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Project title	Barmouth North Promenade	Job number
		264326
cc	Paz Arteijo Robin Campbell	File reference
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Subject	Key considerations for OBC ground and structural investigation	

1 Introduction

Ove Arup and Partners (Arup) were appointed in September 2018 by YGC, part of Cyngor Gwynedd Council (CGC), to deliver an Outline Business Case (OBC) for coastal risk management for the Barmouth North Promenade frontage.

In September 2019, Arup were instructed to support YGC to reduce project risks and uncertainty associated with the capital costs of the preferred option. The OBC highlighted key risks associated with the coastal environment, condition of existing structure and buildability of the proposals. Further work and investigations are now being undertaken to better understand these risks, and update the OBC for submission to Welsh Government.

The OBC recommends further ground investigation, structural investigation and surveys to confirm structural integrity, performance and construction details of the existing structure and to inform remedial works design.

This Technical Note highlights the key considerations for the ground and structural investigation.

1.1 Background

The Outline Business Case (OBC) demonstrates a strong case for change to reduce the coastal risk threat to the community. The preferred way forward is an adaptive pathway approach. The most economically favourable immediate action is the betterment of the existing defences. This will safeguard the community and the recreational value of the promenade in the medium term and is estimated to achieve a 1 in 50 annual chance standard of protection with allowance for the impact of climate change to 2069. Beyond 2069, managing coastal risk is increasingly challenging and the preferred approach is to transition to a form of managed realignment for the northern section, with beach management to the south.

The OBC included a technical note (OBC Appendix E) summarising and collating available historic information on the arrangement and condition of the coastal defence structures (Arup, 2018).

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Appendix 1 of that note includes visual condition information from various available historical and recent condition inspections, arranged by chainage.

The preliminary budget estimate of the preferred option of betterment of the existing defences totalled £23.1M (non-discounted costs). The OBC recognised the significant uncertainty in the scale and form of preferred option, and followed best-practice to include 60% optimism bias totalling £8.1M. Further work is recommended to reduce uncertainty before proceeding to the next stage (detailed design and consenting before Full Business Case).

The OBC preliminary budget included to replace the wave wall (£0.9M) and install a new set-back flood wall (£0.7M), new sheet piles at the toe (£2.1M) and void repairs (£0.6M), excluding preliminaries, construction contingency and optimism bias. In the absence of information on the existing structure or intrusive surveys, the form/extent of works was inferred. The OBC took the precautionary approach of ignoring the existing primary wave wall, instead a new wave wall was proposed between the promenade and the highway.

The OBC geotechnical desk study recommended ground investigation to inform remedial works design. The OBC recommended structural investigation and surveys to confirm structural integrity, performance and construction details of the existing structure.

Figure 1 – Extract from OBC geotechnical desk study recommendations

- Ground investigation will likely be required to inform the design of any remedial works undertaken. The scope of investigation will be dependent on the preferred option, but the main objectives of the ground could include the following:
 - Establish the ground conditions and their engineering properties along the promenade
 - Establish the groundwater conditions along the promenade
 - Undertaken geo-environmental sampling and subsequent assessment to inform risk to the environment, risk to site users and offsite disposal.
 - The potential localised variation in ground conditions around the historic watercourses.
 - Investigate potential mining activity within the area.
- In addition to the above, further investigation of the existing promenade structure may be required to confirm its conditions, geometry and any required engineering assessments. Elements which may require investigation are as follows:
 - Investigate the potential for voiding beneath the revetment and promenade which may comprises a combination of geophysical and intrusive techniques
 - Depth, condition and ground conditions for the sheet piles
 - Depth, condition and ground conditions for the precast concrete piles
 - Foundation details of the wave wall, secondary and tertiary walls
 - Structural coring of the walls and revetment

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2 Key Considerations for ground investigation

2.1 Potential for voiding beneath the revetment and promenade

A geophysics specification has been prepared by YGC *North Parade Barmouth GPR Survey Specification_BofQ* (Jan 2021), which was reviewed by Arup. TerraDat have been appointed to undertake a GPR survey, which will commence on 2 February 2021. The site works will begin with a small trial, and if successful will be implemented along the full survey area. The surface geophysics targets areas known to have been repaired recently, such as at the northern extent and outfall pipelines that are known to pass beneath the structure.

Following the results of the geophysics, an intrusive investigation will be scoped to prove any anomalies identified. This is likely to include probe holes (for example Super Heavy Dynamic Probes or CPTs), followed by an endoscope camera survey of any voids identified.

Sand filling of voids to be confirmed by ground investigation during detailed design.

2.2 Depth, condition and ground conditions for the sheet piles and precast concrete piles and rock armour works

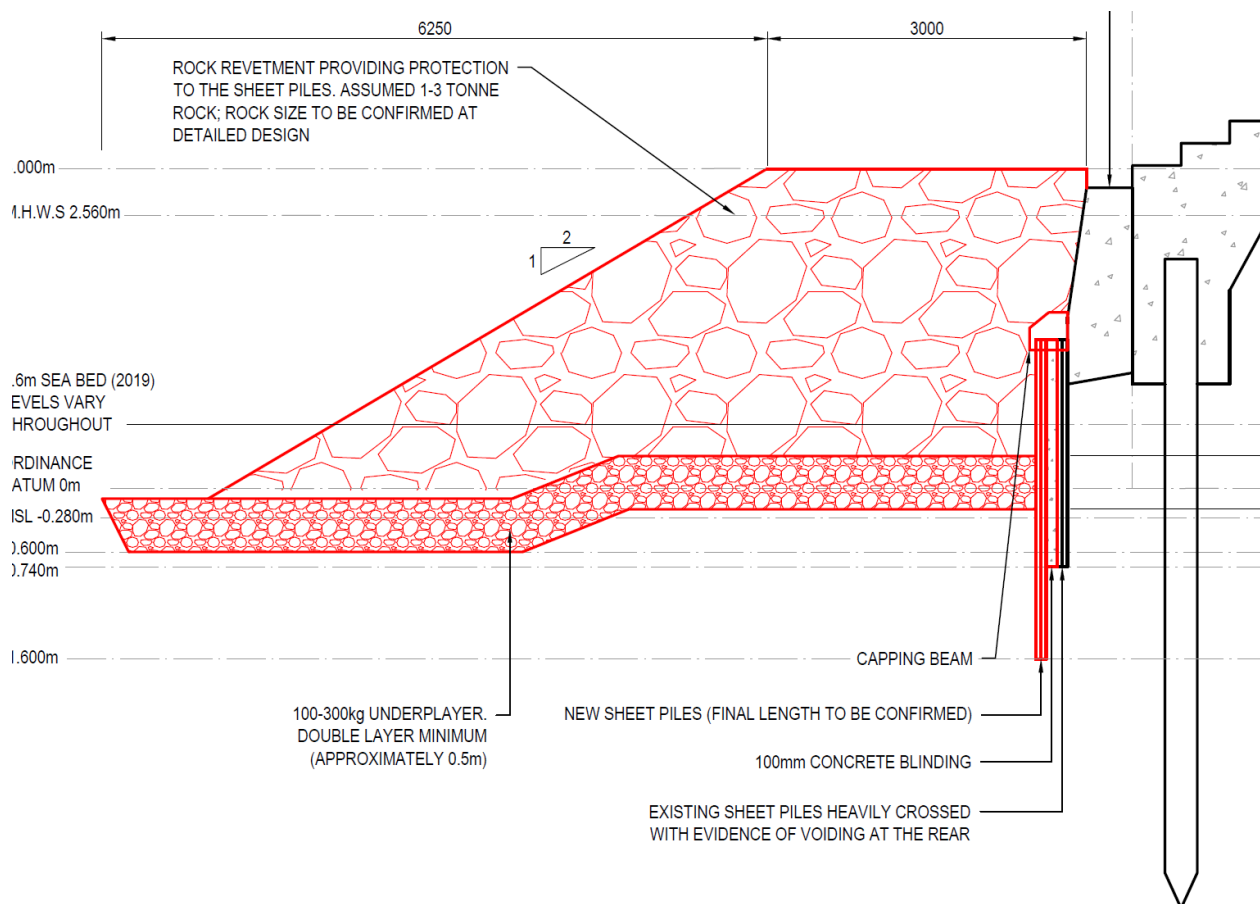


Figure 2 Extract from OBC drawing ARP-XX-EP-DR-CS-0001-SK – proposed sheet piles and rock armour works

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It is proposed to use Cone Penetration Tests (CPTs) to investigate the depth, condition and ground conditions for the proposed sheet piles and inform the embedment depth of existing precast concrete piles. The use of a mag-cone is proposed to measure the depth of existing sheet piles, which has been used successfully in the past on previous Arup scheme. Lankelma have confirmed this technique can be used and advised *'To enable this we will need to get our rig to within 1.5m of the top of the pile and then to push our probe about 2-3m past the depth where the pile ends in order to fully model it. Accuracy will depend on the quality of the data (mainly down to the cone picking up traces of other ferrous objects) and the number of tests we complete.'*

Trial pits are likely to be required to visually inspect the condition of existing sheet piles. Note difficulties encountered in previous phase of GI.

Additional CPTs along the beach would also be useful to inform the ground conditions for the proposed rock armour works along the northern extent of the scheme.

Note any GI undertaken along the beach will need to be surveyed for ground level (m OD) at the time during every low tide, as ground level is likely to change once the tide comes in. This requirement should be made clear to the GI Contractor.

2.3 Foundation details of the proposed secondary and tertiary walls

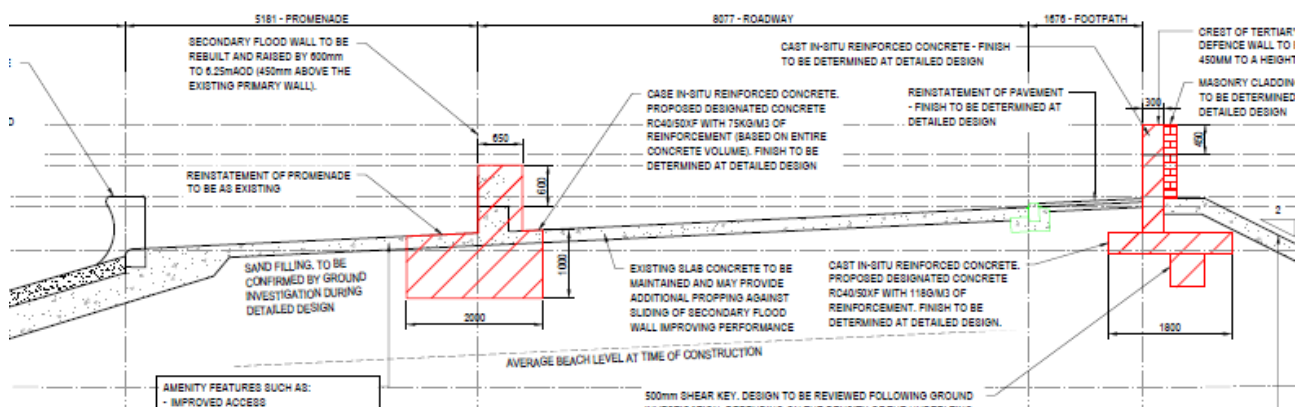


Figure 3 Extract from OBC drawing ARP-XX-EP-DR-CS-0001-SK – proposed secondary and tertiary walls

Trial pits to investigate foundation details of the proposed secondary and tertiary walls. Samples for PSDs / classification and BRE SD1 tests for buried concrete classification. Geo-environmental sampling and to inform risk to the environment, risk to site users and offsite disposal.

Probing (DPs/CPTs) for in-situ strength - possibly combined with requirements to investigate potential voiding beneath proposed secondary and tertiary walls.

500mm shear key design of tertiary wall foundation to be reviewed following ground investigation, depending on the density of the underlying sand foundations, a mass reinforced concrete foundation may be more appropriate.

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2.4 Structural coring of existing wave wall, revetment and promenade

Structural coring of the promenade and revetment will be required to enable the probing (DP/CPTs) proposed to investigate ground conditions and potential voiding beneath the revetment and promenade. Information for the assessment of the existing structure could be obtained from these. Additional horizontal cores of the existing wave wall may also be required to assist in rebar and concrete condition. Due to working conditions it is understood it may be difficult to obtain cores on the sloped part of the revetment.

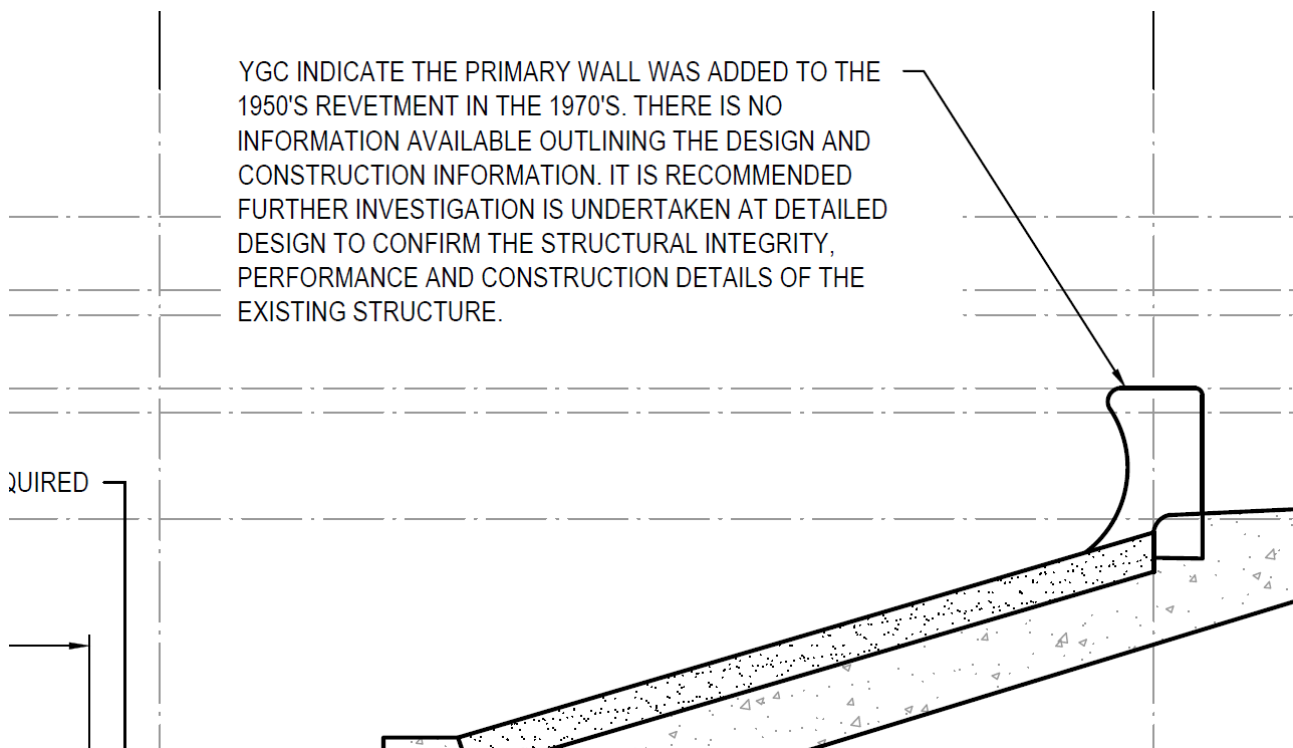


Figure 4 Extract from OBC drawing ARP-XX-EP-DR-CS-0001-SK – Existing wave return wall

There is no information available outlining the design and construction information the primary wall, believed to be added to the revetment in the 1970s. it is recommended further investigation is undertaken at detailed design to confirm the structural integrity, performance and construction details of the existing structure. Some cores on the promenade close to the wave wall would help understand how it is anchored to the revetment.

2.5 Establish the ground conditions and their engineering properties along the promenade and groundwater conditions

The geotechnical desk study identifies the general ground conditions to comprise Blown Sand over the Rhinog Formation. The BGS Lexicon describes Blown Sand as 'sand, pale brown, fine grained, uncemented sand' and the Rhinog Formation as 'grey to bluish grey, thick bedded turbiditic sandstones, conglomerates and laminated sandstones, with thin siltstone and mudstones intercalations'. The desk study also identified potential localised variation in ground conditions around the historic watercourses.

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The CPTs proposed along the beach (if undertaken to refusal) should provide a useful profile of the top of the Rhinog Formation and any local variations along the extent of the scheme.

Deeper boreholes with piezometer installation should be considered to investigate and establish the general ground and groundwater conditions and their engineering properties along the promenade.

Groundwater conditions beneath the promenade and revetment are likely to be highly influence by the tide, and could be measured accurately by piezometer dataloggers. The tide levels should also be recorded during the datalogger investigation, and an idea of any tidal lag within the promenade fill could be identified.

3 Other considerations

The Specification shall be *UK Specification for Ground Investigation* (2nd edition) published by ICE in 2012, with information, amendments and additions as described in the Schedules.

The specification and drawings should include a CDM Designer's Risk Register, which identifies risks such as buried utilities, intertidal working, working on a slope / at height.

Any trial pit excavations along the beach to investigate the existing sheet piles should consider UXO risk. The use of the CPT mag-cone at trial pit locations could be used to mitigate this risk.

Interaction with the public should also be considered along the promenade and Marine Parade.

DOCUMENT CHECKING (not mandatory for File Note)

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