Application of DualSPHysics in the Development of a Wave Absorbing Wall

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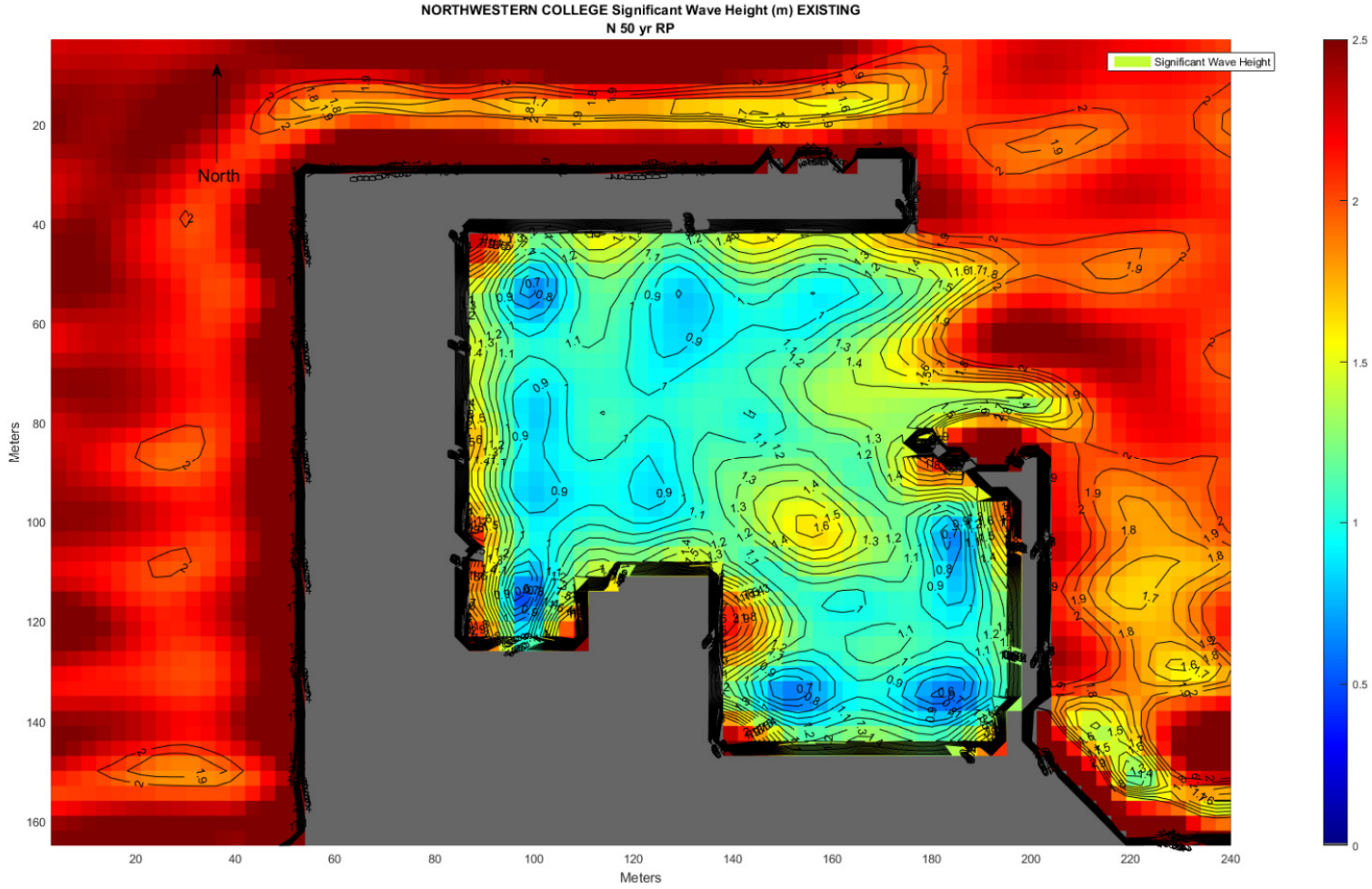
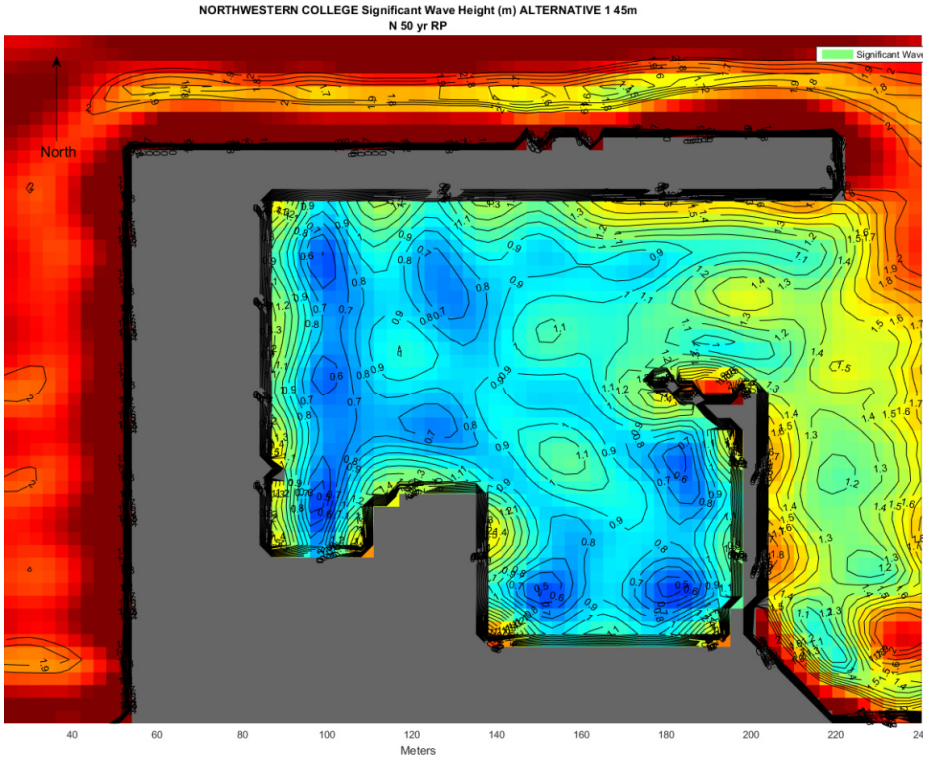
HARBOUR AGITATION

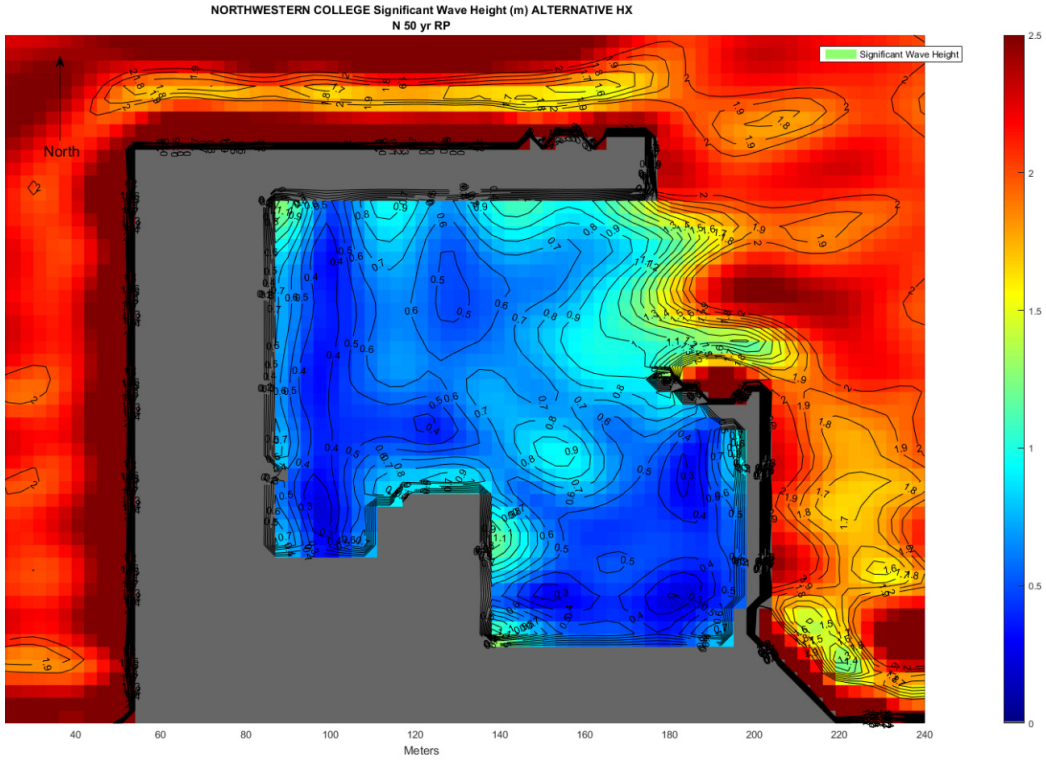
- Harbors are designed to provide sheltered waters for the moorage and berthing of ships
- Quay walls and perimeter walls within harbors are typically built as a solid vertical face to make it easier to moor a vessel.
- Vertical Walls also maximize both the usable water area and land area.
- When waves interact with these vertical surfaces, they reflect and little to no energy is absorbed or dissipated
- The lack of energy absorption of typical vertical solid quaywalls increases oscillations of multiple reflected waves, reducing the required calmness for safety and operability of harbors, creating what is known as seiche within the harbor

CASE STUDY


NORTHWESTERN COLLEGE Significant Wave Height (m) EXISTING
N 50 yr RP
Significant Wave Height
North
Meters
Meters
20
40
60
80
100
120
140
160
180
200
220
240
0
0.5
1
1.5
2
2.5

CASE STUDY: Breakwater Extension vs Reducing Reflection

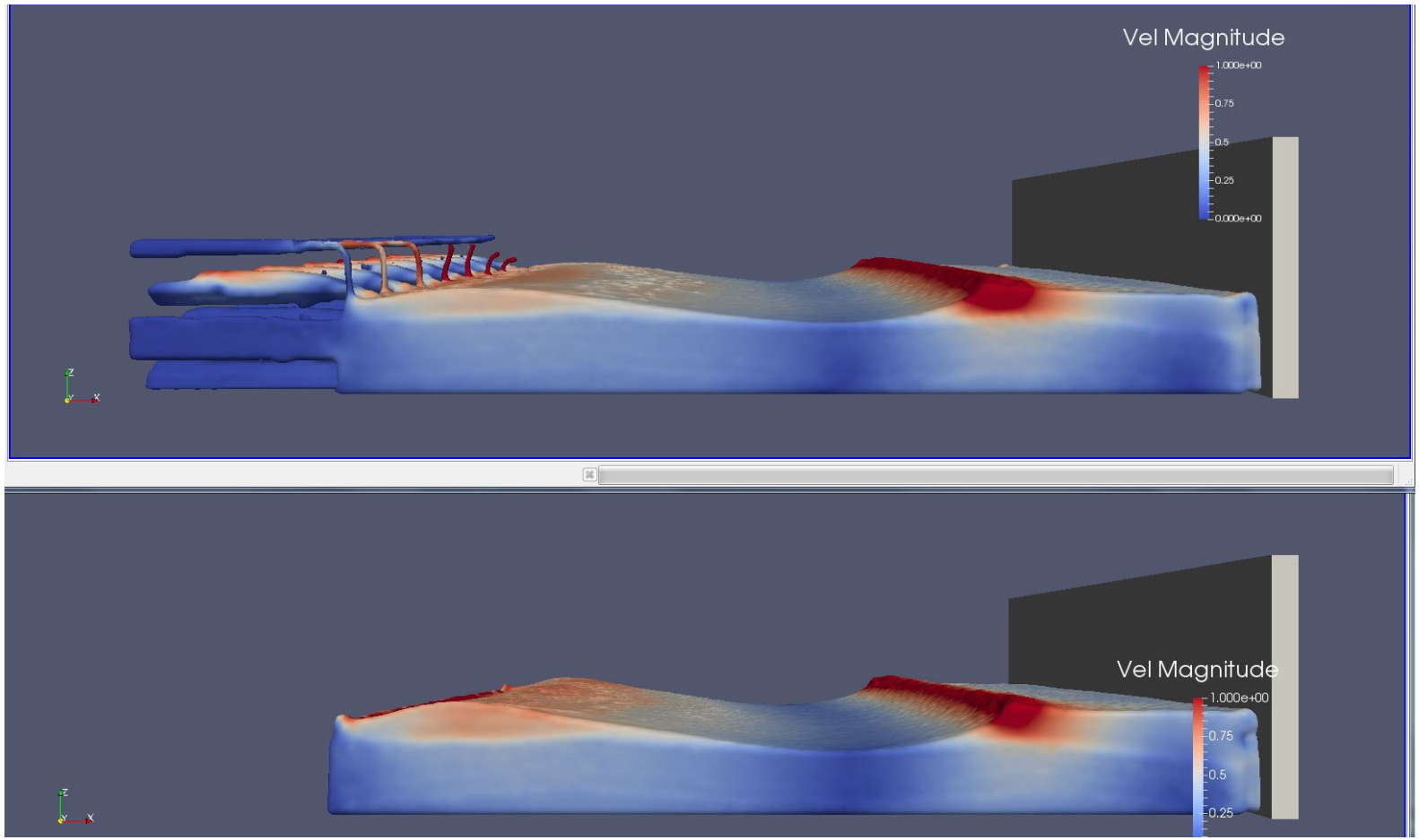




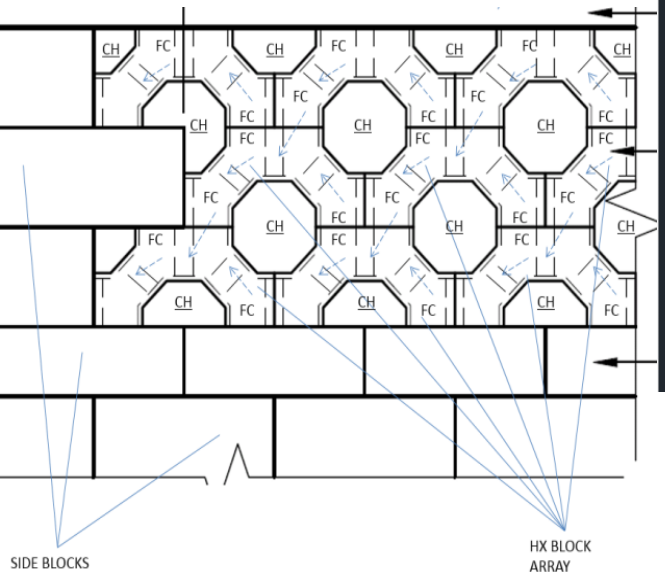
REDUCE WAVE REFLECTION WITH A VERTICAL WALL

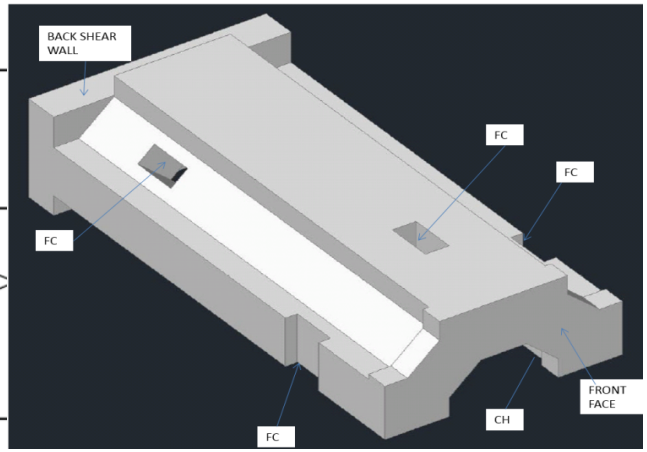
- The first phase of the design development of this conceptualized block wall was to test the wave reflections using the **DualSPHysics** model
- The main objective was to obtain first an opening ratio between 30 and 50%. Physical model tests carried out at HR Wallingford of slit caissons early on in the development of the inner perimeter of the project had indicated an optimal opening ratio of 38%(2015).
- After several configurations the octagonal shape formed by three blocks was invented.

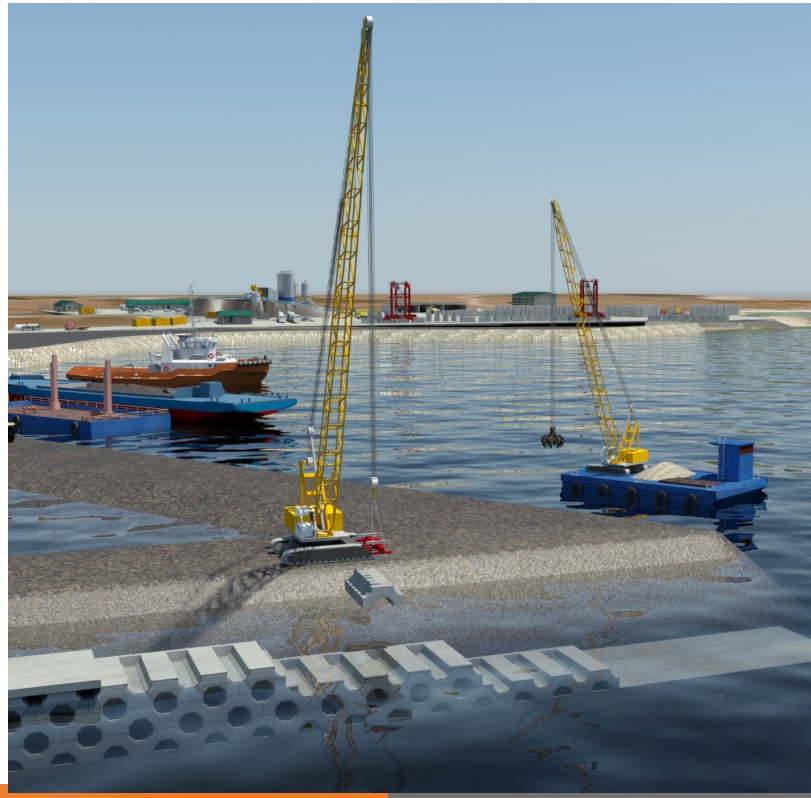
Perimeter Wave Absorbing Wall Design Process



- A 3D cad model was created shortly after of the block and was used to build a wall on a virtual numerical flume to test the reflection characteristics of the wall itself.



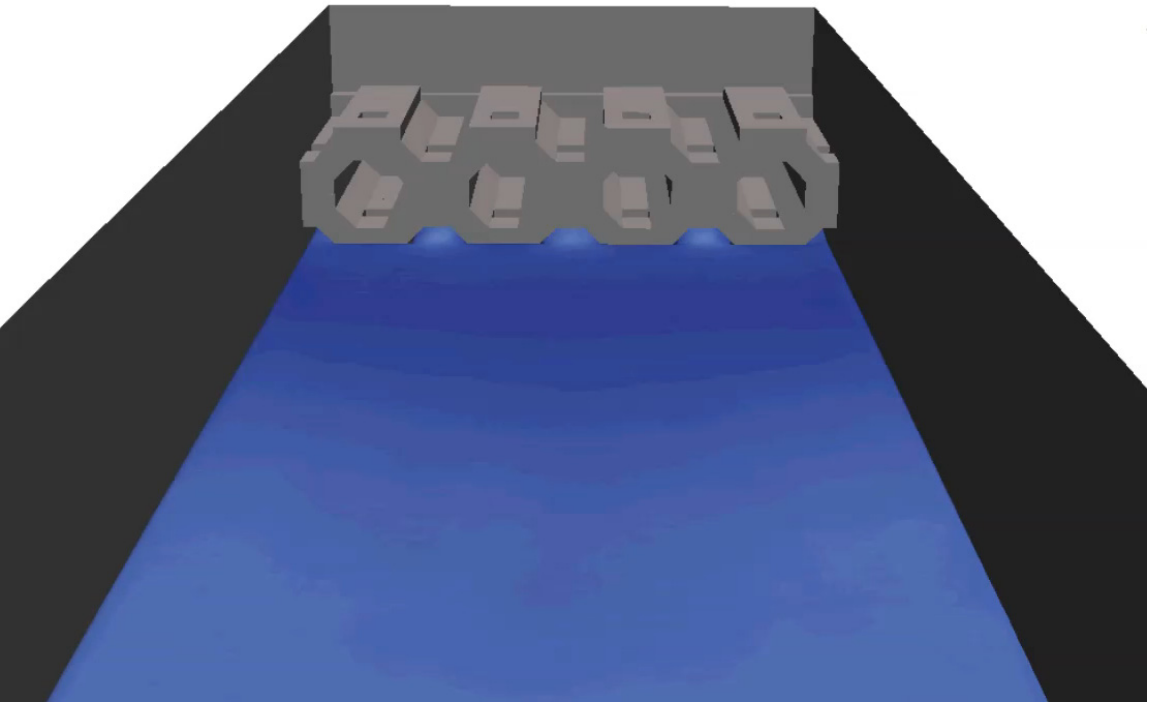


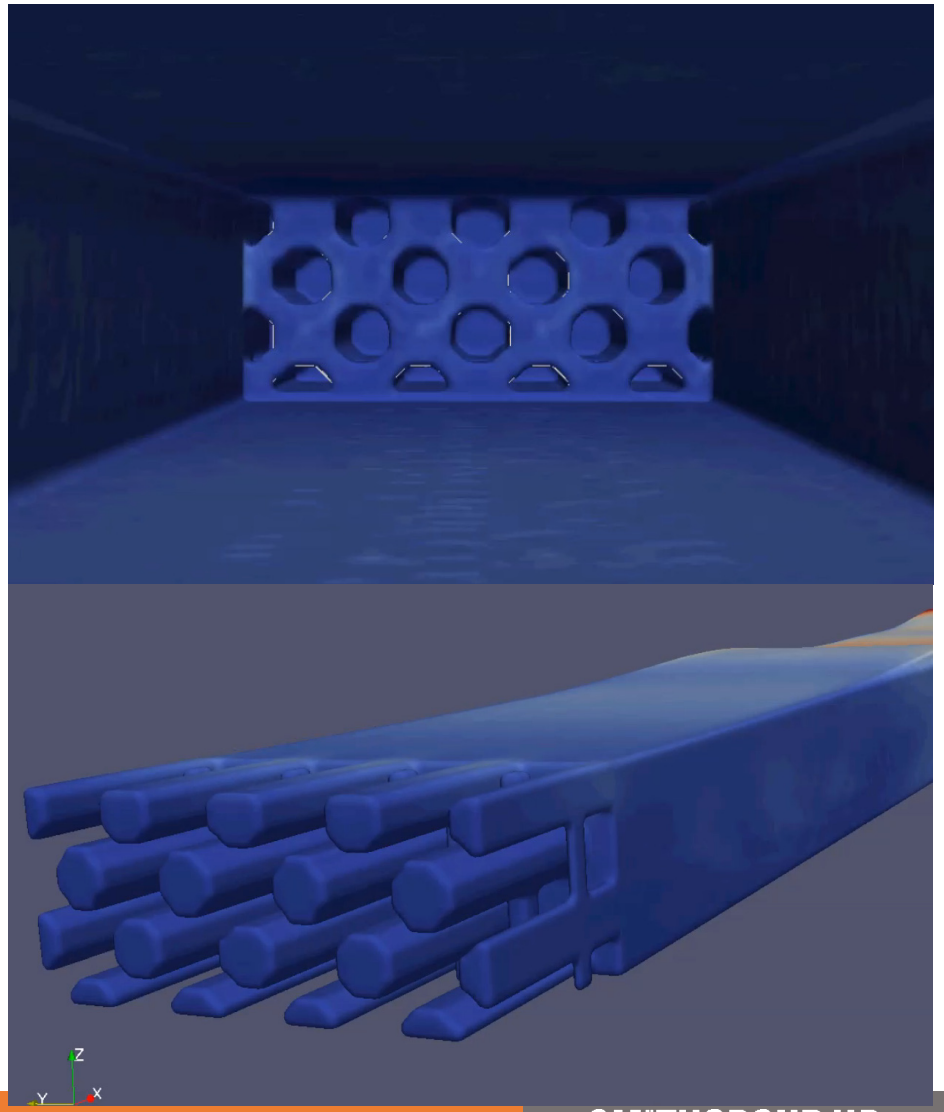


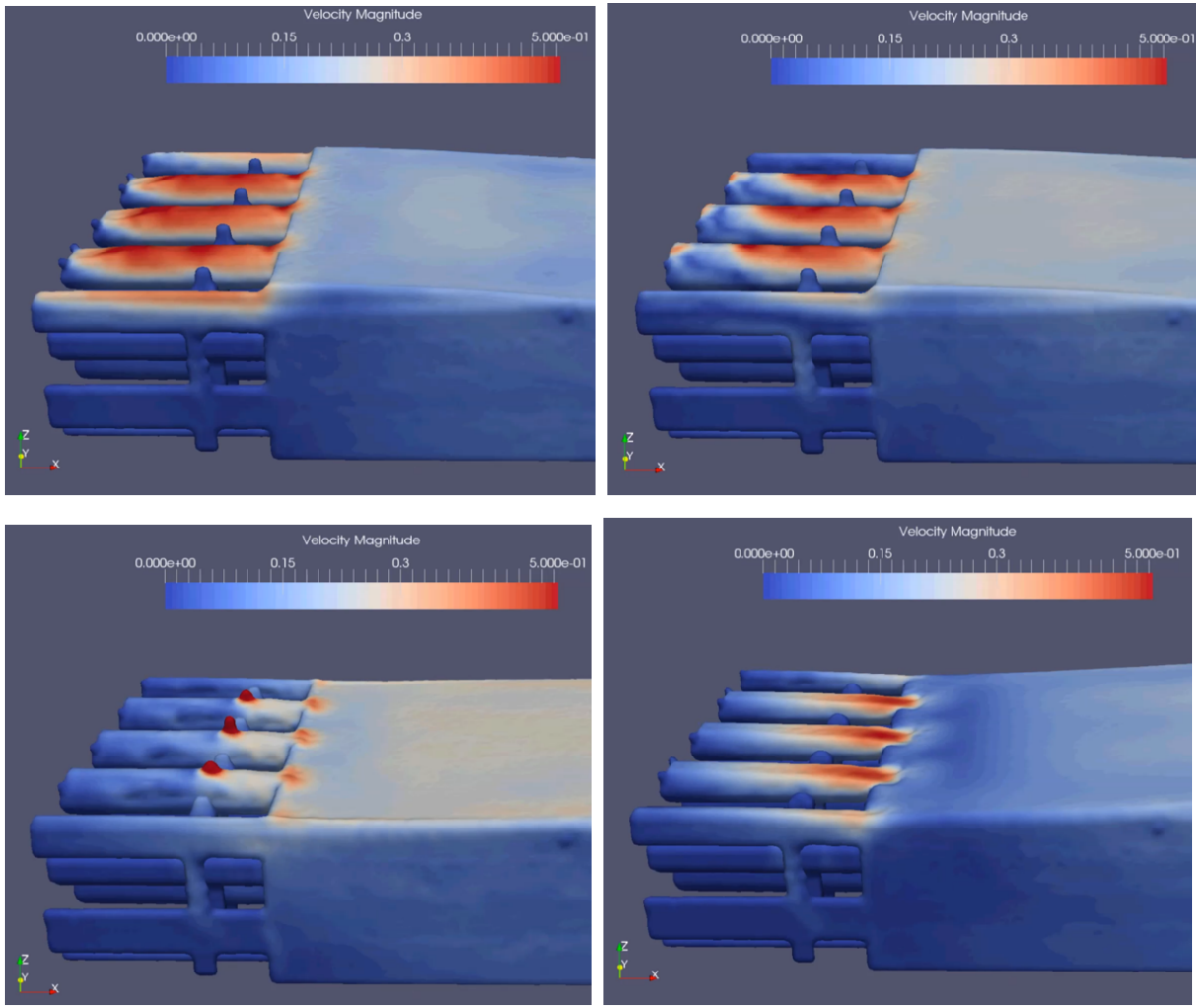
DUALSPHYSICS NUMERICAL MODEL TESTS

- The initial wave absorbing block wall was tested in a numerical flume with a size of 70m long by 6m deep and 8m wide.
- A Regular piston type wave generator was programmed to generate 20 waves for regular wave periods of 4, 6, 8 and 10 seconds with 1 meter in height in the flume.
- The reflection coefficient was estimated using the node-antinode method obtained by setting wave gauges at every 0.1m along the central line of the flume

DUALSPHYSICS






Velocity Magnitude
0.000e+00
0.15
0.3
5.000e-01
Velocity Magnitude
0.000e+00
0.15
0.3
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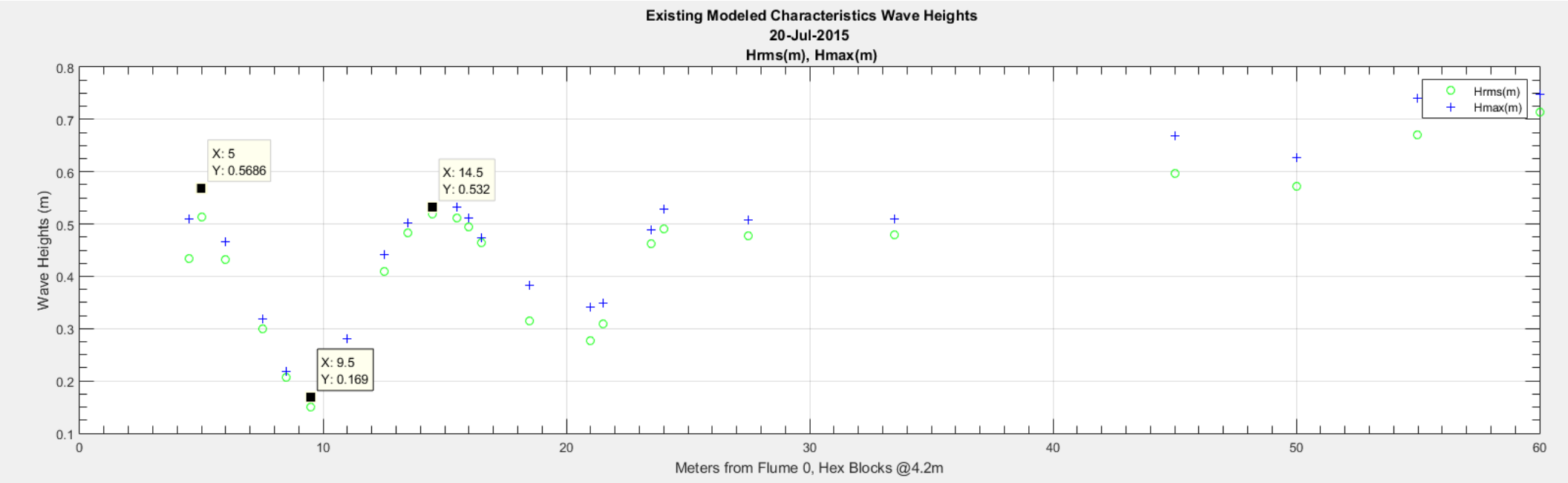
Velocity Magnitude
0.000e+00
0.15
0.3
5.000e-01
Velocity Magnitude
0.000e+00
0.15
0.3
5.000e-01

WAVE REFLECTION COEFFICIENT

- Partial wave reflection yields a standing wave that varies in wave height with distance. The analysis of this standing wave provides the reflection coefficient for regular waves:

$$Kr = \frac{H_r}{H_i} = \frac{H_{max} - H_{min}}{H_{max} + H_{min}}$$



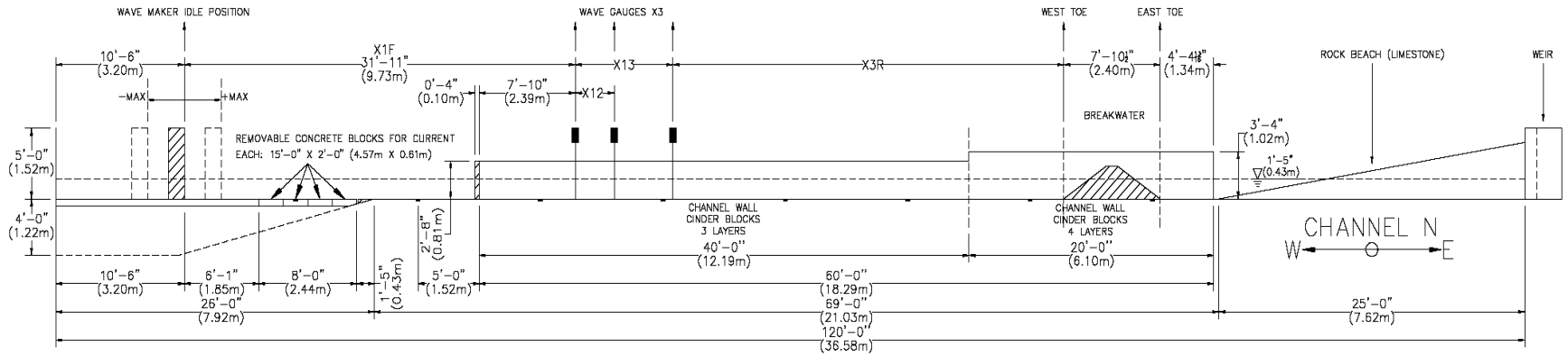
DUALSPHYSICS NUMERICAL MODEL

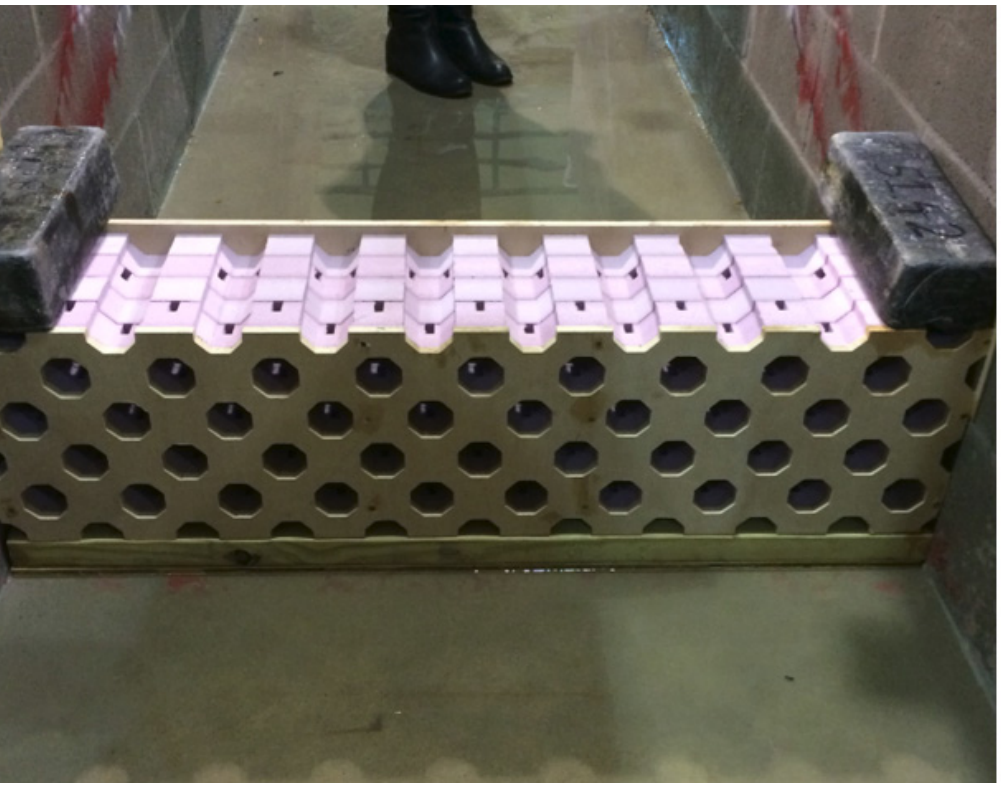
- The reflection analysis using the numerical model showed promising results, Kr between 0.52 and 0.79 was obtained.
- Given this results further testing was allocated for the development of the technology.
- Validation of the results was done using a physical model

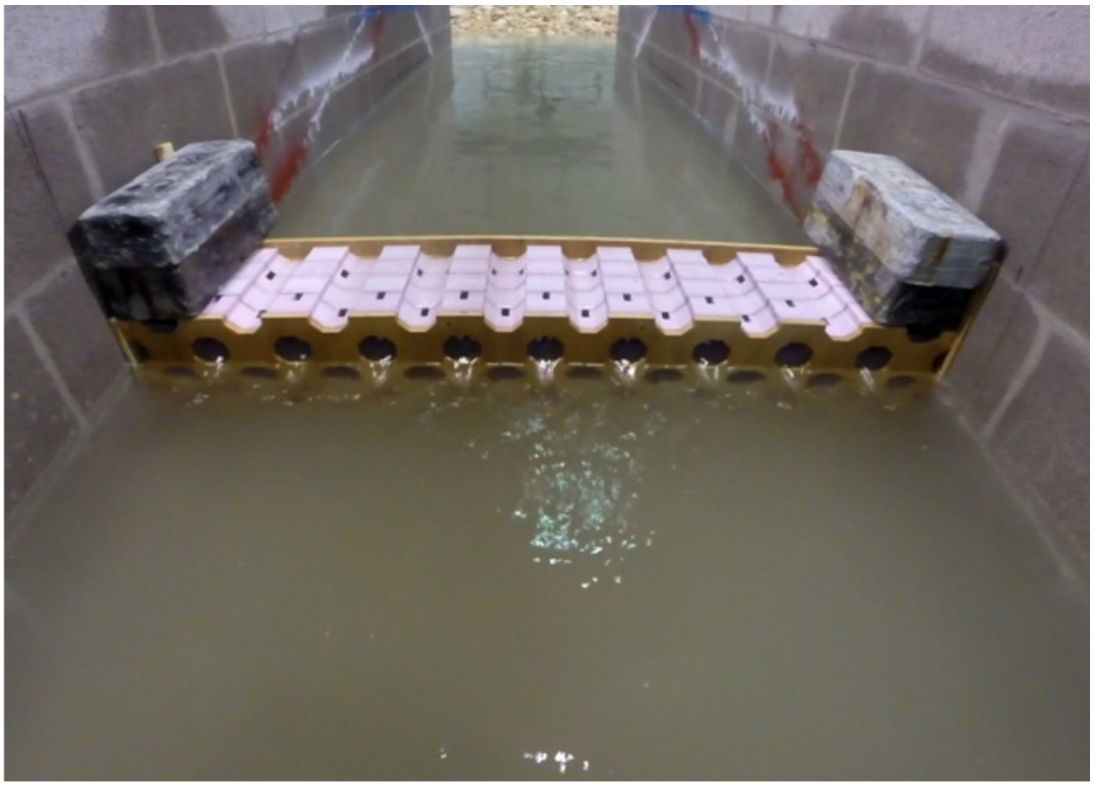
T (s)	Kr=
4	0.518
6	0.638
8	0.710
10	0.792

HX BLOCK PHYSICAL MODEL TESTING

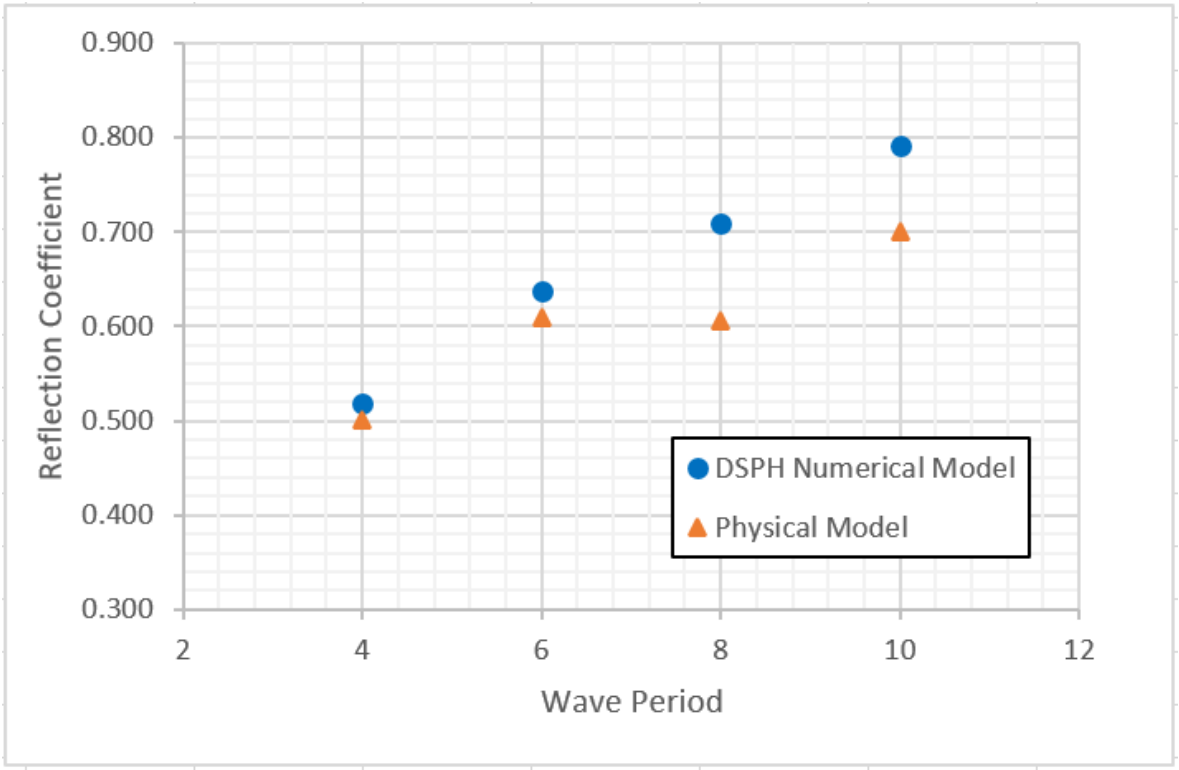
- A reflection analysis on the proposed HX block wall was performed at the Haynes Coastal Engineering Laboratory at Texas A&M University.
- Physical model tests were carried on the wave absorber block wall in a 1:20 model scale
- 3 Wave probe method was used to obtain the reflection coefficient







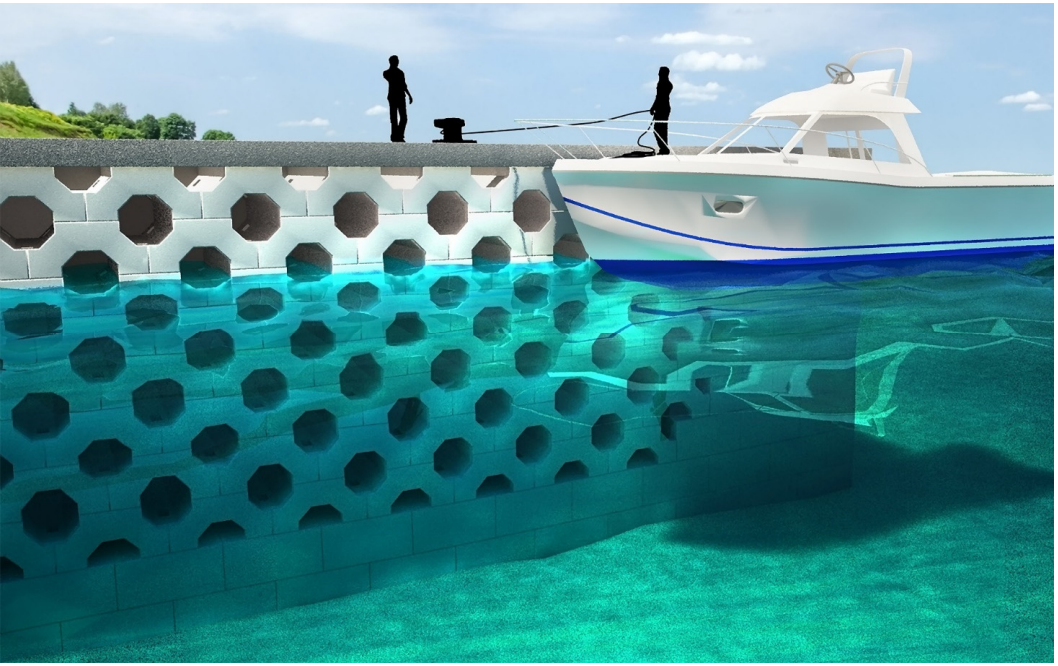
PHYSICAL MODEL RESULTS AVERAGED REFLECTION COEFFICIENT

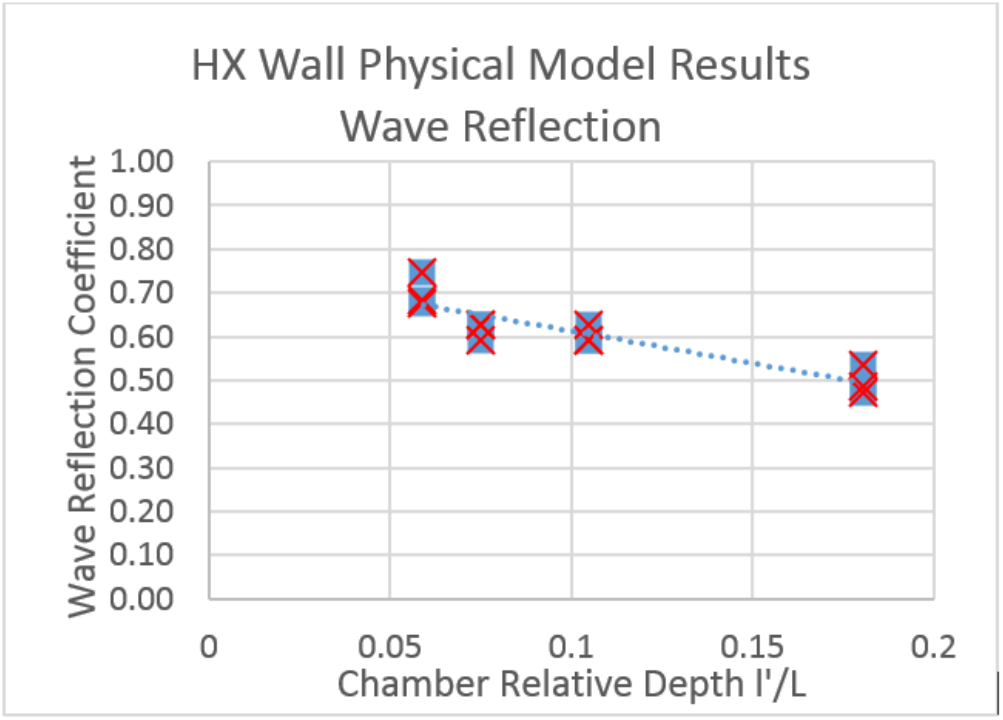


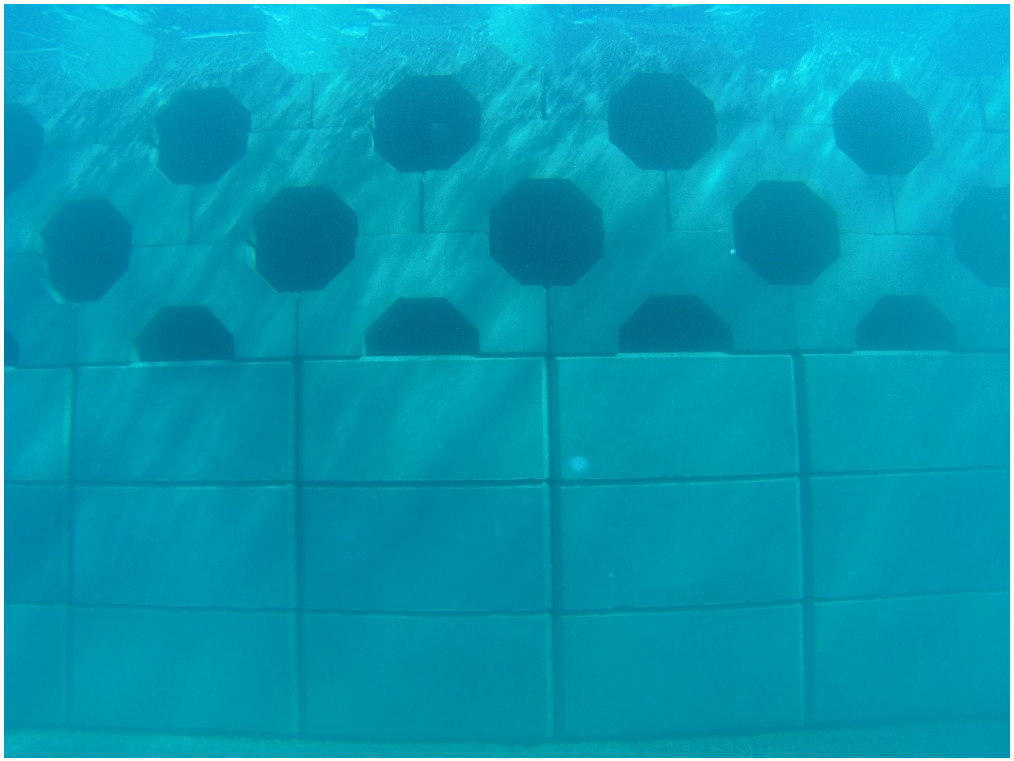
CONCLUSIONS

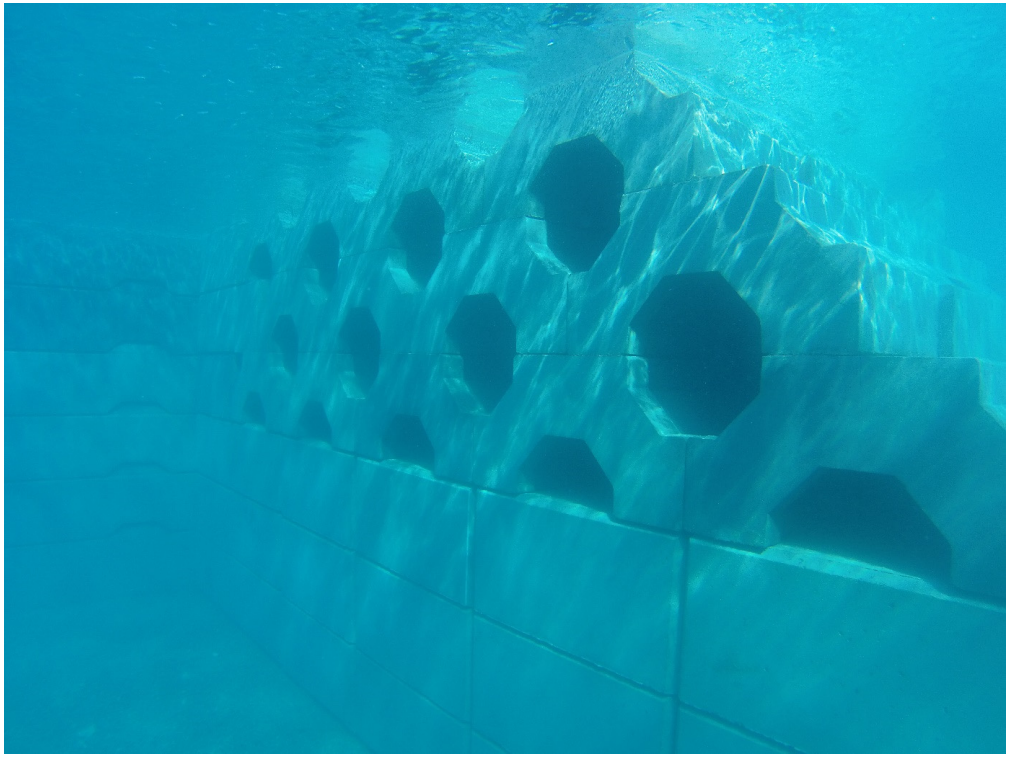
- The creation of a gravity vertical block wall, that can absorb the wave energy, was achieved by testing the concept with DualSphysics model.
- The design development involved taking the concept through an initial trail and error phase using advanced free surface numerical models, and later validating and refining the concept in scaled physical models.
- The block wall reduces wave reflections minimazing seiche.
- The proposed Hxblock, 4 meters deep, absorbs wave periods between 4 and 10 seconds. For other wave lengths modifying the chamber width can provide additional reflection reduction.

The author wishes to acknowledge the important role that the Dual Sphysics numerical model had in the development of the Block.









Questions?