HV Cables – General Construction Methodology

PE424-F7001-R00-001-001

ESBI Engineering & Facility Management Ltd
Stephen Court, 18/21 St Stephen's Green, Dublin 2, Ireland
Telephone+353-1-703 8000 Fax+353-1-661 6600
www.esbi.ie

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ESB International

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Prepared by:	**Colin Choyce**
Title:	

APPROVED: M. Byrne ***TITLE:*** ***Consultant***	***DATE:*** 09/01/2012

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Input of Additional Information and Photographs

Change History of Report

Date	New Rev	Author	Summary of Change
9/01/2012	001	C. Choyce	Further details and Photographs added

Executive Summary

The purpose of this report is to inform the reader of the typical methods for installing an underground cable along public roads. This includes information about typical trench construction, duct installation, trench reinstatement and joint bay construction including reinstatement.

The report contains some information to briefly describe the equipment required for cable pulling and a short description of the process including typical resources required on site. Information is also included in relation to heavy or large equipment that may be on site during cable jointing.

The information and descriptions contained within this report are typical of the construction process associated with high voltage underground cables. No project specific information is contained within the report. Where information is required in relation to any particular project, please contact the relevant personnel in the ESBI Engineering – High Voltage Cables

Contents

1 HV Cables – Construction Methodology

1.1 Site Preparation

It is important that the civil works associated with the cable trench are planned in advance in order to ensure that the work is completed in the most efficient manner with the least disruption to the general public.

This includes preplanning of works such as traffic management, working hours, permits, public consultation, site access, site lay down, signage/cones, Heras fencing etc. This preplanning enables a safe efficient working environment where the potential for accidents or mistakes is minimised.

1.2 Identifying the Actual Route of the High Voltage Cable

The majority of high voltage cable routes are located along public roads and open spaces. It is very unusual for a cable route to cross private open ground but this may be the case on occasion.

The civil contractor will scan the ground using a cable avoidance tool (CAT), carry out a visual inspection of existing services and compare the information with the utility service records which they will have obtained from the various service providers in advance. The cable route identified on the design drawing is verified by excavating a number of slit trenches positioned perpendicular to the route of the cable at intervals of approximately 50m to 200m depending on the site location and the congestion of existing services. Virtual slit trenches may be carried out by using Ground Penetrating Radar (GPR). This is a non intrusive technique of gathering information on the location of underground services without excavation of the public road. This technique is used to verify cable routes and joint bay locations while minimising disruption to the general public. If any previously unidentified services are discovered the site engineer will adjust the cable route accordingly.

1.3 Extent of the Civil Works

High voltage underground cable is supplied in pre-ordered lengths of up 900m on large cable drums. A typical cable length on one drum would be in the order of 600m/750m. The overall installation of a cable route over a large distance is broken down into sections of cable that are connected using a cable joint. These cable joints are installed in joint bays. Joint bays are typically concrete structures buried underground ranging in size up to 6m long, 2.5m wide and 1.8m deep. The cable may weigh anything from 7kg/m up to 50kg/m depending on the cable size required. When the cable is on the cable drum, the combined weight may be up to 20000kg.

If the cable was installed directly in the ground the entire trench from joint bay to joint bay must be fully excavated. The advantage with installing cable in pre-laid ducts is that only a short section of cable trench, up to 100m is open at any time. This helps to minimise the impact on the local residents and minimise traffic impact at any given time. The site also progresses along the route of the cable on a daily basis which again has the effect of reducing the impact on local residents.

1.4 Excavating the Trench

There are currently a number of different trench cross sections that may be installed depending on the voltage, type and size of the proposed cable circuit. A number of the current standard trench cross sections have been included in the appendix.

Typically the trench width is marked on the ground using standard line marking spray paint. The overall trench width will vary depending on the circuit or circuits to be installed. The typical width of the trench ranges from 600mm to 1250mm. The two edges of the trench are then saw cut using a concrete saw. A rock breaker attached to an appropriate excavator then breaks the surface to a depth of approximately 150mm. The trench is then excavated to a depth of 1200mm by using a toothless bucket attached to the excavator machine. If underground services are present in the trench, excavation around these services shall be hand dug. The spoil material is removed from site by a dumper or suitable lorry and is treated if required before being disposed of appropriately in a licensed facility. The bottom of the trench should be graded. Any water which gathers in the trench should be collected, treated appropriately on site before being disposed of in accordance with the conditions set out by the relevant authorities.

Typical resources on site at any time are a crew of one excavator operator, a banks man and up to three other operatives. The crew will operate an excavator and hand held motorised equipment. They will also require a large van, dumper truck and welfare facilities. The refuelling of all machinery shall take place in the contractor’s site compound / lay down located off site.

1.5 Installing HDPE Ducts in the Trench

Assuming the cable ducts are being installed in a trench in the public road, a 100mm thick bed of CBM4 (CL 1039) will be laid along the section of open trench. The three power cable ducts are then placed on the bed of CBM4 in the formation shown on the appropriate trench cross section drawing. The ducts are then surrounded in CBM4 (CL 1039) to a level 100mm above the top of the power cable ducts. The CBM4 (CL 1039) is then compacted to CL 1035 of NRA Specification for road works (15N/mmsq after 7 days). A rope is inserted into the ducts to facilitate cable pulling.

An as constructed record of the duct locations to the relevant specification is then surveyed by a qualified surveyor so that the location of the power cable can be identified at any time in the future.

A cable warning slab is then placed on top of the CBM4 (CL 1039) with the communications ducts installed as shown on the appropriate trench cross section. The remainder of the trench is then backfilled as per the trench cross section drawing. All trench work must comply with the ‘Guidelines for Opening, Backfilling and Reinstatement of trenches in Public Roads’ and any other conditions imposed on the contractor by the relevant road authority.

Once the trench reinstatement has been completed, the appropriate resurfacing of the road is carried out as per agreement with the relevant local roads authority. This completes the civil works on this section of the cable route and the following day a new section of road can be excavated and the ducting installed. The civil works proceed in this manner along the cable route until all ducting is installed.

Figure 1 : Typical 110kV Trench Excavation (Ducts in Trefoil Formation)

1.6 Conflict with Third Party Services

When installing the cable trench some conflict with third party services is unavoidable. When installing a cable trench parallel to an existing underground service, a minimum of 300mm clearance must be maintained from the edge of the communication ducts to the edge of the third party duct. This allows for a separation of approximately 375mm to the edge of the power cable duct when arranged in trefoil formation. A minimum of 300mm clearance must be maintained from the edge of the power cable ducts when arranged in flat formation. This distance may be increased depending on the size and depth of the third party service. If there are high pressure services in the area the third party service provider must be contacted before excavation takes place to agree the appropriate working methods. For large third party pipes or high pressure pipelines a minimum of 600mm separation from the edge of the communication ducts to the edge of the third party duct should be maintained. This allows for a separation of approximately 675mm to the edge of the power cable duct when arranged in trefoil formation. A minimum of 600mm clearance must be maintained from the edge of the power cable ducts when arranged in flat formation.

When crossing third party services a 300mm clearance is maintained at all times. It is good practise to route high voltage cables under existing services whenever possible as this reduces the possibility of cable faults from 3rd party excavations. This however is not always possible. As a general rule high voltage cables should not be installed at a depth of less than 700mm.

The level and position of all third party services crossed along the cable route must be recorded by the qualified surveyor for the route record.

1.7 Conflict with Water Courses

When installing a cable route along a road it is likely that a number of water courses may be encountered along the route. These may take the form of a bridge over a river or a culvert.

The preferred option is to install the power cables ducts within the road structure above the deck or key stones of the bridge structure. If there is not sufficient depth within the road structure then alternative route options must be considered. In this scenario it may be possible to attach the power cable ducts to the side of the bridge, construct a new cable bridge adjacent to the existing bridge or install the cables in the land adjacent to the bridge or road. The power cable ducts will be installed in a trench as described in section 1.5 above. This involves installing the ducts below the water course by cut and cover methods provided the relevant authorities consent to such an installation. If this is not possible trenchless installation methods must be considered. These will be discussed in section 1.9

If the water course passes through a culvert under the road it is most likely that the cable may be installed above or below the culvert. In the unlikely event that this is not possible then the power cable will again have to be routed to the side of the road/culvert in the manner described in the paragraph above.

1.8 Construction of Joint Bays

The location of joint bays will be selected to maximise each section length of cable. The locations chosen will also be determined by the density of existing services, likely disruption to traffic, consultation with local residents and space requirements for cable drums and cable pulling equipment.

The joint bay is normally located within or adjacent to the public road. An excavation is undertaken, approximately 7m x 3m and 2m deep. A reinforced concrete joint bay is then constructed within the excavation. An alternative is to lay a blinding lay of compacted material and to position a precast joint bay into the excavation. This method reduces the amount of time required to construct a joint chamber.

The locations of all joint bays are surveyed by a qualified surveyor and included on the as constructed record.

A typical Joint bay drawing is included in the appendix. The photograph below is an example of a typical joint bay excavation located adjacent to the public road.

C2 communication chambers are constructed adjacent to each joint bay along the cable route. The communication ducts are installed within the trench above the power cable ducts from C2 chamber to C2 chamber. This allows for associated communications fibre cable to be installed along the circuit.

The standard drawings for C2 communications chamber can be found in the appendix.

Figure 2: Typical Joint Bay Construction Adjacent to Public Road

1.9 Power Cable Installation

Once the underground cable ducts have been installed from joint bay to joint bay it is then necessary to carry out a test to ensure that they have been installed to the required standard. To do this the ducts are thoroughly cleaned, brushed and a propriety mandrel is pulled through the ducts a number of times. The contractor must provide signed proof that these tests were carried out successfully.

The three power cable drums are then brought to site on a suitable transporter. They are removed from the transporter by a crane and positioned in line at the rear of the joint bay. A cable winch attached to an appropriate vehicle is positioned at the next joint bay location. The power cable is then pulled through the ducting using a steel wire and the cable winch.

Once the power cables have been installed they are then jointed to each other by a cable joint. This involves the placing of a large container on top of the joint chamber. This container contains all of the tools required for the jointing process. It also helps to create a clean dry environment for jointing which will help prevent the contamination of the joint by foreign bodies.

This work will be carried out by a jointer and an assistant. They will travel to site in a large van. On completion the three joints will be supported in the joint chamber on a number of sand bags.

Figure 3: Typical HV Cable Installation

1.10 Reinstatement of Joint Chambers

Once the cable joints have been completed the joint bays will be permanently reinstated. The actual joints will be surrounded by a layer of thermal sand approximately 100mm/150mm thick. The remainder of the joint chamber will be backfilled using appropriate material as required by the site conditions and relevant road authority.

1.11 Underground Cable Physical Impact

It is the policy of EirGrid and ESB Networks that, in so far as possible, high voltage underground cable shall only be installed under public roads. One of the advantages of laying cables under a roadway is that there is usually no permanent impact on the environment additional to that caused by the presence of the roadway. When an underground cable is laid under an existing roadway there is a short term temporary impact during the construction phase.

A standard underground cable installation will complete between 50 and 150 linear metres of trench in a roadway per day depending on the site conditions. As with all road works, traffic management procedures are required when installing cables within public roads. It may be a requirement that some of the roads would have to be closed for the duration of the works along that section. This can have a disruptive effect on local residents over the period of the installation works. In the case of wider primary roads one carriage may have to be closed with use of the other carriageway restricted and controlled by temporary traffic lights for the duration of the works.

Existing road bridges over water courses can not always accommodate high voltage cables. In such cases it will be necessary pass underneath the water course often using a trenchless technology such as directional drilling.

2 Trenchless Installation Methods

2.1 Why use Trenchless Technology Installation Methods

There are a number of examples when it is necessary to install cable ducting using trenchless technology. This may be where the cable crosses a river, railway line, motorway or even a location very congested with existing services.

The trenchless technology chosen may depend upon many different factors such as the length of the trenchless section, ground conditions at the specific site, suitability of staging areas either side of the trenchless section and budget costs. These trenchless installation methods may involve horizontal directional drilling, micro tunnelling, pipe ramming, pipe jacking, moling or auger boring. The most commonly used method of trenchless installation utilised on HV cable circuits in Ireland at present is horizontal direction drilling.

2.2 Description of a Typical Horizontal Directional Drill

The drilling contractor prepares a site area up to $40m^2$, accommodated within the agreed site area. If areas are overgrown with thick vegetation it would be removed sympathetically and disposed of via a licensed waste contractor. The area is then levelled where required by using the front bucket of an 180^0 excavator; however there is no requirement for the working area to be stripped of topsoil. Instead it may be overlain with a suitable geotextile material and 200mm of appropriate stone. The boundaries of the rig up area and exit area would both be defined with security fencing positioned to ensure adequate access is maintained.

The drilling rig and fluid handling units may be placed on bunded 0.5mm PVC to contain any fluid spills and storm water run-off. Entry and exit pits (1m x 1m x 2m) are excavated using a 180^0 excavator and the resultant spoil bunded in 0.5mm PVC liner within the designated working areas. A 1m x 1m x 2m steel box is placed in the ground to control drilling fluid returns from the borehole. Drilling fluid is pumped down the drill string and through the down hole motor, which converts the fluids hydraulic power to mechanical power and rotates the drill bit. The drill bit is oriented by the surveyor, and the driller pushes the drill string into the ground maintaining the bore path. The drilled cuttings are flushed back by the drill fluid flowing via nozzles in the bit, up the annulus to surface, where they are separated from the fluid fraction for disposal. A comprehensive closed-loop drilling fluid mixing and circulation system with recycling capability is utilised to minimise the volume of fluids required on site. Constant monitoring of fluid volume, pressure, pH, weight and viscosity is undertaken. Constant attention is given to amount of cuttings produced so that no over cutting takes place and that hole cleaning is maintained. The mud returns are pumped to the circulation system trailer by means of a bunded centrifugal pump.

A steering system, guided by tri-axial magnetometers and accelerometers that provide real time directional information to the surveyor at the driller’s console, is used to navigate the bores.

Once the first pilot hole has been completed a hole-opener or back reamer is fitted at the exit side and pulled back through the bore to the entry side. A drill pipe is added at the exit side to ensure that a mechanical presence is always present within the bore.

On completion of the hole-opening phase a towing assembly consisting of tow heads, a swivel and a reamer will be used to pull the ducts into the bore. Close attention is paid to modelled drag forces during pullback with constant monitoring of load stress undertaken to ensure that modelled tensile stress, collapse pressures, hoop stress and buckling stress are not exceeded.

Figure 4: Typical HDD rig site area

On completion of the works, the stone and geo-membrane are carefully removed using a backhoe or 360^0 excavator and transported to a licensed disposal unit. The site area is reinstated as per the landowner and statutory requirements

The ducts are tested and proved and the duct bundles are also gyro-surveyed to provide an accurate as constructed record.

Typical plant to be utilised on site would comprise the following: -

2 No. 4 x4 Twin cab pick-up truck

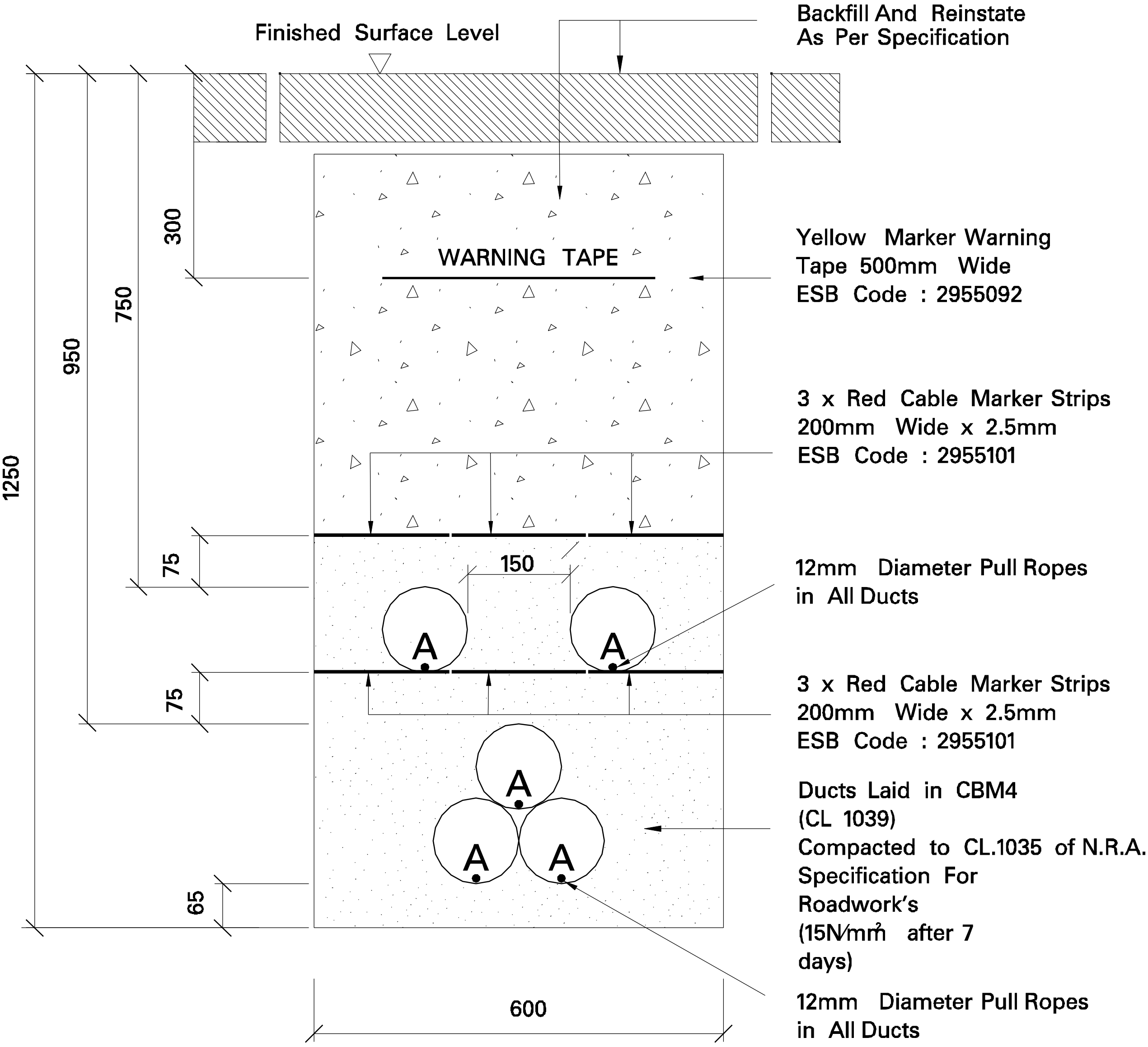
1 No. Luton Box Van

JCB 3CX 180° Backhoe Loader

Terrain 7m Telehandler.

JCB Fastrac and 2000 gallon bowser

A crew of approximately six people operate all of the above equipment.



A = 125mm Outer Diameter HDPE ESB Approved Duct, SDR = 17.6, ESB Code : 9317552

All Dimensions in Millimetres

ESB International

ESBI Engineering & Facility Management Ltd
Stephen Court, 18/21 St Stephen's Green, Dublin 2 Ireland
Telephone + 353-1-703 8000 Fax + 353-1-661-5359
www.esbi.ie
Registered Office as above
Registered in Ireland No. 155249

Rev	Date	Revision Description	Drn	Prod	Ver	App
5	10/11	NEW REVISION	JD	JD	JD	JD
4	4/11	Trench width changed to 600 Millimetres	JM	JM	JD	JD
3	03/10	Trench Dimensions Updated	DR	RD	KC	RD
2	03/09	Trench Dimensions Updated	DR	DR	KC	JD
1	02/09	Trench Dimensions Updated	JD	KC	JD	JD

Purpose of issue – Preliminary unless indicated

Tender ☐ Client Approval ☐ Construction ☐ As-built ☐ Revised ☐

Drawn	Produced	Verified	Approved	Approved date
J.Dillon	J.Dillon	J.Daly	J.Daly	18/10/11

Client Ref	No. of Shts	Size	Scale
TC200007	3/7	A4	1:10

Drawing Number: PE424–D7001–001–003–005 (SHEET REV)

Client: ESB NETWORKS

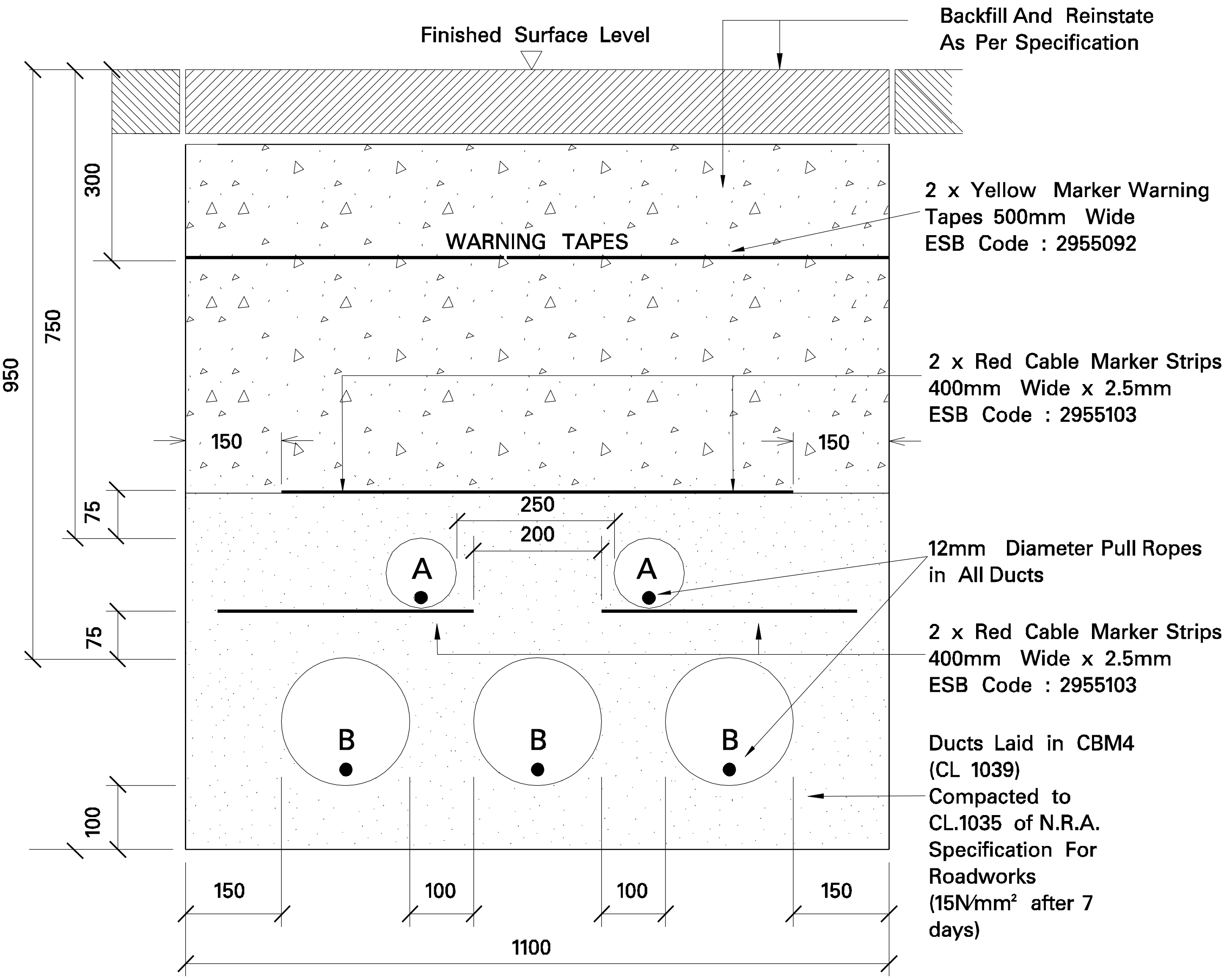
Project: HV Cables Standards

Drawing Title:
TRENCH CROSS SECTION
110 kV SINGLE CIRCUIT
TREFOIL 5 WAY DUCT FORMATION

Contract: CABLE SERVICES TO ESB

Production Unit: High Voltage Engineering

A4 CAD



A = 125mm Outer Diameter HDPE ESB Approved Duct, SDR = 17.6, ESB Code : 9317552

B = 200mm Outer Diameter HDPE ESB Approved Duct, SDR = 17.6, ESB Code : 9317590

All Dimensions in Millimetres

ESB International

ESBI Engineering & Facility Management Ltd
Stephen Court, 18/21 St Stephen's Green, Dublin 2 Ireland
Telephone +353-1-703 8000 Fax +353-1-661-5359
www.esbi.ie
Registered Office as above
Registered in Ireland No. 155249

Rev	Date	Revision Description	Drn	Prod	Ver	App
2	10/11	NEW REVISION	JD	JD	JD	JD
1	03/09	NEW REVISION	DR	DR	KC	JD

Purpose of issue – Preliminary unless indicated
Tender ☐ Client Approval ☐ Construction ☐ As-built ☐ Revised ☐

Drawn	Produced	Verified	Approved	Approved date
J.Dillon	J.Dillon	J.Daly	J.Daly	18/10/11

Client Ref	No. of Shts	Size	Scale
TC200007	5/7	A4	N/A

Drawing Number: PE424–D7001–001–005–002 (SHEET REV)

Client: ESB NETWORKS

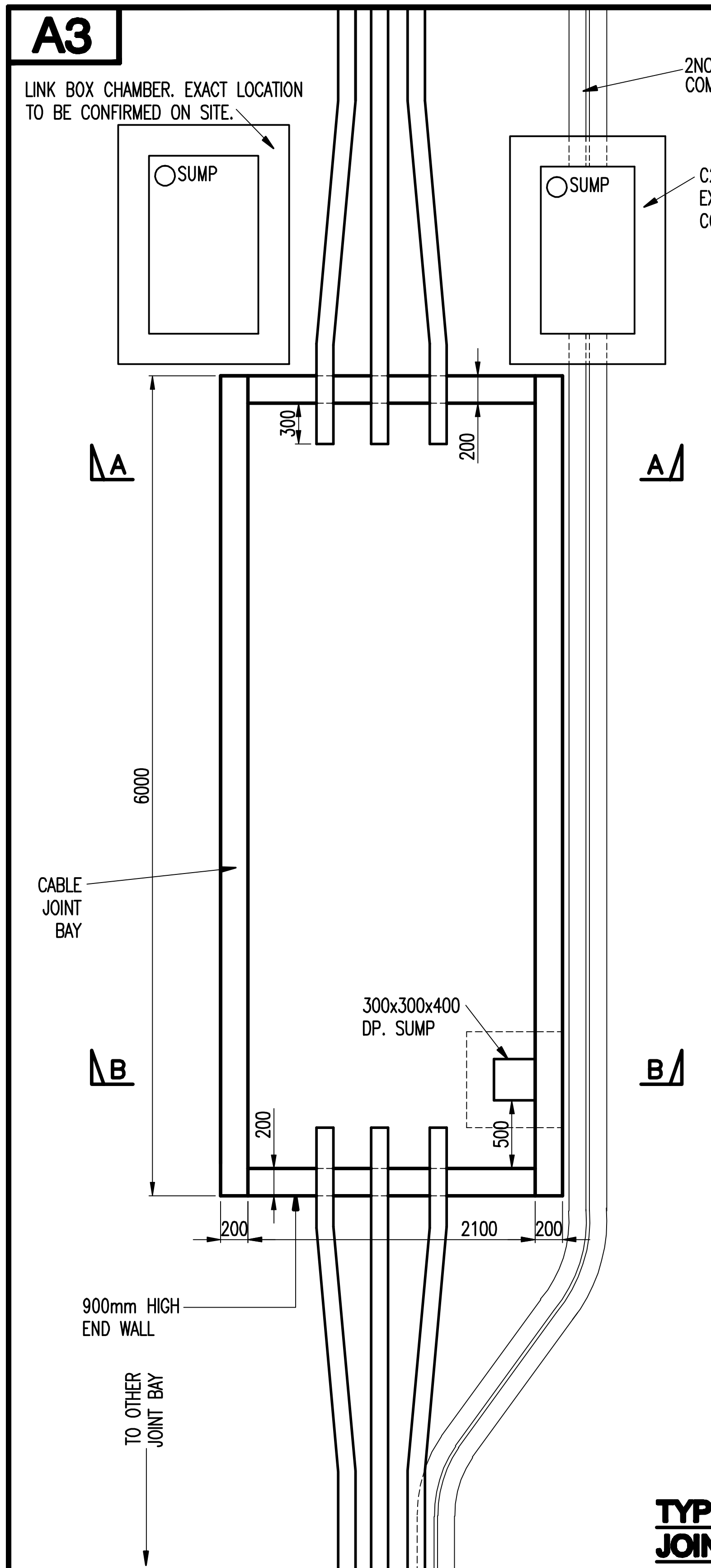
Project: HV Cables Standards

Contract: CABLE SERVICES TO ESB

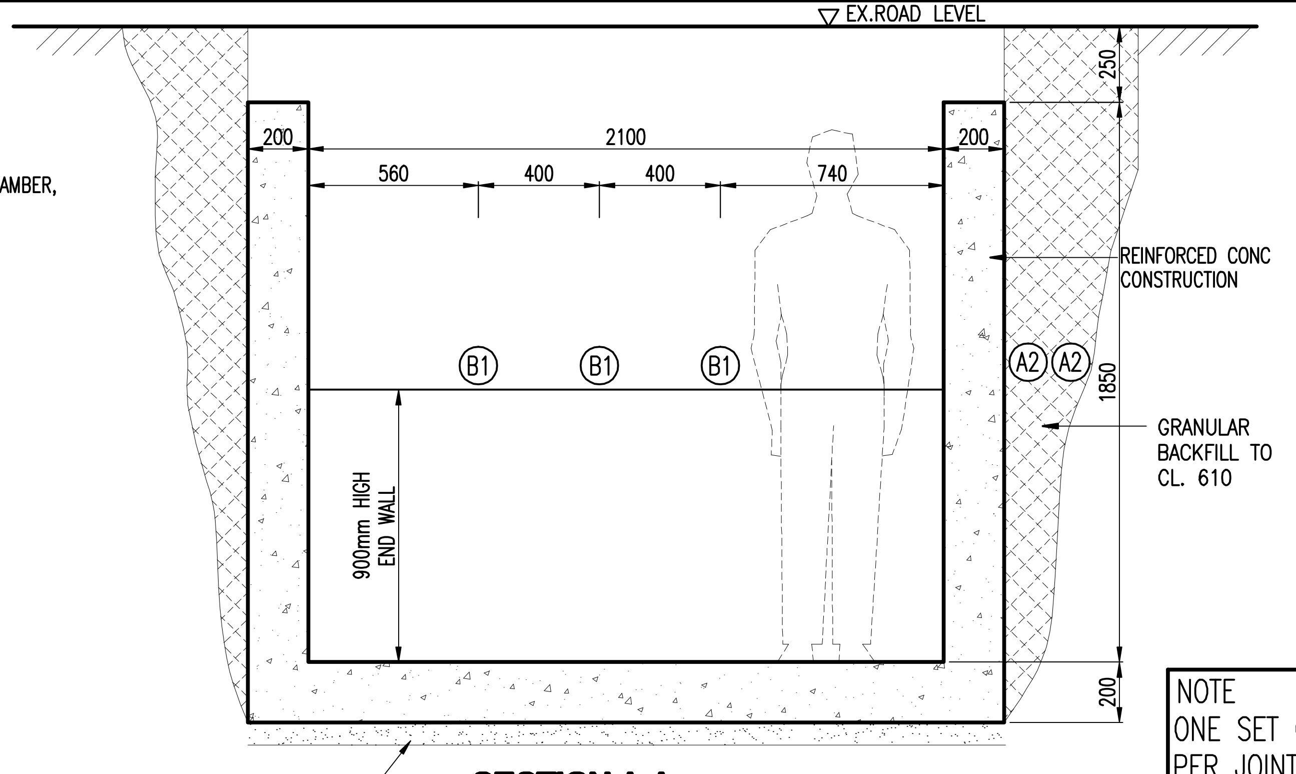
Production Unit: High Voltage Engineering

Drawing Title:
TRENCH CROSS SECTION
110kV & 220kV SINGLE CIRCUIT
FLAT FORMATION
WITHIN SUBSTATION
DUCTED INSTALLATION

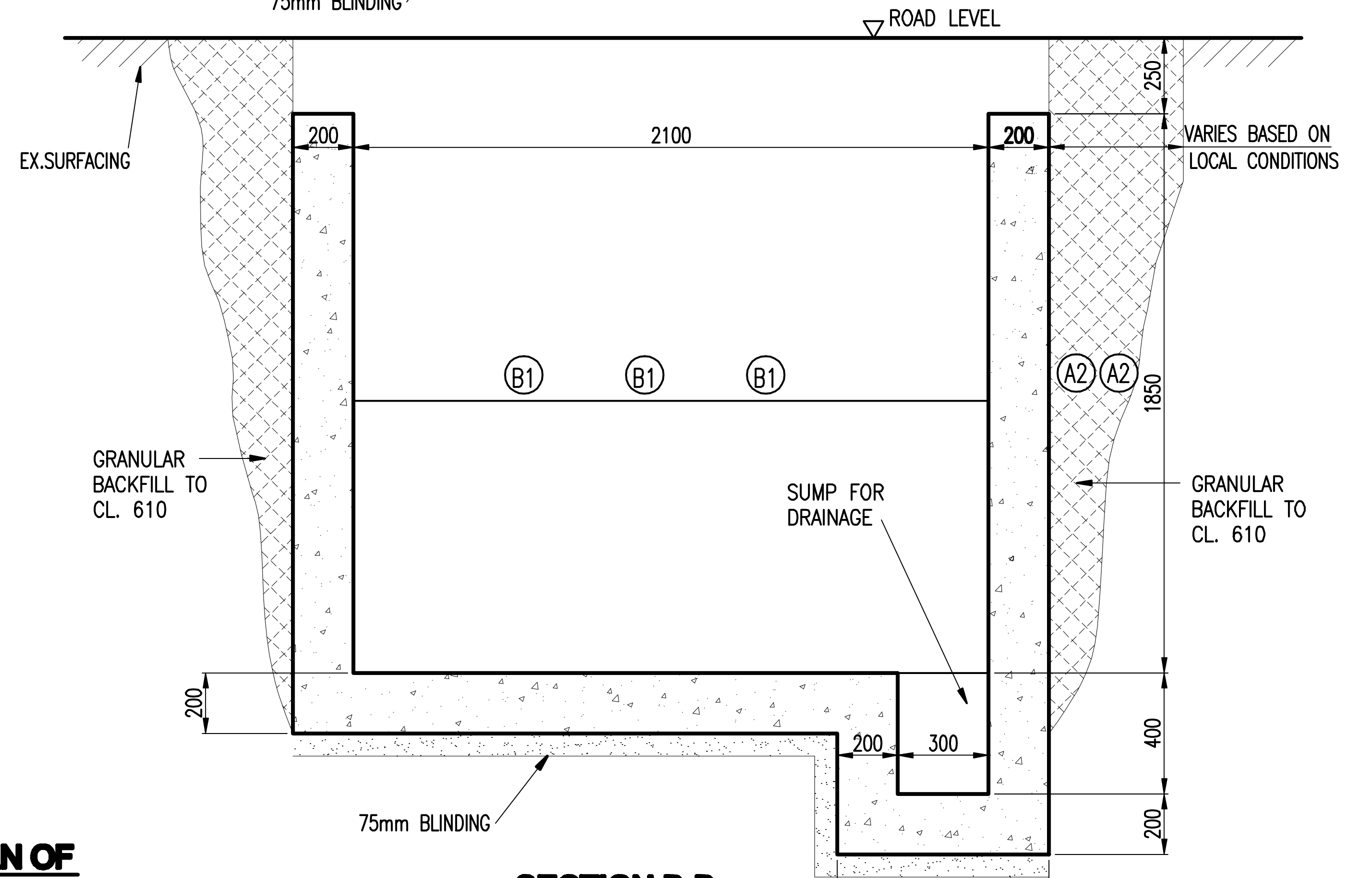
A3



TYPICAL PLAN OF JOINT BAY IN ROAD



SECTION A-A



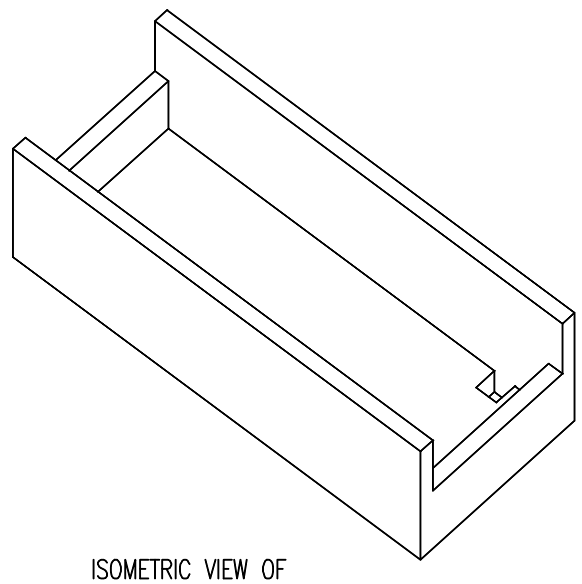
SECTION B-B

NOTES:

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT ENGINEER'S, ARCHITECT'S AND ESBI DRAWINGS & SPECIFICATIONS.
2. ALL DIMENSIONS ARE IN mm.
3. DO NOT SCALE DIMENSIONS.
4. THE CONTRACTOR SHALL CHECK ALL DIMENSIONS PRIOR TO CONSTRUCTION, ANY DISCREPANCIES TO BE NOTIFIED TO THIS OFFICE IN WRITING IMMEDIATELY.
5. CONCRETE GRADE C28/35.
6. CONCRETE COVER TO REINFORCEMENT TO BE 40mm.

NOTE
ONE SET OF DUCTS PER JOINT BAY

A2=125mm DIA HDPE DUCT (COMMS)
B1=125mm DIA. HDPE DUCT (110kV)
B1=200mm DIA. HDPE DUCT (220kV)



ISOMETRIC VIEW OF JOINT BAY

Rev.	Date	Revision description	Drn.	Prod.	Ver.	App.
1	18.11.11	DEPTH OF PIT INCREASED & MINOR REVISIONS	CJ	MA	TS	JD
0	00.00.00	ISSUED FOR --	AS	AS	AS	AS

Purpose of issue - Preliminary unless indicated

Tender ☐ Client approval ☐ Construction ☐ As-built ☐ Revised ☐

International
ESBI Energy Innovation

ESBI Engineering Solutions, Stephen Court, 18-21 St. Stephen's Green, Dublin 2, Ireland. Tel: +353 (0)1 703 8000 Fax: +353 (0)1 703 7186
Email: marketing@esbi.ie Web: www.esbi.ie
ESBI Engineering Solutions is a trading name of ESBI Engineering & Facility Management Limited.
Registered Office: as above Registered in Ireland No. 155249

Client

Project: HV Cables Standards

Contract: HV CABLES STANDARDS

Drawing title: GENERAL ARRANGEMENT OF 6m x 2.5m JOINT BAY

Production unit: Civil & Structural Engineering

Drawn	Produced	Verified	Approved	Approved date
C.Jordan	M.Amet	T.Sheridan	J.Daly	30/11/2011

Client ref.	No. of sheets	Size	Scale
TC201191	5	A3	N.T.S

Drawing number: PE424-D7001-008-002-001 Sheet Rev

BF-DRG-013-004-001

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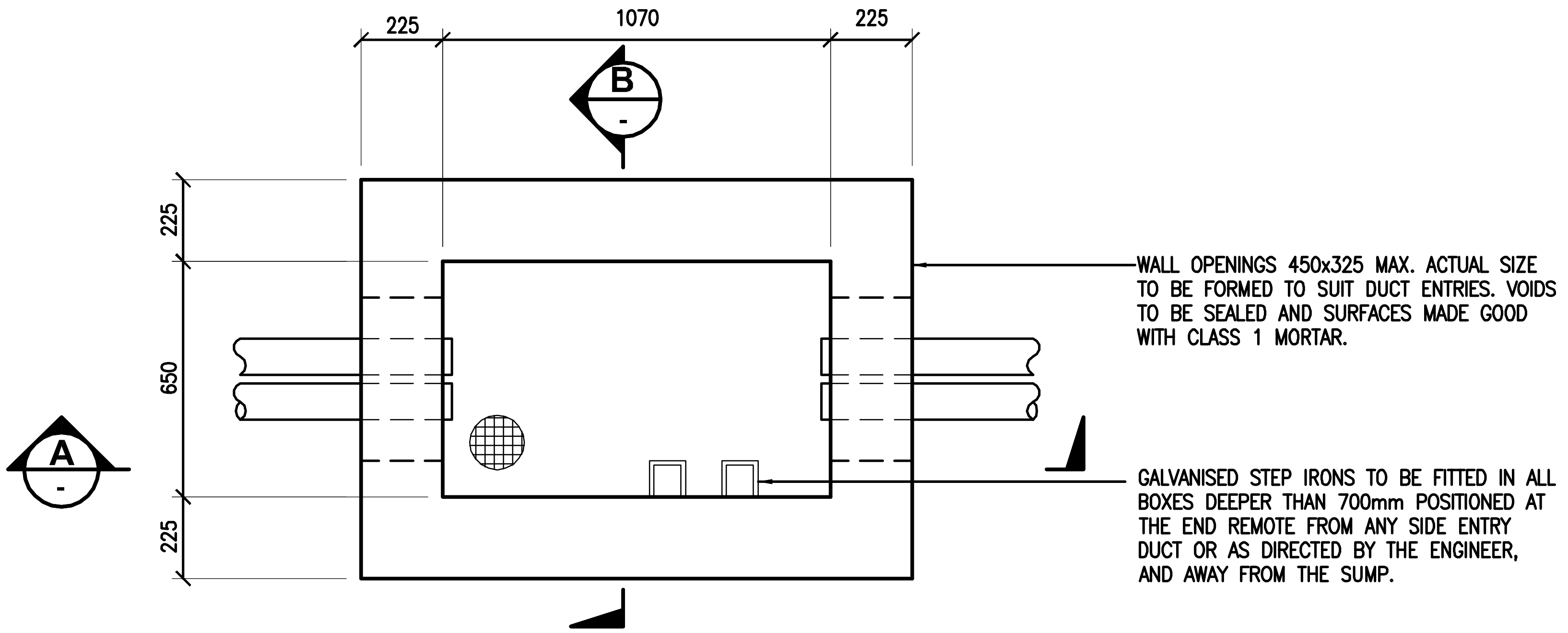
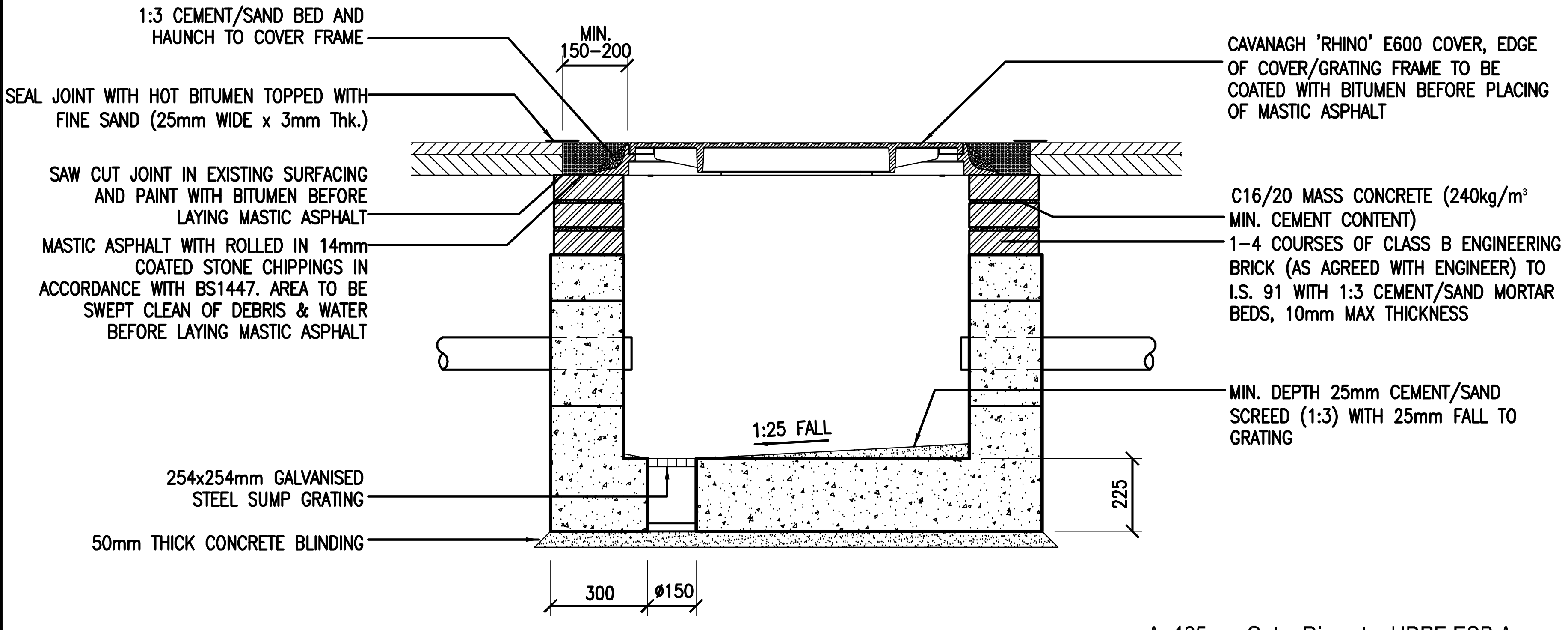
A3 CAD



PLAN
SCALE 1:20
[COVER, FRAME & DUCTS OMITTED FOR CLARITY]

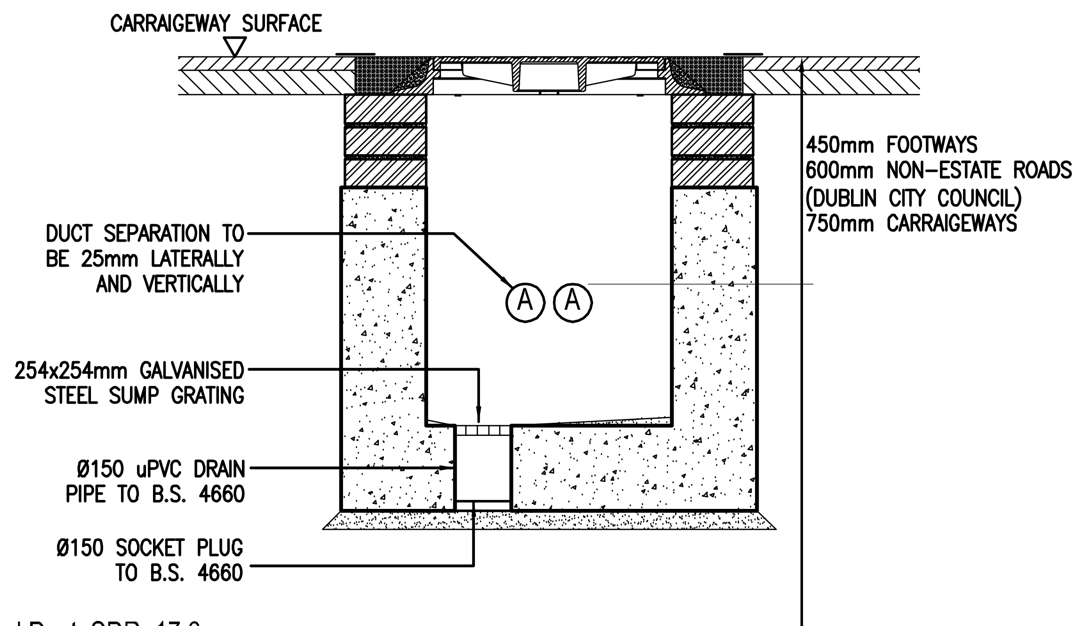
NOTES:

1. ALL DIMENSIONS IN MILLIMETRES.
2. REINSTATEMENT TO COMPLY WITH REQUIREMENTS OF THE RELEVANT LOCAL AUTHORITY.
3. END DUCTS TO BE IN LINE.
4. ALL MATERIALS AND WORKMANSHIP TO BE IN ACCORDANCE WITH THE NRA SPECIFICATION FOR ROADWORKS, MAY 2005 & SUBSEQUENT REVISIONS.
5. REINFORCED CONCRETE TO BE MINIMUM GRADE C32/40 TO I.S.EN 206. SULPHATE RESISTING CEMENT TO BE USED WHERE AGGRESSIVE SOIL CONDITIONS APPLY, REFER TO TABLE 6.1 OF B.S. 8110.
6. CARRIAGEWAY COVERS AND FRAMES TO BE TO B.S. EN 124.
7. ALL COVERS SHALL HAVE 'ESB' LOGO INCORPORATED IN THEM TO THE APPROVAL OF THE ENGINEER.
8. STEP IRONS TO BE HOT DIPPED GALVANISED TO B.S. 729 AND POSITIONED AS SHOWN ON ANY CHAMBER DEEPER THAN 700mm ON THE END REMOTE FROM ANY SIDE ENTRY DUCT.
9. BRICKWORK TO BE CLASS B ENGINEERING. BEDS AND JOINTS TO BE CLASS 1 MORTAR.



SECTION A
SCALE 1:20

A=125mm Outer Diameter HDPE ESB Approved Duct, SDR=17.6,
ESB Code : 9317552
All Dimensions in Millimetres



SECTION B
SCALE 1:20

Rev.	Date	Revision description	Drn.	Ver.	App.
1	07/11	New Revision - Comms duct			

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ESBI Engineering & Facility Management Ltd.
Stephen Court, 18/ 21 St Stephen's Green, Dublin 2 Ireland
Telephone+353–1–703 8000 Fax+353–1–661–6600
Website www.esbi.ie
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Client: ESB NETWORKS
Project: HV Cables Standards
Contract: CABLES SERVICES TO ESB
Drawing title: C2 COMMUNICATIONS CHAMBER GENERAL ARRANGMENT
Production unit: High Voltage Engineering

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J.Dillon	M.Byrne	M.Byrne	19/07/11
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TC200033	4	A3	- A3

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