Coastal defence and historic harbour development: Mevagissey

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Introduction

Mevagissey is a small fishing village located on the South coast of Cornwall, the village is protected from two outer breakwaters built in 1880 and a inner harbour wall.

Figure 1: Overtopping at Mevagissey Harbour

Figure 2: Custom built survey vessel (MHA, 2022)

Figure 1 shows the overtopping of the breakwaters during a 2018 storm. The harbour Authority had inspection survey completed which identified areas on the Northern and Southern breakwater which had been undercut and appeared to missing material.

A sea level rise study completed by the Marine I, has generated the predicted the sea level increase in Mevagissey for 3 different climate change scenarios for 2035, 2050 and 2100.

Year/Scenario	RCP 2.6	RCP 4.5	RCP 8.5
2035	70 mm (2.8 in)	70 mm (2.8 in)	100 mm (3.9 in)
2050	150 mm (5.9 in)	170 mm (6.7 in)	210 mm (8.3 in)
2100	370 mm (14.6 in)	470 mm (18.5 in)	700 mm (27.6 in)

Figure 3: Sea level rise predictions generated from IPCC data , (Marine I, 2021)

Aim:

To develop an effective protection strategy for the Mevagissey outer breakwaters and arrive at both a conceptual design and indicative values for design to enhance the existing structure in preparation for sea level rise.

Objectives:

- Understand the wave conditions at Mevagissey
- Understand how climate change will increase sea levels
- Calculate an extreme wave height and period
- Calculate a rock size to protect the breakwater from the extreme wave.
- Calculate the overtopping discharges in 2023 and 2100 of the breakwater

Figure 4: Mevagissey Breakwaters

Methodology

1. Data collection from the Plymouth coastal observatory, data collected from 2011-2021 and all error data removed.

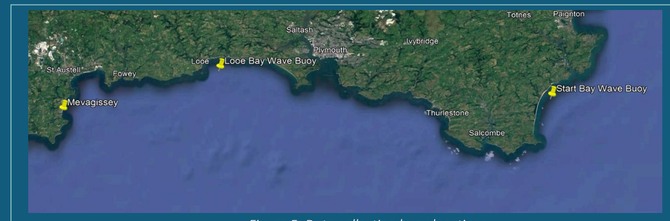

Figure 5: Data collection buoy locations

2. Extreme value analysis to generate the worst case wave in a 100 year return period (Wave height and period)

Year	Wave height, Hmax (m)	Wave Period, Tp (s)
2011	3.27	7.7
2012	4.36	9.1
2013	3.78	9.1
2014	5.25	14.3
2015	3.22	11.1
2016	3.89	8.3
2017	3.38	7.7
2018	5.46	10
2019	3.48	11.8
2020	4.3	10
2021	4.41	9.1

Figure 6: Data used in Extreme value analysis

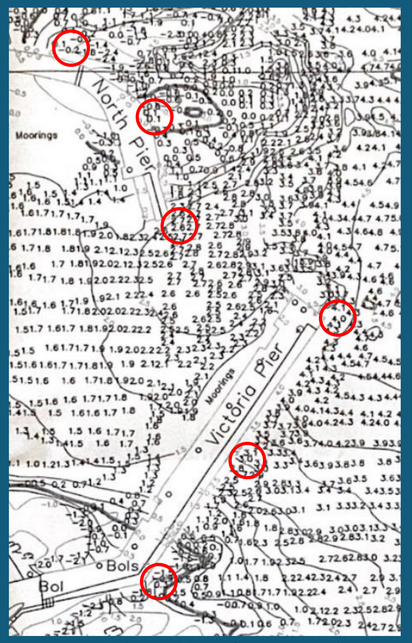

Figure 7: Bathymetric Survey of Mevagissey Harbour

3. Wave shoaling calculations into 6 locations along the 2 breakwaters.

4. The shoaled waves are input into the Hudson Equation to calculate the required rock size for various slopes.

$$M_{50} = \frac{\rho_s \times H_{des}^3}{K_D\left[\left(\frac{\rho_s}{\rho_w}\right) - 1\right] \times \cot\alpha}$$

Equation 1: Hudson Equation (Thoresen, 2018)

5. The overtopping discharges are calculated for the existing structure (2023) following guidance from the EurOtop manual (Van de Meer, 2018) .

6. The required crest freeboard is calculated by using a rearranged overtopping equation, there the required discharge can be input

$$R_c = \left[-ln\left(\frac{q}{0.1035 \times \sqrt{g \times H_{mo}^3}}\right)\right]^{\frac{1}{1.3}} \times \frac{H_{mo} \times \gamma_f \times \gamma_\beta}{1.35}$$

Equation 2: Rearranged overtopping equation

Results:

- EVA calculated 6.67 m max wave height and 13.98 s wave period
- Shoaled waves between 5.25 m to 7.07 m, with waves being limited by depth at 3 locations
- 2023 Overtopping discharges were calculated between 1.06 m^3/s and 2.11 m^3/s. The mean of these values was 1.607 m^3/s.
- Hudson Equation provided rock sizes for various slopes, for a 34 degree (1:1.5) slope the required rock weight is 7.2 tonnes, 1.4 m nominal diameter.

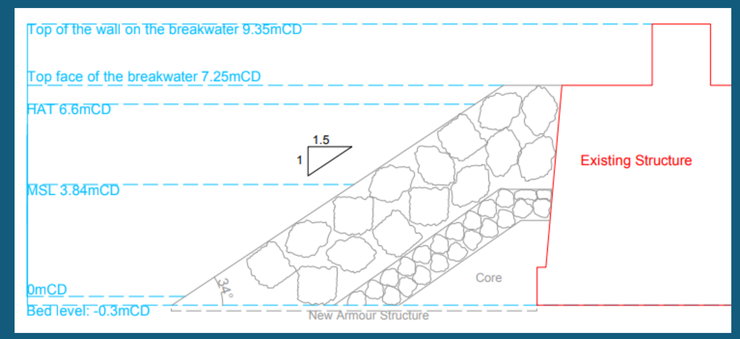

Figure 8: Cross section, Southern breakwater, location 3

- 2100 required crest freeboard was originally calculated by using the tolerable overtopping level from the EurOtop manual (Van de Meer, 2018). However this produced extreme crest heights.
- The 2100 overtopping was limited to the 2023 mean, 1.607 m^3/s. The required crest freeboard was 3.5 m.

Conclusion:

The study provides the key stages in the preliminary design to enhancement the breakwater at Mevagissey. Climate change reinforces the need for development to retain the historic structure and to continue its important role within the community.

References:

Marine I (2021) Potential Future High Water Levels at Mevagissey Harbour: To inform future need for defence. Available at: https://www.mevagisseyharbour.co.uk/wp-content/uploads/2022/02/Marine-i-Mevagissey-Sea-Level-Report-1.pdf (Accessed: 20/11/2022)

Thoresen C A, (2018) Port Designers Handbook. Fourth ed London: ICE Publishing

Van der Meer, J.W. et al., (2018) EurOtop, Manual on wave overtopping and sea defences and related structures. 2nd Edition. Available at: http://www.overtopping-manual.com/eurotop/downloads/ (Accessed: 05/12/22)