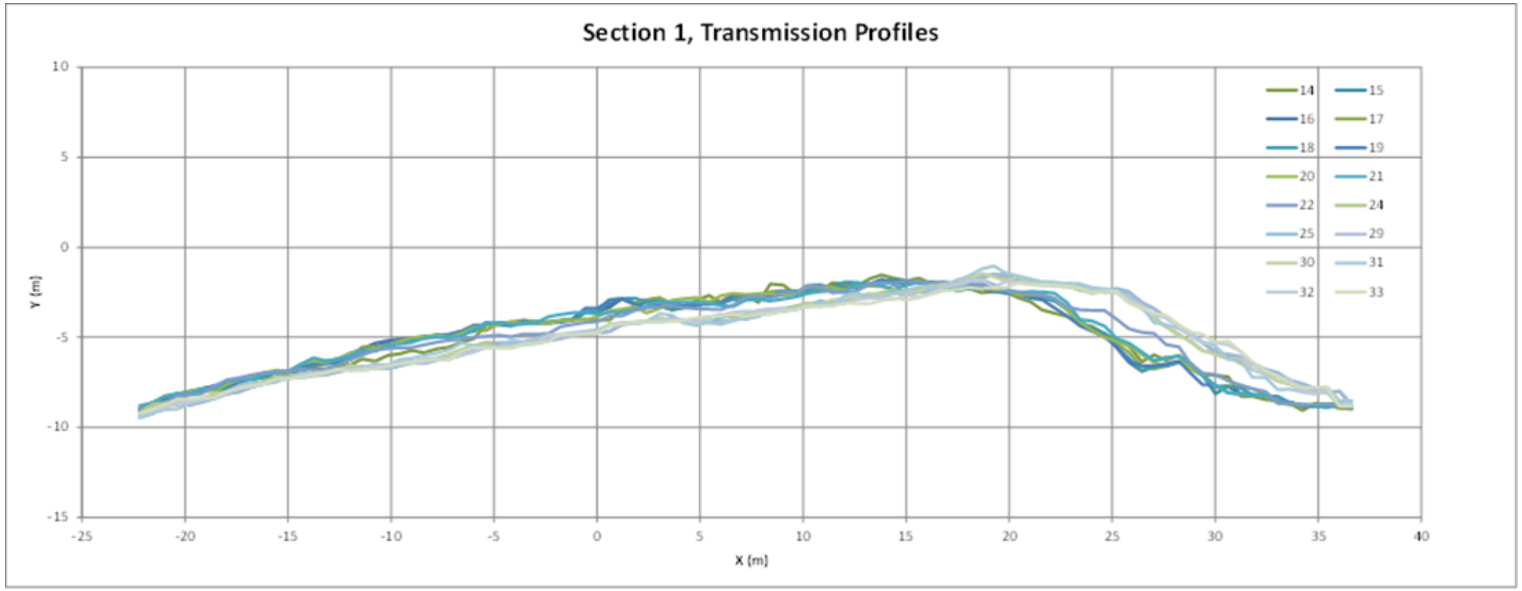
The Orphan Breakwater problem – design of model tests

Idealised test breakwater, 37% blocks, 63% fill.

The Orphan Breakwater problem – design of model tests

Damage progress, front wall collapse, then rear wall.





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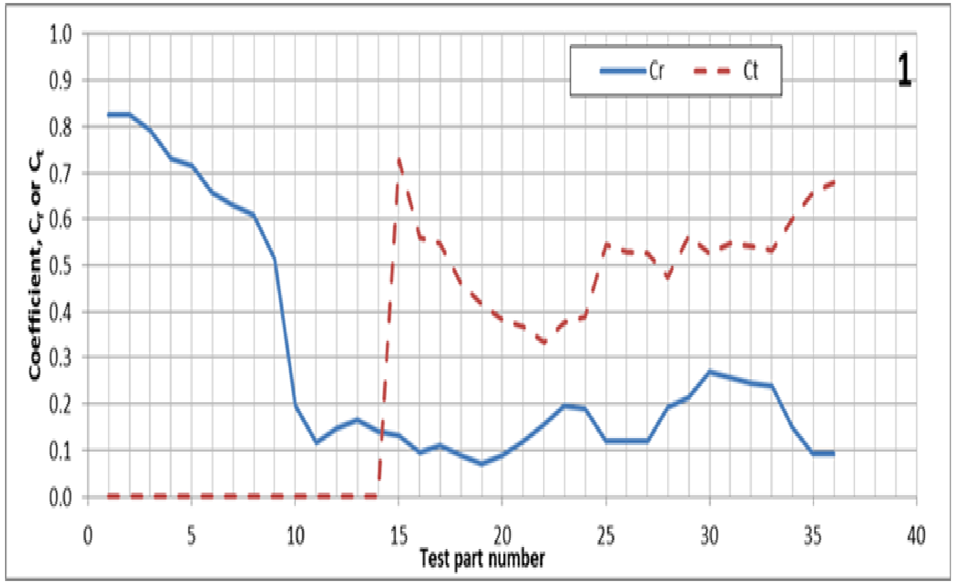
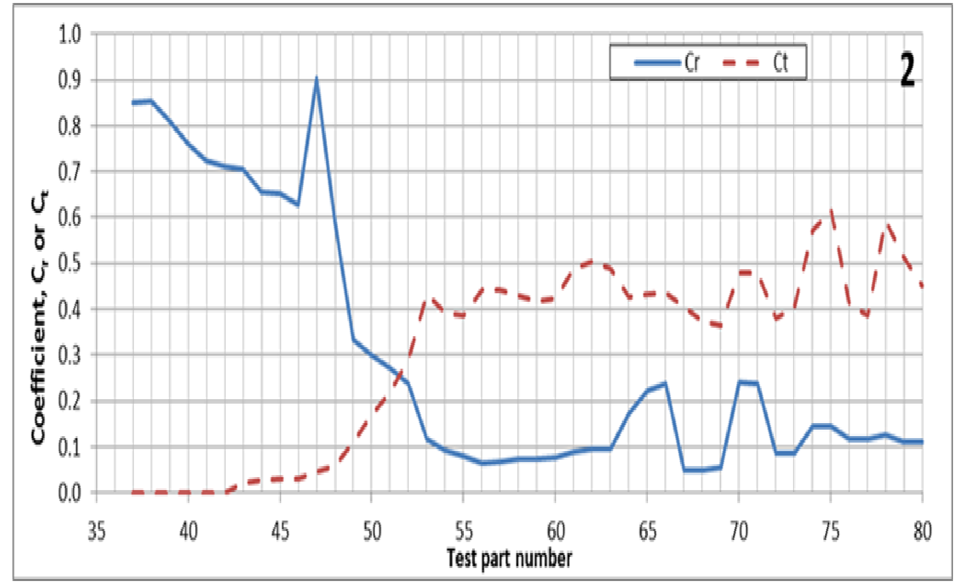
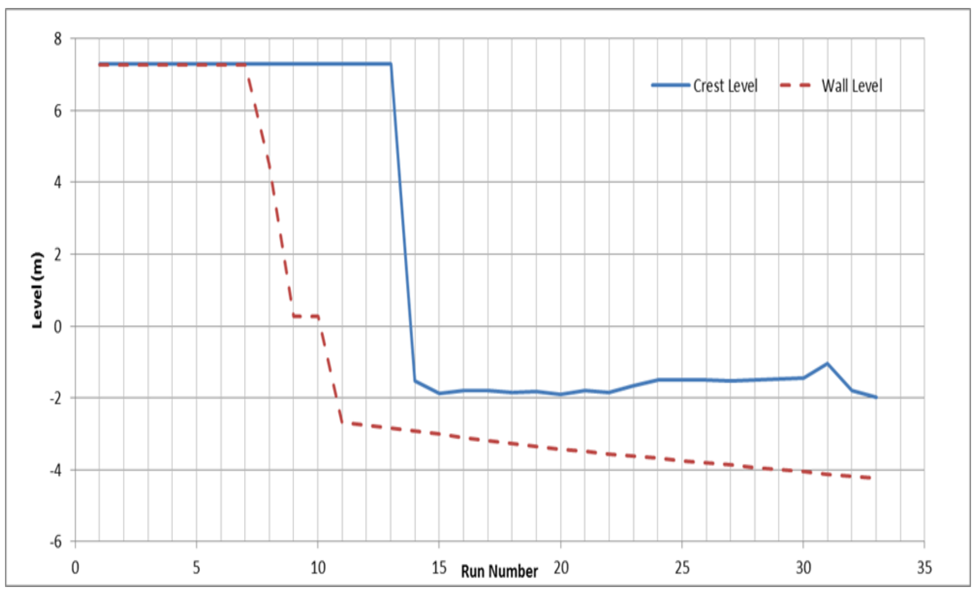
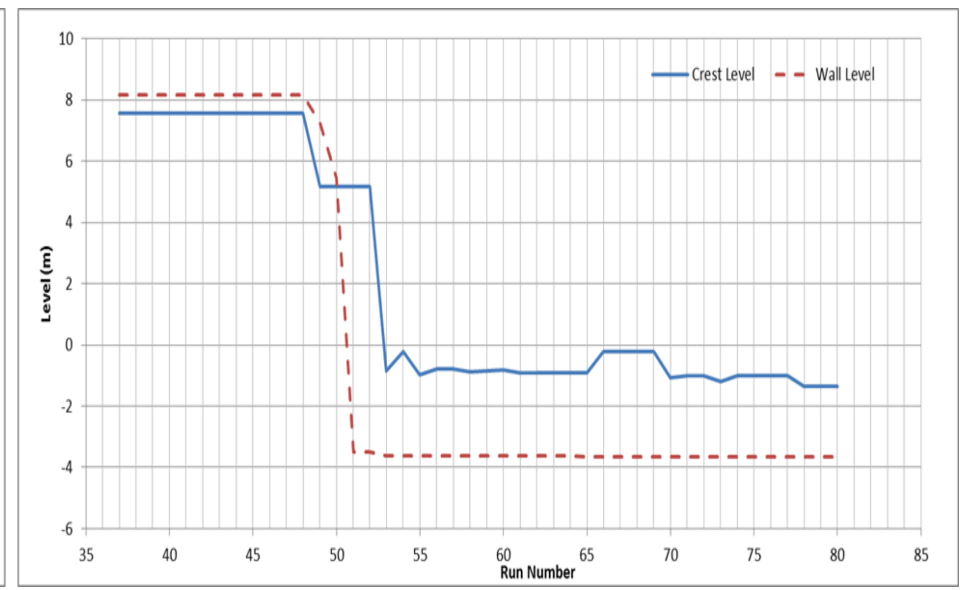
The Orphan Breakwater problem – model test results

Transmission and reflections, crest levels, through the tests.









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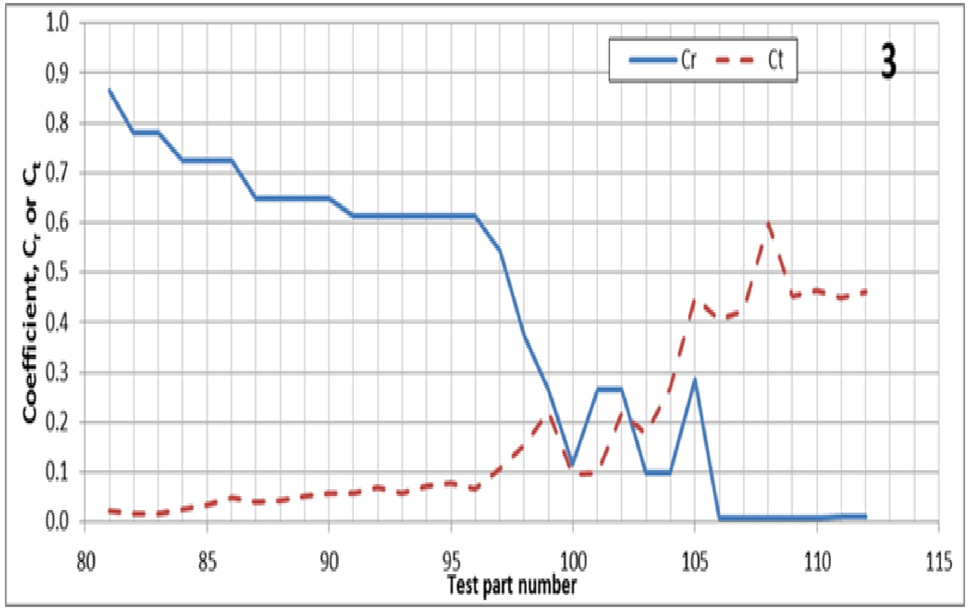

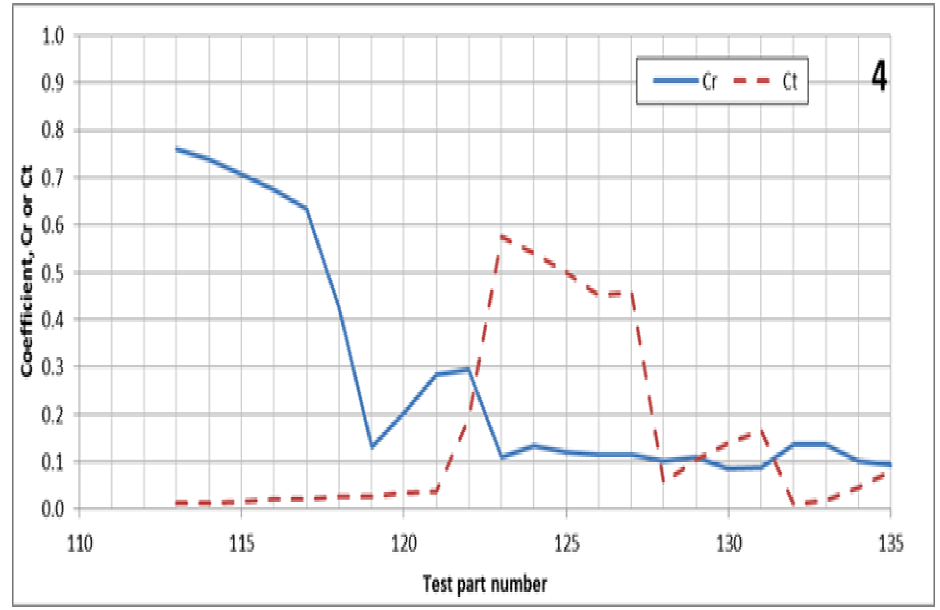

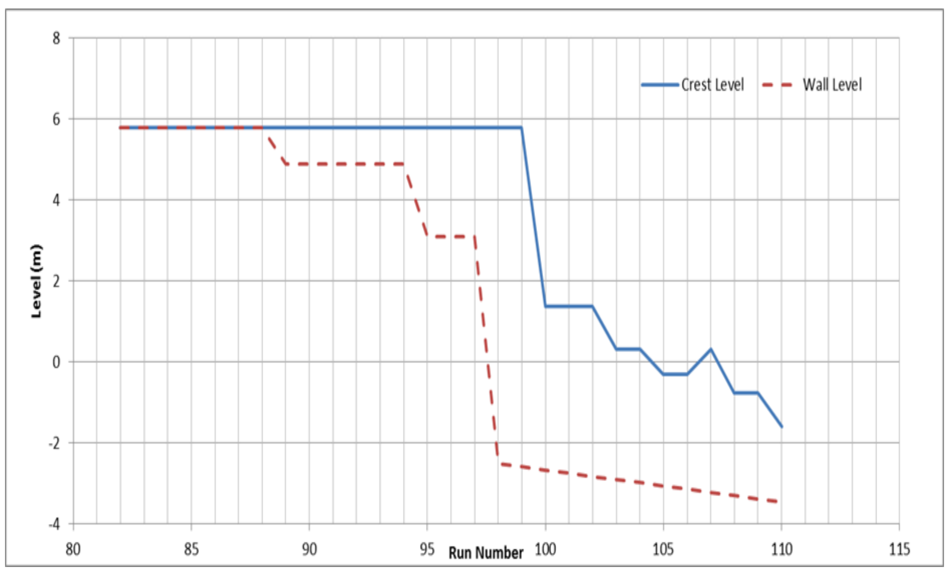

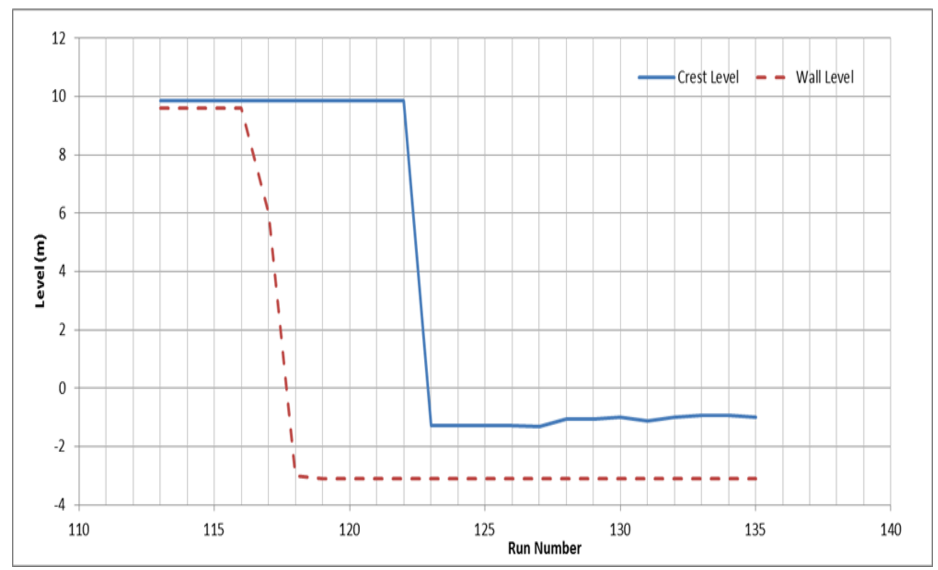

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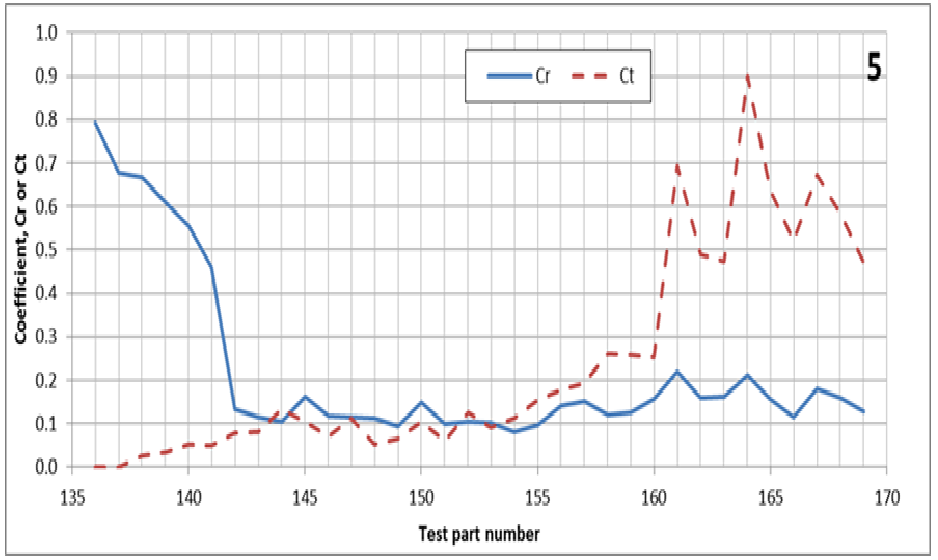

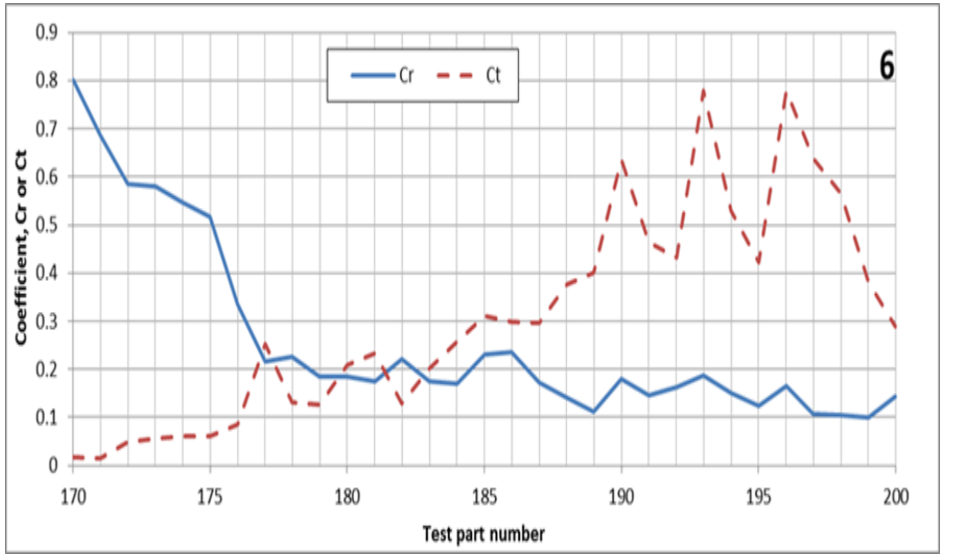

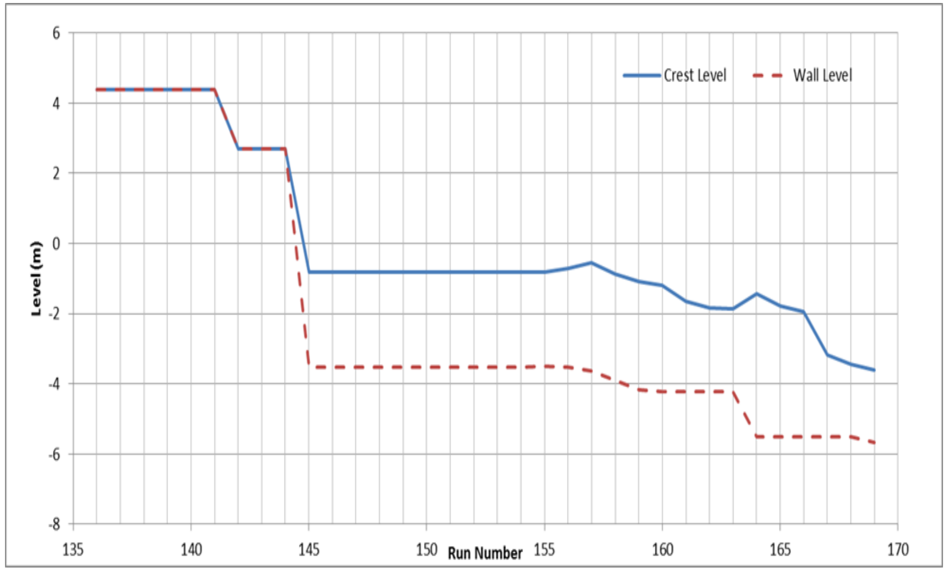

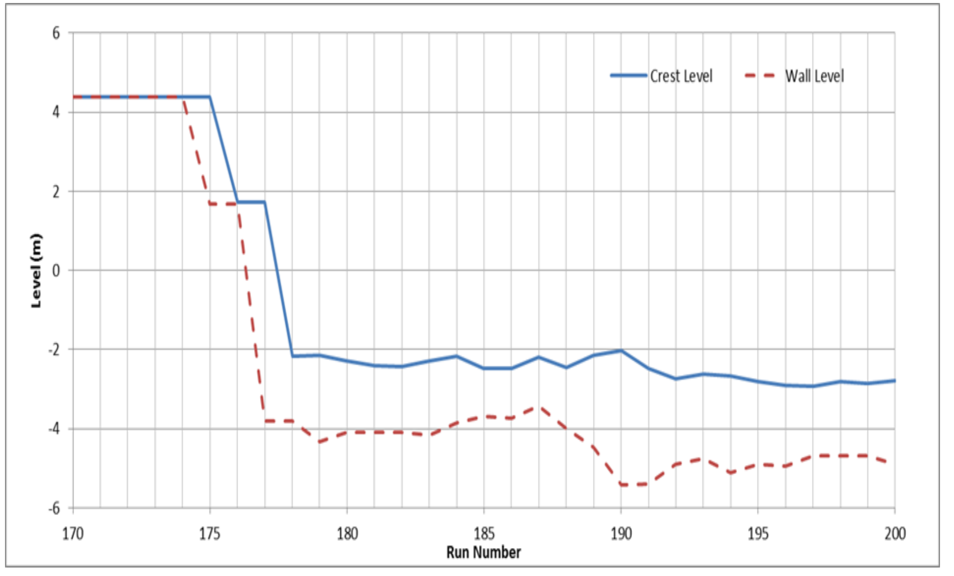

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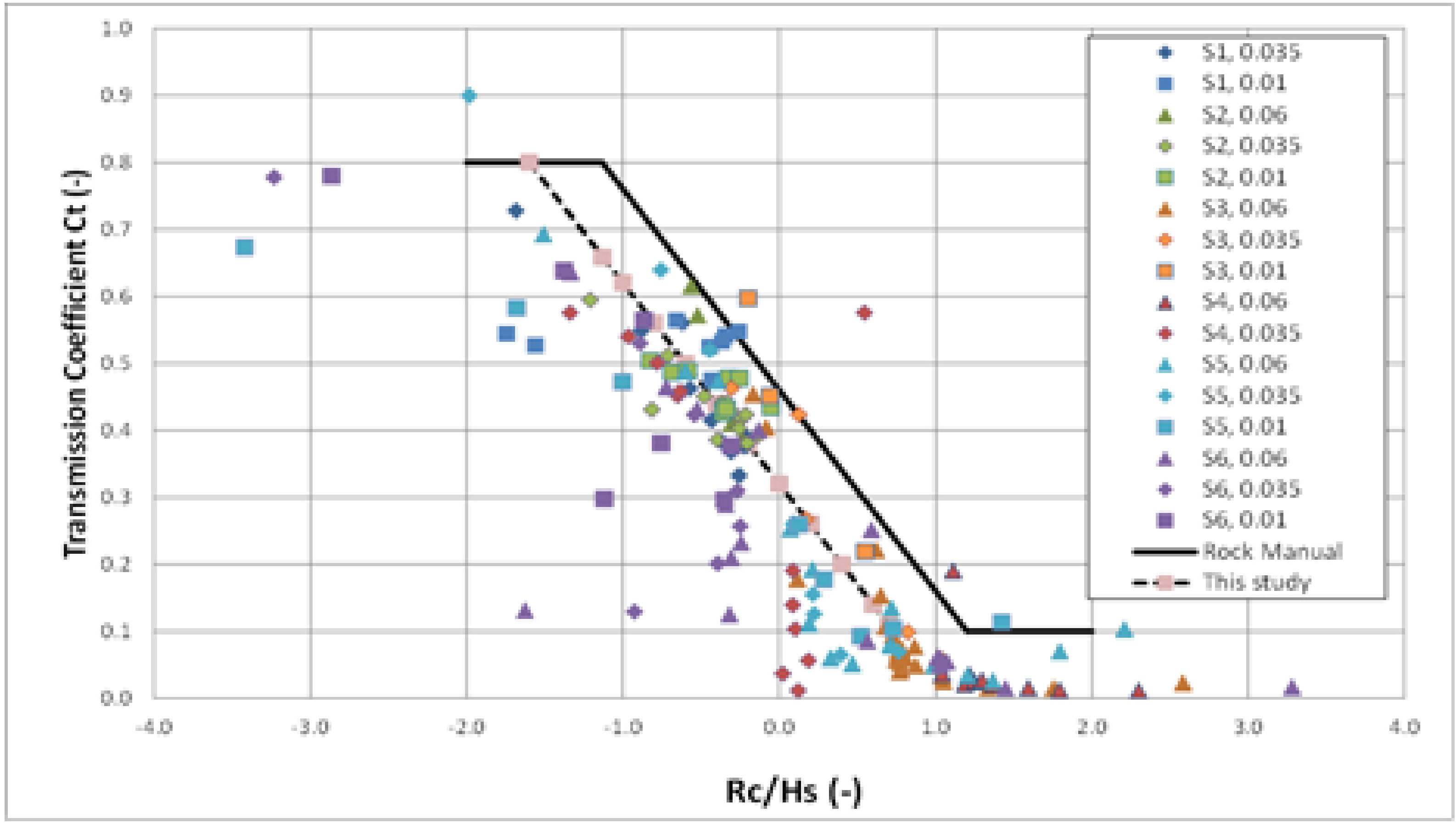
Orphan Breakwater – wave transmission prediction

Transmission coefficient, C_t vs dimensionless freeboard



$-4 < R_c/H_s < -1.6$	$C_t=0.8$
$-1.6 < R_c/H_s < 0.7$	$C_t= 0.32 – 0.3\ Rc/Hs$
$0.7 < R_c/H_s < 3.0$	$C_t= 0.1$

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Orphan Breakwater – crest recession

Crest recession – influence of wall toe.

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Orphan Breakwater – collapse profile - Skateraw

Skateraw harbour, East Lothian – breakwater was probably destroyed 1853 -1892.

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Orphan Breakwater – collapse profile - Skateraw

Remains of toe wall – breakwater was probably destroyed 1853 -1892.

These photos - 2016

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Orphan Breakwater – Acknowledgements

This research was made possible by input / support from:

My co-authors: Professor Tom Bruce and Adrian Pearson

ICE R & D Enabling Fund

University of Edinburgh

States of Guernsey; Dover Harbour Board; Dublin Port, Jacobs; States of Jersey; Channel Islands Group of Professional Engineers (CIGPE)

Aberdeen Harbour and Arch. Henderson & Partners

Mike Chrimes (ICE); ICE Maritime Board

BloCSnet and PROVERBS partners and contributors;

Steve Warrington, Kathy Moore, (Univ. Edinburgh)

Dr. Gerald Muller (Univ. Southampton) and co-researchers

Dr. Adam Bezuijen and Martin De Groot (GeoDelft)

Nick Hanousek (HRW)

Prof Jane Smallman

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