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**Modern and Traditional construction
Managing the Design and construction Process/Civil
Engineering Technology**

HND Building Surveying

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Introduction

Paxton St car park Swansea: The site is to accommodate a superstructure of 17 stories with a substructure of three levels for underground car parking. The location is in close proximity to the coastline on a site that has been used previously for heavy industry so could contain contaminants that could require remedial works. Borehole samples have been taken to a depth of 22 meters to establish soil type, rock formation and water table. The borehole samples suggest the water table is around 5.95m, however, sources at the site suggested this is much higher due to the recent heavy rainfall. As the site area is close to the coast a further sweep was carried out to determine the presence of unexploded ordnance following bombing raid during the Second World War.

Substructure: The building dimensions are 30m square, so 900m². It will require excavation and removal of all spoil from site. All excavation processes are to be calculated and appropriate ramp detail designed to accommodate diggers, crane and vehicular removal of spoil. Foundations for the basement construction require temporary and permanent solutions to be designed with full explanation of the choices made. Due to the close proximity of the site to the coastline, and the high-water table, drainage systems both temporary during excavation and permanent will also be part of the design.

Superstructure: The 17-storey building requires the design of the vertical envelope including façade, insulation envelope, pillars, beams and fixings used throughout.

Excavation

The footprint of the building is 900m² with three substructure levels each around 3.33m in depth. This will include the depth of each concrete floor slab and beams to a maximum depth of 10m. The total amount of earth spoil to be removed from site is 9900m³ assuming a bulk factor of 1.10.

$900\text{m}^2 \times 1.10 = 990\text{m}^2 \times 10\text{m} = 9900\text{m}^3$ so approximately 22,500 tonnes. 1m³ soil weighs between 1.2 and 1.7 metric tonnes. As topsoil weighs less than compacted

soil an assumption has been made to split the difference and assume for each 1m³ of soil the weight is calculated at 1.45 metric tonnes.

Using a hydraulic excavator, for example Komatsu PC490, which takes 1hr to remove around 50m³ (72t) assuming the excavator is working for 8hrs per day it can excavate 400m³ (580t) per day. The 8-wheel tipper truck can hold a maximum load weight of 20t. It takes at least 60 minutes round trip to drop the spoil and return to site. Assuming traffic is clear, this allows 20 minutes each way and 10 minutes to offload as well as 5 minutes to exit the ramp and site. Four tipper trucks would be needed to ensure the continuous process of spoil removal. Based on these figures it would take approximately 8 weeks to remove the spoil from site.

Dependant on the weighting of the tender/procurement route, time savings could be made by hiring larger machinery, however, this will raise costs. Therefore, a balance must be achieved when hiring plant. The site is also confined and the ramp access to the excavation is neat. Access roads around the site are in the middle of the city so become very congested during busy periods. Therefore, particular attention should be made to size and number of plant machinery used to enable safe working systems.

Safety on Site

The main contractor will always ensure it is compliant with Health & Safety requirements on site at all times, this includes all staff and visitors to the site. (Health & Safety at work Act 1974)

- All staff and visitors to site will watch a short H&S video.
- Clear signage will be displayed throughout the site.
- One-way system will be in operations for all vehicles. **(site map appendix 1)**
- Designated turning points will be clearly marked for vehicles that need to reposition.
- Pedestrian walkways will be separated from vehicle and plant machinery by fencing.
- Access to operational areas will be restricted at all times.
- Banksman will be used for any vehicles reversing or manoeuvring.

Legal requirements on site

The list below outlines some of the legislation that is designed to help keep all staff and visitors to the site safe and free from harm, the legislation below must be adhered to at all times.

- Health and Safety at Work etc Act 1974 (HSW Act)
- Management of Health and Safety at Work Regulations 1999 (the Management Regulations)
- Construction (Design and Management) Regulations 2007 (CDM)
- Work at Height Regulations 2005
- Supply of Machinery (Safety) Regulations 1992
- Provision and Use of Work Equipment Regulations 1998 (PUWER)

Plant

The main working plant required on site is listed below.

- Hydraulic Excavator (CAT 324E)
- Tipper dump trucks x 4 32t
- Plainer (to form the ramp access to the excavation site) CAT12 M2 AWD
- Single barrel Roller (to compact hardcore at the ramp access) BOMAG BW213
- Crane SAEZ TL55 Maximum lifting weight 5,000kg
- Piling rig SR-45 CFA
- Temporary power supply for construction site (electricity) UK powersupplies
- Water supply – water direct.co.uk

Ramp Access

By using an 8-wheeled, 32t tipper truck, the ramp access into the site is calculated with the maximum gradient of 12% to ensure safety of vehicles and operatives at all times.

The excavated site measures 30mx30m with a 6m long platform prior to ramps and 4.5m turning spaces to manoeuvre the corners and a width of 3m for ramps. The depth of excavation is 10m to accommodate 3 levels of substructure car parking facilities. Secant piling will form the perimeter of the excavation site. To form the ramp

access and allow the retention of ground, sheet piling will form the walls within the excavation. Hardcore will be added and compacted to form a stable working area for the tipper trucks. For the ramp access into the excavated area adhering to the 12% gradient a maximum depth of 9.18m can be achieved, therefore the additional 0.82m will require the ground to be reduced outwith excavation area prior to the initial platform access.

Only one tipper truck will be allowed on the excavation ramps at one time.

Table 1

Datum	Length (m)	Depth (m)
Platform	6.0	0.00
Ramp	19.5	-2.34
Turning point	4.5	0.00
Ramp	21.0	-4.86
Turning point	4.5	0.00
Ramp	21.0	-7.38
Turning point	4.5	0.00
Ramp	15.0	-9.18
Base		0.82m reduce outwith excavation area

Table 2 - Hardcore

Area	Amount	Total
Turning spaces	4.5mx4.5m=20.25m x 4	81.00
Platform	6mx3m=	18.00
Ramp 1	19.5mx3m=	58.50
Ramp 2&3	21mx3x2m=	126.00
Ramp 4	15mx3m=	45.00
TOTAL		328.5m³

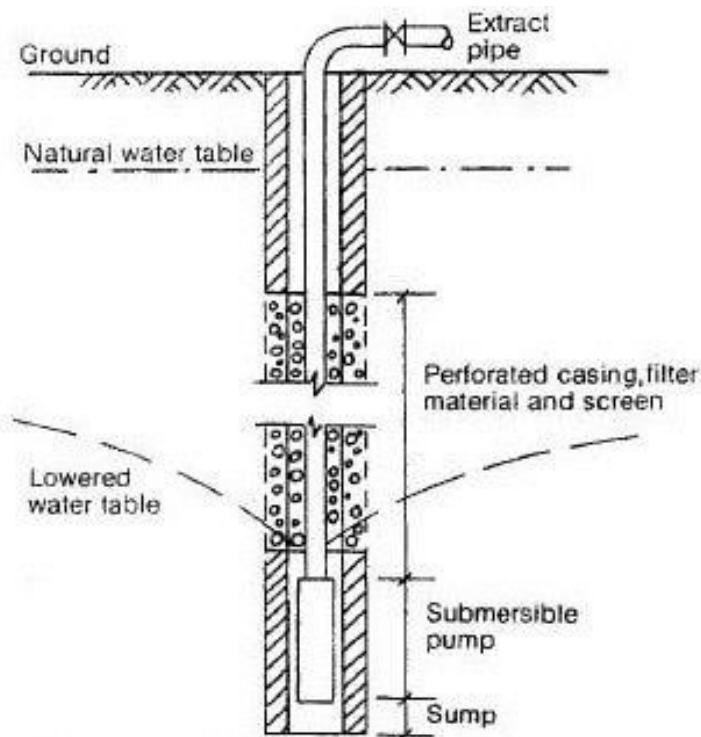
Allowing a depth of 300mm for hardcore, the volume needed will be 98.55m³. As the excavation area is limited for large plant and alternative could be that hydraulic excavators with a 10m reach are hired and the excavation is carried out from the perimeter of the site at ground level.

Drainage Systems Temporary

The basement excavation depth is 10m and, since the water table from the borehole report suggests it is around 5.95m, a deep well system will be used to dewater the site prior to excavation beginning. This will ensure the water table is reduced below the level of excavation so will be carried out as a dry excavation.

To use a deep well system a series of wells are bored and fitted with a submersible pump. The wells can be between 10-50m apart, this will be dependent on the volume of water to be reduced. Therefore, one well at each corner of the excavation would be sufficient. Water is then pumped from each well reducing the water level to below that required for the excavation works. Once the well is bored a perforated filter screen is fitted inside, this helps collect any particles that would clog up the system from silt. The pump is fitted inside the filter screen by a drop lead and water is pumped up via a riser pipe to the surface. The flow of water will determine the diameter of the well, typically these can vary from around 125mm-350mm. (groundwater engineering.com)

Deep well system



(groundwater engineering.com)

Basement Construction

Secant piling will be used as a permanent solution, this will also help with the initial waterproofing of the basement car park and provide a strong and stable platform for the superstructure. First, a guide wall is installed around the perimeter of the excavation to accept the piling. This ensures the correct positioning of the piles. Secant piling is carried out by boring the ground prior to installing primary and secondary piles that interlock, providing a good waterproof seal. First a casing is driven into the ground using pile rig to core before the primary pile (female) is cast in situ using a tremie pipe to fill the inner section of the casing with the specific concrete mix. The mix will depend on when the interlocking cuts are made and the long-term use of the pile. The concrete mix for piling can vary wildly dependant on whether it needs to be soft non-structural or hard-structural, typically strength will vary from 0.5Mpa to 40Mpa (Megapascal, measurement of compressive strength) (ICE: Institute Civil Engineering). A space is left between each primary pile. The secondary pile (male) is then inserted either side of the primary pile cutting into each side to interlock the piles together. Both primary and secondary piles can be reinforced but it is common for just one set of piles to be reinforced using a steel frame and the other of unreinforced poured concrete. (designingbuildings.co.uk)



(Anchored secant piles) (Bascol.co.uk)

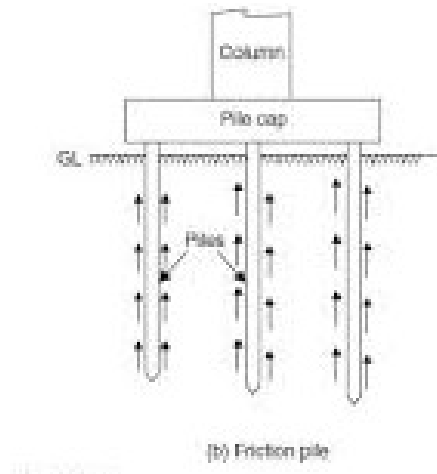


(Braced secant piles) (Bascol.co.uk)

Secant piling can be anchored using tension rods that are fixed through the pile into the ground adjacent. An injected concrete grout is injected and spreads out in the surrounding ground forming a plug creating an anchor. Alternatively, they can be braced across the corners to ensure stability while excavations are ongoing. For this

project, anchoring would be used as the braced approach would impede the access ramp for excavation.

Friction piles will be forced through the ground using vibration to a depth of approximately 10-12m which will be into 3-5m of stiff boulder clay.



Concrete floor slabs will form the floors of the build, as concrete has a high compressive strength, but low tensile strength, so it is necessary to reinforce the material when used to form a floor. By using post tension reinforced concrete many benefits can be achieved that considerably save time and money but still deliver on quality. For the construction of this build, two types of concrete slab will be used to maximise on the cost, time and efficiency. For the basement floor slab a post tensioned (PT) flat slab will be used with post tension beam and slab used thereafter for the remainder of the substructure and the super-structure. PT floor slabs can be either bonded or unbonded, the bonded system being the most widely used in the UK with over 90% of the suspended floor market. Bonded refers to the grouting that is applied to the tendon along the length of the section. (MPA The Concrete Centre). The choice of floors has been mainly due to the cost, speed and flexibility of construction when using this system. The concrete flat slab can be laid quickly using the minimum amount of concrete but with high grade steel tendons, the first tensioning can be carried out within days of the concrete curing. Using this system helps reduce carbon footprint as there is less use of raw materials and less transportation costs. A carefully designed PT flat slab will maximise on the reduced need for supporting columns. Holes can be cut into post-tensioned floor slabs easily if identified at the design stage,

with smaller holes being cut anywhere in the slab between the tendons and larger holes cut by displacing tendons.

Additional benefits such as PT beam and slab floors do not require high-strength concrete and can have relatively light weight reinforcement, as the beam is post tensioned, rather than the floor slab.

Benefits of post tensioning concrete slabs

- Minimum storey heights – reduction of overall build height due to floors being slimmer.
- Minimum number of columns – can be reduced due to the flexibility in length of spans available
- Rapid construction – systems are compatible with fast track construction
- Savings on cost and programme – less materials required
- Maximum design flexibility – with irregular shaped builds
- Optimum clear spans - with reduction of columns large open spaces can be achieved within the car park and open plan offices with light weight partitions.
- Joint-free, crack-free construction –
- Controlled deflections - more control over the tensioning of the reinforcement bars as the concrete is curing and shrinking.

(Cross section of PT floor slab/Column appendix2)

Walls will be reinforced concrete with a layer of Piledrain type membrane applied directly onto the concrete wall acting as a waterproof membrane.

Drainage System Permanent

The car park basement has been constructed using secant piling, with reinforced concrete walls and floor slab. Applied to the walls will be Newton 508 8mm cavity waterproofing membrane system that will collect water via channel/conduit drainage system cut into the concrete floor slab. Run-off water will be taken to the corners of the basement into a trapped gulley. The sump will operate on demand to pump water up to ground level into mains drains. The Newton 508 cavity system complies with BS 8102:2009 waterproofing standards. (Newton waterproofing.co.uk)

Superstructure – Vertical Envelope

The considerations for the substructure will be based inherently on cost and speed of construction. Whole life costs should also be considered as should the lifespan of materials and its flexibility and recycling properties. Concrete has many benefits – such as energy storage in terms of thermal mass, good fire resistance and acoustic

insulation. This often results in lower operating costs and lower maintenance. (MPA The Concrete Centre). Therefore, the superstructure will be concrete framed infilled with thermalite blocks and a rain screen cladding. Due to the close proximity of the build to the coast, consideration has been made for continuous weather effects of salt blown rain and wind resistance. By using the PT concrete floor systems, the overall height of the build can be reduced by one floor in every 10 as the floors of the super structure are a slim deck system.

Inner leaf

Thermalite aircrete blocks are lightweight, versatile and durable. They provide good acoustic insulation and are widely used in the construction industry for internal and external use. Thermalite blocks are good for water resistance and fire protection as they are non-combustible and comply with BS EN771-4. Rainscreen cladding is generally lightweight and simple to use with some systems clicking into place on the inner frame. However, in light of the tragic events of Grenfell, external cladding is now required to have an in-built layer to prevent the spread of fire. The product chosen complies with the European building standards in relation to class A1:EN13501

A1:EN13501

“Products are described as having no contribution to fire at any stage. The BS EN 13501 test sets several thresholds for combustion performance when tested to both EN ISO 1716 and EN ISO 1182. A1 certified products have no sustained flaming when tested. Typical products meeting this classification include most inorganic materials such as metal, stone, and glass”. (labc.co.uk)

Cladding

Rainscreen cladding is a non-structural external finish to a building that attaches to the main building frame. There are two basic types:

Drained and Ventilated: Penetrating moisture is drained or evaporate and ventilate to the outside. Façade detail is important to ensure that rainwater cannot cross the gap between the rainscreen and the internal walls.

Pressure – Equalised: This allows the passage of air between the inside and outside of the rainscreen. As the pressure is equalised it does not get sucked or driven through the joints. (designingbuildings.co.uk)

Junctions/fixings

Rainscreen systems have a simple but effective multi-layer. The internal leaf of thermalite block work provides the base for the system to be anchored to: The design must be in accordance with BS6399-2-1997, and the correct wind loading is critical especially a high rise building in a coastal location.

Pressure – Equalised system

- Internal block work – Thermalite
- Breathable membrane
- Simple aluminium framework in a grid pattern that is attached to the inner blockwork.
- Insulation
- Air gap
- Metal/metallic cladding

(Cross section of rain screen cladding at floor slab appendix 3)
(Pressurised-Equalisation of rain screen cladding appendix 4)

Conclusion

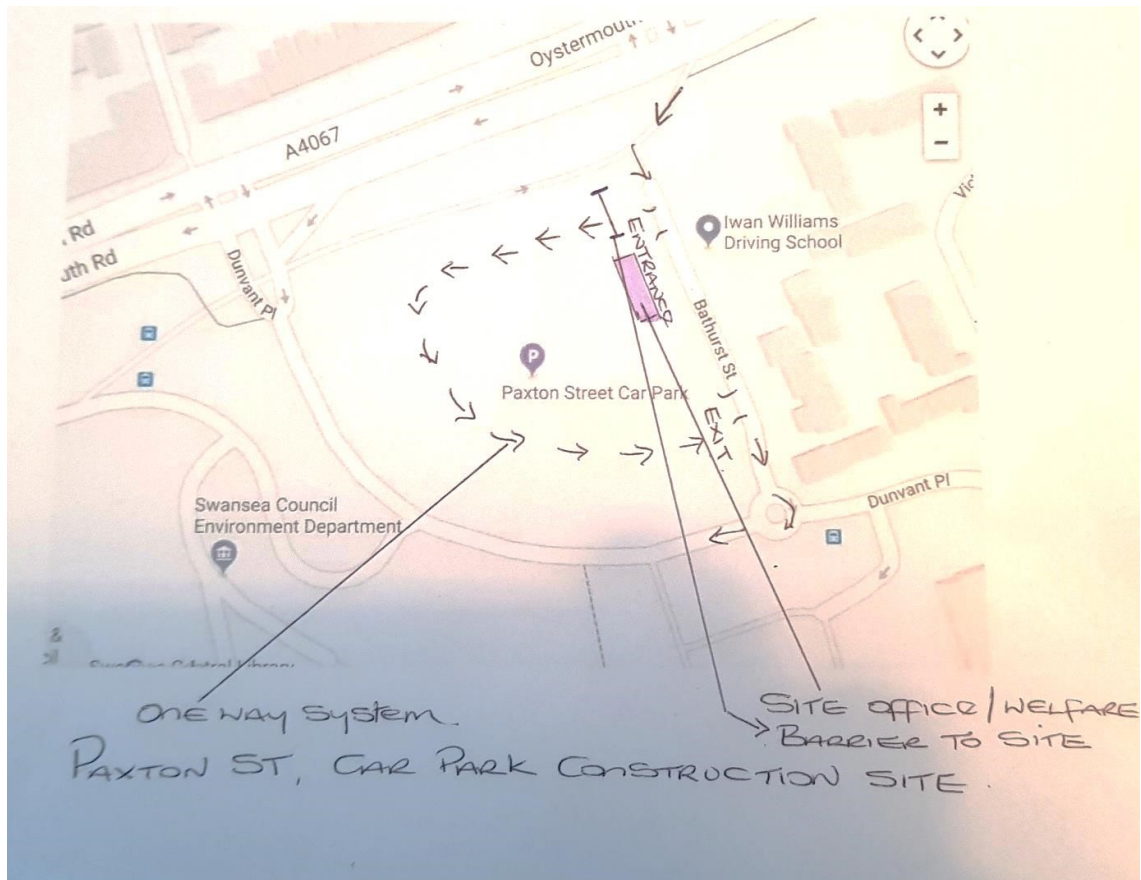
Modern construction has many cost and time savings systems available to complete builds in record time. From the excavation to the finished cladding, systems have been developed to speed up the processes throughout. Further use of IT systems like Building Information Modelling (BIM) that support the multi-team project can ensure a building is created within the software package to the tiniest detail before the building is has even started excavation. When incorporating the whole lifecycle from cradle to cradle, the materials we use should be sustainable, locally sourced where possible and recyclable once they come to the end of their lifespan. Although speed is off the essence in today's fast-paced society, attention to detail still needs to be quality controlled to ensure these new buildings do not look shabby within a short period of time.

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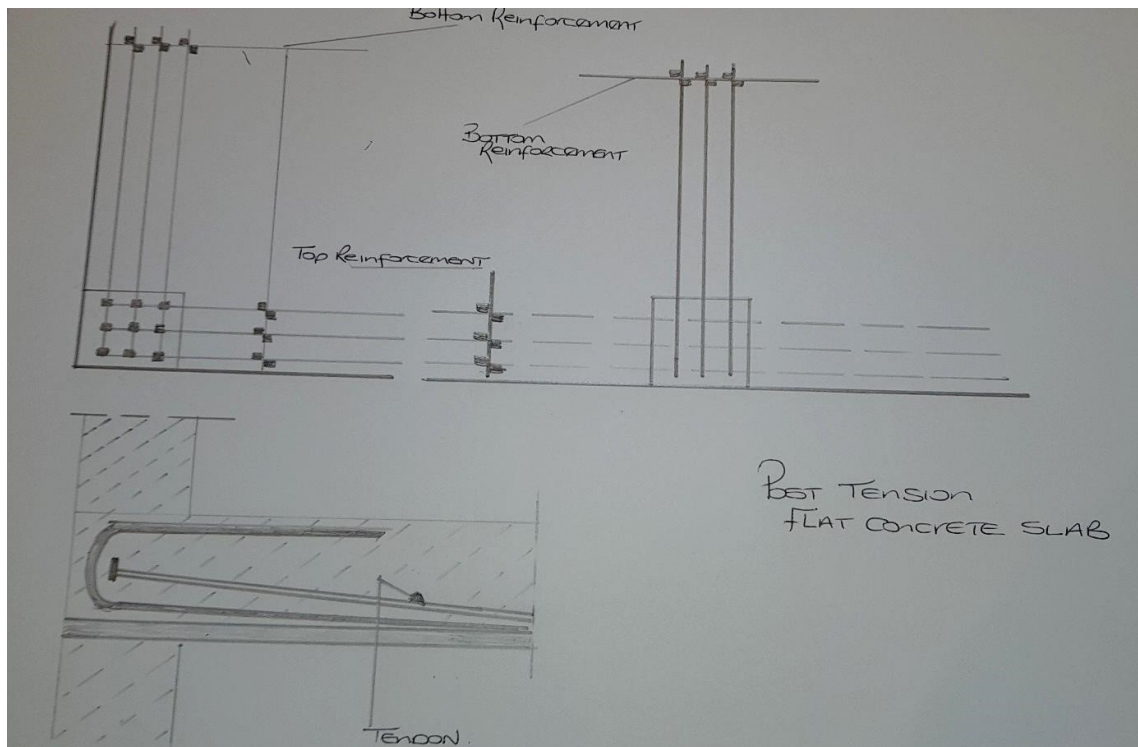
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Appendices

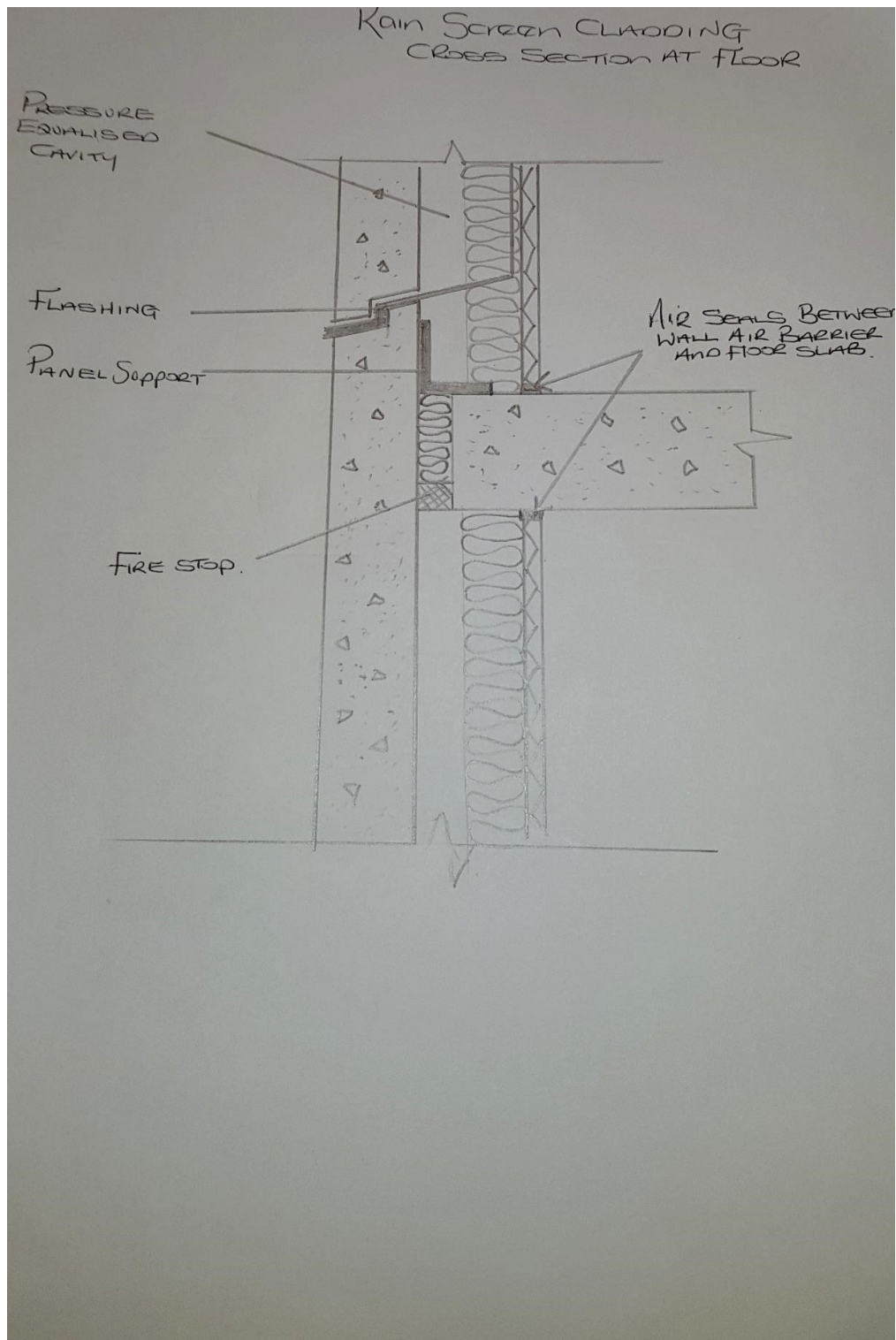
Appendix 1: Site map showing direction of traffic to and from the site.



Appendix 2: Post Tension Flat concrete floor slab



Appendix 3: Cross section of rain screen cladding at floor slab



Appendix 4: Pressurised-Equalisation of rain screen cladding

