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Site Investigation Case Study – Swansea Docklands

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Brief

The University is about to enter a new stage of its campus development, with a three storey, steel framed building, a Universal learning/lecture hall building, needed for the large number of lectures to be undertaken during term time. The estimation is that 10 lecture rooms for 30 students and 4 lecture theatres for 100 students are required over three floors.

You are to assume that you work as a junior construction professional, requested to initiate a preliminary study that will inform a full site investigation (to be carried out by specialist ground contractors) as part of the feasibility stage of the project.

Introduction

As the University is about to enter a new stage of its campus development, with a three story, steel framed building to accommodate additional lecture rooms. As a junior construction professional, I will conduct a full site investigation to reveal any hidden implications the site may have beneath its surface. Due to the site's rich historical background this may unveil some problems that will need to be taken into consideration first before the building commences. This site investigation will delve firstly into the historical background of the Swansea docklands, and then investigate the geological profile of the site. Evaluating soil and rock types, assessing groundwater conditions, and identifying any potentially hazardous risks. Finally, I will advise on what foundation type is most suitable for due to the site conditions and type of building.

Historical Background of Swansea Docklands

The Swansea docklands site is famous for what was its very famous port in the early eighteenth century. The port grew in popularity due to an increase in the region's coal and iron production, as well as the start of copper smelting and tinplate manufacturing (www.swanseadocks.co.uk, n.d.).

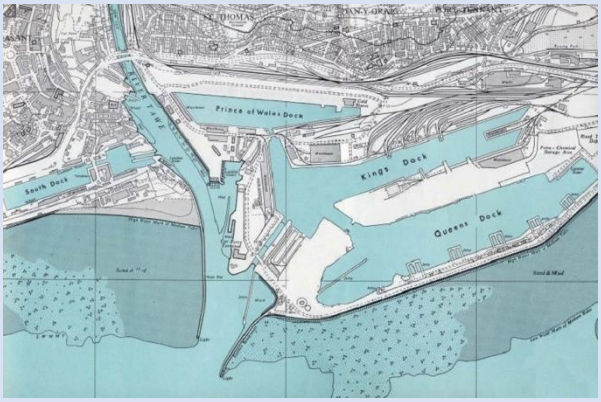


Fig 1. Swansea Docks in 1969 (www.swanseadocks.co.uk, n.d.)

The Swansea Canal, which connected Ystradgynlais and Swansea, was completed in 1978 because of the ongoing increase in traffic between the port and the collieries and metal industries, with a need for better transportation links. This development was key to Swansea's maritime trade. (www.swanseadocks.co.uk, n.d.).

Due to the easy access to high-grade anthracite coal, which is necessary for the copper smelting process, the local copper industry, which had started with the construction of the Landore Copperworks in 1717, was thriving at this point. Swansea was home to seventeen of the eighteen copperworks in Great Britain at the height of their operations in the middle of the nineteenth century. The technical expertise and knowledge gained in this sector made Swansea a recognised global leader in the production and processing of metallurgical materials (www.swanseadocks.co.uk, n.d.).

Over 1.5 million tonnes were handled annually by the port by 1870, and in 1877 it was noted that "no other harbour in the Kingdom where such an amount of work is done on a given space as at Swansea". The Swansea Harbour Trust started building a new dock on the east bank of the River Tawe in 1879, including the entirety of Fabian's Bay, as a result of the port's increasing population, which made additional facilities necessary. It was named the Prince of Wales Dock and was finished in 1881. (www.swanseadocks.co.uk, n.d.).



Fig 2. Prince of Wales Dock, Swansea 1949 (Aerofilms Ltd, 2011)

Swansea was still a thriving port by the end of the nineteenth century, even though the local copper trade had drastically declined. Over 2 million tonnes of coal were exported from the port alone annually. By 1895, Swansea's main traffic was mostly composed of tinplate exportation, which had grown from 6,000 tonnes in 1875 to almost 250,000 tonnes. Work on Kings Dock, a larger dock on the coastal side of the Prince of Wales Dock, began in 1905 as result of the need for yet another port expansion, and was completed in 1909. The lengthy sea wall enclosing a further body of water that would be known as Queens Dock upon its official opening in 1920 was also finished (www.swanseadocks.co.uk, n.d.).

In 1913 as the Kings Dock was put to use, the amount of coal, coke and patent fuel exported through the port rapidly increased, setting a record of 5.5 million tonnes. When 621,000 tonnes of tinplate were transported through the port in 1924, tinplate exports peaked. The shift from coal to oil as an industrial energy resource started in the early 1900's. in 1918, the United Kingdom's first oil refinery, at Llandarcy was finished. Around 8 million tonnes of oil were imported and exported through the Port of Swansea annually in the early 1950's (www.swanseadocks.co.uk, n.d.).

Imports & Exports through Swansea Docks – 1913

Imports	*Tons*
Iron Ore	77,375
Copper & other Ores	108,726
Iron & Steel	252,925
Timber & Deals	80,382
Pitwood & Mining Timber	137,496
Wheat, Barley, etc.	173,627
Oil	13,396
Sulphur Ore, Pyrites, etc.	70,878
General Merchandise	182,194
Total Imports	1,096,999
Exports	
Coal & Coke	4,530,352
Patent Fuel	924,731
Iron & Steel	95,046
Tinplate	468,229
Grain & Flour	22,779
Oil	4,780
General Merchandise	88,334
Total Exports	6,134,251
Total Imports & Exports 1913	7,231,250

Fig 3. Imports & Exports through Swansea docks 1913 (www.swanseadocks.co.uk, n.d.)

As a result of the construction of a new dock system on the east bank of the River Tawe and the gradual decline in coal exports brought about by the growing use of oil, the west bank docks were outdated. Although the North Dock closed in 1930, the Basin was still open until 1969. The South dock closed in 1971, but then was revived a few years after to become Swansea's renowned Maritime Quarter (www.swanseadocks.co.uk, n.d.).

In these days the Prince of Wales Dock is the centre of attention for the new SA1 redevelopment plan. While the closures of the BP Chemicals facility at Baglan Bay and the Llandarcy Oil Refinery has made the Queens Dock all but useless. Consequently, the Kings Dock is primarily responsible for managing the remainder of commercial traffic that passes through the Port of Swansea today (www.swanseadocks.co.uk, n.d.).

Site Details



(Fig 4. Google Maps, n.d.)

Here is a screenshot of the site's location from Google Maps. The site is located to the east side of Swansea's city centre, and to the south-west of Port Tennant. As you can see the King's Dock is to the south of the site, and the Prince of Wales Dock is to the north-west of the site. The river Tawe runs down the western side of the site. The area is predominantly a commercial area with businesses such as car garages. However, there is some recently developed housing to the north of the site on Langdon Road, there for considerate contracting must be considered. The current UWTSD SA1 Waterfront Campus is situated to the west of the site. As you can see from the map the site has several access routes that would make entrances for heavy machinery and deliveries during the project easier. The ground of the site looks very much untouched and unused for many years, with some vegetation growth and rock or rubble type surface.

Geological Appraisal

The district of Swansea includes the city of Swansea in the centre and stretches from Port Talbot and Neath in the east, to east Gower and Llanelli. Coal measures cover the coastal area from Swansea Bay eastwards, while limestones from the Pembroke Limestone Group emerge in the Gower. Sandstones, known as Pennant, from the Warwickshire group lay beneath most of the area (Barclay, 2011).

Made ground is common in the Swansea area, which can be natural rock or artificial deposits. As the area's history in coal mining and metal works, waste from these industries may be found in the ground which has been filled over during developments. (Waters et al., n.d.).

Waste from the metal industries is the most found source of made ground in the area, which can potentially be contaminative. Slag has been used as hardcore in the region for a very long time. During the redevelopment of the Lower Swansea Valley in 1967, they elevated the level of the Tawe floodplain and constructed embankments by using spoil. (Waters et al., n.d.).

In the Swansea area the main materials that have been quarried are sandstone, clay and coal. These operations produced a lot of waste material, which were quite often tipped close to the quarried sites which produced piles of made ground. Quarries which were left unfilled, usually have lower amounts of contamination than quarries that have been filled in. Although, there may still be small traces of harmful or contaminated materials left behind (Waters et al., n.d.).

Areas of infilled ground are areas which there has been excavation by humans, and then been filled in with artificial deposits. In some cases, quarries would be partly filled with waste from the original mineral extraction, but in most cases would use waste that has been imported into the site. This imported waste can be excavation waste, construction and demolition waste and industrial waste. Relevant to the Swansea area, the Swansea Canal was filled with waste which came from the local Morfa Copperworks (Waters et al., n.d.).

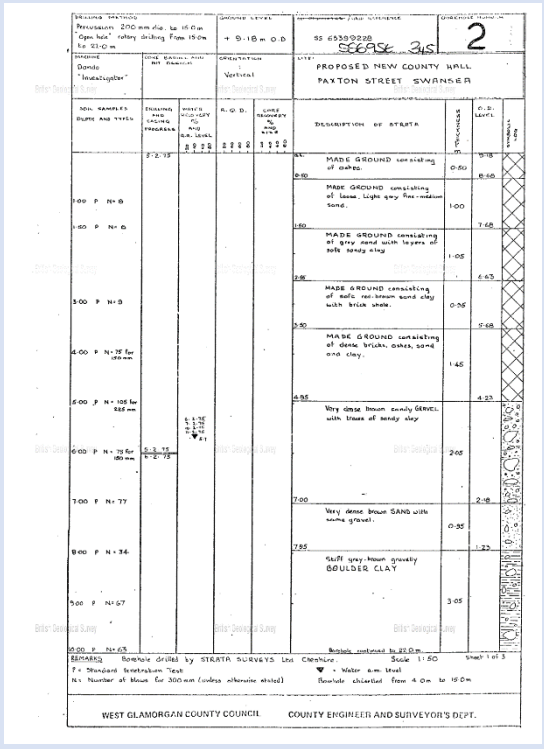
Because bedrock composition and character affect groundwater flow pathways and rates, they are significant to the study. The Swansea area is situated on the southern side of the South Wales Coalfield. Grey clay stones and siltstones make up the majority of the coal measures. Almost 90% of the region is covered by the widespread outcrops of the Warwickshire Group. (Waters et al., n.d.).

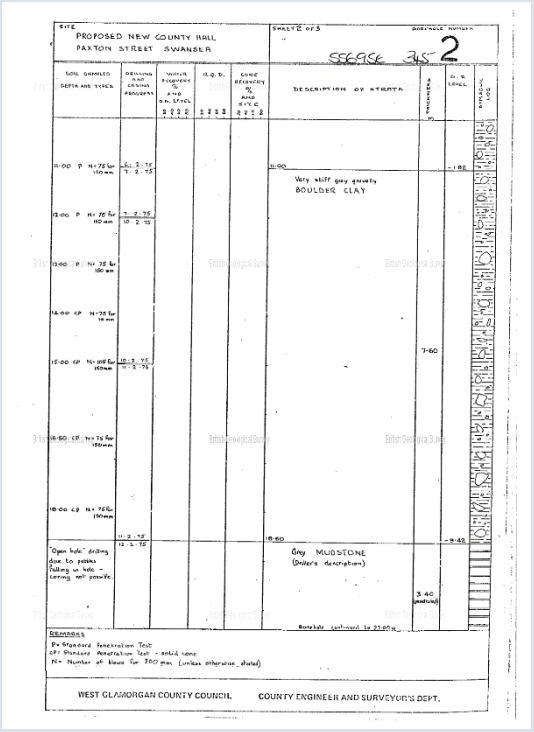
Due to its location upon carboniferous coal deposits, Swansea's history and growth have been significantly impacted by the coal industry. Although the area's soils have not been extensively studied, there is a high possibility that significant peat deposits and alluvium connected to the river Tawe do exist (Bowen, 2011).

Geological Hazards

In areas such as Swansea, which used to be heavily industrialised the contamination of land and possible groundwater pollution can be a major issue. Areas which are filled with made ground from colliery and metal work waste could have toxic residues. Mining subsidence left behind by previous coal mining could yet materialise. In addition to radon, methane produced by the breakdown of household waste in landfills is one type of gas emission that occurs naturally together with carbon dioxide. Small amounts of uranium can be found in all rocks and soils, but the argillaceous rocks of the carboniferous period have larger concentrations of uranium, which naturally decays to produce radon. When it builds up in inadequately ventilated buildings, it poses a health danger (Barclay, 2011).

Borehole Log


PROPOSED NEW COUNTY HALL
PAXTON STREET SWANSEA
SS 65390228
SS69SE 345
2
MADE GROUND consisting of ashes.
MADE GROUND consisting of loose, light grey fine-medium sand.
MADE GROUND consisting of grey sand with layers of soft sandy clay
MADE GROUND consisting of soft red-brown sand clay with brick shale.
MADE GROUND consisting of dense bricks, ashes, sand and clay.
Very dense brown sandy GRAVEL with traces of sandy clay
Very dense brown SAND with some gravel.
Stiff grey-brown gravelly BOULDER CLAY
Borehole continued to 22.0 m
Borehole drilled by STRATA SURVEYS Ltd Cheshire. Scale 1:50 Sheet 1 of 3
WEST GLAMORGAN COUNTY COUNCIL COUNTY ENGINEER AND SURVEYOR'S DEPT.


PROPOSED NEW COUNTY HALL
PAXTON STREET SWANSEA
SS69SE 345
2
Very stiff grey gravelly BOULDER CLAY
Grey MUDSTONE (Driller's description)
"Open hole" drilling due to pebbles falling in hole - coring not possible.
Borehole continued to 22.00 m
WEST GLAMORGAN COUNTY COUNCIL COUNTY ENGINEER AND SURVEYOR'S DEPT.

Here is a borehole log that was taken from a nearby site in Swansea for the proposed new County Hall, on Paxton Street. This borehole log was taken from the West Glamorgan County Council archives. This borehole was drilled to a depth of 22 metres. The first 15 metres were percussion drilled at a diameter of 200 mm, and the remainder was 'open hole' rotary drilled to 22 metres deep.

As you read the borehole log you can see that the main components discovered were ash, sand, clay, bricks, gravel, and grey mudstone. The two materials that are most prominent however are sand and clay. You would expect to find a lot of sand in the borehole log as it is a coastal area. Sand has very good natural drainage characteristics, however a very sandy soil is not ideal to build a foundation upon (magnum admin, 2018). Clay soil is very susceptible to swelling and shrinkage, depending on weather conditions. Therefore, buildings foundations on such soil can cause problems, as it causes the concrete to move and crack (Brannan, 2022). It is important note the finding of bricks during the borehole drilling, as this may be an indication of infilled ground from previous industrial use.

Archaeological Appraisal

During the 1860's the Neath railway was constructed to improve transportation routes to the Swansea Docks. These railway lines ran until the 1970's, until the area was cleared to build Langdon Road, as seen today near the site (Homes, 2017).

Archaeological investigations have taken place near to the site of build, which have shown some structural remains which relate to the history of the railways that ran across the area. Deeper excavations have also revealed peat deposits of paleoenvironmental significance. As a result, it is thought that there may be some archaeological artefacts that remain in the area (Homes, 2017).

Flood Risks and Water Conditions

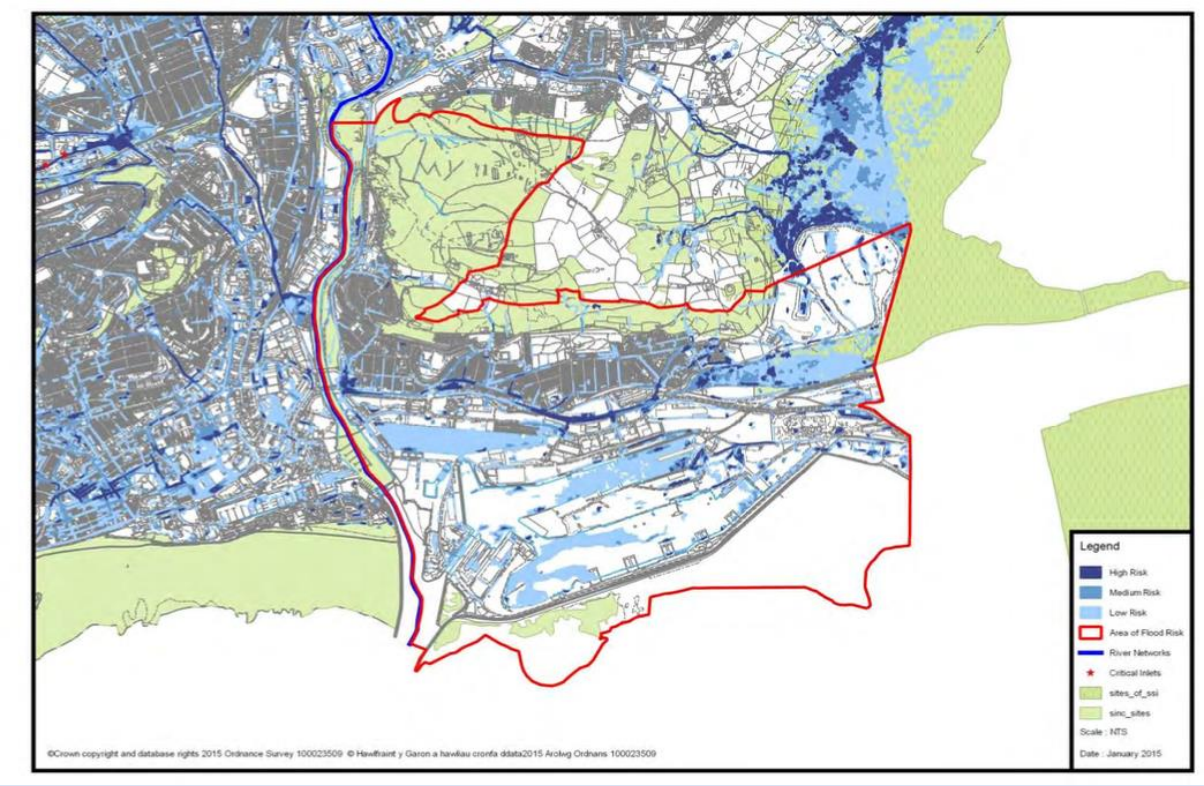


Fig 5. St Thomas – Flood Risk Map (City and County of Swansea, 2015)

Here is a map of the flood risk area that the site comes under in St Thomas. This flood risk management plan by the City and County of Swansea done in 2015 states that the main cause of flooding for the area "relates to ordinary watercourses and the intakes to existing surface water culverts". Fabian's way is shown as high-risk flooding on the map, which is the main road into the city centre from the east from the M4 (City and County of Swansea, 2015).

However, as the site of the build is in the centre of the Swansea docks and very near to the sea, meaning that it isn't very high above sea level I would assume that there is a risk of flooding. According to National Resources Wales there is a 3.3% risk of flooding each year from rivers and the sea, and the area is categorised as 'high risk' (National Resources Wales, n.d.).

The domestic water supply of the area was originally from streams, wells, springs and canals. Although by the early nineteenth century these supplies had been contaminated by sewage and mine waters. This contamination sparked the outbreak of cholera in Swansea in 1832 and 1848/9. The water supply in the area was improved by piped water from local reservoirs by the mid nineteenth century. As the area is rich with Pennant Sandstone this can cause groundwater to contain iron-oxide (Waters et al., n.d.).

Sites of Special Scientific Interest – Crymlyn Burrows

Something that needs to be taken into careful consideration is the SSSI of Crymlyn Burrows in Swansea. This site is to the east of the city centre and near to the site of build. It is the largest lowland fen in Wales, and is home to a range of wetland plants, birds, and insects. The site has remained unaffected by the amount of industrial activity in the surrounding areas. If the work carried out will affect the SSSI, then consent from National Resources Wales is needed. Usually, contractors can work with the company to limit the effects on the protected areas. Sometimes you may have to comply with specific rules, such as how and when the work is undertaken, to ensure the site remains unaffected (National Resources Wales, 2023).

Considerate Constructors Scheme (CCS)

This scheme highlights the importance of taking into consideration the effects that construction work can have on others and puts practices into play for construction companies to follow which allow for working responsibly and respectfully.

This scheme ensures that there is a respect for the community around the project. It also ensures that contractors minimise their impact on the natural environment surrounding the site. Finally, the scheme promotes creating a supportive, inclusive, and healthy work environment (Considerate Constructors Scheme, n.d.).

This is important to this site as there is many businesses surrounding the area, there is also housing, the university and a church. Therefore, contractors must be considerate regarding traffic entering and exiting the site, and noise pollution caused during the project.

Suggested Foundation Type

The foundation type I would highly recommend used for this specific project would be pile foundations. Pile foundations are a very deep type of foundation. They are long, columnar shaped elements usually made from steel or reinforced concrete. Most of the time piles are driven or hammered deep into the ground but can also be poured in-situ (Designing Buildings, 2022).

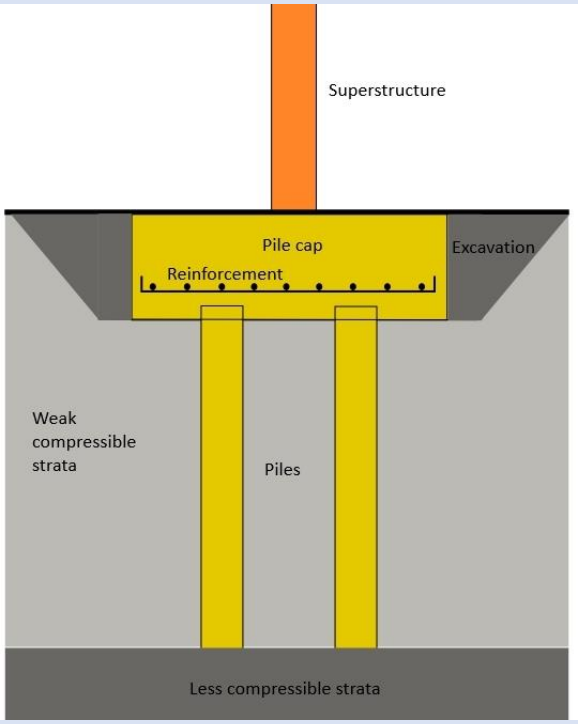


Fig 6. Pile Foundations Diagram (Designing Buildings, 2022)

I believe that this type of foundation is most suitable to this project as we have seen from the borehole log that the softer top layers contain a lot of sand and clay, which are not ideal materials to build a solid foundation on. Drilling deeper means that the piles can reach more stable soil or rock layers. Pile foundations have very high load bearing capacity which is needed for a building of this type as there could be up to 700 people in the building at once. Another advantage of using piles is their versatility to be able to adapt to different soil types as seen in the borehole log. Pile foundations have very good settlement control which means that the building can remain stable over a long time. Pile foundations also provide great resistance to lateral forces. As this site is in a coastal area, a pile foundation would resist the powerful wind forces expected (Engineering, n.d.). The piles can be strategically placed to ensure stability if more is needed in certain areas.

Pile foundations are highly durable which is very important to this site as it could suffer from coastal erosion (Phillip, 2020).

Conclusion

Concluding the Swansea Docklands site investigation, I have found and highlighted the area's diverse geology and rich industrial background. Understanding soil properties, possible contaminations and groundwater behaviours is vital to this development. The findings in these investigations along with taking care in SSSI sites and considerate contracting will allow for a successful project. I've suggested to use pile foundations for this project as this is the foundation type I believe is most suitable to this specific site.

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