

Assignment 1. Fundamentals of Construction Technology

CASE STUDY: SITE INVESTIGATION

(Preliminary desktop study and report document)

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reference listing and appendices.

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1. Introduction

1.1. General

City of Swansea and Marriot Hotels are considering the creation of a new restaurant on Swansea foreshore, at the 'Site'. A preliminary desktop study and report document will uncover environmental, geo-technical and operational risks to the proposal, will



provide direction for the next stage of detailed Site investigation and will recommend suitable foundations for the restaurant building. This study is limited to publicly available information. Site activity is limited to a reconnaissance walk-through and photography.

1.2. Compliance - Legislation & Codes of Practice

The local planning authority are contacted at an early stage in order to discuss the feasibility of the restaurant and how it fits in with development plans. Outline planning permission is to be sought in the first instance, a more detailed planning stage will follow, all in accordance with the Planning Act, 2008. Other relevant legislation will be the Building Act, the Highways Act, and the Health & Safety at Work Act. (Gov Legislation Portal, 2021).

Regulations taken from the legislative acts are applied to the creation of the restaurant, i.e., the Building Regulations, 2010 and the CDM regulations, 2015. The local authority building control office are responsible for upholding these standards. 'How to create' the restaurant is derived from the many specific industry codes of practice. The British Standards Institute (BSI) provide many of these as do the International Standards Organisation and other expert organisations. (BSI, 2021)

2. Desktop Study

2.1. Site Details - Table 1

	Description / Detail
Address	Swansea foreshore, between County Hall and the Marriot Hotel, SA13SA
Description	Generally rectangular in shape, ground floor gross internal area is to be 300m ² containing the restaurant, café bar, ice-cream parlour, kitchen, & food-stores. Total footprint, including terrace and pathway is 500m ² . Self-contained manager's apartment and staff welfare facilities at first floor level.
Location	Accessed off Dunvant Place. Is bounded immediately to the north, east and west by tarmacadam car park and publicly accessible landscaped areas owned by the City of Swansea Council and Marriot Hotels, and to the south by the promenade and shore.
Coordinates & topography	51°36'47.6"N 3°56'43.0"W, (Earth, 2021) 10m above ordnance survey ordnance datum, (Appendix 1)
Notable current land use nearby	West; 50m City of Swansea County Hall. East; 30m Marriot Swansea Hotel. South; promenade and shore. North; tarmacadam car park leading to the trunk road A4067, Oystermouth Road at 300m.

2.2. Site Walk-through (fig2.)

North – landscaping
including mature trees.



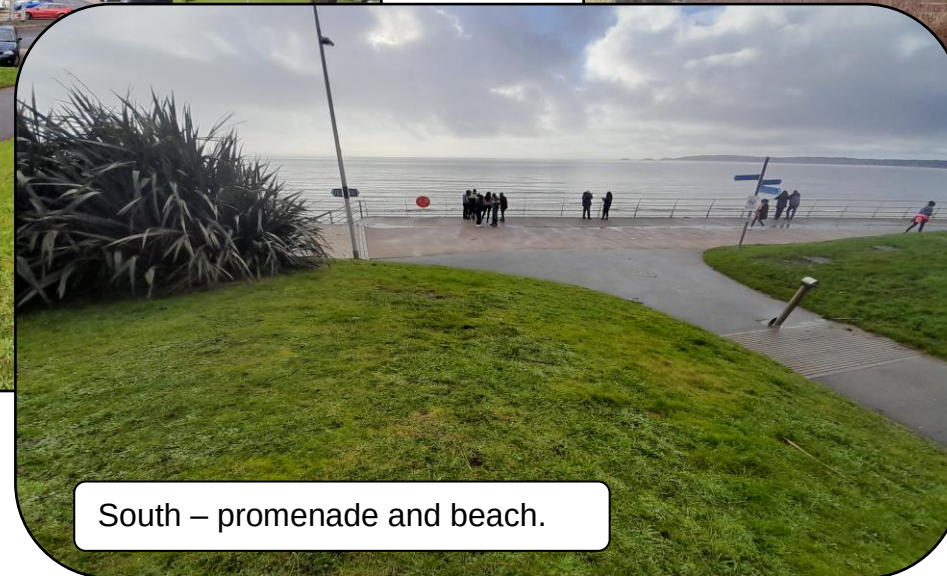
West – car park and
raised landscaping, no
apparent soil deficiencies.



East – landscaping, 2m
above path, at highest point.



South – promenade and beach.

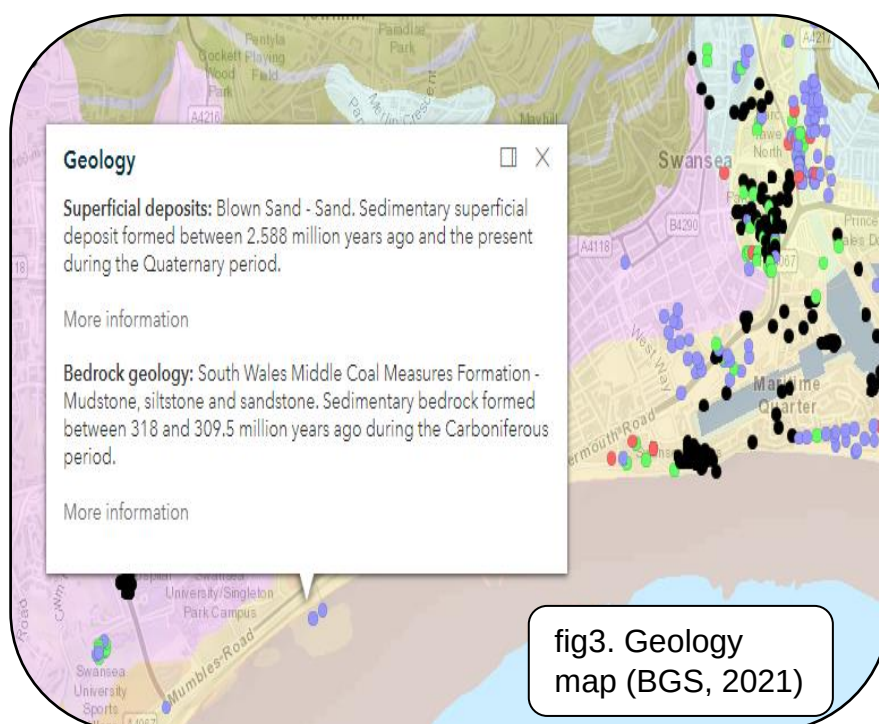


2.3. Site History - Table 2 (with reference to archived maps Appendix 2)

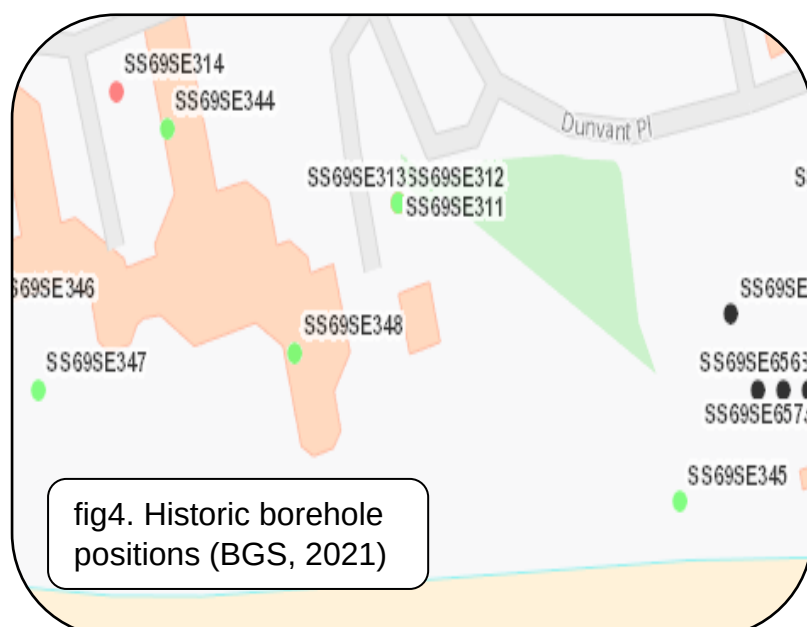
Date / Planning	At Site	Near Site
1884	Swansea to Mumbles railway track.	Hospital for contagious disease. Residential housing. Swansea Docks Tawe Basin with sawmills & warehouses. Swansea prison. The Royal Arsenal. Gas Works.
1921	The railway facilities are expanded to include an engine shed and sidings.	The hospital is removed. Dockside canister works to the east.
1951	No significant change.	Removal of some structures at the Gas Works.
1990	Car park, promenade and landscaped area.	County Hall and Marriot Hotel are built.
Historic planning applications.	No recent or relevant applications could be found. (Planning Portal, 2021).	The County Hall and Marriot Hotel applications are listed but not available via on-line research.

2.4. Geological and Environmental Information

Geology of the UK is well mapped by British Geological Survey. (BGS, 2021)



Data from historic borehole investigations is publicly available, the dots on fig4 indicate nearby historic borehole location. (BGS, 2021)



- Borehole SS69SE345 is within the Site boundary. Appendix 4.
- Borehole SS69SE348 60m west of Site has been reviewed.
- Borehole SS69SE311 60m north west of Site has been reviewed
- Boreholes adjacent to the site east and north east are unfortunately confidential.

Based upon the reviewed information (Appendix 1,2,4), the probable geological and environmental conditions for the site can be tabled:

2.4.1. Probable Site Conditions - Table 3.

Ground Factors	Strata / Metres	Description	Comments
Made-ground	The pre-existing land surface has been raised by artificial deposits.		
	0.20	Hardstanding 50mm tarmacadam on a 150mm packed hardcore fill.	Car park and pathway surface.
	0.20	Landscaped, topsoil to 200mm	Landscaped areas.
	<1.5	Loose, light, grey, fine and medium sand, ash, and rubble; comprising brick and fragments of wood.	Remains of many years of industrial use.
	<5	More dense sand, ash, clay and shale.	Compacted over time.
Superficial deposits	Recorded as blown sand. Sedimentary superficial deposit.		
	5-7	Very dense brown sandy gravel with traces of sandy clay.	Typical throughout surrounding area, at approximate depth of 5m, but exact depths vary.
	7-18	Very dense and stiff gravelly large boulder clay.	Boulders increasing with depth.
Bedrock	Recorded as South Wales middle coal measures formation - mudstone, siltstone and sandstone.		
	>18	Grey mudstone and minor siltstone, sandstone.	Typical throughout surrounding area with depths varying between 18m and 25m.

Contamination	No historic reports could be found, however, industrial history suggests ground contamination is possible.
Aquifer, flooding & groundwater vulnerability	The area is recorded as Secondary A type aquifer; comprising permeable layers that can support local water supplies. The site is not within a floodplain but is 37m South West of a Zone 2 floodplain. Nearby water table has been recorded as 6m. The site appears is well drained with generally little standing water. It is expected that any groundwater flows will be southwards towards the sea. (Appendix 1 & 4)
Coal mining	The Coal Authority online map shows the Site to be located on a coalfield and recommends an Enviro All-in-One report be commissioned. (TCA, 2021)
Radon	Naturally occurring radioactive gas levels are classed low, at 1-3% range. (Appendix 1)

2.5. Summary of Desktop Survey

The Site walk-through suggests this is a prime location for a hospitality development, with existing car parks and pedestrian access directly from the busy promenade. From a construction point of view; it is fairly level with easy access for logistics, spacious surroundings for storage and evidence of nearby water, electricity, telecommunications, sewer and storm drainage. It is also likely that the adjacent Marriot Hotel will be supplied by mains gas. Connecting to existing nearby utilities will avoid the costly extension of mains services.

Table 2 shows the Site has been within or close to major industry or heavy transport for the first 100 of the past 150 years. This suggests a lot of change to the higher ground strata plus a possibility of residual soil or groundwater contamination. The Site sits directly atop the old Swansea to Mumbles railway where oils and fuels would have been abundant. Close proximity to dockside factories such as the canister works could have seen ground exposure to metals. Slightly further afield, the Royal Arsenal and Gas Works could have been a source of dangerous pollutants.

Table 3 shows that the probable geology of the site is complicated; with the likelihood of made-ground to depths of around 5m. Composition of the made-ground is unknown and may be associated with demolition of the former buildings, this may include potentially hazardous materials such as asbestos.

Although unlikely, the trees to the north of the site could have tree preservation orders, local authority planning control must be contacted. (Planning Portal, 2021)

Historic images of the construction of the neighbouring County Hall, circa 1983, shows the very deep (bedrock level) foundations that were needed to support the significant load of this impressive building. The foundation perimeter is protected by displacement sheet piles that are driven down to bedrock, see Appendix 3.

Previous geological surveys suggest loose made-ground to a depth of 3.5m, followed by 1.5m of compacted made-ground. Superficial deposits described as dense sandy gravel with some clay, are reached at 5m. This is classed by BS18004 and BS15930 as having a load bearing capacity of 200 to 600 kN/m². For preliminary design purposes, taken as a worst-case of 200 kN/m², this subsoil does have the engineering properties to support the restaurant. (Appendix 5)

3. Recommendations for Detailed Site Investigation

A targeted geo-environmental and geo-technical ground investigation in accordance with BSI5930. To confirm anticipated ground conditions and to:

- detail the composition of made-ground to ensure clear passage for foundations and utilities.
- confirm the load bearing engineering qualities of the superficial deposits.
- identify ground contamination.

See figure 5 below:

at A - trial pit beyond level of superficial deposits, (just outside of proposed building footprint, to avoid disturbance of build ground) to assess ground conditions and obtain samples of soils and rock for laboratory testing.

at B - a single deep intrusive ground investigation, utilising a combination rotary hammer rig to deliver a cable percussive borehole 200mm diameter to 15m depth, with open hole rotary drilling follow-on to beyond bedrock level (approximately 22m).

at C - 2 off, intrusive ground investigation as above, to 10m depth to determine superficial deposit strength parameters for use in pile design.

at D - installation of gas standpipes to monitor for a minimum of 6 visits over a 3-month period in accordance with BSI8485.

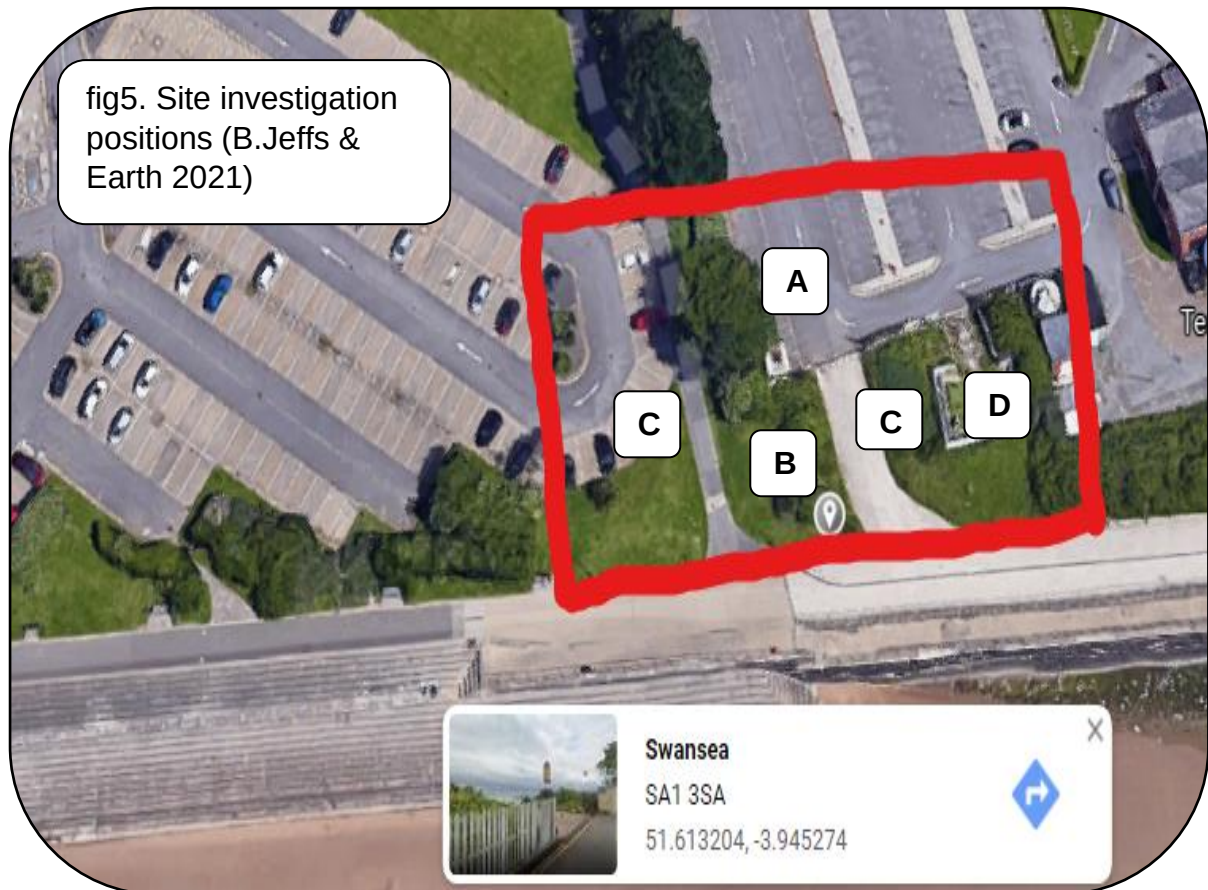
Also required:

Laboratory geo-technical testing to determine strength parameters for use in pile design.

Laboratory chemical testing of soils to identify contamination.

Mapping of nearby utilities, utilising ground penetrating radar.

Factual and interpretative reporting, providing recommendations.



4. Foundations Suitable for the Restaurant

The foundation is the base on which the restaurant will rest and its purpose is to safely transfer the dead, imposed and wind load of the building to a suitable subsoil. (Building Regulations, 2010).

BSI8004 gives guidance on foundations. The most secure foundation for the restaurant would be a deep piled foundation at bedrock, as with the County Hall. This however, may be prohibitively expensive for the small restaurant and possibly overkill in terms of engineering. Another possible solution would be to float the building on a raft foundation, had the geological problem been simply poor load bearing soil, then this may have been the answer, however with the unknown engineering qualities of the made-ground, possibly to 5m depth, this is not recommended.

Although a commercial building, the restaurant is only two stories high, with the upper floor used as a dwelling and welfare facility. It will be built in traditional methods similar to a domestic dwelling, therefore building loads will not be too dissimilar.

At this stage the most suitable solution is Short Bored Piles. These are to be sunk to a depth below the made-ground, finding the 200kN/m^2 (minimum) load bearing qualities of the dense superficial deposits. They are to support a reinforced concrete beam, strip foundation at the points of concentrated load i.e., around the building perimeter with a centre brace to retain upper spans.

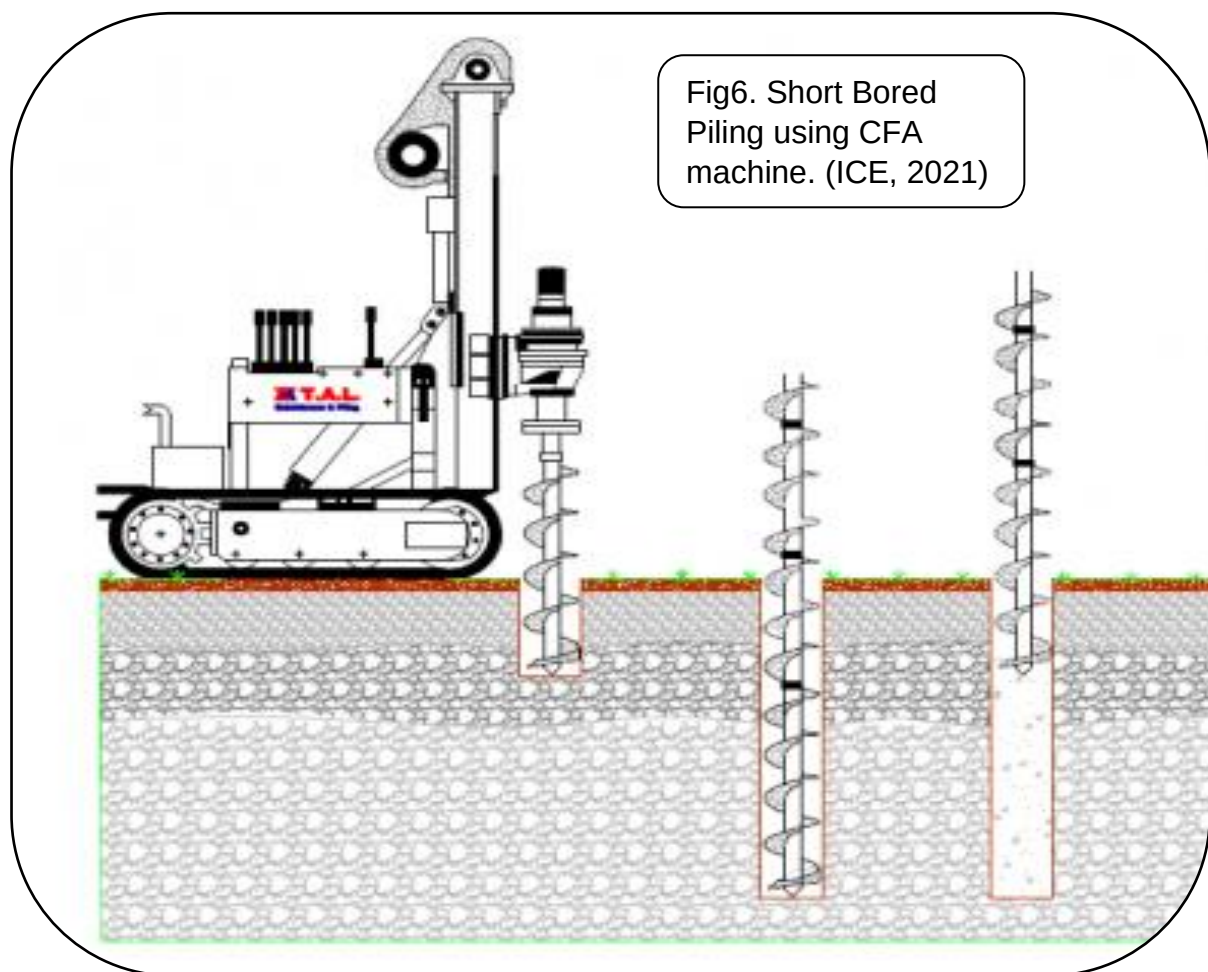
The reinforced concrete beam strip foundation will require detailed design from a structural engineer. For preliminary design purposes, the beam can be roughly sized. See Appendix 5.

For a total building load (per meter run) of 82.5kN and load bearing capacity of soil at 200kN ;

the dimensions are:

400mm width x 200mm depth

To avoid ground movement the foundation beam is to be cast at 1m below ground level. The 250mm diameter piles are bored and cast in situ using mass concrete. The piles are formed by a machine mounted auger, called Continuous Flight Augering (CFA), it is a fast and economic technique (when compared to other methods) to create a deep concrete foundation. A CFA drill is used to excavate a hole, no casing is required and concrete is injected through a hollow shaft under pressure as the auger is extracted.



The piles are laid to a depth of 4.5m below beam level. Each capable of bearing a 100kN load, they are spaced at 2m intervals, resulting in 40 off short bored piles. These relatively small piling machines are quick and efficient, typically capable of drilling 80 piles per day. (Riley, 2015).

fig 7. Restaurant foundation - section view (B.Jeffs with reference to, Chudley & Greeno, 2013)

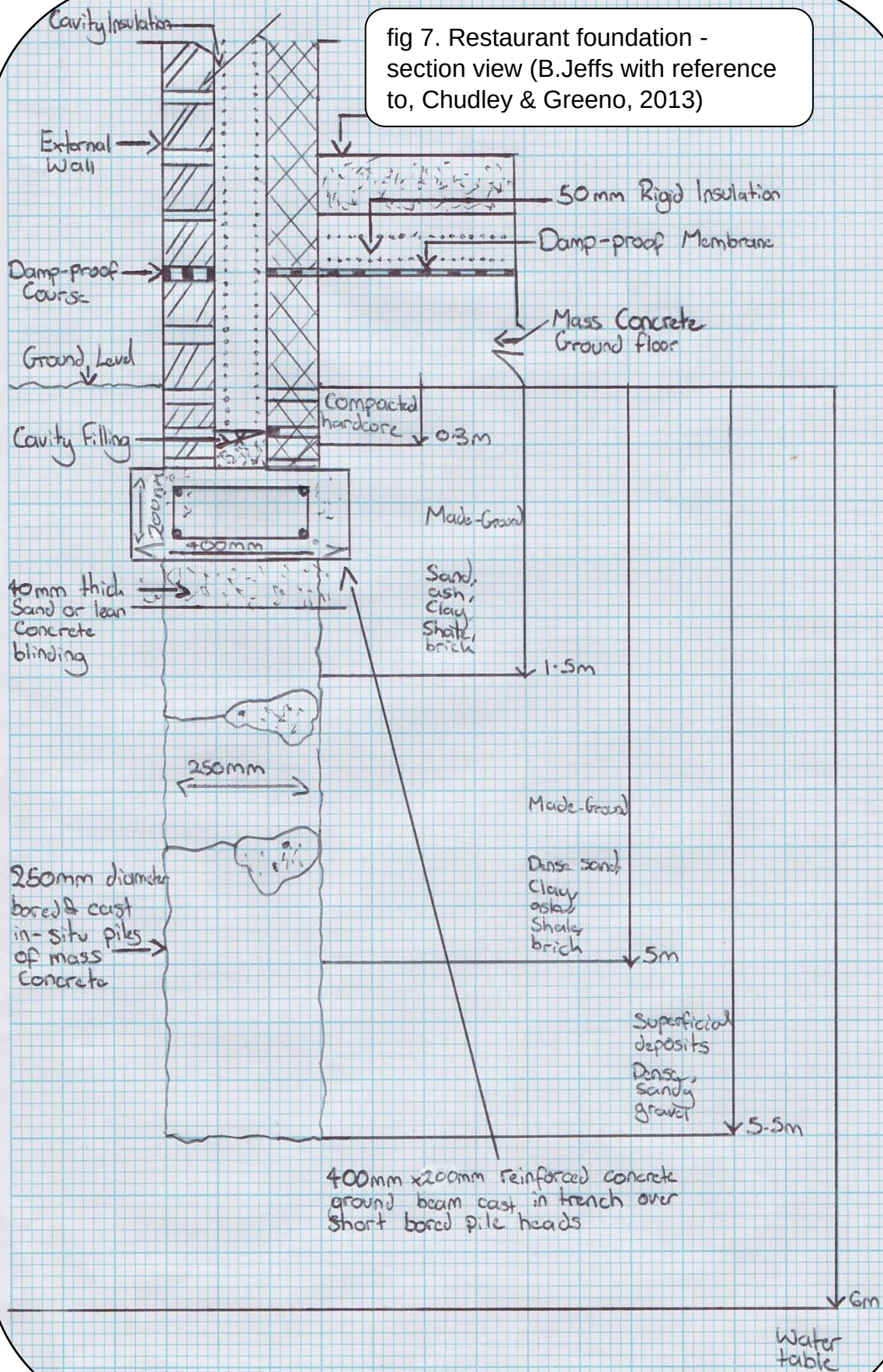
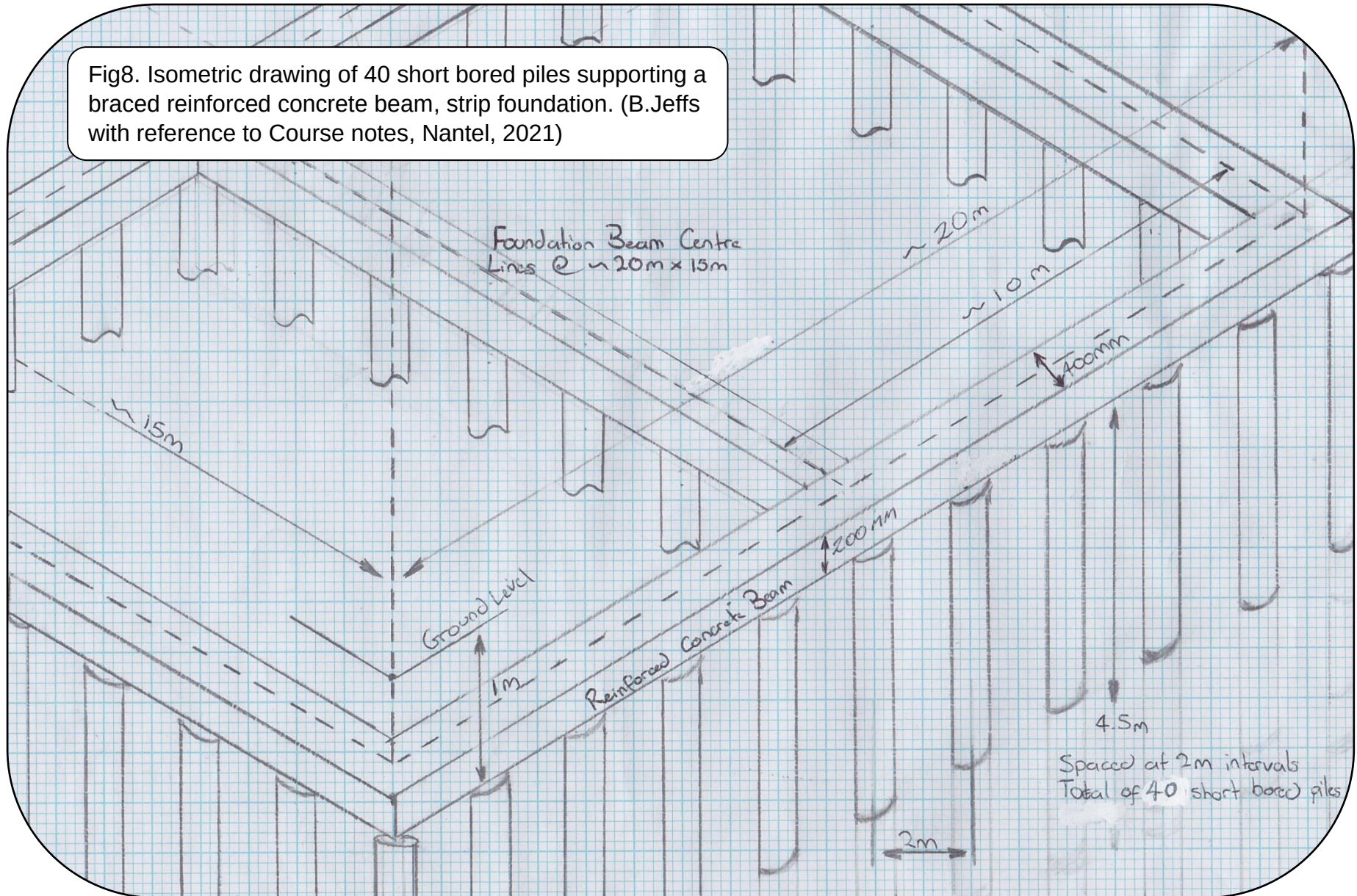


Fig8. Isometric drawing of 40 short bored piles supporting a braced reinforced concrete beam, strip foundation. (B.Jeffs with reference to Course notes, Nantel, 2021)



5. Conclusion

Upon first impressions the Site appears to be ideal for the construction of a restaurant. Accessibility, topography and existing nearby infrastructure adds to the Sites desirability. Uncovering the Sites long history and researching the probable geology suggests things might not be as straight forward as first thought.

Despite the topsoil seeming healthy and normal, there is a possibility that the ground will be contaminated in some way. The 'Detailed Site Investigation' will expose this and may result in a need for additional corrective works to the ground itself before any construction commences.

The unknowns relating to the composition of the deep made-ground throw added complications and prevent the application of more straight forward foundation solutions.

Compliance with the legislation and guidance from codes of practice lead to a recommended solution of short bored piles, supporting a reinforced concrete beam, strip foundation. This is the fastest and most economical way to creating a relatively deep foundation. To proceed, the 'Detailed Site Investigation' must show that the CFA operation will not be impeded by obstructions in the made ground, and that the load bearing engineering qualities of the dense superficial deposits at 5m depth are as anticipated.

Should there be unfavourable results from the 'Detailed Site Investigation' then deeper piled foundations may be required, obviously with significant increase to build cost.

6. References (references were accessed December 2021, in alphabetic order)

(BGS, 2021) British Geological Survey, available at <https://www.bgs.ac.uk/>

(BL, 2021) British Library, available at <https://www.bl.uk/>

(BSI, 2021) British Standards Institute, various codes of practice, available at <https://www.bsigroup.com/en-GB/standards/>

(Building Regulations, 2010) UK Building Regulations, available at <https://www.gov.uk/government/collections/approved-documents>

(Chudley & Greeno, 2013), Construction Handbook, Abingdon, Routledge.

(Earth, 2021) from Google, available at <https://earth.google.com/web/@0,0,0a,22251752.77375655d,35y,0h,0t,0r>

(Gov Legislation Portal, 2021). UK government's legislative portal, available at <https://www.legislation.gov.uk>

(ICE, 2021) Institution of Civil Engineers, available at <https://www.ice.org.uk/>

(LLE, 2021) Geo Portal for Wales, available at <https://lle.gov.wales/home>

(Nantel, 2021), UWTSD course notes, Fundamentals of Construction Technology.

(NLW, 2021) National Library of Wales, available at <https://www.library.wales/index.php?id=1>

(Planning Portal, 2021) Swansea City Council Planning Portal, available at <https://www.swansea.gov.uk/planning>

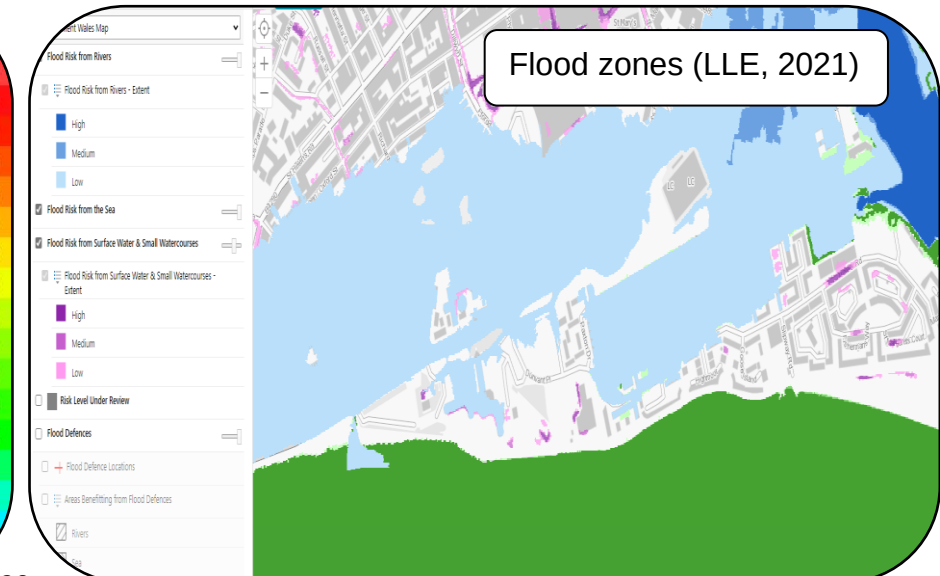
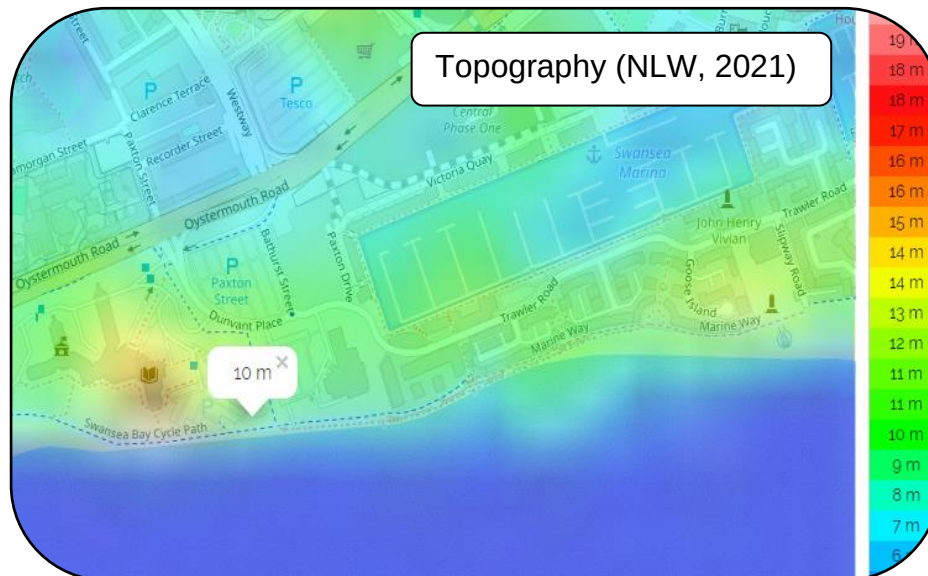
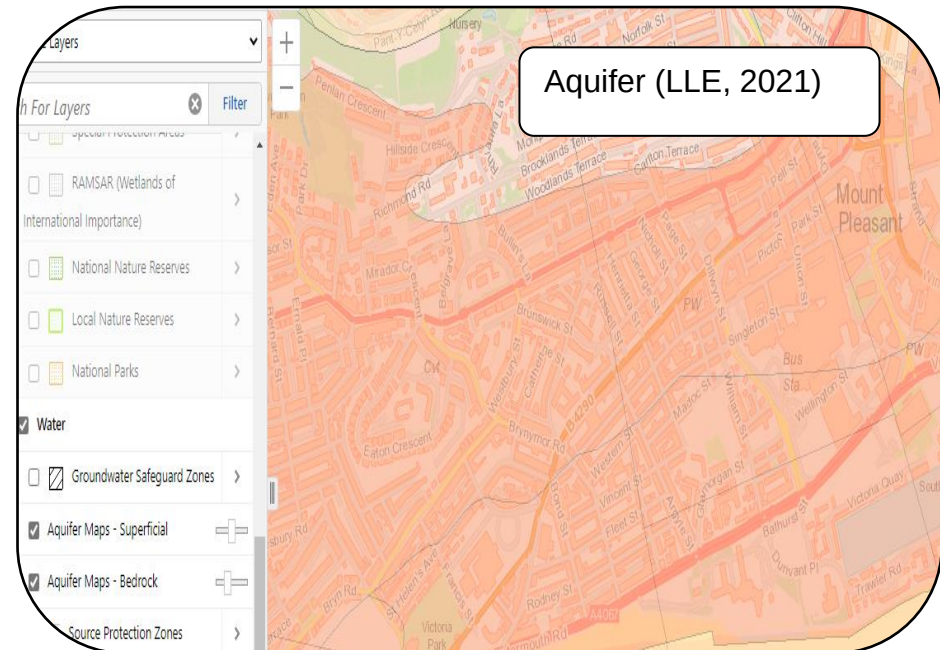
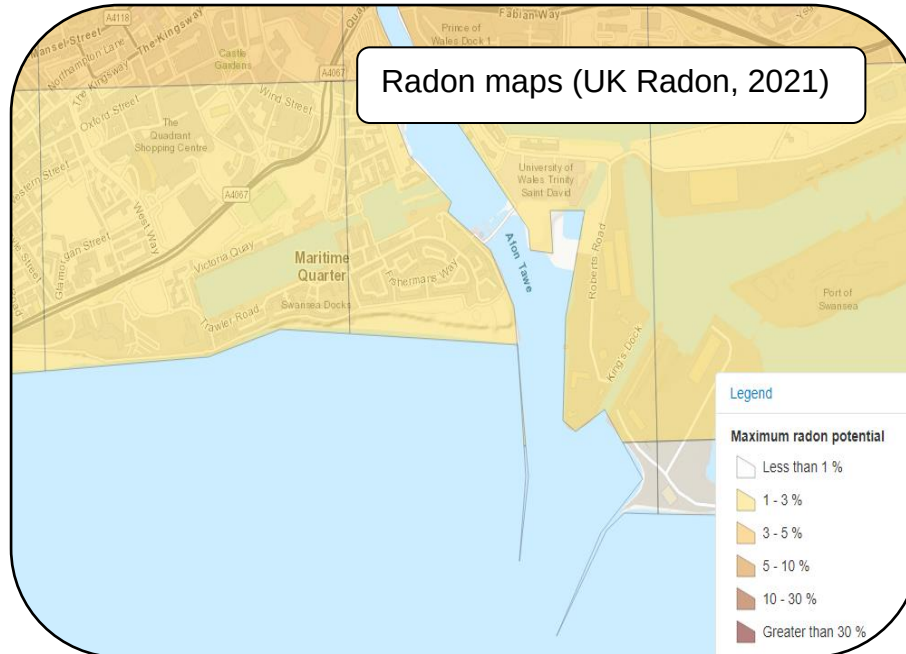
(Riley, 2015), Construction Technology 2 I&C Building, London, Palgrave Macmillan.

(SCA, 2021), Swansea City Archives, available at <http://www1.swansea.gov.uk/calmview/Advanced.aspx>

(TCA, 2021) The Coal Authority, available at <https://www.groundstability.com/public/web/home.xhtml>

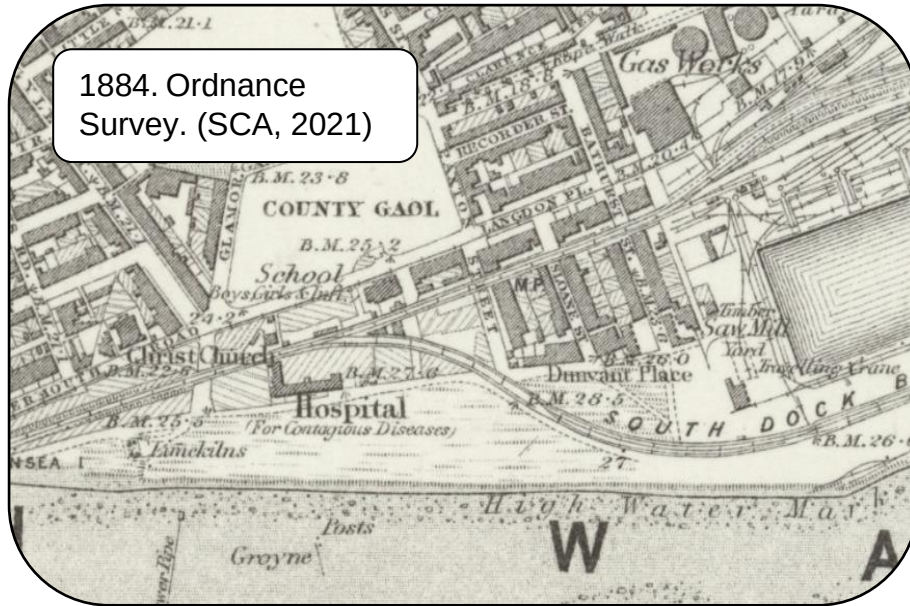
(UK Radon, 2021) UK government radon maps, available at <https://www.ukradon.org/information/ukmaps>

Appendix 1: Research Maps of the Site

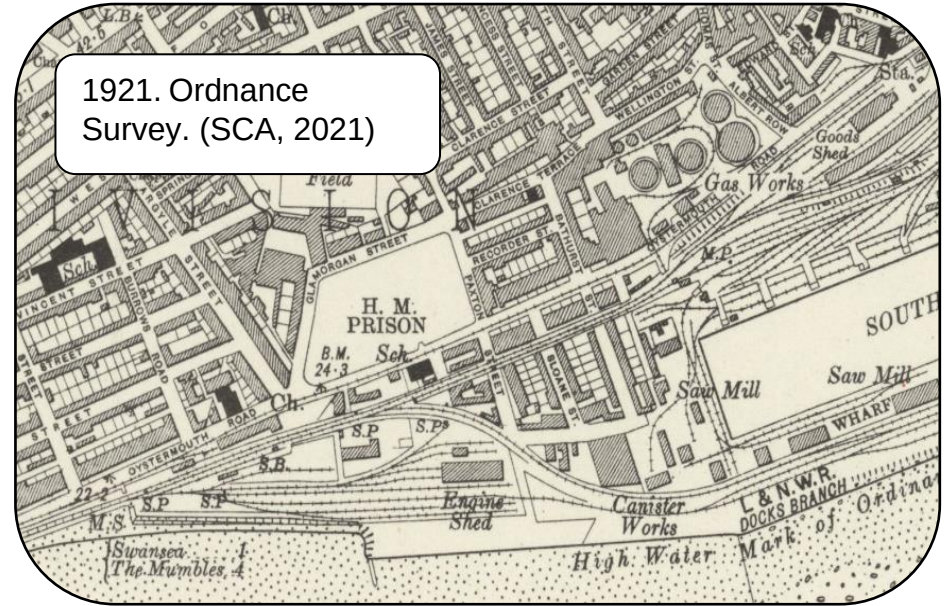


Appendix 2: Archived Maps of the Site

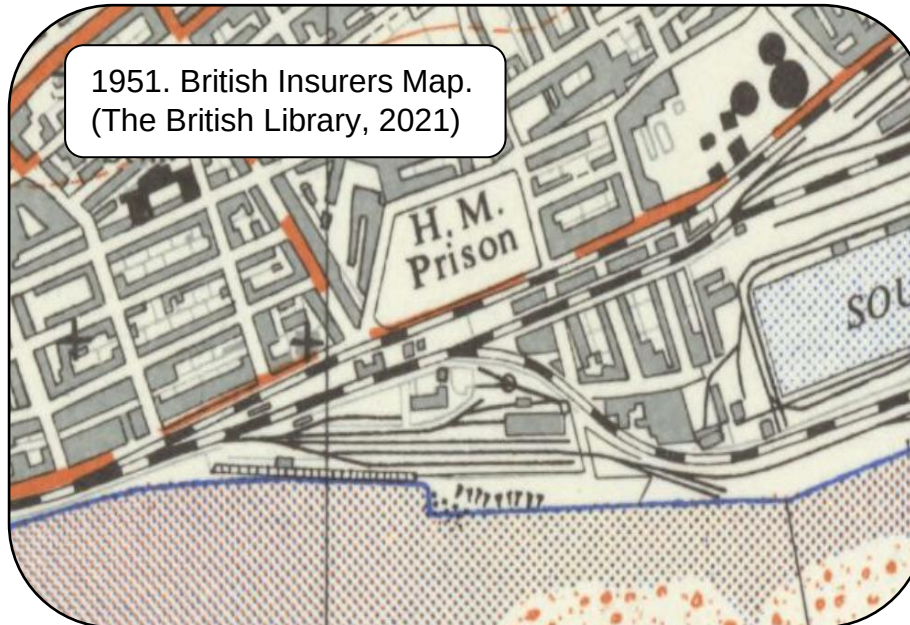
1884. Ordnance Survey. (SCA, 2021)



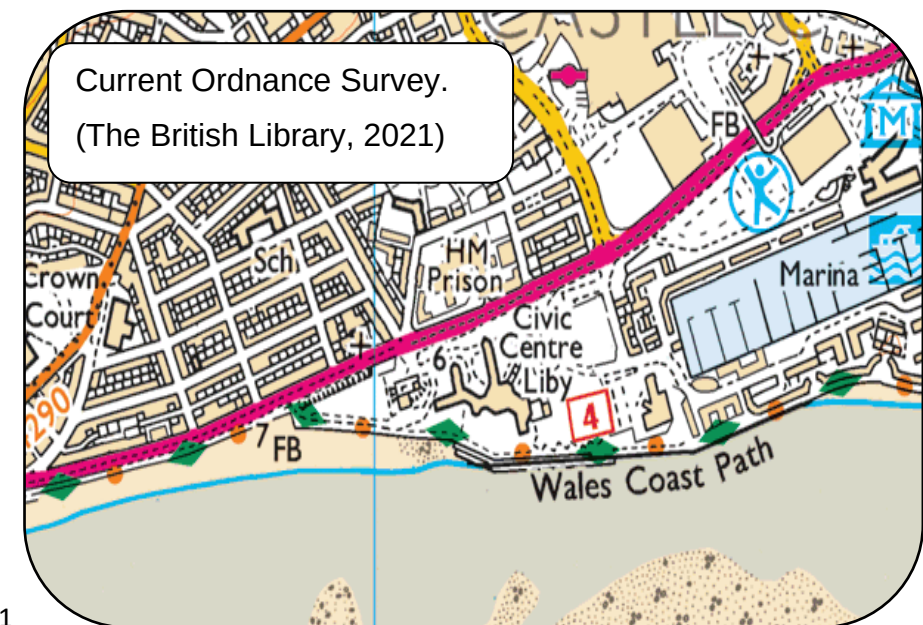
1921. Ordnance Survey. (SCA, 2021)



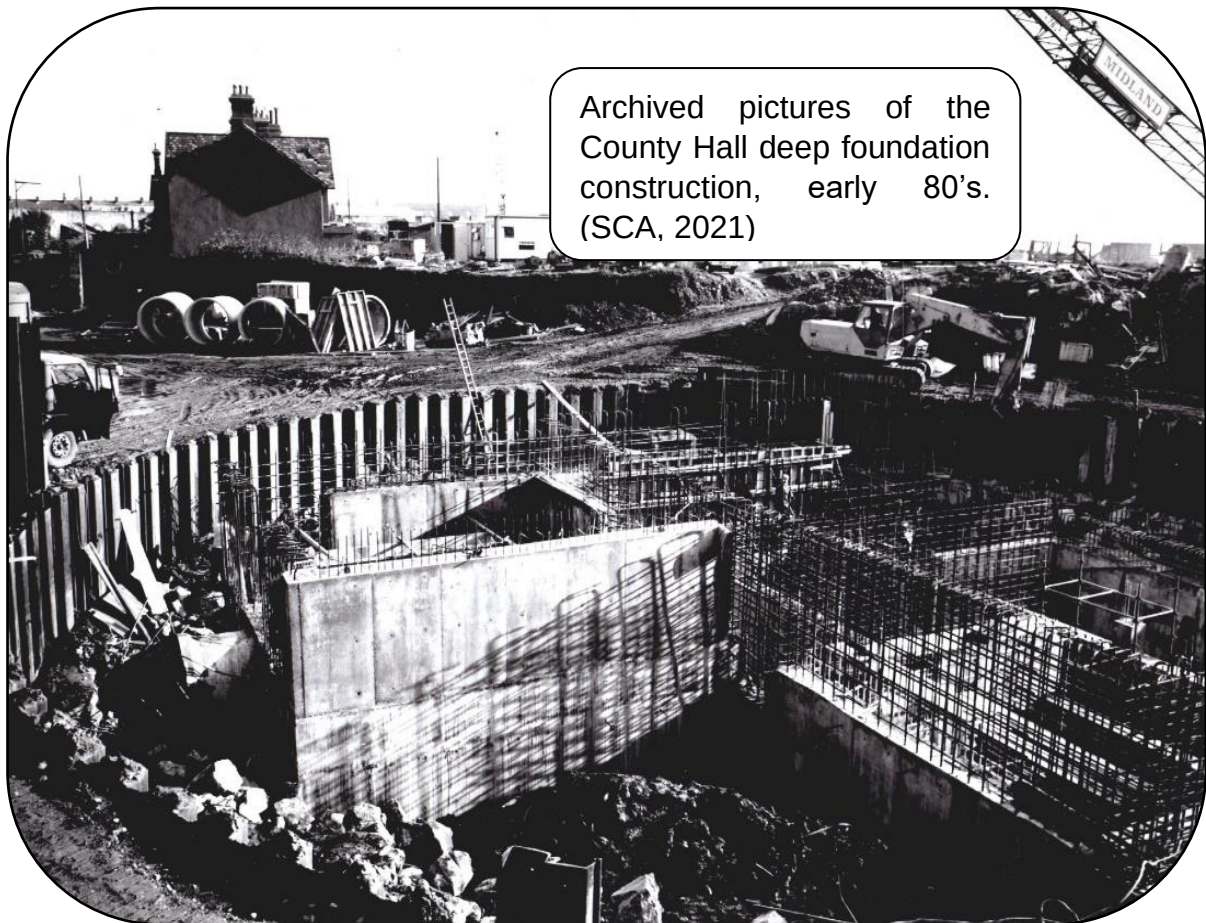
1951. British Insurers Map. (The British Library, 2021)



Current Ordnance Survey. (The British Library, 2021)



Appendix 3: Archived Pictures of the County Hall Foundations



Appendix 4: Historic Borehole at Site

DRILLING METHOD		GROUND LEVEL		Historic borehole at Site (sheet 1 of 3) (BGS, 2021)	
Percussion 200 mm dia. to 15.0 m "Open hole" rotary drilling From 15.0 m to 22.0 m		+ 9.18 m O.D		PROPOSED NEW COUNTY HALL PAXTON STREET SWANSEA	
MACHINE	COKE BARREL AND BIT DESIGN	ORIENTATION			
Dando "Investigator"		Vertical			
SOIL SAMPLES DEPTH AND TYPES	DRILLING AND CASING PROGRESS	WATER RECOVERY % AND A.M. LEVEL	R. Q. D.	CORE RECOVERY % AND SIZE	DESCRIPTION OF STRATA
	5-2-75				
1.00 P N= 8					MADE GROUND consisting of ashes.
1.50 P N= 6					MADE GROUND consisting of loose, light grey fine-medium sand.
3.00 P N= 9					MADE GROUND consisting of grey sand with layers of soft sandy clay
4.00 P N= 75 for 150 mm					MADE GROUND consisting of soft red-brown sand clay with brick shale.
5.00 P N= 105 for 225 mm					MADE GROUND consisting of dense bricks, ashes, sand and clay.
6.00 P N= 75 for 150 mm	5-2-75 6-2-75	6-2-75 7-2-75 10-2-75 11-2-75 ▼ 5-7			Very dense brown sandy GRAVEL with traces of sandy clay
7.00 P N= 77					Very dense brown SAND with same gravel.
8.00 P N= 34					Stiff grey-brown gravelly BOULDER CLAY
9.00 P N= 67					
10.00 P N= 63					

Borehole continued to 22.0 m.

REMARKS Borehole drilled by STRATA SURVEYS Ltd Cheshire. Scale 1:50 Sheet 1 of 3

P = Standard Penetration Test

N = Number of blows for 300 mm (Unless otherwise stated)

▼ = Water a.m. Level

Borehole chiselled from 4.0 m to 15.0 m

WEST GLAMORGAN COUNTY COUNCIL COUNTY ENGINEER AND SURVEYOR'S DEPT.

Appendix 4: Historic Borehole at Site

SITE PROPOSED NEW COUNTY HALL PAXTON STREET SWANSEA				SHEET 2 OF 3		BOREHOLE NUMBER	
SOIL SAMPLES DEPTH AND TYPES		DRILLING AND CASING PROGRESS	WATER RECOVERY % AND O.M. LEVEL	R.Q.D.	CORE RECOVERY % AND SIZE	DESCRIPTION OF STRATA	SYMBOLIC LOG
			20 40 60 80	20 40 60 80	20 40 60 80		
11-00 P N=75 for 150mm	6-2-75 7-2-75					11-00 Very stiff grey gravelly BOULDER CLAY	
12-00 P N=75 for 150mm	7-2-75 10-2-75						
13-00 P N=75 for 150mm							
14-00 CP N=75 for 75mm							
15-00 CP N=105 for 150mm	10-2-75 11-2-75						
16-50 CP N=75 for 150mm							
18-00 CP N=75 for 150mm	11-2-75 12-2-75						
"Open hole" drilling due to pebbles falling in hole - coring not possible.						18-60 Grey MUDSTONE (Driller's description)	
Borehole continued to 22-00m						3-40 (penetrated)	
REMARKS P= Standard Penetration Test CP= Standard Penetration Test - solid cone N= Number of blows for 300mm (unless otherwise stated)							
WEST GLAMORGAN COUNTY COUNCIL				COUNTY ENGINEER AND SURVEYOR'S DEPT.			

Appendix 4: Historic Borehole at Site

[illegible]

Appendix 5: Calculations for Strip Foundation Beam

Width of beam (per meter run) = $\frac{\text{total load of building}}{\text{bearing capacity of soil}}$

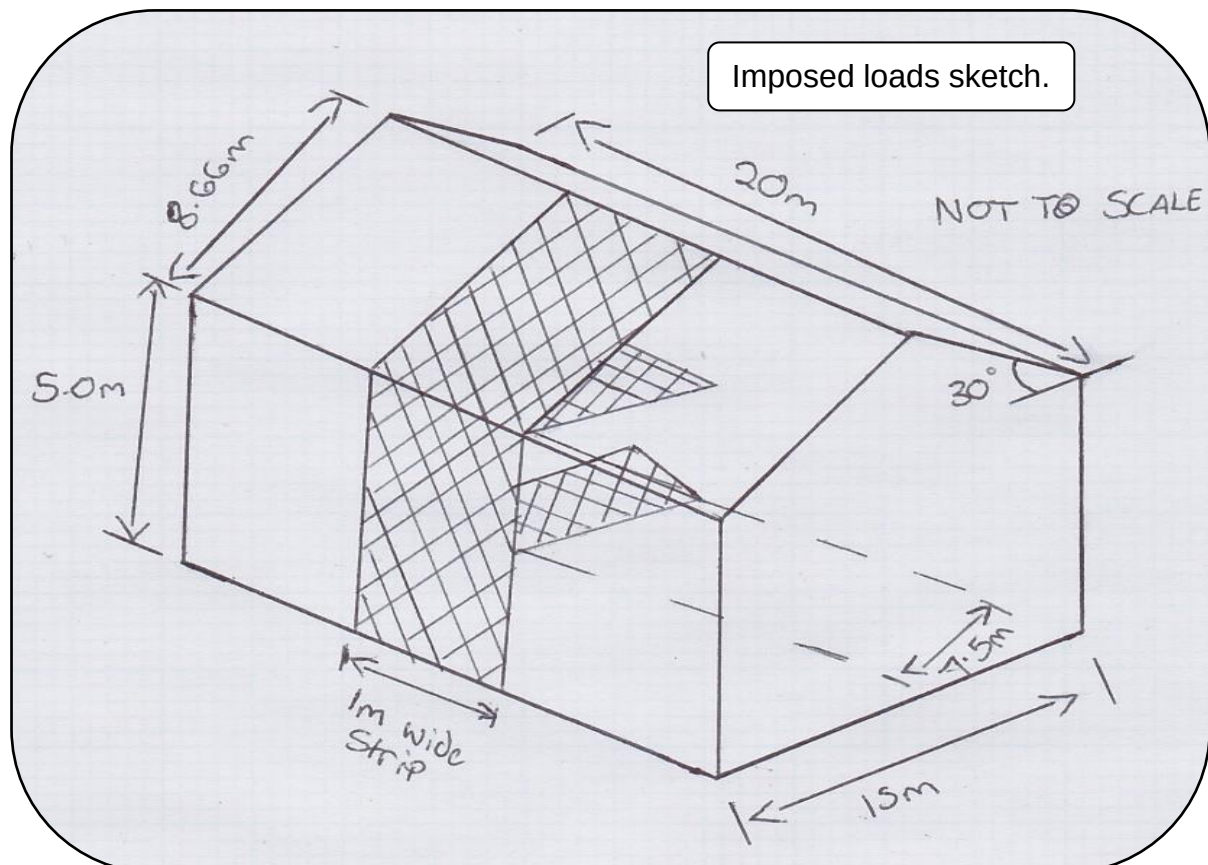
Total load of building is made up of dead load (weight of all materials), imposed load (from usage of building) and dynamic load (from outside influences such as wind).

BS1991 gives schedules of material weights, which are used to calculate dead loads. Chudley and Greeno Building Construction Handbook page 39, shows the dead weight of a typical two-story domestic building is 26.56kN. The restaurant has potentially heavier materials e.g., polished metals, kitchenware, so a contingency of 10% is added.

Dead Load = 29kN

British Standard 1991, gives imposed loads for a restaurant as 2.7kN per metre run concentrated at the outer edge.

The first-floor dwelling is given as 1.5kN but the shared welfare area as 2.7kN, taking the worst case of 2.7kN for both floors.



Appendix 5: Calculations for Strip Foundation Beam

Floors $7.5\text{m} \times 1\text{m} \times 2.7\text{Kn} \times 2 \text{ (floors)} = 40.5\text{kN}$

The roof, imposed loads from snow is given as 1.5kN

$$\begin{aligned} \text{Roof at 30 degrees} &= \text{hypotenuse} = \frac{\text{adjacent}}{\cosine 30} = \frac{7.5\text{m}}{0.866\text{m}} = 8.66\text{m} \\ &= 8.66\text{m} \times 1\text{m} \times 1.5\text{kN} = 13\text{kN} \end{aligned}$$

Total imposed load = $40.5\text{kN} + 13\text{kN} = 53.5\text{kN}$

Total load = $29\text{kN} + 53.5\text{kN} = 82.5\text{kN}$

$$\begin{aligned} \text{Width of beam (per meter run)} &= \frac{\text{total load of building}}{\text{bearing capacity of soil}} \\ &= \frac{82.5\text{kN}}{200\text{kN}} = 0.41 \text{ m or } \mathbf{400\text{mm width}} \end{aligned}$$

minimum depth of the reinforced beam is 150mm , depth of beam will be = **200mm**

(BSI, 2021), (Chudley and Greeno, 2013).