Appendix D7

Subway Construction Evaluation

1. CIVIL, STRUCTURAL AND GEOTECHNICAL ISSUES

1.1 GEOLOGY

The Tsim Sha Tsui Peninsula is made up of a geological sequence consisting of granites, alluvium, colluvium, marine sediments and fill materials. The granites being the oldest material and the fill being the youngest.

Figures 1.1 to 1.4 inclusive indicate the typical geotechnical stratigraphy along the subway based on available site investigation data. An additional site investigation will commence shortly, which will provide additional data on stratigraphy and soil parameters.

The entire site in underlain by medium grained granite of the Kowloon Pluton. This pluton is one of the youngest in Hong Kong and as a result has not been intruded. The granite has subsequently weathered and the thickness of the weathering profile varies considerably. For consistency 'rock head' in taken to be Grade III or better rock. The rockhead level at the western end of Mody Road is generally about –10mPD. The rockhead rises to about –1.5mPD at Blenheim Avenue and drops to about –15mPD at the eastern end of Mody Road. Along Blenheim Avenue the rock head rises to the south towards Signal Hill.

The alluvial materials are found to be of variable thickness over the site. Where found, the alluvium (which is clarified as the Chek Lap Kok Formation), is the result of sedimentation from ancient rivers that flowed south from the Kowloon Peninsula during a period of lower Sea Level. The materials making up this lithology are likely to be diverse in nature, ranging from clays, to silts, sands and even some gravels. The boundary between the weathered bedrock and the alluvium is an old erosional surface and, as a result, will be very irregular.

The marine deposits generally overlay the alluvial deposits. The depth of the marine deposits is highly variable. The marine deposit forms part of the Hang Hau Formation, which is the most recently formed geological material in Hong Kong waters. The marine deposit generally consists of silts and sands formed adjacent to the old shore lines and are old beach deposits. The boundary between the alluvium and marine deposit is an old erosional surface and will be irregular.

The fill materials extend over the entire area of the site and are significantly thicker in areas of reclamation. The fill material by its very nature, is highly variable.

The site stratigraphy is summarised in Table 1.1.

Table 1.1: Soil Profile Summary from Existing Boreholes

Stratum	Top Level of Stratum(mPD)	Thickness of Stratum(m)
Fill	+3.9 to +5.3	0.5 to 7.0
Marine Deposits	+2.0 to -3.0	0 to 7.0
Alluvium	+1.5 to -7.0	0 to 7.5
Colluvium	+2.5 to -1.0	0 to 6.0
Completely Decomposed Granite (CDG)	+4.0 to -14.0	1.5 to 13.0
Highly Decomposed Granite (HDG)	+2.0 to -18.0	0 to 4.5
Moderately Decomposed Granite/Slightly Decomposed Granite (M/SDG)	+1.0 to -22.0	-

The existing ground level along the subway alignment varies. Along Mody road existing ground level varies from about +4mPD at the junction with Nathan Road to +4.2mPD at the junction with Chatham Road. The existing ground level along Blenheim Avenue varies between +4.4mPD at the junction with Mody Road rising to +5.2mPD adjacent to Signal Hill.

All of the proposed subway structure will remain below the existing ground level (with the exception of entrances). Sufficient cover to the subway will be provided to ensure sufficient depth for utility and drainage reinstatement.

1.2 Temporary Works

Due to the need to maximise the internal width of the subway for passenger flow requirements (see section 2.1), the installation of Temporary Works will have to be at the extreme edge of the working area in order to maximise the width of permanent works between. As such, the proposed method of temporary work installation is severely limited by the need to maintain pedestrian access to the adjacent property, emergency vehicle access (EVA) and to ensure clearance to the overhang of the building above. See Figure 1.5 to 1.8.

Various methods of construction have been considered in an attempt to minimise the construction zone and provide the greatest internal dimension to the subway. This has included a Diaphragm Wall solution where the temporary retaining walls are eventually cast intergral with the roof slab and floor slab to form the permanent 'box'. Although this solution would remove the need for a separate Temporary Works zone outside the permanent walls, the construction plant would need both considerable headroom and working space around the setting-out line, which result in the works having to be inset from the extremities of the working area.

The excavation options considered are composed in Table 1.2.

Table 1.2 : Temporary Retaining Wall Options

Options	Comparison	Results
Diaphragm wall	· Cast insitu or precast section of diaphragm wall to be constructed under bentonite. · Excavation supported by diaphragm wall together with strutting system. · Toe grouting will be required where rockhead is high to provide groundwater cutoff. Advantages:- · Form permanent subway wall that will maximize the internal width of subway. · Provide higher stiffness which will cause less deflection during excavation. · no stability problem in case of grouting deficiency. Disadvantages:- · Stitch drilling will be required if local hard stratum or underground obstructions are encountered in view of the close proximity of existing buildings. · Shear pin required to provide toe stability at high rockhead area. · Subway will not be completely wrapped-around by water proofing. · Requires large working area and EVA cannot be maintained. · Less feasible when encountering non-divertible utilities. · Larger ground settlement during diaphragm wall installation. · Where canopy of existing buildings exists, limited headroom will prohibit the use of diaphragm wall.	Not feasible in some areas. Not recommended.

Options	Comparison	Results
Contiguous bored pile wall	· Cast insitu bored piles to be installed in close spacing. · Excavation supported by contiguous bored pile wall together with strutting system. · Grouting behind the wall to ensure groundwater cutoff. Advantages:- · Form permanent wall resisting earth loads, the subway wall can be thinner. · Provide a reasonably stiff wall which will cause less deflection during excavation. · Provided temporary casing is used, smaller ground settlement is expected during pile installation when compared to that of diaphragm wall. · Underground obstructions can be overcome by Reverse Circulation Drilling · No stability problem in case of grouting deficiency. Disadvantages:- · Shear pin required to provide toe stability at high rockhead area unless the pile is extended below excavation level. · Requires large working area and EVA cannot be maintained. · Less feasible when encountering widely spaced non-divertible utilities. · Where canopy of existing buildings exists, limited headroom will prohibit the use of contiguous bored pile wall.	Not feasible in some areas. Not recommended.
Sheet Pile wall	· Sheet pile section to be installed by vibrating or jacking method. · Excavation supported by temporary sheet pile wall together with strutting system. · Grouting behind the wall may be required to ensure groundwater cutoff. Advantages:- · With suitable ground, quick to install. · No stability problem in case of grouting deficiency. Disadvantages:- · Prebore required if underground obstructions are encountered. · Prebore required for sheet piles taking vertical loads from traffic diversion unless additional kingposts are to be installed. · Shear pin required to provide toe stability at high rockhead area and special details required. · Vibration induced may not be tolerable by adjacent structures. · Noise permit required implies longer construction programme.	Feasible

Options	Comparison	Results
Caisson Wall	· Hand excavation and may be installed at close spacing. · Excavation supported by caisson wall together with strutting system. · Grouting behind the wall to ensure groundwater cut-off. Advantages:- · Form permanent wall resisting earth loads, the subway wall can be thinner. · Provide a stiffwall which will result in less deflection during excavation. · Underground obstructions can be easily overcome. · Maybe easily extended into rock. · Requires small working area. Disadvantages:- · Tend to be slow. · May have difficulty obtaining experienced workers. · Greater safety risk to workers. Probably will not be accepted by BD and GEO.	Feasible. Not recommended
Soldier Pile Wall + Lagging	· Installation of H section soldier piles by overburden drilling or down-the-hole method. · Excavation supported by soldier pipes with lagging together with strutting system. · Grouting behind the wall to provide groundwater cutoff. Advantages:- · Flexible when encountering non-divertible utilities. · Piles can be extended to below excavation level, no shear pin required. Disadvantages:- · Programme is slow in view of installation of lagging panels. · Piping and heaving of excavation have to be taken in account, higher risk of instability is higher in case of deficiency in grouting works.	Feasible

Options	Comparison	Results
Pipe Pile wall	· Circular hollow sections at close centres installed by overburden drilling or down-the-hole method. · Excavation supported by pipe pile wall together with strutting system · Grouting behind the wall to provide seepage cutoff Advantages:- · Excavation supported by pipe pile wall together with strutting system. · Piles can be extended to below excavation level, no shear pin required. · Flexible when encountering non-divertible utilities. · No stability problem in case of grouting deficiency. Disadvantages:- · Installation time will be longer than soldier piles due to increased number of piles (but will gain time during excavation).	Feasible

The principle option taken forward in this report, is a temporary pipe pile wall placed at the edge of the working area, with the subway box constructed inside. The envisaged construction sequence drawings show this pile wall to be steel CHS or pipe piles, with external grouting to achieve an acceptable level of water cut-off for the excavation. Preliminary design shows that a 273mm diameter, 10mm thick section will provide sufficient temporary support and that these will need to be socketed into the rockhead by approximately 2.0m. Alternatively, they will extend below the formation by at least 3.5m to 4m, where rockhead is deeper. In these areas, foundation piles at 5.0m centres will be required to be driven to rockhead to support the adjacent sections of the pipe pile wall. A typical subway construction sequence is given in Figure 1.9.

Grout holes at 1m C/C will be installed behind the wall and a grout curtain formed by TAM grouting.

At two intermediate levels, a traditional arrangement of waling and props will be required, together with a king post in the centre of the excavation. This is required to support the temporary decking and to permit the work to advance in the sequence shown. See Figure 1.9.

The envisage arrangement of temporary works requires a zone of approximately 500mm. This width would also be suitable for an alternative installation of sheet piles (e.g. Larssen 25W, which have a pitched width of 480mm). Sheet piles, being continuous, would reduce the need for grouting and may be removable. This may lead to a more economical solution. However, unless a 'silent' piling technique was used, the consequencies of the driving operation in such a densely populated urban area would almost certainly be prohibitive.

The height limitation of the adjacent buildings on both pipe pile and sheet pile installations could be over-come by jointing the piles. However, this is likely to be expensive. As part of the proposed scheme, it is envisaged that overhanging signs and canopies will be demolished.

It should be noted at this point, that this pipe pile arrangement, decking and strutting is an envisaged arrangement and will not form part of the specified works for the contract. The exact choice of system will be left to the Contractor for the benefit of economy and programme. Assuming a pipe pile wall temporary retaining wall is constructed as close as practicable to the existing buildings along the route of the interchange subway the following maximum cut and cover subway widths may be achieved:

Mody Road	-	6.8m
Blenheim Avenue	-	5.6m
Across Chatham Road	-	6.8m

1.3 FOUNDATIONS

The subway can be either supported by deep foundation or bearing on ground (floating). After review of the available geological conditions and preliminary assessment shows that the subway can be floated. At areas where soft soils are encountered, soil improvement works may be required.

1.4 UPLIFT

The construction of the interchange subway will require excavation of insitu materials which are replaced by a concrete box structure. In some areas, the total weight of subway structure may be less than the water uplift after applying safety factors in accordance with KCRC design criteria. Several measures to resist the resultant uplift force are considered and are compared below :-

Table 1.3 : Restraint Against Buoyancy

Options	Comparison	Results
Gravity	· Increase dead load of the subway structure. Advantages:- · Fast to construct. Disadvantages:- · May result in an insufficient utility zone above the subway if roof slab is thickened. · May reduce the internal width of the subway. · Sensitive to the vertical alignment of the subway. · Deeper excavation if base slab is thickened.	Feasible. Not recommended
Underground drainage	· Place permanent drainage layer underneath the subway. Advantages:- · Lower risk of leaking through deficient membrane. · Thinner structure due to smaller water pressure. Disadvantages:- · Depth of excavation will be increased to accommodate the under-drainage layer. · Requires permanent cut-off which is difficult to build. · Requires a permanent high capacity pumping system.	Feasible. Not recommended
Mini-pile	· After excavation to the lowest formation level, install minipiles socketing into rock connected with the baseslab. Advantages:- · Pile spacing can be easily adjusted to suit the final design. Disadvantages:- · Requires additional drilling within the excavation. · Additional cost since the temporary king-posts will be abandoned.	Feasible. Not recommended

Prebore H-pile	· To re-use the temporary king-posts which support temporary deck for traffic diversion, as permanent tension piles. Advantages:- · Economic to re-use the king-post although the king-post has to be designed as part of permanent structure. · High capacity so fewer piles required. Disadvantages:- · Less flexible in design change of subway once the temporary king-post had been installed unless spare capacity has been reserved.	Feasible. Recommended

The prebore H-pile is considered to be the most feasible and economic solution since it may be installed to facilitate the traffic diversion in temporary condition. It will not required additional drilling inside the excavation and possess high tensile capacity when compared to the mini-pile option.

1.5 TYPICAL WALL DEFLECTION AND GROUND MOVEMENT

The excavation and depropping sequence was modelled by OASYS program FREW to assess the deflection of the temporary wall and associated ground movement.

The soil strength parameters recommended in the Technical Study Geotechnical Basis of Design Report (GBDR) had been reviewed and the following parameters were adopted in the FREW analysis. These values are subjected to review after the site investigation works and laboratory testings has been completed.

Table 1.4 : Geotechnical Shear Strength Parameters

Soil Type	c= (kPa)	ö (degree)	ã(kN/m^3)	Ko	Kah	Kph	E= (kPa)
Fill	0	33	19	0.46	0.25	5.09	10,000
Marine Sand	0	33	19	0.46	0.25	5.09	15,000
Alluvial Sand	0	35	19	0.43	0.22	5.96	15,000
Colluvium	0	35	19	0.43	0.22	5.96	15,000
CDG	5	35	19	0.43	0.22	5.96	Eo=20,000 at B5mPD, dE/dy=1000/m
Grade III Rock	1000	45	25	0.29	0.19	12.11	1,000,000

The stiffness (E) of each soil stratum is estimated from the SPT >N= values in the previous boreholes. E is considered to be equal to 1.0 x >N= (MPa). Angle of friction ä= between wall and soil is assumed to be half ö= for both active and passive sides.

After review of the technical study report, groundwater level is assumed to be +3.0mPD or 1m below ground whichever is higher.

For the buildings founded on shallow foundations, building surcharge was assumed to be 10kPa UDL per storey in accordance with Table 16 of GEOGUIDE 1. For the envisaged scheme using pipe pile wall, by taking into account the traffic and building surcharges, the maximum horizontal deflection along Mody Road is about 40mm. The typical deflection profile is shown in Figure 1.11.

The ground movement outside the subway will be caused by the following activities:-

- Temporary retaining wall installation
- Lateral movement of pipe pile wall during bulk excavation
- Temporary groundwater drawdown

For the pipe pile wall scheme, with careful control on the drilling and pressure of air flushing, it is envisaged that the ground loss due to pipe pile installation will be minimal. Near sensitive structures such as buildings supported by shallow footings or sensitive utilities, flushing medium will be changed to water to minimize the disturbance. It is therefore assumed that the ground settlement due to the pipe pile installation will be negligible.

The ground settlement associated with the lateral movement of the pipe pile wall will be assessed as recommended by Milligan (1983) from which the maximum settlement will be equal to half of the maximum deflection of the pipe pile wall which will be analysed by FREW.

To provide a dry working area, it is envisaged that temporary dewatering is required to lower the groundwater within the subway. In view of the close proximity of the utilities or building structures, it is proposed to install a grout curtain outside the pipe pile wall to control groundwater seepage. OASYS finite element program SEEP is used to analyse the seepage condition during pumping inside the site. Using the permeabilities of different materials during the technical study stage, the associated ground settlement with the water drawdown was about 5mm maximum near the wall. The assumed permeabilities will be verified in the site investigation works for the detailed design.

A combined settlement profile is shown in Figure 1.11. It can be seen that the maximum settlement is about 25mm and the maximum angular distortion is about 1:800.

1.6 EXISTING BUILDING FOUNDATION

The building structures located adjacent to the subway have various types of foundations. Some of the existing building foundation plans were reviewed in the Buildings Department. Some of the information are pending reply from BD. Based on the existing information, the type of building foundations are shown in Figure 1.12. It is noted that building nos. 18 to 21 and 25 to 26 are being redeveloped by Land Development Corporation. The building no. 24 is under redeveloping by Henderson Land Development Co. Ltd. The foundation of these new developments will consider the effect on the proposed interchange subway.

Some buildings are supported on deep foundations which are believed to be founded on rock or close to rock. These buildings will be less suspectable to settlement during the construction of the subway. It is envisaged that building no. 22 (nos.19-30 Mody Road) and building no. 13 (no. 13-15 Minden Avenue) will be most critical. These buildings are 4-storey high with residential structures on the roof. The building is supported by shallow footings with unknown founding level although it is likely to be on CDG. Trial pits will be carried out to determine the founding level of the footings.

1.7 BUILDING PROTECTION

The distortion of a structure will depend on the stiffness (both vertical and horizontal) of the structure, the type and depth of foundation as well as the deformation of the ground due to construction works. Complex soil-structure interaction can occur and this is also influenced by the overall condition and integrity of the structure.

According to Boscardin and Cording (1989), based on the angular distortion and the horizontal strain of the building, the degree of damage to the building can be predicted. The building damage classification is presented in Table 1.5. In general, it is intended that the damage to general building structures should not be permitted to exceed Category 2 as defined in Table 1.5. The preliminary assessment of the construction of subway by pipe pile wall indicated the effect to the adjacent structures will fall within Category 2.

Table 1.5: Building Damage Classification

Building Damage Classification (After Burland et al, 1977 and Boscarding and Cording, 1989)					Approximately Equivalent Ground Settlements and Slopes (after Rankine 1987)	
Risk Category	Description of Degree of Damage	Description of Typical Damage and Likely Forms of Repair for Typical Masonry Buildings	Approx. Crack Width (mm)	Max Tensile Strain %	Max Slope of Ground	Max Settlement of Building (mm)
0	Negligible	Hairline Cracks		Less than 0.05		
1	Very slight	Fine cracks easily treated during normal redecoration. Perhaps isolated slight fracture in building. Cracks in exterior brickwork visible upon close inspection.	0.1 to 1	0.05 to 0.075	Less than 1:500	less than 10
2	Slight	Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible: some repainting may be required for weather-tightness. Doors and windows may stick slightly	1 to 5	0.075 to 0.15	1:500 to 1:200	10 to 50
3	Moderate	Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Tuck pointing and possibly replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired.	5 to 15 or a number of cracks greater than 3	0.015 to 0.3	1:200 to 1:50	50 to 75
4	Severe	Extensive repair involving removal and replacement of sections of walls, especially over doors and windows required. Windows and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably. Some loss of bearing in beams. Utility services disrupted.	15 to 25 but also depends on number of cracks	Greater than 0.3	1:200 to 1:50	Greater than 75
5	Very severe	Major repair required involving partial or ' complete reconstruction. Beams lose bearing, walls lean badly and require shoring. Windows broken by distortion. Danger of instability.	Usually greater than 25 but depends on number of cracks		Greater than 1:50	Greater than 75

After receiving all the building foundation information, the existing buildings and other structures within the zone of influence will be evaluated. Recommendations for protection of each structure will be submitted. The recommendations shall fall into one of the following categories:-

Existing structures requiring protection by underpinning and/or a protection wall system, or any other suitable alternative system will be designed by OAP.

Existing structures requiring protection in a less critical condition, the protection system will be designed by the Contractor. OAP will outline the design parameters and review the design.

Existing structures not requiring special protection. OAP will outline on the drawings any precautions to be exercised by the Contractor during the construction of the works.

Based on the existing information, it is envisaged that most of the buildings will not require underpinning works or special protection systems.

1.8 STRUCTURAL ASPECTS

The basic cross section of the proposed subway box is shown in Figure 1.13. The subway cross section will vary due to restrictions in available working space. Typical subway sections that may be achieved at different locations are indicated in Figure 1.13.

As the subway box structur41e is to be cast bottom-up, construction joints are proposed at the side walls. Depending on the final prop locations and the sequence of the temporary props removal the side walls may be designed to have one or two waterproof construction joints.

As noted in an earlier section, it is intended to provide future provision for extension of the subway for both the future property development (LDC site and Henderson Land site), as well as the continuation of the subway along Mody Road to Chatham Road and Wing On Plaza. Recessed panels or niches are a practical option for this, as not only do they provide sufficient and separated working space for future break out works but, in the interim, can be fitted out as station trading outlets. This would fulfill the requirement for facilities to relieve the problems associated with a long passageway appearance.

A drop beam over the recess opening will be required to support the roof and maintain the overall integrity of the structure during the future breakout works.

These niches are coordinated with the proposed plant room facilities at the Hanoi Road junction. Other knock out panels/recess would be provided at Cornwall Avenue [LDC site] Mody Road [future extension to Wing On Plaza] and Blenheim Avenue [HLC site].

1.9 UTILITIES

A large number of utilites are located beneath the roads and pavements in the vicinity of the proposed subway alignment. Generally utilities are located within 2m of the ground surface. All known utilities in the area are indicated on the utility drawings and summarised in a separate Utilities Report.

Crossing services will generally need to be 'hung' from the temporary traffic deck and incorporated into the final filling above the structure. If, due to the required levels, drainage pipes conflict with the roof slab, a local trough may be provided with additional reinforcement and/or up-stand beams, if necessary, where amendments to the drainage falls cannot be incorporated.

A typical section across Mody Road West will show the following existing utilities:

Under the carriage way (approximately 10,500mm wide)

- 6 number 132kV CLP cables
- DSD sewer and stormwaters pipes
- WSD water mains

Under the footpath

- 11kV CLP cables
- 33kV CLP cables
- MV, LV and PL CLP cables
- HK Telecom cables
- WSD salt water mains
- Towngas pipes

A typical section across Blenheim Avenue will show the following existing utilities.

Under the carriage way (approximately 8500 wide)

- Towngas pipes
- DSD sewer and storm water pipes
- WSD water mains and salt water mains

Under the footpath (approximately 1700 wide)

- 11kV CLP cables
- LV and PL CLP cables
- HK Telecom cables

In view of the congestion of the utilities at the footpaths, it is recommended not to divert any utility from the carriage way to the footpaths during the subway construction.

In general services shall be hung from the temporary deck, however, at entrance locations service diversions will be required. At the Chatham Road crossing a 1200 diameter trunk sewer pipe and 1200 diameter foul sewer pipe require the subway to be lowered to a slab level of –6.2mPD. There are ongoing discussions with DSD to agree a suitable diversion for the pipes to allow the subway to be raised at this location.

1.10 MOVEMENT JOINTS

The general strategy is to avoid providing movement joints along the length of the subway, for the benefit of water tightness. However, a movement joint is proposed at the interface with the MTR TST station to provide a line of demarcation and to avoid the transfer of load to the existing MTR station structure.

A piled foundation is proposed for the station structure located at Wing On Garden Plaza, a movement joint is, therefore, also proposed at this interface. All expansion joints will be detailed to satisfy KCRC's waterproofing criteria.

A 'late cast' construction joint is proposed at the interface between the cut and cover subway in Blenhein Avenue and the Signal Hill tunnel portal. This is to allow the settlement of the structure to occur before the connection is made to the rock tunnel. This will minimise the differential settlement at this location.

1.11 WATERPROOFING

In order to maximise the structure width within the tight constraints of the Temporary Works, the waterproofing to the permanent subway wall will be a membrane placed against the pipe pile wall which will form a back shutter for the concrete pour. Above the roof, the waterproofing membrane will be protected with a 75mm thick cement sand screed, which will be laid to fall to the outer edge. All laps and joints will be in accordance with manufacturers recommendation's and KCRC standard specification. Waterstops and Hydrophilic strips will be positioned at all construction joints.

1.12 MICROTUNNELLING

The section of interchange subway along Blenheim Avenue to the tunnel portal at the northern face of Signal Hill is limited in width due to constraints imposed by the existing buildings.

To maximise the subway width along Blenheim Avenue the use of microtunnelling techniques have been considered.

For microtunnelling horizontal steel support pipes are installed to form a rectangular box. The steel support pipes will be infilled with concrete with reinforcement inserted across the pipe joints for stiffness, buckling and shear resistance. The steel support pipes will be left in place permanently.

The steel support pipes would be installed from a driving shaft located at the junction of Mody Road and Blenheim Avenue. The steel support pipes would be installed to a reception shaft located at the tunnel portal at the northern face of Signal Hill. The length of installation is approximately 60m which is greater than previously installed lengths in Hong Kong and therefore further advice will require to be sought from the manufacturers on the practicality of driving 60m lengths.

Penetration grouting within the steel support pipe envelope may be required to be injected from the access shafts. This may be required to strengthen the tunnel face during excavation.

After completion of the penetration grouting then low pressure chemical grout will be required to be injected from the access shafts around the sides and above the roof to prevent water ingress during excavation.

During excavation rectangular steel frames are installed at 1.0 to 1.25m centres to support the steel support pipes. These steel support frames will be cast into the permanent concrete structure of the subway.

The steel support pipes at roof level will clash with a number of utilities in Blenheim Avenue. These are summarised in Table 6 below:

Table 1.6: Utilities which may clash with microtunnelling.

The Utility lower 1.5m from the G.L.	Approx. depth below G.L.	Description
4 x 33kV Cable	1600 mm	- Crossing the Blenheim Avenue near Mody Road
7 x 11kV	1600 mm	- Crossing the Blenheim Avenue near Mody Road
1 x 225 dia. Storm Water Main	Around 2300 mm	- Running along the Blenheim Avenue from Mody Road to Minden Avenue
1 x 375 dia. to 150 dia. Storm Water Main	Various, around 2400 mm	- Running along the whole Blenheim Avenue
1 x 150 dia. Foul Sewer Main	Various, around 2000 mm	- Running along the whole Blenheim Avenue
1 x 150 dia. Salt Water Main	1750 mm	- Running along the whole Blenheim Avenue
1 x 300 dia Fresh Water Main	1500 mm	- Running along the part of the Blenheim Avenue near Mody Road

Note: The bottom level / invert level of C.L.P. cable, W.S.D. Main and H.K.T. cable are assumed.

Prior to commencement of support pipe pile installation these utilities will be required to be relocated to provide sufficient clearance to the pipes.

A typical section through a subway section installed by microtunnelling is indicated in Figure 1.14.

The feasibility of the microtunnelling technique in Blenheim Avenue has not yet been confirmed.

2. CIVIL ASPECTS OF SIGNAL HILL SUBWAY

2.1 Geology

The available borehole data indicate that in general the Signal Hill subway tunnel will lie in Grade II granite, close to the Grade III lower boundary. At the north end, the subway tunnel may well pass through predominantly Grade III rock. Hard rock tunnelling conditions, therefore, can be expected for the majority of the works.

The historic site investigation data do not indicate that groundwater will be a problem but, as the tunnel lies below sea level, for design purposes it has been assumed that groundwater could be present. Further ground investigation boreholes are planned in order to confirm the depth and topography of the Grade II/Grade III granite boundary.

The ground conditions are expected to consist of a full face of grade II granite for most of the length of the tunnel. Mixed face conditions with grade II granite in the invert, and grade III/IV in the crown is expected at the northern end of the subway tunnel.

2.2 Excavation

2.2.1 Physical Constraints

The bored subway tunnel has been designed to provide a 6 metre clear width, with provision for a travelator if required, as shown on drawing HDD300/32/C40/001.

The subway will be constructed as bored tunnel from a portal located in the Middle Road playground, due to the extreme limitations on worksites in Blenheim Avenue. The subway tunnel will be driven directly in line with the cut and cover subway within Blenheim Avenue. At this, northern, end of the subway, a 4 metre diameter natural light shaft will be constructed.

The proposed subway site is in a high profile, densely populated commercial location. The excavation methods used must minimise aspects such as dust and noise pollution in order to reduce the incidence of political and potential compensation claim generating issues. In addition, as access will not be possible from Blenheim Avenue, all excavation work will have to be carried out from within the station box excavation.

The station site is bounded on two sides by major roads carrying high volumes of traffic so traffic management arrangements will have to cause as little interference to flows as possible. The construction methods employed must minimise any impact on the traffic flow by ensuring truck numbers are as low as possible.

Signal Hill is a historical site. Consequently there is a possibility delays could arise if historical or archaeological items are found during the construction work.

2.2.2 Excavation Method

Several options have been considered for excavation of the Signal Hill Subway tunnel.

i) Drill and blast

Excavation by drill and blast will give a high, consistent advance rate irrespective of the rock strength. Protective measures will be required but dust and noise will be restricted by a limit of only one blast per day.

ii) Chemical Expansion Grouts

These are silent and not subject to restrictions on use but are expensive, unpredictable, unreliable and require a high drilling density.

iii) Mechanical Breakers

The use of breakers allows for a consistent advance rate but gives rise to noise and dust problems. In hard rock the excavation rate is slow.

iv) Hand Splitting

This is a flexible method which gives consistent advance rates and good profile control. As it is labour intensive, however, it is expensive and slow.

v) Hydraulic Splitting

Hydraulic splitting has the same advantages as hand splitting but has the further disadvantage that a drill rig is required.

vi) Sun Burst/Boulder Burster

The advantage of this method is that vibration levels are low, so it is useful in sensitive areas, but other methods have to be employed for profile control. A licence is required for its use and output is very dependent upon rock quality.

The most effective method of carrying out the excavation will be by drill and blast provided that all safety issues can be addressed satisfactorily and that the requisite licence can be obtained. For areas where blasting will not be suitable, for example, for environmental or regulatory reasons, hydraulic splitting will be the most appropriate alternative method.

As it will not be possible to commence tunnel excavation until work in the relevant section of the station box has been completed, it is unlikely that the time required to obtain a blasting licence will give rise to any delay.

2.2.3 Mines Department

In order for blasting to be used on a project the proposed procedures must comply with the Mines Department rules and regulations. The Mines Department's brief is to ensure public safety and there are two principle areas of concern:-

i) Vibration

A construction site is licenced for explosives to be used based on a chargeweight relative to distance table, prepared utilising known structures' and utilities' vibration limits, drawn up by the contractor. The table is prepared on the basis of a peak particle velocity (ppv) less than or equal to that given by the Mines Department formula ppv = $644(D/\sqrt{W})^{-1.22}$ which is based on a mixture of blasting results from various sources and blast designs throughout Hong Kong. This is a conservative starting point, site specific data being used to redefine the site specific constants of 644 and −1.22 once blasting is underway.

In addition to the licence to blast a permit is required to use explosives in the licenced area. If the blasting limits are exceeded on an adjacent structure, the permit will be suspended.

ii) Flyrock

Protection measures against flyrock are required at levels sufficient to guarantee public safety. These are generally in the following forms:-

a.	Ground Cover:	25 mm diamond mesh sheets and gunny sacks weighed down with sand bags, placed by hand
b.	Blasting Cages:	Steel cages of "I" beam or tubular steel construction with diamond mesh walls and ceiling, placed by backhoe or crane.
c.	Vertical Screens:	Steel "I" beam frames with diamond mesh, mounted on sledges and manoeuvred by bulldozer
d.	Roof Over:	Double or single layers of 25 mm diamond mesh forming a "tent" over the area to be blasted. Normally used in conjunction with ground cover.
e.	Rock Fall Fences:	"I" beam posts, usually mounted in concrete filled oil drums with diamond mesh. These are semi-permanent installations between a public area and any slope deemed to be potentially problematic.

a, b, and c are mobile whilst e is dependent on geological assessment and acceptance by Mines Department and Geotechnical Engineering Office.

It is most likely that this site will require a roof over and ground cover for surface blasting to form the tunnel portal. Any portal started directly requires enclosed steel doors with protected vents, for air blast, at least 3 m from the face.

In view of the "safety distance" available, it is considered extremely unlikely that Mines Department will allow a magazine to be located on site, even underground. This means that blasting times and quantities will be governed by the frequency and timing of deliveries from the Mines Department. This will consist, most probably, of one delivery daily around midday. Once on site the explosive can not be stored, i.e. it must be loaded and fired immediately. Consequently all of the blasting cycles will be governed by this and multiple face blasting around the clock may not be possible at this site.

2.2.4 Utilities and Structure

It will be necessary to establish the limiting criteria outside the site and their respective vibration limits, i.e. buildings, utilities, slopes and roads etc.

The peak particle velocity limit for utilities is generally 25 mm/sec. However, for electrical joints and water retaining structures a limit of 13 mm/sec is applicable. The locations of all electrical joints and water retaining structures in the area must be confirmed by excavation or other methods before work commences on site.

2.2.5 Geotechnical Engineering Office

The principal concerns of the Geotechnical Engineering Office (GEO) are the surrounding slopes and their safety when subject to the additional loads imposed by construction methods. Signal Hill slope is of major concern due to its location, age and construction. The current slope factor of safety is assumed to be less than 1.2.

Slopes are assessed by applying formula No. 16 from GEO Report No. 15 using data on, *inter alia*, joint roughness, block size, dip angle and orientation, which are determined from exposures undertaken by the contractor at the start of work on site. Slope peak particle velocity limitations can be assessed at 5 or 10 mm/sec which means that proximity to the slope could impede blasting progress unless improvement work to increase the permitted ppv can be carried out. Until the slope has been assessed to the GEO's satisfaction, Mines Department will not issue a licence for blasting in the area.

In the light of its age and proximity to the works, it is considered very likely that this slope will be the governing factor in the peak particle velocity limitation considerations. Slope stabilisation work directed towards lessening the impact on the underground excavation will have to be assessed carefully.

2.2.6 Excavation Procedure

In hard rock conditions in Hong Kong an average advance rate by blasting could be expected to be around 1 m per day. Assuming a slope peak particle velocity limitation of 13 mm/sec, 0.5 kg per delay would be possible up to 17.3 m from the slope. With a limit of 25 mm/sec the distance reduces to 10.1 m. It is probable, therefore, that initial excavation of the subway tunnel, and completion at the north end, will have to utilise non blasting methods until the required separation has been achieved.

Assuming it will be possible to obtain a Noise Construction Permit allowing trucks in and out of the site between 07.00 and 19.00, a midday explosives delivery which will allow blasting and mucking to be completed by 19.00 and no deliveries on Sundays, Public Holidays and during typhoons, an advance rate of 25 m per month should be achievable. If the peak particle velocity limit is greater than 13 mm/sec, as it is expected to be as the excavation proceeds further from surface constraints, a higher advance rate should be possible. For planning purposes, however, 25 m per month is considered to be practicable. It is probable that excavated muck from the tunnel will be removed from site with the arisings from the station box construction.

2.2.7 Safety Considerations

With respect to blasting and the handling of explosives, safety procedures will be covered largely by the Mines Department requirements. At present the shotfirer has to attend a site specific interview to discuss potential hazards but it is possible that a requirement to have a suitably qualified blasting engineer could be introduced.

There is a potential for stray currents from any 11kV and 33kV cables in the area. Consequently it is likely that a Nonel explosives initiation system will be stipulated by Mines Department. This method will have the additional advantage of providing for better control of vibration and flyrock since an infinite number of delays can be linked in series, thereby permitting smaller chargeweights per delay. The limit for electric detonators is 36 delays.

It is probable that Mines Department will require tunnel portal protection to be in place for the duration of the excavation at this site. Roof over and ground cover will be necessary for the initial ramp development.

When appraising for this report the use of blasting, the worst utility case has been covered by assuming a peak particle velocity of 13 mm/sec. If the slope assessment indicates that a lower limit is applicable, remedial measures and slope treatment will be the best option.

2.3 DESIGN STANDARDS

Ground loadings in rock and primary support design have been assessed by means of the Norwegian Geotechnical Institute's (NGI) Q rock classification system which was published as NGI Publication Nr. 106 in 1974. The support requirements were refined subsequently by Grimstad and Barton of NGI and published in 1993. Rock loadings have been assessed also by means of Terzaghi's ground arching theory.

Secondary tunnel linings have been designed as cast in situ concrete to British Standards BS5400 and BS8110. The lining stresses have been calculated using the Muir Wood-Curtis equations for circular tunnels in elastic ground.

2.4 PRIMARY LINING

General

The tunnel lining has been designed to be installed in two stages, with a primary lining of reinforced sprayed concrete and rock bolts, followed by a secondary permanent lining of cast in situ concrete. A waterproofing system will be installed between the primary and secondary linings.

Primary lining design

The primary lining has been designed to provide adequate temporary support to the excavation during construction. Rockbolt arrays have been designed to provide full support to any unstable rock wedges that may form, without utilising the strength of the sprayed concrete lining. The reinforced sprayed concrete is designed to provide immediate structural support to the excavation, utilising the strength of the rock itself. Although capable of providing long term support, this has not been considered as part of the permanent lining due to possible damage caused during blasting in adjacent areas.

On completion of excavation a permanent lining of cast in situ concrete will be constructed. The secondary lining has been designed to provide the full permanent support, neglecting any contribution to stability which might be afforded by the primary lining.

The primary lining has been designed using the Q system of assessing support pressures developed by the Norwegian Geotechnical Institute (NGI). The parameters on which this is based, obtained from the ground investigation data are:

Rock quality designation	RQD
Joint set number	J_n
Joint roughness number	J_r
Joint alteration number	J_a
Joint water reduction factor	J_w
Stress reduction factor	SRF

The rock mass quality number Q is determined from:

$$Q = RQD/\ J_n \times J_r/\ J_a \times J_w/SRF$$

Roof and wall support pressures are calculated from the Q values by means of the following relationships:

$$P_{roof} = \frac{2\sqrt{J_n}}{30J_r} Q^{-\frac{1}{3}}$$

$$P_{wall} = \frac{2\sqrt{J_n}}{30J_r} (2.5Q)^{-\frac{1}{3}}$$

Data for calculating the Q values have been estimated from Boreholes ERE/BH10, ERE/BH11 and ERE/BH12 drilled by Bachy Soletanche in April 1998, and borehole BH3 drilled by Fugro in June 1979. The parameter values deduced are:-

	RQD	J_n	J_r	J_a	J_w	SRF
Fugro BH3	95 – 55	12-15	1-1.5	4	1	5
ERE/BH10	100 - 95	12-15	1-1.5	4	1	5
ERE/BH11	100 - 77	12-15	1-1.5	4	1	5
ERE/BH12	100 - 95	12-15	1-1.5	4	1	5

The calculated Q values for each of the tunnels are:-

	RQD	J_n	J_r	J_a	J_w	SRF	Q
Subway Tunnel	55	15	1.5	4	1	5	0.03

A further factor used in the lining design is the excavation support ratio (ESR), the value of which is related to the end use of the underground excavation. As the primary lining is considered as temporary support, the recommended value for a roadway tunnel has been increased by a factor of 1.5, as recommended by NGI. The ESR is used with the excavation span to give the equivalent dimension, D_e. The support required is established from a graphical relationship between Q and D_e prepared by NGI.

The primary support requirements determined by this method are:-

	Q	Span	ESR	D_e	Support	
					Shotcrete	Rock bolts
Subway Tunnel	0.01	7.6	1.0	5.1	150 mm	2.5 m long

As the Q system does not take into account directly rock strength and joint orientation, potential wedge failures have been determined using the computer program UNWEDGE. Joint orientation data have been taken from the Final Technical Report, Appendix E, Geotechnical Basis of Design, and potential unstable wedges identified. Rockbolt support was then calculated, with simple pattern arrays designed to provide full support to the wedges identified.

The analyses for potential wedge failures indicated that the Q system was too general for determining specific lengths of rock bolts required. In addition, the required pattern of rock bolting according to the potential failure mechanism is not given directly by this method. The required rock bolt lengths and patterns determined using the UNWEDGE program are:-

Tunnel	Wedge Falling (Crown)		Wedge Sliding (Side)		Wedge Rotating (Side)	
	Length	Pattern	Length	Pattern	Length	Pattern
Subway	3.50 m	2.0 m x 2.0 m	-	-	2.00 m	2.0 m x 2.0 m

Monitoring

In order to confirm the validity of the assumptions made for the primary lining design and the adequacy of the ground support, convergence monitoring arrays will be installed in the tunnel at ten metre intervals.

By measuring any movements of the tunnel wall and comparing the results with theoretical predictions it will be possible to anticipate potentially significant changes and install additional support, in the form of shotcrete or rockbolts, as necessary.

2.5 PORTALS

The south portal of the subway will be formed in the cut slope of the open cut station concourse works. For options 3a and 4, this will be below the toe level of the new retaining wall supporting the south side of Signal Hill. The vertical loading applied by the wall will be 1000 kN/m2, which is less than the factored design load for the subway tunnel in general. No additional permanent support is therefore required.

In order to form the portal, additional support in the form of 6 metre long rockbolts will be installed around the tunnel eye at 1 metre centres. Excavation for the subway tunnel would commence cautiously, with 0.5 metre advances and steel arch and lagging support installed after each advance, to provide immediate full support. The steel arches will be continued from the portal to 1 metre past the wall, and will be subsequently encased within the permanent lining concrete. Typical details of Portal support are given on Figure 7.1.

2.6 GROUND TREATMENT

It is anticipated that the north portal area of the subway tunnel will be in Grade III, possibly Grade IV, granite and it might be necessary to carry out ground treatment work in order to stabilise the ground prior to excavation.

A primary ring of 4 metre long holes at 1.5 m centres around the tunnel profile will be drilled and grouted from the tunnel face. If further treatment is considered necessary, secondary holes will be drilled and grouted between the primary holes. A cementitious grout will be suitable for the anticipated ground conditions.

2.7 SHAFT CONSTRUCTION

The natural light shaft at the northern end of the subway tunnel beneath Signal Hill will be constructed by underpinning using precast concrete smoothbore segmental rings.

On completion of the subway excavation a minimum of two holes will be drilled up to the surface at the shaft location. One of these, on the centre-line, will be used to drop excavated material down into the tunnel for removal via the subway tunnel. The other hole or holes will be used for services, such as compressed air lines. Staging will be erected in the crown of the tunnel for support and safety during excavation and construction of the lower rings of the shaft.

A working platform will be erected at the bottom of the slope at the southern end of Blenheim Avenue on which will be installed a crane. This crane will be used for handling the shaft segments, off-loading them from a lorry and lifting them up to the shaft. This will be the only plant and transport required in Blenheim Avenue.

The top of the shaft will be formed of four part rings (if 1 m long segments are used, 6 rings of 0.6 m segments are used) but because of the height of the back face it will not be possible to excavate for these in open cut. Therefore, using a minimum of excavation for level control and keying into the slope, part rings will be built on the slope. Following this, excavation for the top ring will be completed and the plates installed. The lower part rings will then be completed by excavation and installation of the plates by underpinning. After excavation and construction of a further ring by under-pinning the segments of the top rings not underground will be removed.

Construction of the shaft down to the tunnel will be completed by underpinning.

In the event that ground conditions prove to be unsuitable for shaft construction by under-pinning, after the top rings have been completed the shaft will be sunk by means of sequential sinking: rings will be added to the top of the shaft and it will sink under its own weight as the bottom is excavated. On completion of sinking the top plates above ground surface will be removed.

2.8 FINAL LINING

2.8.1 Waterproofing

A PVC or Polyethylene waterproofing membrane/Drainage fleece approximately 2mm in thickness will be provided subsequent to the application of a sealing shotcrete layer (approximately 50mm thick) to act both as a watertight shell and as a separation layer minimising cracking of the secondary lining. The membrane shall consist of an impermeable heat welded sheeting fixed over a geotextile drainage and protective sheeting.

2.8.2 Permanent Lining Design

The permanent lining, consisting of cast in situ concrete, has been designed using a number of stages, to allow for the influence of the local topography, and the presence of adjacent tunnels.

The first stage used the PHASES finite element program to model the in situ and post tunnelling stresses beneath Signal Hill. This program allows the sequential excavation of each tunnel to be modelled, giving resulting stress distributions and lining stresses. Although only capable of modelling in two dimensions, by analysing a sequence of models it is possible to allow for the influence of the access passages on the platform tunnels.

The individual tunnel linings were designed using the programmes TUNGEN and SAND. TUNGEN was used to determine the effect of the tunnel lining within the ground, using the Curtis-Muir Wood method. SAND was then used to determine the stresses within the resulting structural model of each tunnel lining.

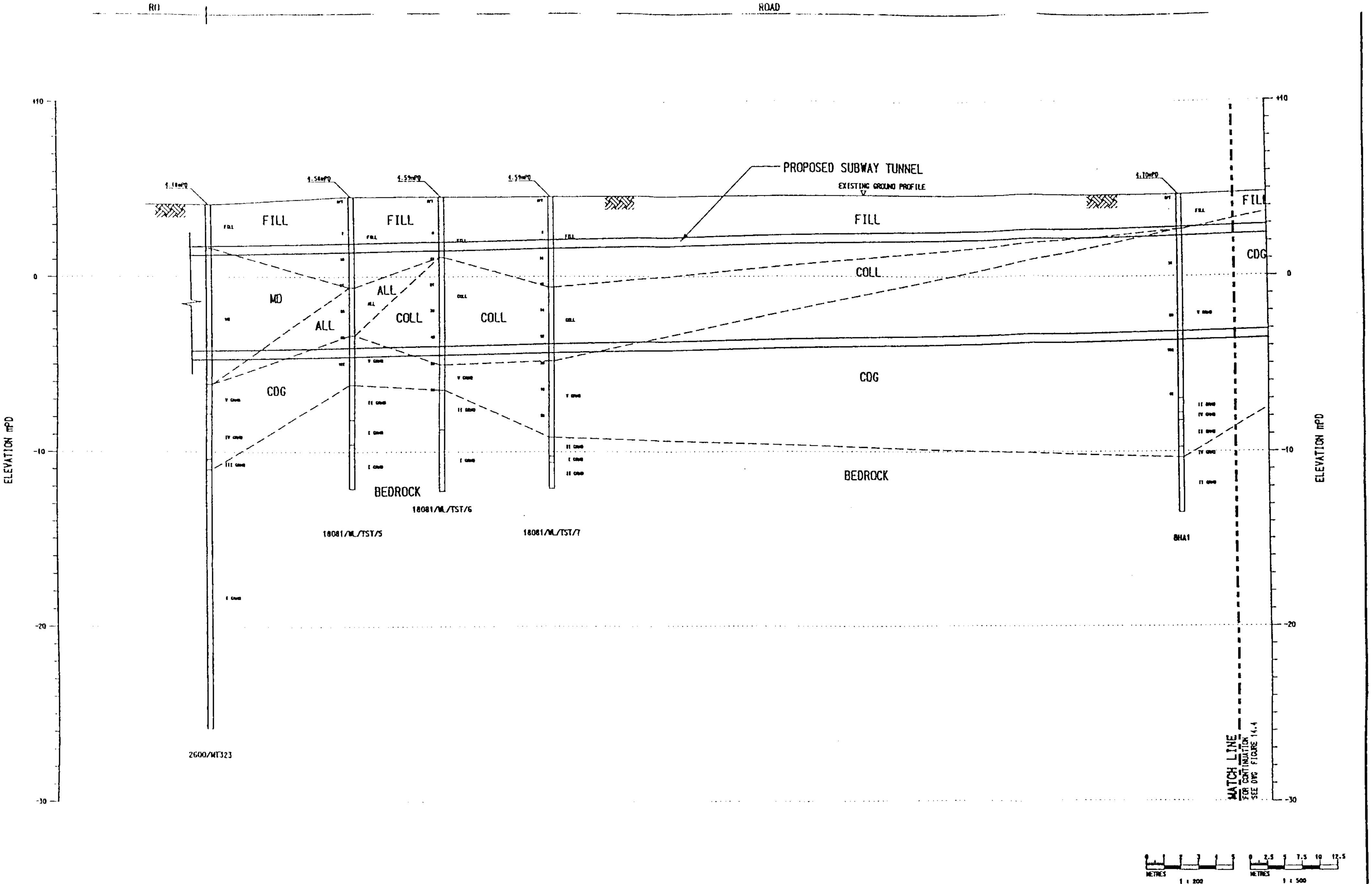
Roof and wall support pressures are calculated from the Q values by means of the following relationships:

$$P_{\text{roof}} = \frac{2\sqrt{J_n}}{30J_r} Q^{-\frac{1}{3}}$$

$$P_{\text{wall}} = \frac{2\sqrt{J_n}}{30J_r} (2.5Q)^{-\frac{1}{3}}$$

Load factors were then applied to allow for the effects of adjacent tunnels and multilevel tunnels, as derived from the PHASES modelling.

Hydrostatic loading was applied assuming a piezometric surface equal to the general ground level of +5mPD.



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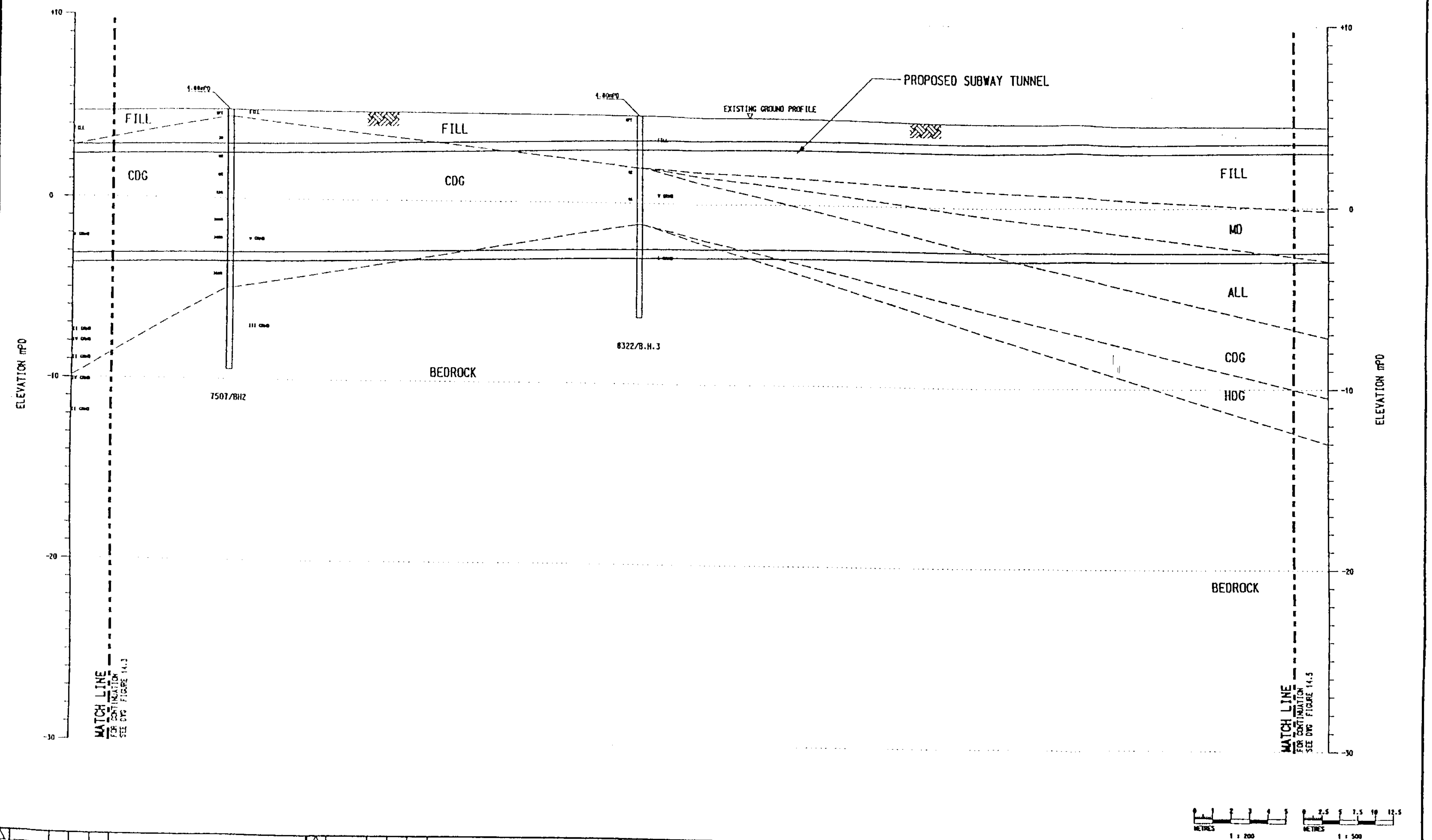
HOD-300 EAST TSIM SHA TSUI STATION AND TUNNELS TO HUNG HOM

Geological Section

Sheet 1 of 4

FIGURE 6.1



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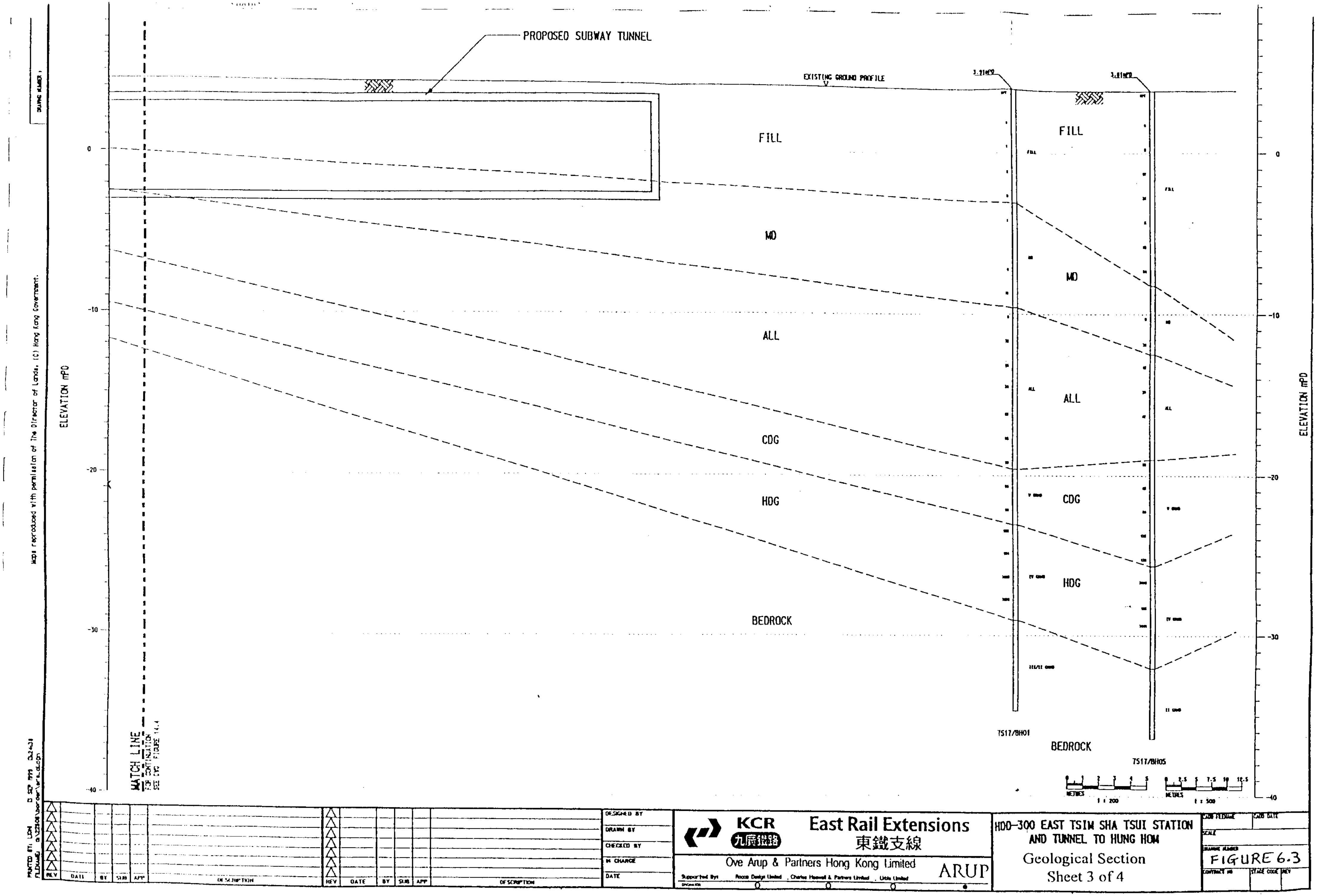
HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

Geological Section
Sheet 2 of 4

FIGURE 6.2



PROPOSED SUBWAY TUNNEL
EXISTING GROUND PROFILE
FILL
MD
ALL
CDG
HDG
BEDROCK
ELEVATION mPD
0
-10
-20
-30
-40
MATCH LINE
FOR CONTINUATION
SEE DWG FIGURE 14.4
7517/BH01
7517/BH05
METRES
1 : 200
1 : 500
KCR
九廣鐵路
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東鐵支線
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HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM
Geological Section
Sheet 3 of 4
FIGURE 6.3
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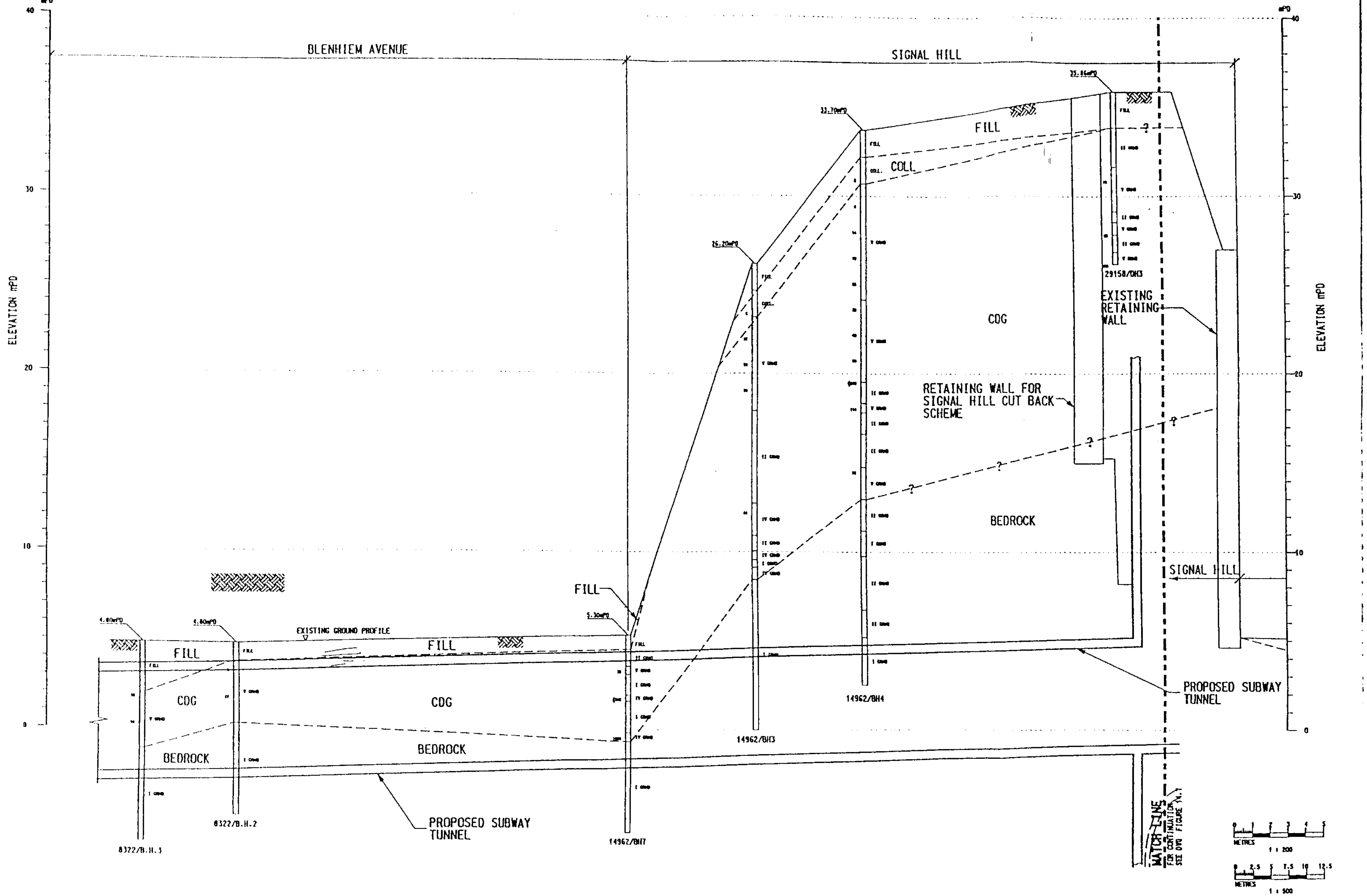

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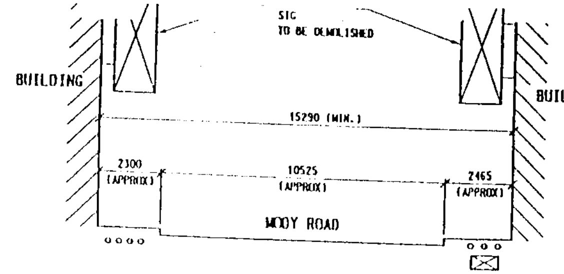
1100-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

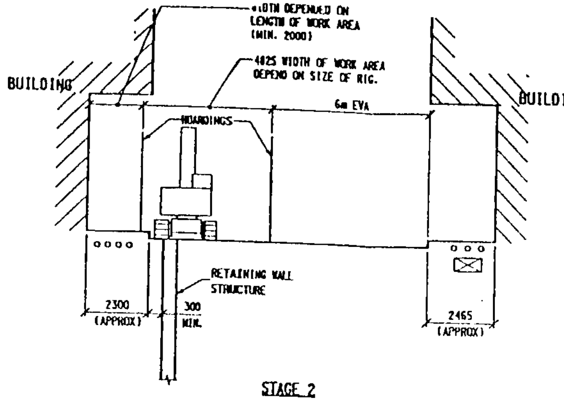
Geological Section
Sheet 4 of 4

FIGURE 6.4



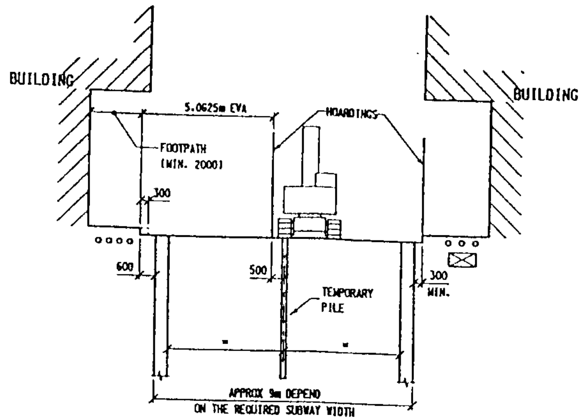
STAGE 1

1. DEMOLISHING OF ANY PROJECTION FROM THE EXISTING BUILDING.



STAGE 2

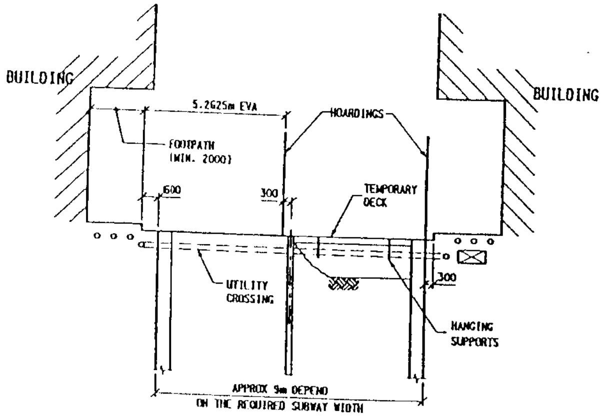
1. ERECT HOARDING.
2. CONSTRUCT TEMPORARY RETAINING WALL AT ONE SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.
3. CONSTRUCT TEMPORARY RETAINING WALL AT THE OTHER SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.



STAGE 3

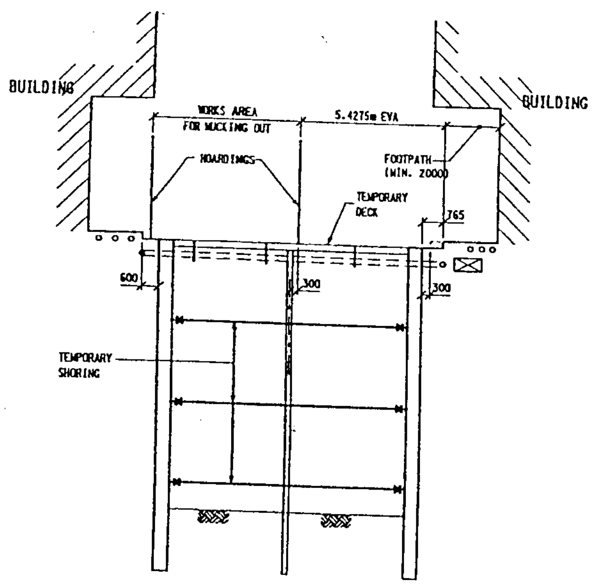
1. ERECT HOARDING.
2. MODIFY THE ROAD KERB.
3. CONSTRUCT TEMPORARY PILE NEAR THE SITE CENTRE.

(PROBLEM: 6m WIDE EVA ACCESS CANNOT BE MAINTAINED)



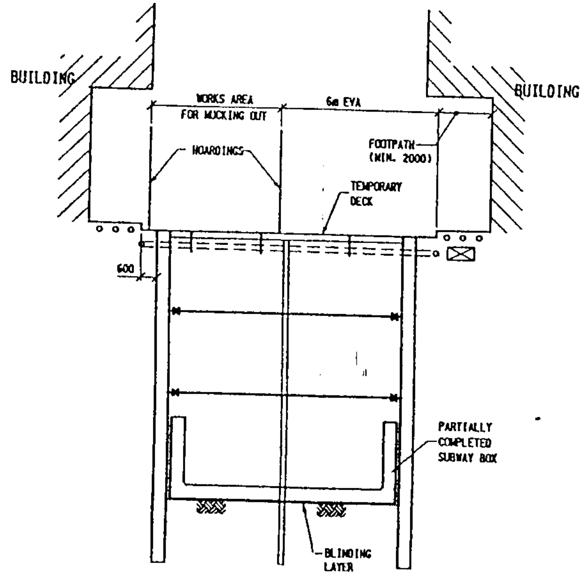
STAGE 4

1. PERFORM EXCAVATION AT ONE SIDE
2. ERECT TEMP DECK AT ON SIDE.
3. PROVIDE SUPPORT TO HANG UTILITY, WHICH IS REQUIRED TO CROSS THE ROAD.



STAGE 5

1. PERFORM EXCAVATION AT OTHER SIDE.
2. ERECT TEMP DECK AT OTHER SIDE.
3. MODIFY ROAD KERB.
4. HANG THE CROSSING UTILITY.
5. ERECT SHORING.
6. PROCEED WITH EXCAVATION TO THE FORMATION LEVEL.



STAGE 6

1. CAST BLINDING LAYER.
2. CONSTRUCT SUBWAY BOX BOTTOM UP.
3. REMOVE TEMPORARY STRUTS.

METRES 1 : 100

REV	DATE	BY	SUB	APP	DESCRIPTION
A	24AUG1999	CYH			SETTING OUT ADDED.

DESIGNED BY C Y HO
DRAWN BY M KWONG
CHECKED BY S YOUNG
IN CHARGE K CHONG
DATE 24AUG1999

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East Rail Extensions 東鐵支線
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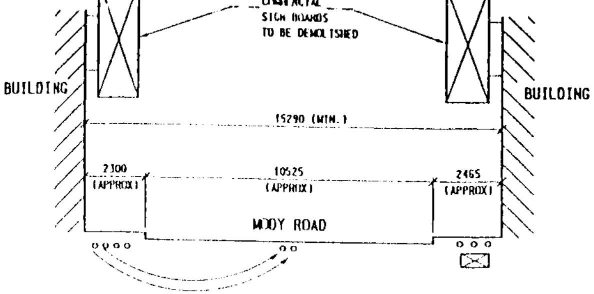
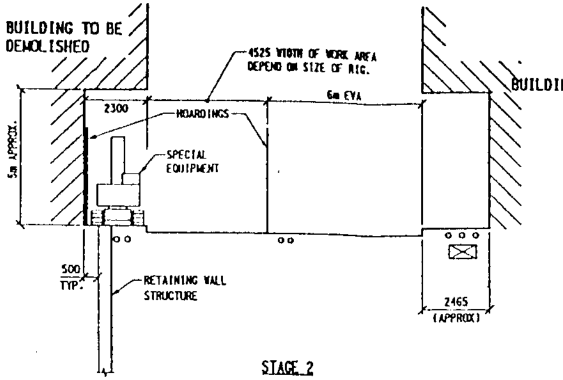
HDO-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM
OPTION 1 - PRELIMINARY CONSTRUCTION SEQUENCE OF INTERCHANGE SUBWAY AT MOOY ROAD

CADD FILENAME FIG-20-2.DGN
CADD DATE 28JULY1999
SCALE 1 : 100
DRAWING NUMBER FIGURE 6.5
CONTRACT NO HDO-300
STAGE CODE P
REV A



STAGE 1

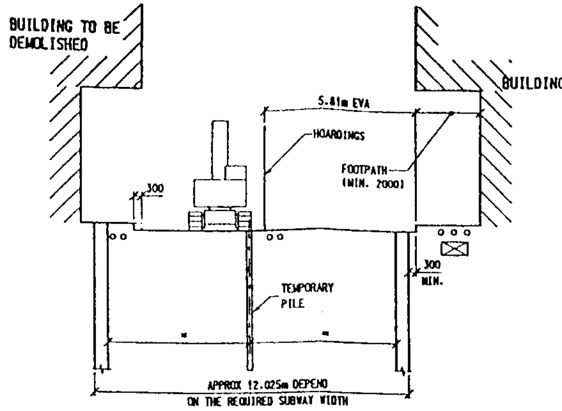
1. DEMOLISHING OF ANY PROJECTION FROM THE EXISTING BUILDING.
2. DIVERSION OF UTILITIES ADJACENT TO THE EXISTING BUILDINGS.



STAGE 2

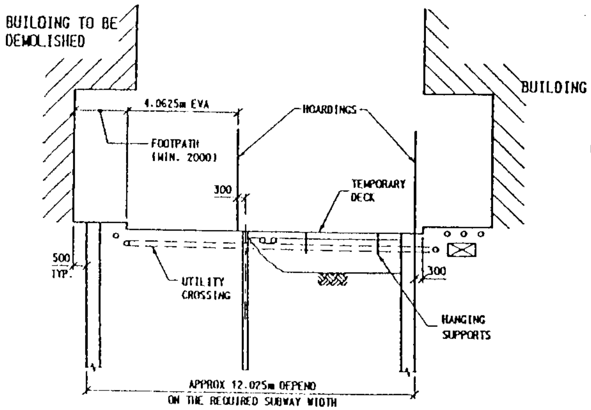
1. ERECT HOARDING.
2. CONSTRUCT TEMPORARY RETAINING WALL AT ONE SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.
3. CONSTRUCT TEMPORARY RETAINING WALL AT THE OTHER SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.

(PROBLEM: - FOOTPATH CANNOT BE MAINTAINED SO THE BUILDING MUST BE DEMOLISHED
- SPECIAL PILING MACHINE WORKING UNDER TIGHT HEADROOM IF EXISTING BUILDING IS NOT TO BE DEMOLISHED IN TIME.)



STAGE 3

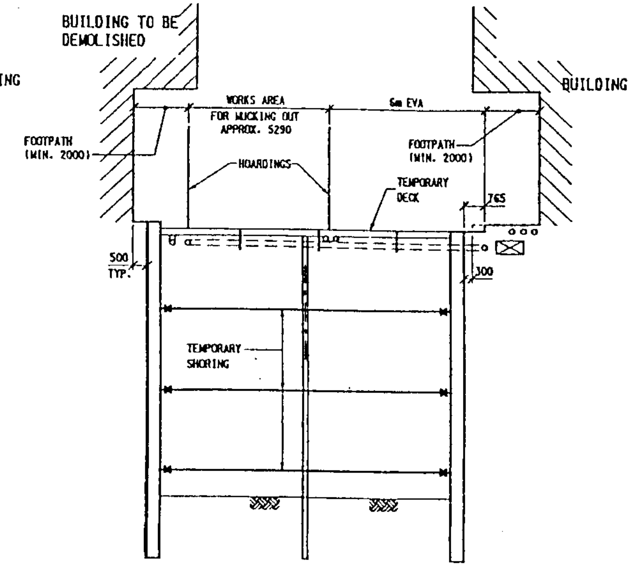
1. ERECT HOARDING.
2. MODIFY THE ROAD KERB.
3. CONSTRUCT TEMPORARY PILE NEAR THE SITE CENTRE.



STAGE 4

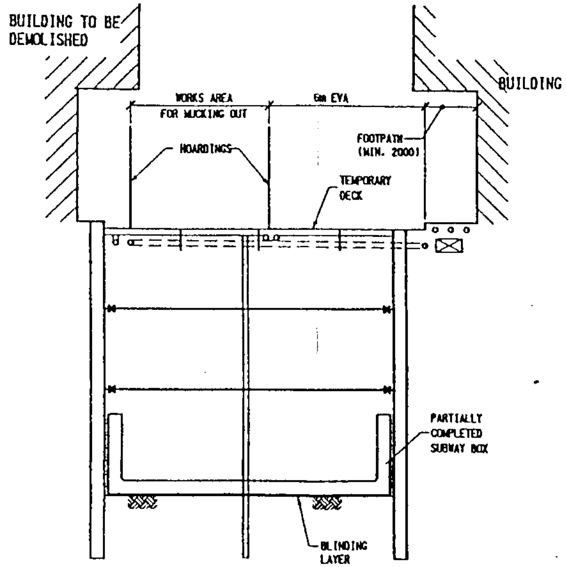
1. PERFORM EXCAVATION AT ONE SIDE
2. ERECT TEMP DECK AT ON SIDE.
3. PROVIDE SUPPORT TO HANG THE DIVERTED UTILITY.

(PROBLEM: 6m EVA ACCESS WIDTH CANNOT BE MAINTAINED IF BUILDING IS NOT TO BE DEMOLISHED.)



STAGE 5

1. PERFORM EXCAVATION AT THE OTHER SIDE.
2. ERECT TEMP DECK AT THE OTHER SIDE.
3. MODIFY ROAD KERB.
4. HANG THE CROSSING UTILITY AND THE UTILITY ALONG THE FOOTPATH.
5. ERECT SHORING.
6. PROCEED WITH EXCAVATION TO THE FORMATION LEVEL.



STAGE 6

1. CAST BLINDING LAYER.
2. CONSTRUCT SUBWAY BOX BOTTOM UP.
3. REMOVE TEMPORARY STRUTS.

METRES 1 : 100

REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED BY C Y HO
DRAWN BY H KWONG
CHECKED BY S HOPE
IN CHARGE K CHONG
DATE 27AUG1999

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HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

OPTION 2 - PRELIMINARY CONSTRUCTION SEQUENCE OF INTERCHANGE SUBWAY AT MODY ROAD

CADD FILENAME FIG-20-4.DGN | CADD DATE 26AUG1999
SCALE 1 : 100
DRAWING NUMBER FIGURE 6.6
CONTRACT NO HDD-300 | STAGE CODE P | REV -

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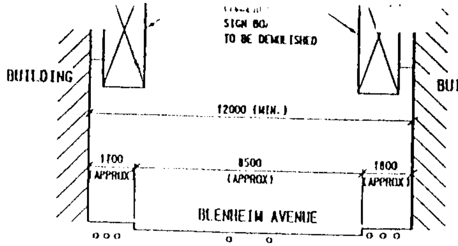
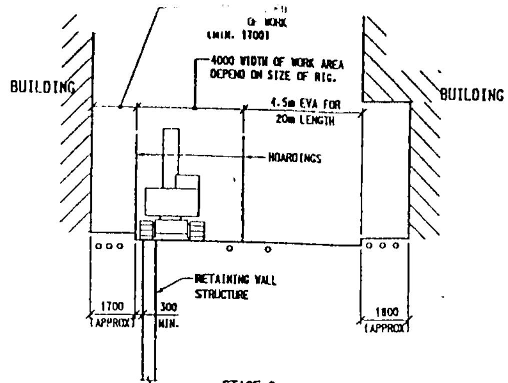


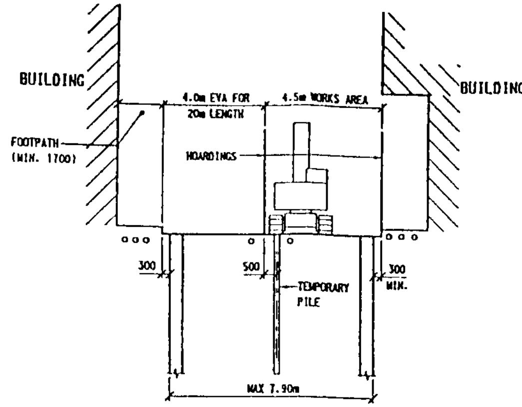
STAGE 1

1. DEMOLISHING OF ANY PROJECTION FROM THE EXISTING BUILDING.



STAGE 2

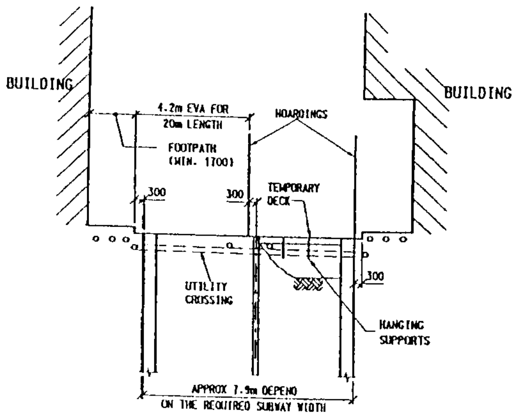
1. ERECT HOARDING.
2. CONSTRUCT TEMPORARY RETAINING WALL AT ONE SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.



STAGE 3

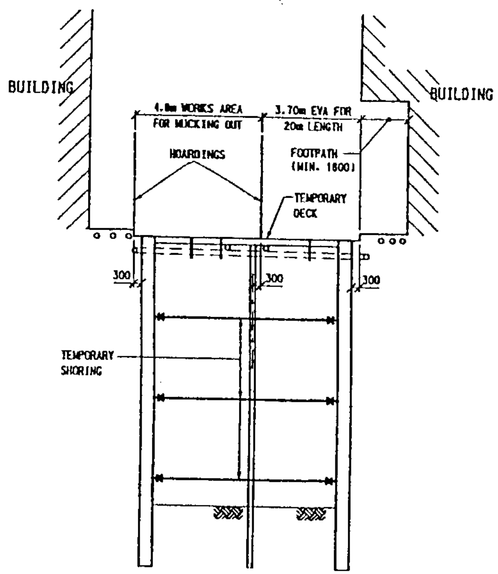
1. ERECT HOARDING.
2. CONSTRUCT TEMPORARY PILE NEAR THE SITE CENTRE.
3. CONSTRUCT TEMPORARY RETAINING WALL AT THE OTHER SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.

(PROBLEM: 6m WIDE EVA ACCESS CANNOT BE MAINTAINED)



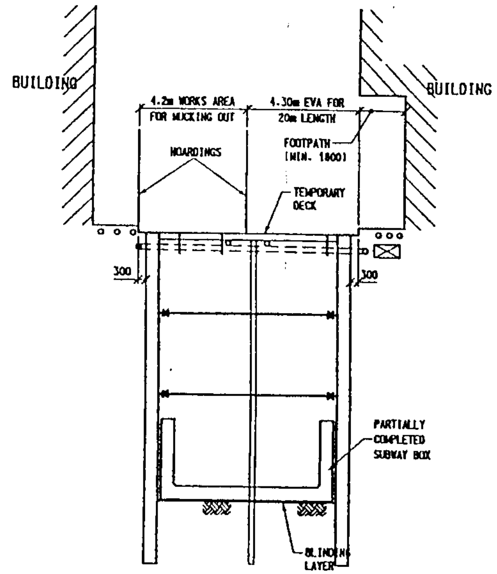
STAGE 4

1. PERFORM EXCAVATION AT ONE SIDE
2. ERECT TEMP DECK AT ON SIDE.
3. PROVIDE SUPPORT TO HANG UTILITY, WHICH IS REQUIRED TO CROSS THE ROAD.



STAGE 5

1. PERFORM EXCAVATION AT OTHER SIDE.
2. ERECT TEMP DECK AT OTHER SIDE.
3. HANG THE AFFECTED UTILITY.
4. ERECT SHORING.
5. PROCEED WITH EXCAVATION TO THE FORMATION LEVEL.



STAGE 6

1. CAST BLINDING LAYER.
2. CONSTRUCT SUBWAY BOX BOTTOM UP.
3. REMOVE TEMPORARY STRUTS.

METRES 1 : 100

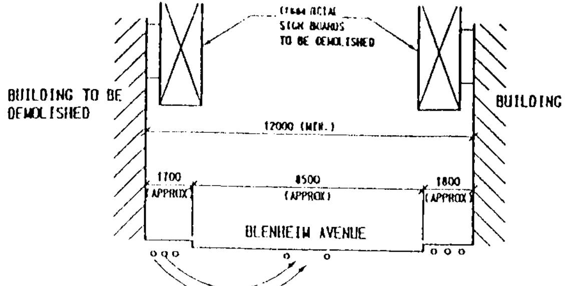
REV	DATE	BY	SUB	APP	DESCRIPTION
A	24AUG1999	CYH			SETTING OUT ADDED.

DESIGNED BY C Y HO
DRAWN BY M KWONG
CHECKED BY S YOUNG
IN CHARGE K CHONG
DATE 24AUG1999

KCR 九廣鐵路
East Rail Extensions 東鐵支線
Ove Arup & Partners Hong Kong Limited
ARUP
Supported By: Rocco Design Limited, Charles Haswell & Partners Limited, Urbis Limited

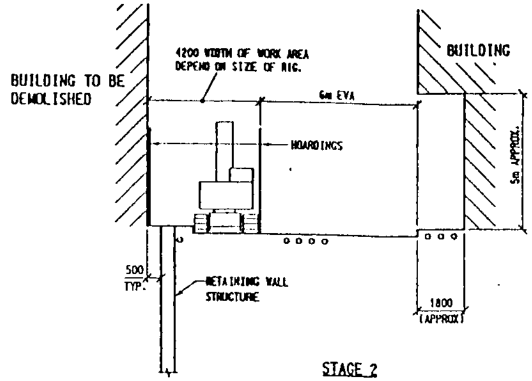
HDO-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM
OPTION 1 - PRELIMINARY CONSTRUCTION SEQUENCE OF INTERCHANGE SUBWAY AT BLENHEIM AVENUE

CADD FILENAME FIG-20-5.DGN
CADD DATE 28JULY1999
SCALE 1 : 100
DRAWING NUMBER FIGURE 6.7
CONTRACT NO HDO-300
STAGE CODE P
REV -



STAGE 1

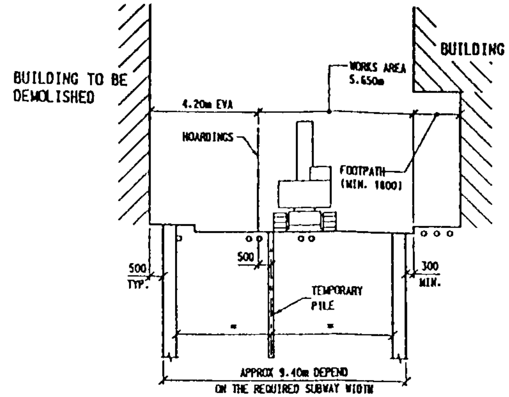
1. DEMOLISHING OF ANY PROJECTION FROM THE EXISTING BUILDING.
2. DIVERSION OF UTILITIES ADJACENT TO THE EXISTING BUILDINGS.



STAGE 2

1. ERECT HOARDING.
2. CONSTRUCT TEMPORARY RETAINING WALL AT ONE SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.
3. CONSTRUCT TEMPORARY RETAINING WALL AT THE OTHER SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.

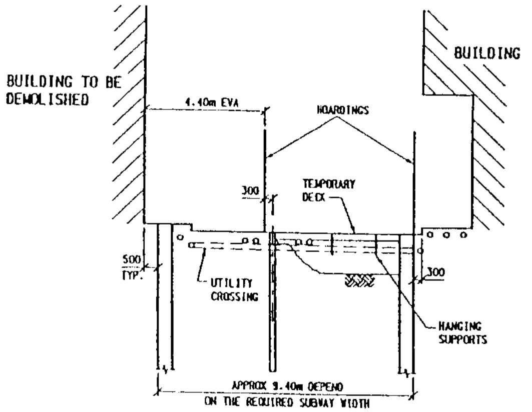
(PROBLEM: - FOOTPATH CANNOT BE MAINTAINED SO THE BUILDING MUST BE DEMOLISHED
- SPECIAL PILING MACHINE WORKING UNDER TIGHT HEADROOM IF EXISTING BUILDING IS NOT TO BE DEMOLISHED IN TIME.)



STAGE 3

1. ERECT HOARDING.
2. CONSTRUCT TEMPORARY RETAINING WALL AT THE OTHER SIDE TOGETHER WITH POSSIBLE GROUTING WORKS.
3. CONSTRUCT TEMPORARY PILE NEAR THE SITE CENTRE.

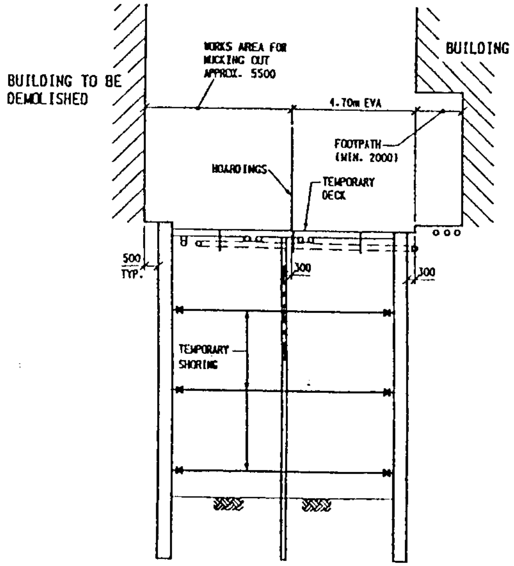
(PROBLEM: 6m WIDE EVA CANNOT BE MAINTAINED NO FOOTPATH CAN BE MAINTAINED AT ONE SIDE OF THE ROAD.)



STAGE 4

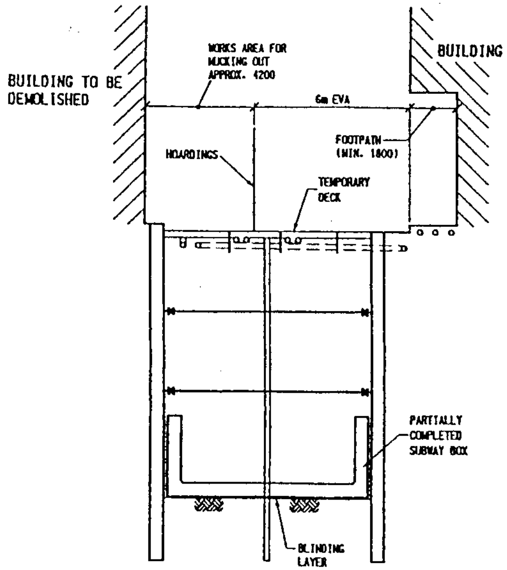
1. PERFORM EXCAVATION AT ONE SIDE
2. ERECT TEMP DECK AT ONE SIDE.
3. PROVIDE SUPPORT TO HANG THE DIVERTED UTILITY.

(PROBLEM: 6m EVA ACCESS WIDTH CANNOT BE MAINTAINED IF BUILDING IS NOT TO BE DEMOLISHED.)



STAGE 5

1. PERFORM EXCAVATION AT THE OTHER SIDE.
2. ERECT TEMP DECK AT THE OTHER SIDE.
3. HANG THE AFFECTED UTILITY.
4. ERECT SHORING.
5. PROCEED WITH EXCAVATION TO THE FORMATION LEVEL.



STAGE 6

1. CAST BLINDING LAYER.
2. CONSTRUCT SUBWAY BOX BOTTOM UP.
3. REMOVE TEMPORARY STRUTS.

METRES 1 : 100

REV	DATE	BY	SUB	APP	DESCRIPTION	REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED BY C Y HO
DRAWN BY M KWONG
CHECKED BY S HOPE
IN CHARGE K CHONG
DATE 27AUG1999

KCR 九廣鐵路 East Rail Extensions 東鐵支線

Ove Arup & Partners Hong Kong Limited ARUP

Supported by: Rocco Design Limited, Charles Haswell & Partners Limited, Ucle Limited

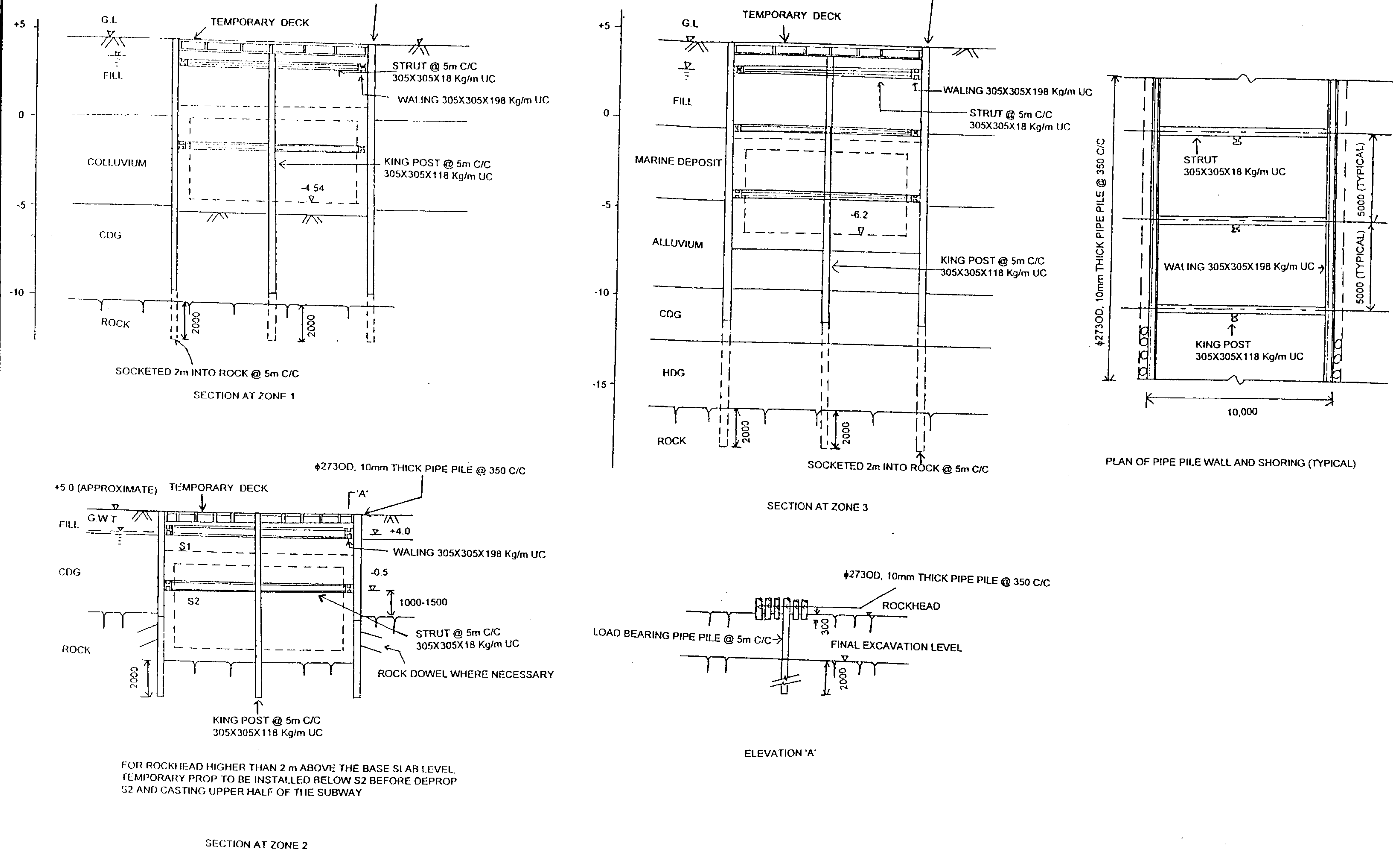
HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

OPTION 2 - PRELIMINARY CONSTRUCTION SEQUENCE OF INTERCHANGE SUBWAY AT BLENHEIM AVENUE

CADD FILENAME FIG-20-6.DGN
CADD DATE 26AUG1999
SCALE 1 : 100
DRAWING NUMBER FIGURE 6.8
CONTRACT NO HDD-300
STAGE CODE P
REV -

PRINTED BY: 02 SEP 1999
FILENAME: ...\fig-20-6.dgn

DRAWING NUMBER :



KCR 九廣鐵路

East Rail Extensions 東鐵支線

Ove Arup & Partners Hong Kong Limited

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HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

TYPICAL SUBWAY CONSTRUCTION DETAILS AND SEQUENCE

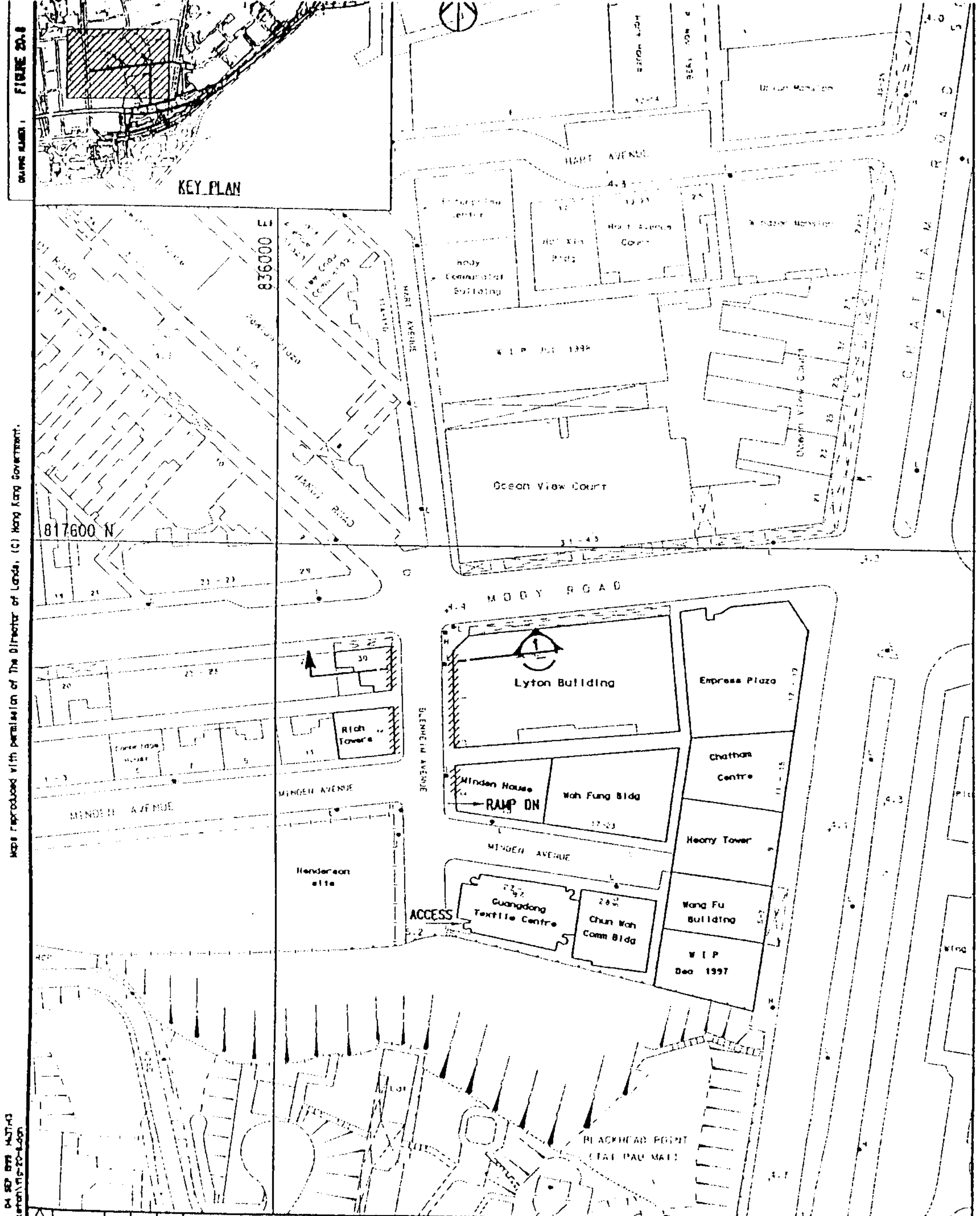
SCALE 1:200

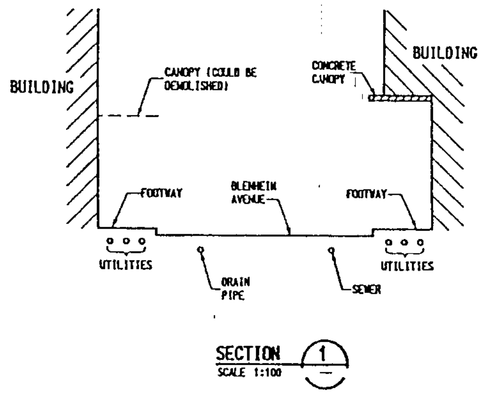
FIGURE 6.9

HDD-300

LEGEND:

SHOP FRONT





SECTION 1
SCALE 1:100

METRES 1:100

METRES 1:500

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REV	DATE	BY	SUB	APP	DESCRIPTION

REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED BY C Y HO
DRAWN BY H KWONG
CHECKED BY S HOPE
IN CHARGE C WADE
DATE

KCR 九廣鐵路

East Rail Extensions 東鐵支線

Ove Arup & Partners Hong Kong Limited

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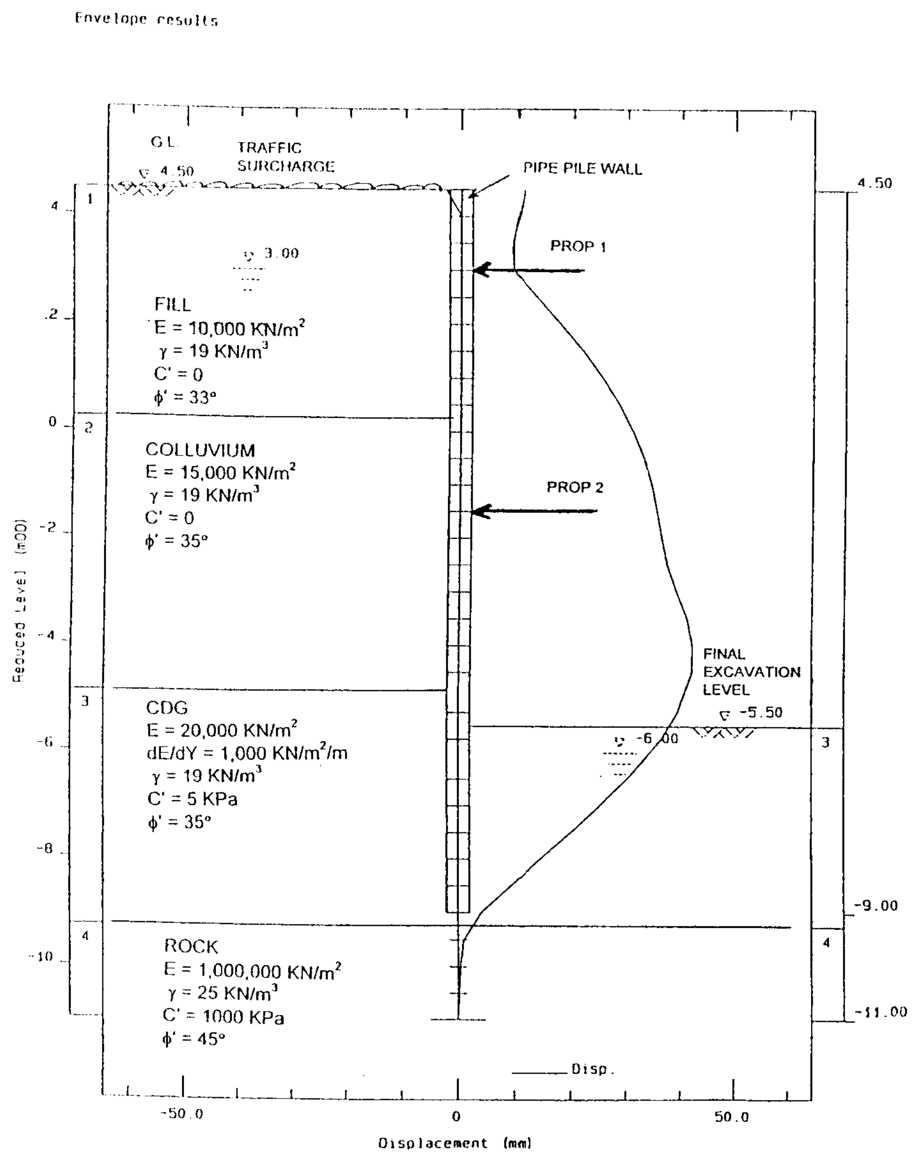
H00-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

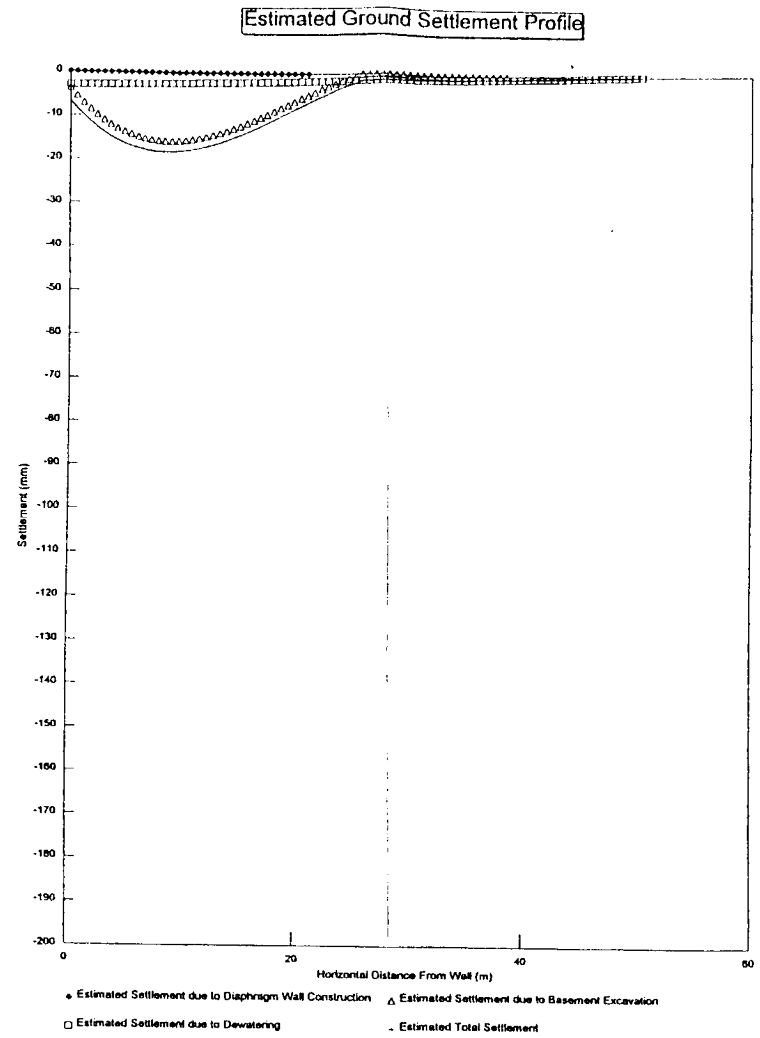
EXISTING SHOP FRONTS LAYOUT AT BLENHEIM AVENUE

CADD FILENAME: F10-20-6.DGN
CADD DATE: 02SEPT1999
SCALE: AS SHOWN
DRAWING NUMBER: FIGURE 6.10
CONTRACT NO: H00-300
STAGE CODE: T
REV: -

PRINTED BY: LDM 04 SEP 1999



TYPICAL DEFLECTION PROFILE OF PIPE PILE WALL



TYPICAL SETTLEMENT PROFILE AT MODY ROAD

KCR 九廣鐵路	East Rail Extensions 東鐵支線
Ove Arup & Partners Hong Kong Limited	ARUP
HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM	WALL AND GROUND MOVEMENT PROFILES
SCALE	NTS AS SHOWN
DRAWING NUMBER	FIGURE 6.11
CONTRACT NO	HDD-300

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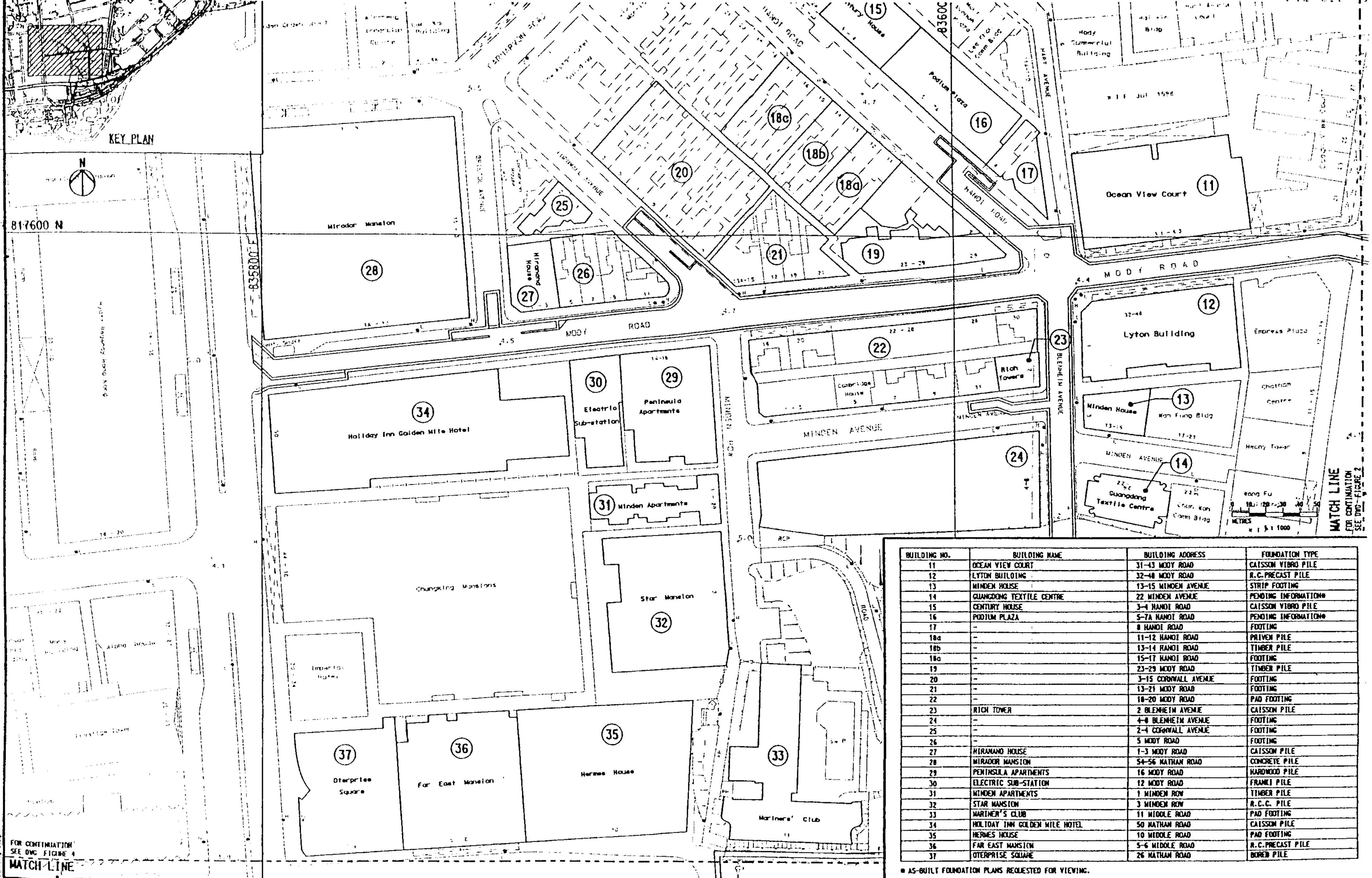


BUILDING NO.	BUILDING NAME	BUILDING ADDRESS	FOUNDATION TYPE
11	OCEAN VIEW COURT	31-43 MODY ROAD	CAISSON VIBRO PILE
12	LYTON BUILDING	32-48 MODY ROAD	R.C.PRECAST PILE
13	MINDEN HOUSE	13-15 MINDEN AVENUE	STRIP FOOTING
14	GUANGDONG TEXTILE CENTRE	22 MINDEN AVENUE	PENDING INFORMATION*
15	CENTURY HOUSE	3-4 HANOI ROAD	CAISSON VIBRO PILE
16	PODIUM PLAZA	5-7A HANOI ROAD	PENDING INFORMATION*
17	-	8 HANOI ROAD	FOOTING
18a	-	11-12 HANOI ROAD	DRIVEN PILE
18b	-	13-14 HANOI ROAD	TIMBER PILE
18c	-	15-17 HANOI ROAD	FOOTING
19	-	23-29 MODY ROAD	TIMBER PILE
20	-	3-15 CORNWALL AVENUE	FOOTING
21	-	13-21 MODY ROAD	FOOTING
22	-	18-20 MODY ROAD	PAD FOOTING
23	RICH TOWER	2 BLENHEIM AVENUE	CAISSON PILE
24	-	4-8 BLENHEIM AVENUE	FOOTING
25	-	2-4 CORNWALL AVENUE	FOOTING
26	-	5 MODY ROAD	FOOTING
27	HIRANAND HOUSE	1-3 MODY ROAD	CAISSON PILE
28	MIRADOR MANSION	54-56 NATHAN ROAD	CONCRETE PILE
29	PENINSULA APARTMENTS	16 MODY ROAD	HARDWOOD PILE
30	ELECTRIC SUB-STATION	12 MODY ROAD	FRANKI PILE
31	MINDEN APARTMENTS	1 MINDEN ROW	TIMBER PILE
32	STAR MANSION	3 MINDEN ROW	R.C.C. PILE
33	MARINER'S CLUB	11 MIDDLE ROAD	PAD FOOTING
34	HOLIDAY INN GOLDEN MILE HOTEL	50 NATHAN ROAD	CAISSON PILE
35	HERMES HOUSE	10 MIDDLE ROAD	PAD FOOTING
36	FAR EAST MANSION	5-6 MIDDLE ROAD	R.C.PRECAST PILE
37	OTERPRISE SQUARE	26 NATHAN ROAD	BORED PILE

* AS-BUILT FOUNDATION PLANS REQUESTED FOR VIEWING.

KCR 九廣鐵路

East Rail Extensions 東鐵支線

Ove Arup & Partners Hong Kong Limited

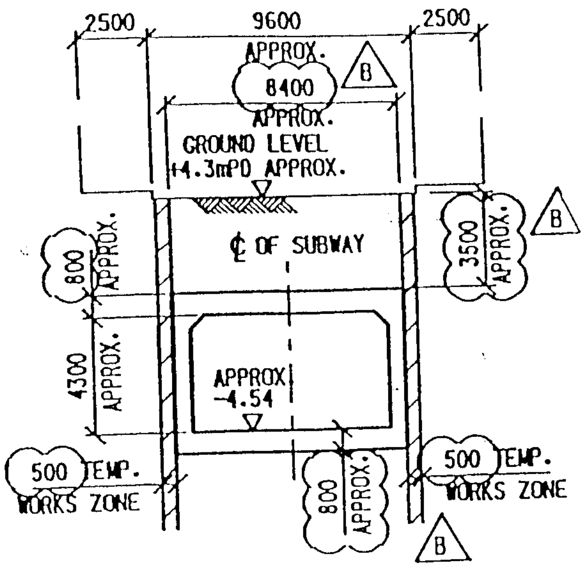
ARUP

HDO-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

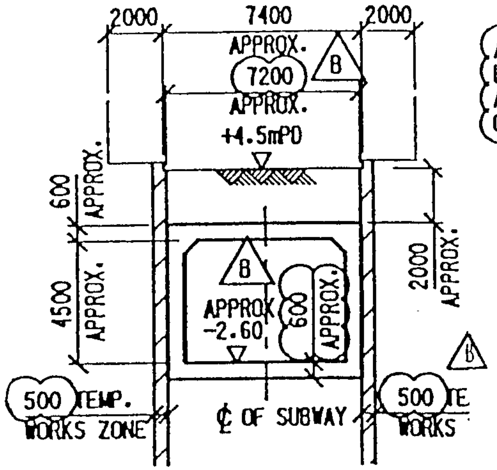
FOUNDATION TYPE OF BUILDING ALONG PROPOSED ALIGNMENT

CADD FILENAME	F10-3.DGN
CADD DATE	26JULY199
SCALE	1 : 1000
DRAWING NUMBER	FIGURE 6.12
CONTRACT NO	HDO-300
STAGE CODE	P

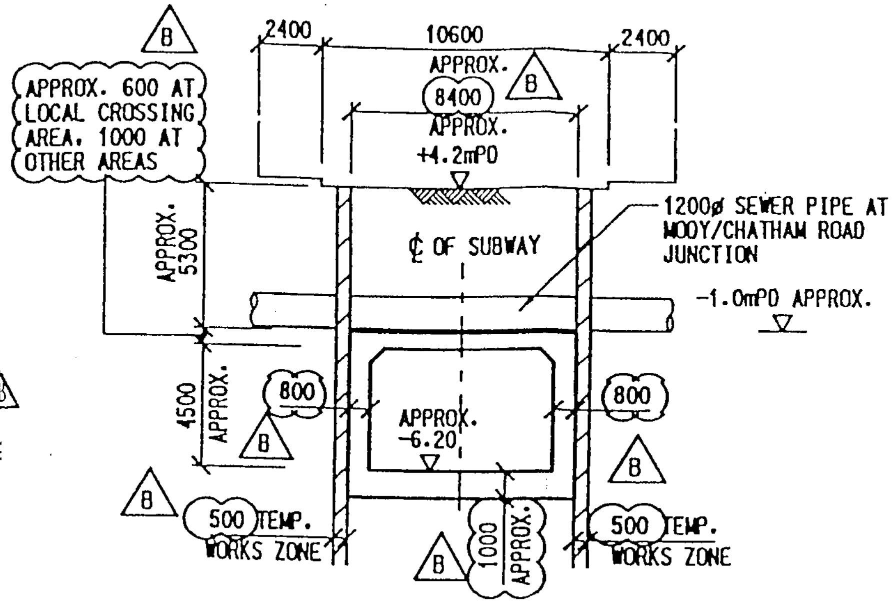
DESIGNED BY I. CHAN
DRAWN BY H. KWONG
CHECKED BY S. YOUNG
IN CHARGE K. CHONG



TYPICAL SECTION MODY ROAD



TYPICAL SECTION BLENHEVIN AVENUE



TYPICAL SECTION CHATHAM ROAD CROSSING

REV	DATE	BY	CHK	APP	DESCRIPTION	REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
DRAWN BY
CHECKED BY
IN CHARGE
DATE

KCR 九廣鐵路 East Rail Extensions 東鐵支線

Ove Arup & Partners Hong Kong Limited ARUP

Supported by: Pacco Design Limited, Charles Haswell & Partners Limited, Ulbs Limited

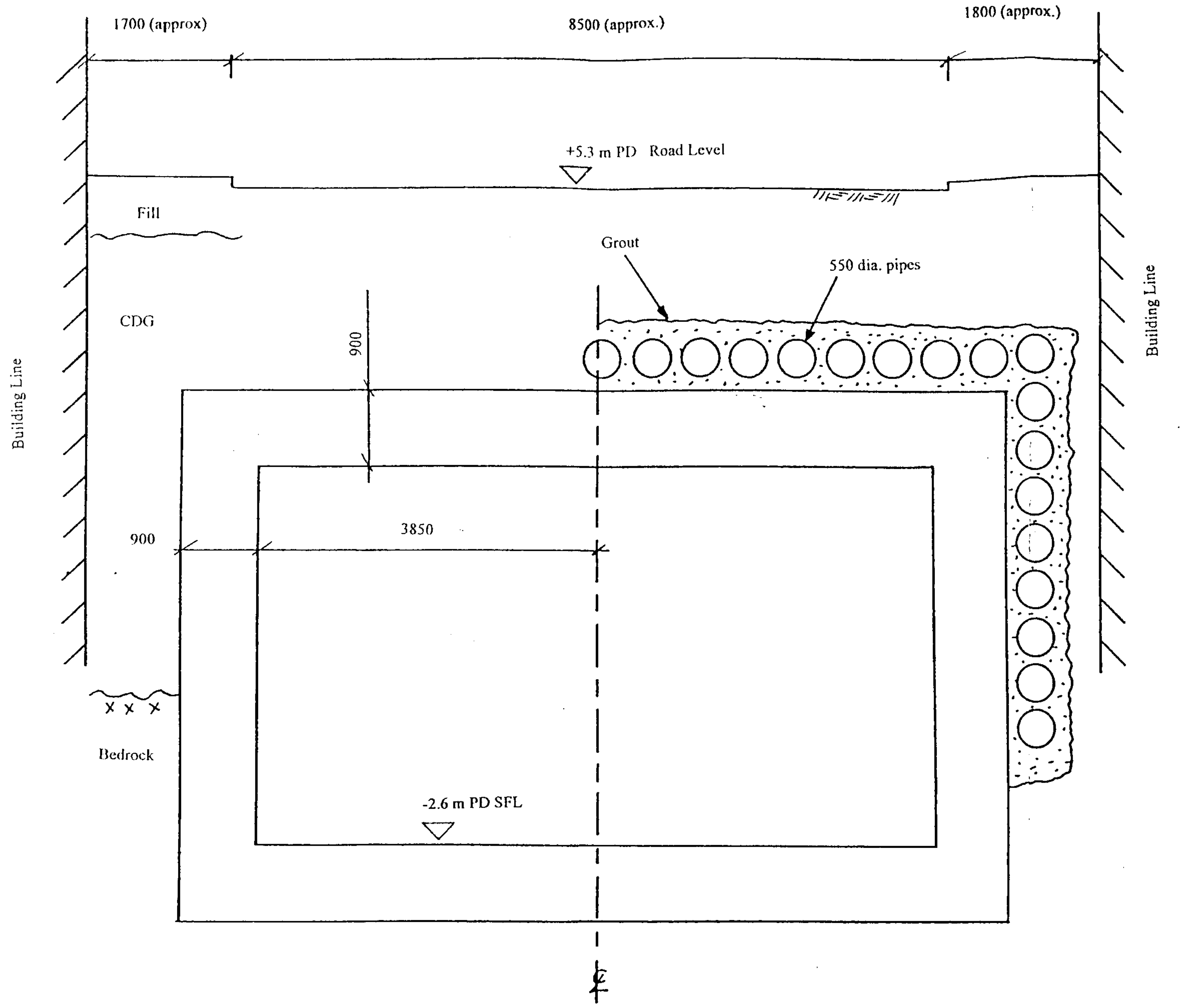
HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM

TYPICAL SUBWAY CROSS SECTIONS

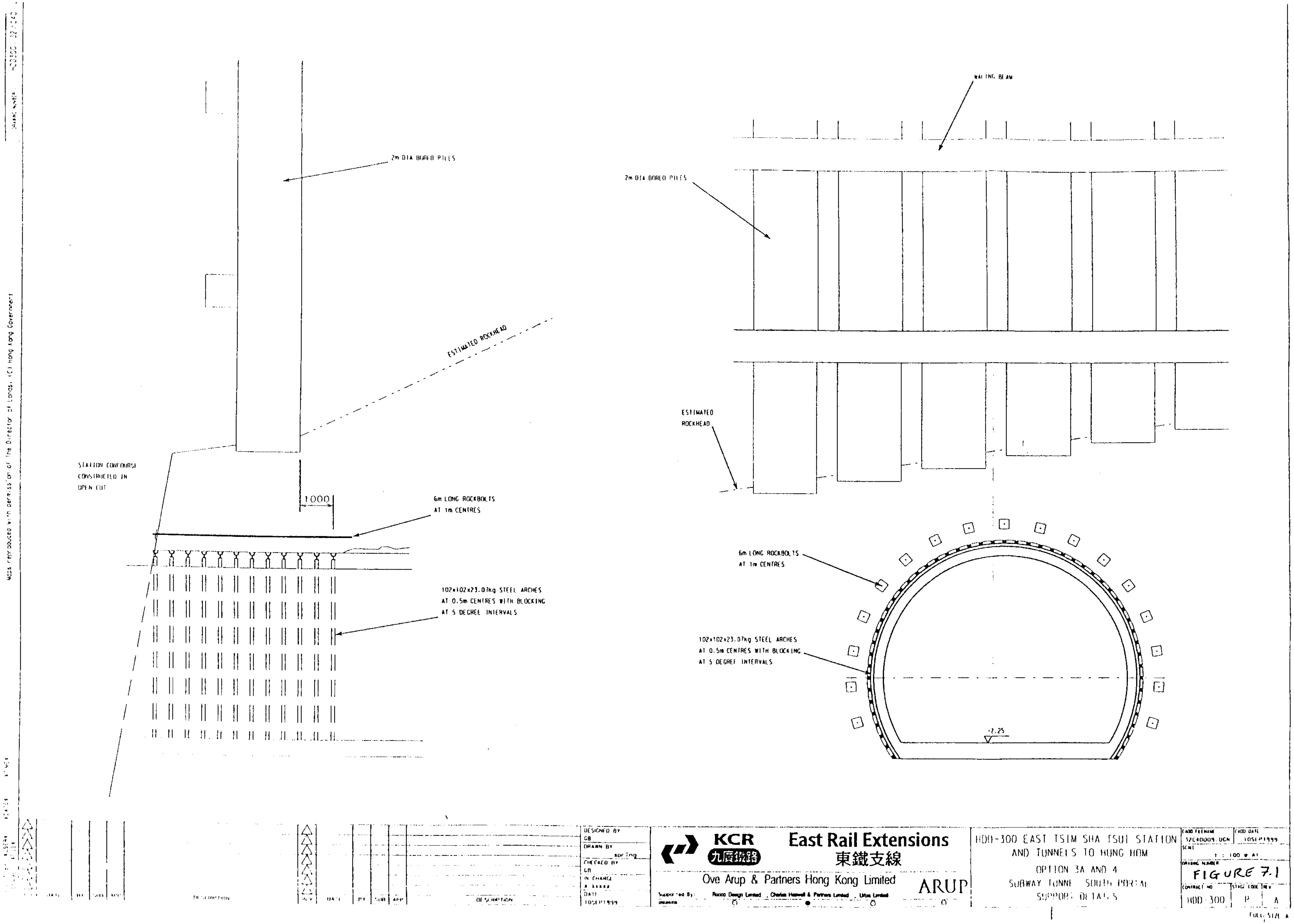
SCALE 1:200

FIGURE 6.13

CONTRACT NO HDD-300



KCR 九廣鐵路 East Rail Extensions 東鐵支線		HDD-300 EAST TSIM SHA TSUI STATION AND TUNNEL TO HUNG HOM	DRAWING NUMBER FIGURE 6.14
Ove Arup & Partners Hong Kong Limited	ARUP	Typical Section Microtunnelling	


2m DIA BORED PILES
ESTIMATED ROCKHEAD
STATION CONCOURSE CONSTRUCTED IN OPEN CUT
1000
6m LONG ROCKBOLTS AT 1m CENTRES
102x102x23.07kg STEEL ARCHES AT 0.5m CENTRES WITH BLOCKING AT 5 DEGREE INTERVALS
WALING BEAM
2m DIA BORED PILES
ESTIMATED ROCKHEAD
6m LONG ROCKBOLTS AT 1m CENTRES
102x102x23.07kg STEEL ARCHES AT 0.5m CENTRES WITH BLOCKING AT 5 DEGREE INTERVALS
-2.25
KCR 九廣鐵路
East Rail Extensions
東鐵支線
Ove Arup & Partners Hong Kong Limited
ARUP
HDD-300 EAST TSIM SHA TSUI STATION AND TUNNELS TO HUNG HOM
OPTION 3A AND 4
SUBWAY TUNNEL SOUTH PORTAL SUPPORT DETAILS
1 : 100 @ A1
FIGURE 7.1
HDD-300
P
A