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Category
Electrical

Title
Underground Installation Configurations for High Voltage and 1500 Vdc Cables

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The technical content of this document has been approved by the relevant ARTC engineering authority and has also been endorsed by the ARTC Safety Committee.

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About This Standard

This publication sets out the basic requirements and approved installation configurations of high voltage underground cables owned by the Australian Rail Track Corporation (ARTC) and other Utilities underground cables located on railway property.

For the purpose of this publication the term “High Voltage Cable” refers to cables for use at voltages in excess of 1000 V and includes the positive and negative cables forming part of the 1500 V dc system.

Document History

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List of Amendments –

ISSUE	DATE	CLAUSE	DESCRIPTION
1.1	11/03/2005	Disclaimer	Minor editorial change

Contents

1 References

Electricity Supply Association of Australia publication C(b)2 “Guide to the Installation of Underground Cables”.

AS 4799	2000 –	Installation of underground utility services and pipelines within railway boundaries.
AS/NZS 2053.2	1995	Conduits and fittings for electrical installations.
AS/NZS 1477	1999	PVC pipes and fittings for pressure applications.
AS/NZS 4130	2001	Polyethylene (PE) pipes for pressure applications.
SAA HB 29	2000	Communications cabling handbook.
AS 4058	1992	Precast Concrete Pipes.

2 Introduction

Early cable installations used a “solid laid” system where the cables were laid in a formed wooden or concrete trough and the trough filled with bitumen around the cable. With the development of steel wire armouring and waterproof oversheaths, the “solid laid” system has mostly been replaced by the direct laid and duct laid systems. The only cables presently installed in a modified solid laid system are 1500 Vdc positive cables.

The choice of system is determined by the cable type, criticality, geographic location, future long-term requirements, expected maintenance requirements, type of reinstatement and long term economic assessment.

3 General

3.1 Cable trenches

The bottom of the trench shall be level across its width and free from any protrusions and rubble that could cause damage to the cable.

Changes of the trench gradient shall be gradual.

Where cables are laid on a gradient and there is a risk of the sand bed being washed away, a 14:1 sand cement mix shall be substituted for the clean sand except for cable crossing points where the cables shall be covered with clean sand.

3.1.1 Trench backfill

The trench is to be progressively backfilled with suitable material having good consolidating qualities. The backfill is to be installed in layers and compacted to prevent future subsidence. The top layer shall be of sufficient quality to form the base for surface restoration.

3.1.2 Warning tapes

Orange warning tapes shall be installed longitudinally in the trench backfill approximately 300 mm directly above cable encasement or concrete danger slabs. The orange warning tapes shall be distributed over the entire trench width in such a manner as to provide at least 50% coverage of the trench.

3.2 Single core high voltage cables

Single core high voltage ac cables of the same circuit shall be installed in a close trefoil formation. The trefoil formation shall be achieved by the use of trefoil clamps or a similar arrangement in the open, on cable trays and ladders and in troughing. When the single core cables are direct laid, the trefoil formation shall be achieved by separation in sand similar to Figure 3 in Section 4.2.3.

4 Cable installation configurations

The various cable installation configurations are detailed in the application matrix shown in Table 1.

	Application					
Configuration	**1500 V positive cables**	**1500 V negative cables**	**2.2.kV cables**	**11 kV cables**	**33 kV cables**	**66 kV cables**
Solid laid	✓					
Direct laid		✓	✓	✓	✓	✓
Duct laid	✓	✓	✓	✓	✓	✓

Table 1 - Application matrix.

4.1 Solid laid system

Solid laid configurations shall be installed in concrete or polycrete troughing with concrete lids as shown in drawing A3-88226. The cable troughing shall be filled with 14:1 sand / cement mix.

Only cables of the same circuit shall be installed in the same concrete or polycrete trough.

4.1.1 Minimum depth of solid laid cables

In all instances the minimum depth from the finished ground line and drain inverts to the top of the concrete lid of solid laid cables shall be:

- 1000 mm.

4.1.2 Cable installed in troughing

Cables of the same circuit shall be installed in concrete or polycrete troughing 410 mm by 210 mm over all with concrete lids. The cables are to be laid in a horizontal formation at a minimum of 150 mm centres located centrally in the troughing on a bed of 14:1 sand / cement mix a minimum of 50 mm deep. The trough is to be filled level with the top with 14:1 sand / cement mix.

A typical solid laid configuration is shown in Figure 1.

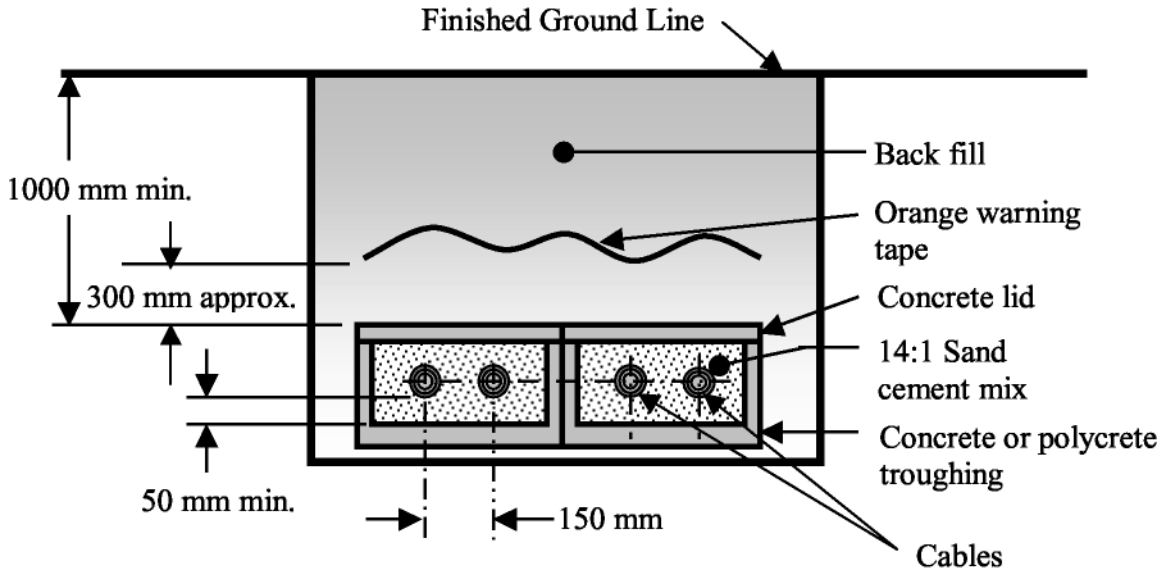


Figure 1 - Solid laid configuration

4.2 Direct laid system

In this system the cable is laid directly in the trench and the earth replaced. Concrete danger slabs are placed 100 mm to 150 mm directly above the cables for mechanical protection and an indication of the cables presence.

In areas where expensive surface restoration is involved cables should be laid in ducts as an alternative to direct laid. Examples of such areas are road and rail crossings, platform and ornamental surfaces.

1500 Vdc negative cable configuration are shown in Section 4.2.3.

A typical direct laid cable configuration is shown in Figure 2.

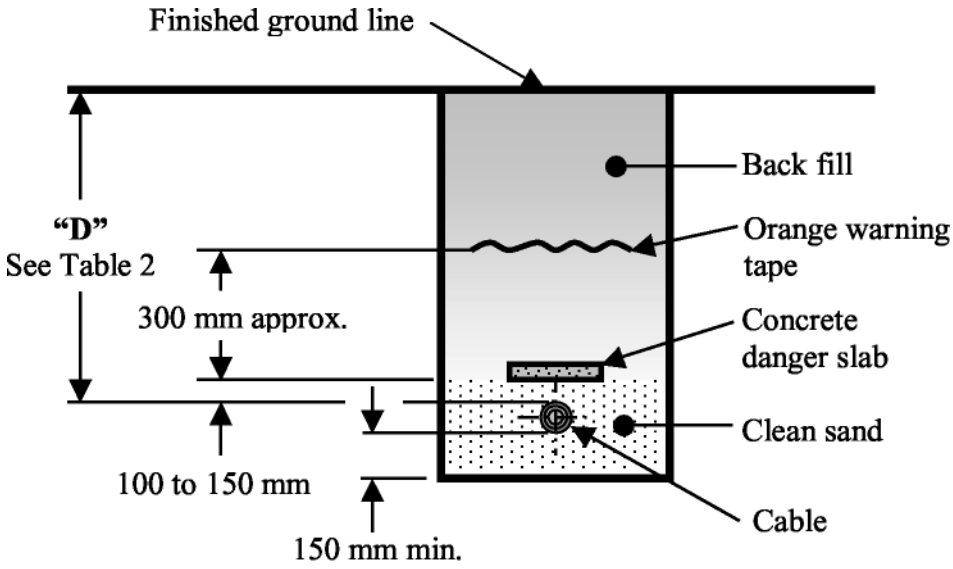


Figure 2 - Direct laid configuration

Before the cable is laid a bed of clean sand shall be prepared in the trench and shall have a minimum depth of 150 mm.

After the cable has been laid the cable shall be covered with clean sand having a cover of 100 mm to 150 mm.

4.2.1 Minimum depth of direct laid cables

The minimum depth from the finished ground line to the top of direct laid cables shall be as shown in Table 2.

Direct laid cables	Cable voltage	Min. depth "D"
Outside the railway corridor	≤ 22 kV	850 mm
	> 22 kV	1000 mm
Inside the railway corridor	≤ 22 kV	1000 mm
	> 22 kV	1000 mm

Table 2 - Minimum depth of direct laid cables

4.2.2 Cable protection

Protective concrete danger slabs manufactured to drawing No.E/55224 shall be placed directly above and completely covering the cable, on top of the sand, to provide maximum mechanical protection and as an indication of the cable's presence below the slab.

4.2.3 1500 Vdc negative cables

1500 V negative cables are to be installed in accordance with Sections 4.2, 4.2.1 and 4.2.2 and with a minimum separation of 150 mm, the bed and covering of clean sand replaced with 14:1 sand / cement mix and the standard danger slab replaced with a 410 mm wide danger slab.

Where space is limited the negative cables may be arranged as shown in Figure 3.

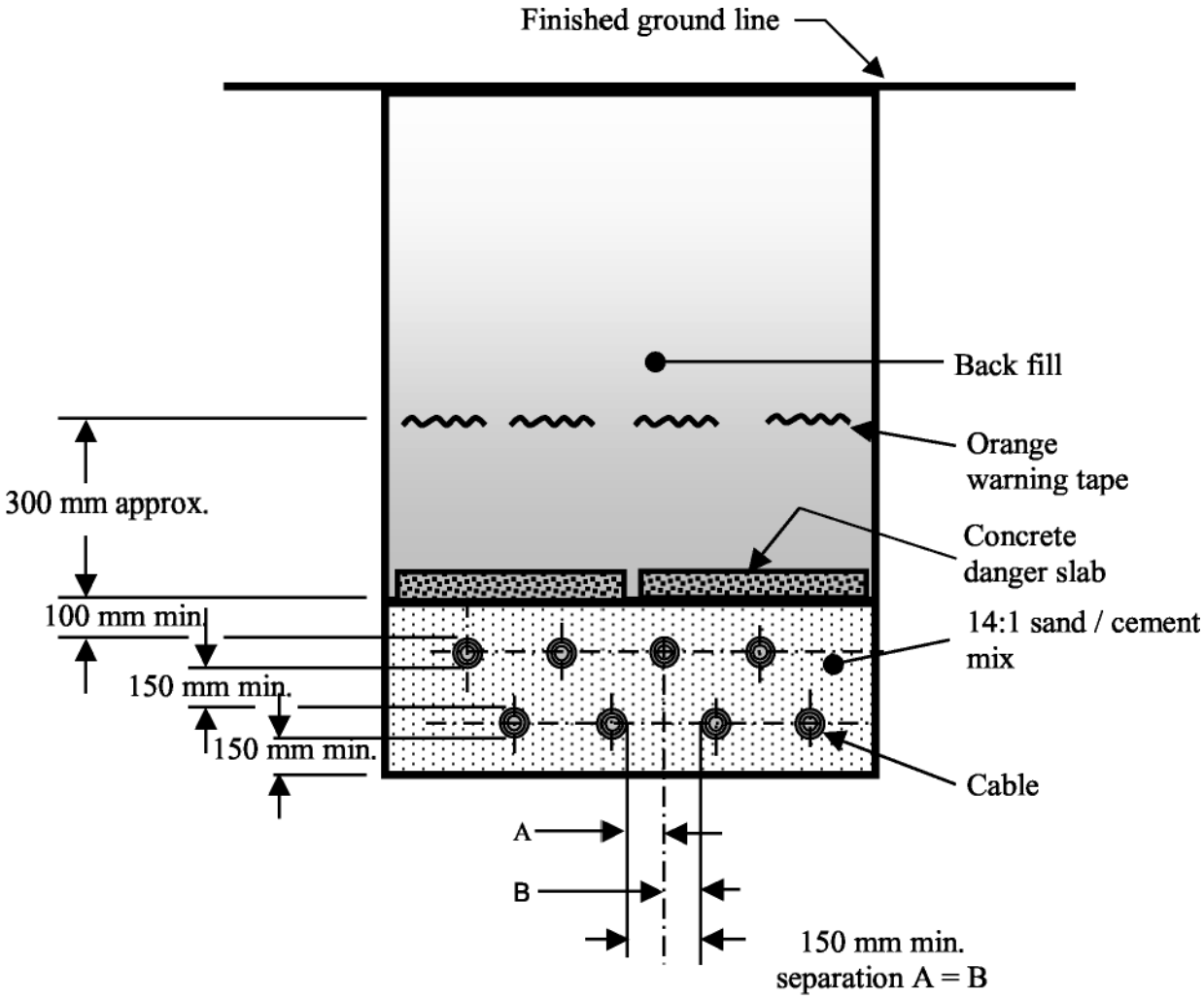


Figure 3 - Typical configuration of 1500 Vdc negative cables

4.3 Duct laid system

In locations such as city streets and other areas where excavation is expensive and inconvenient the duct laid system may be used. This method also allows the installation of additional new cables or the replacement of existing cables with minimum inconvenience.

Ducts or pipes are buried in the ground with pits installed in convenient positions to allow cables to be easily installed. The ducts shall be of a durable material, such as rigid UPVC, fibre cement, concrete or earthenware to provide protection for the cables.

On railway property in the electrified traction area and for one kilometre beyond the end of an electrified traction area, ducts shall not be of any conductive material.

PVC or concrete danger slabs are to be placed approximately 100 mm above the ducts as an indication of the cable's presence.

Ducts shall comply with AS 3000.

All PVC ducts shall be of the rigid heavy-duty type in accordance with AS 2053 or AS 1477 Class PN12.

The ducts and pits should be impervious to water, smooth on the inside and chemically inert.

The duct line shall be as straight as possible with bellmouths provided on the ducts where the ducts enter the pits.

Before cables are installed the ducts are to be rodded with a suitable scraper to remove sharp edges likely to damage the cable outer sheath.

Spare ducts are to be installed and capped to prevent the ingress of dirt and subsequent blockage.

A typical duct laid system configuration is shown in Figure 4.

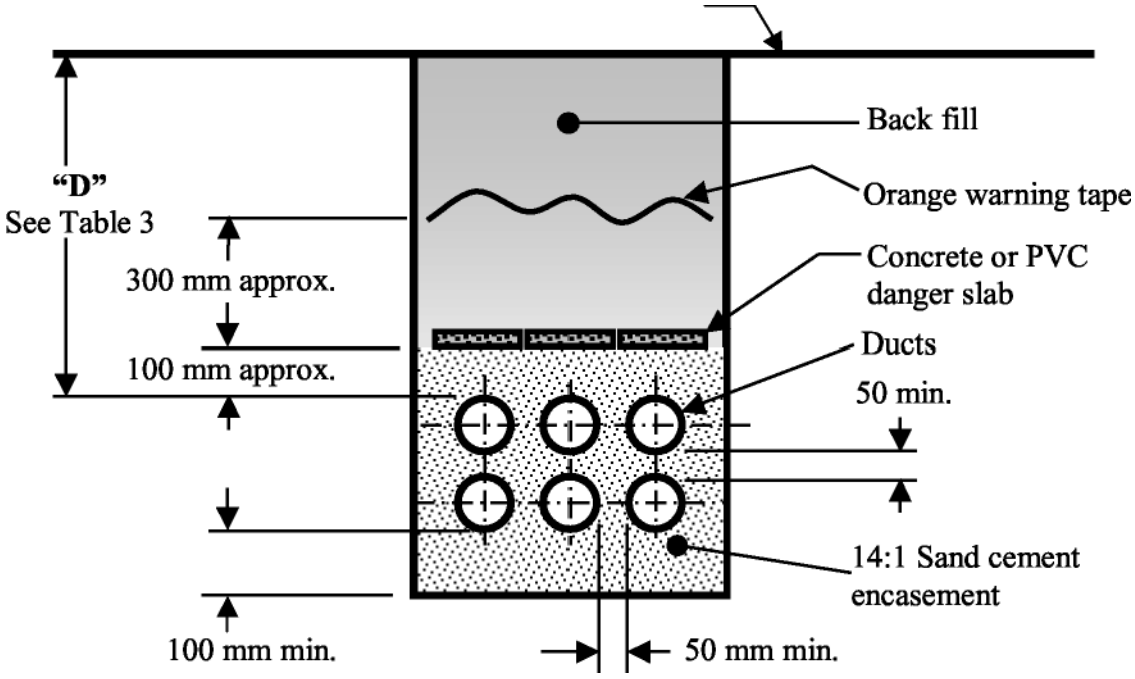


Figure 4 - Ducts laid in banks

4.3.1 Minimum duct diameter

The duct diameter shall be large enough to accommodate the largest cable contemplated taking future requirements into consideration. The cable diameter shall be limited to a maximum of 60% of the duct diameter.

4.3.2 Minimum depths of duct laid systems

On the railway corridor and on land other than the railway corridor, the minimum depth to the top of the top duct from the finished ground line or drain invert shall be as shown in Table 3.

Duct laid systems	Cable voltage	Min. depth "D"
Outside the railway corridor	≤ 22 kV	750 mm
	> 22 kV	1000 mm
Inside the railway corridor	≤ 22 kV	1000 mm
	> 22 kV	1000 mm

Table 3 - Minimum depth of duct systems

4.3.3 Duct protection

Protective concrete "DANGER" slabs manufactured to drawing No. E/55224 or PVC "DANGER" slabs shall be placed 100 mm directly above and completely covering the ducts to provide mechanical protection and an indication of the cable's presence below the slab.

The ducts, whether encased or not, shall be directly covered by concrete or PVC "DANGER" slabs.

NOTE
Old danger slabs may display SRA or RAC as the asset owner. These assets are now owned by ARTC.

4.4 Undertrack crossings

Undertrack crossings shall be installed to ARTC drawing EL 0024639 - Underground Cables, Undertrack Crossing Arrangement.

4.4.1 Encasing pipes

In existing and proposed electrified traction areas and for a distance of one kilometre beyond the end of an electrified traction area, metal or protective covered metal encasing pipes shall not be used.

Steel with a protective covering or bare metallic encasing pipes shall only be used in non electrified traction areas.

4.4.2 Depth of installation

Where power cables pass under tracks, they shall be enclosed in an appropriate "Category A" system in accordance with AS/NZS 3000. The top of the encasing pipe or conduit shall be laid at a depth of not less than 2.0 m below rail level. The depth shall be maintained for not less than 3 m beyond the outer rails measured at right angles to the centre line of the track.

4.4.3 Interface between undertrack crossing and underground installation

Where an undertrack crossing joins to the cable underground installation the immediate area for 1 m each side of this point shall be back filled with clean sand. The sand in this area is to exclude trench back fill, which may contain rocks, or similar material, that may cause damage to the cable.

4.4.4 Bored and jacked crossings

When passing under tracks, cables shall be laid in an encasing pipe. The encasing pipe shall be:

1) Larger than 150 mm nominal diameter - Class 4 reinforced concrete to AS4058 or steel pipe to AS/NZS 2053.

2) Up to 150 mm nominal diameter - Class 4 reinforced concrete to AS 4058, HD UPVC pipe to AS/NZS 2053 or AS/NZS 1477 class PN12, Polyethylene (PE) classification PN12.5 to AS/NZS 4130.

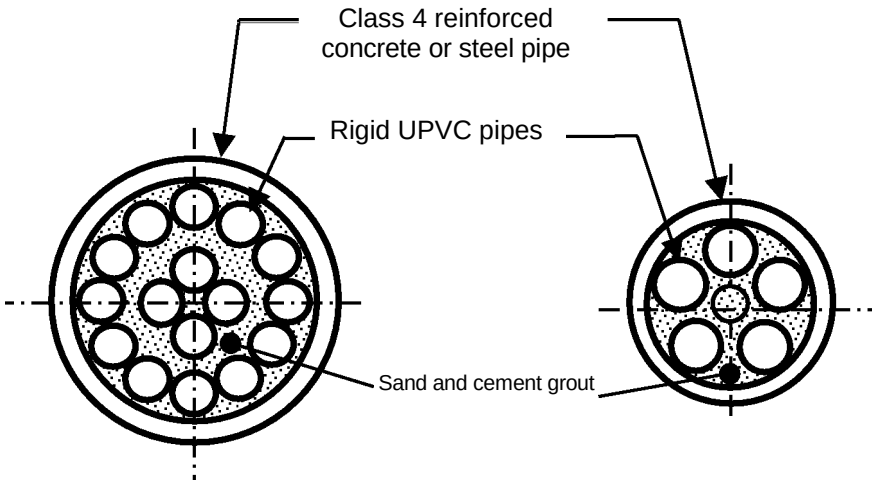
Markers are to be installed at each end of the encasing pipe to indicate the end and depth of the pipe below ground line.

The encasing pipe shall comply with the requirements of the AS 4799 and shall comply with section 4.4.2 of this document.

The selection of under track crossing configuration will depend on such factors as:

- The number of cables to be installed in the under track crossing.
- The approved construction method for the under track crossing.

Typical under track crossing configurations is shown in Figure 7.



Typical cross section of a 15 duct, bored under track crossing

Typical cross section of a 5 duct, bored under track crossing

Figure 7 - Typical under track crossing configurations

In this instance the concrete “DANGER” slabs may be omitted from the portion under the tracks and the section of the ducts protected by the encasing pipe.

4.4.4.1 Ducts in encasing pipes

All ducts installed in encasing pipes shall be rigid UPVC pipe and shall comply to the following:

- Laid in accordance with AS 4799 and AS 3000.
- All voids between the UPVC pipes and the encasing pipe to be filled with sand cement grout mixture that is suitable for use with a concrete pump.
- All UPVC pipes are to be restrained in such a manner to prevent spiralling when grouting mixture is pumped into the encasing pipe.
- All rigid UPVC pipes (Heavy duty type) are to be in accordance with AS/NZS 2053 or AS/NZS 1477 class PN12.
- All joints in rigid UPVC pipes are to be staggered 150 mm and glued.
- All UPVC pipes are to project 300 mm beyond the encasing pipe and are to be capped.

4.4.5 Cables installed in a trench under tracks

When under track crossings are constructed by trenching across the tracks, the cables may be installed in the following configurations:

- Direct laid in accordance with Section 4.2 with a minimum depth from rail level to the top of the danger slabs covering the cable of 2.0 m.
- Duct laid in accordance with Section 4.3 with a minimum depth from rail level to the top of the duct system of 2.0 m. The duct system shall be encased in concrete.
- Ducts laid in an encasing pipe in accordance with Section 4.4 with a minimum depth from rail level to the top of the encasing pipe of 2.0 m.

5 Shared trenches

Trenches may be shared with other ARTC high voltage services, signalling and communications services or services from other supply authorities and utilities.

5.1 Separation between high voltage cables

The separation between cable circuits shall not be less than 150 mm horizontally for circuits laid parallel and 225 mm vertically for cables laid mutually at right angles. Each cable circuit shall be separated by a continuous physical barrier of protective concrete danger slabs installed between each cable circuit to prevent fault damage from adjacent cables.

Where cables pass over or under other utilities cables, the cables shall be separated by not less than 300 mm.

The typical separation configuration of high voltage cables is shown in Figure 5 and Figure 6.

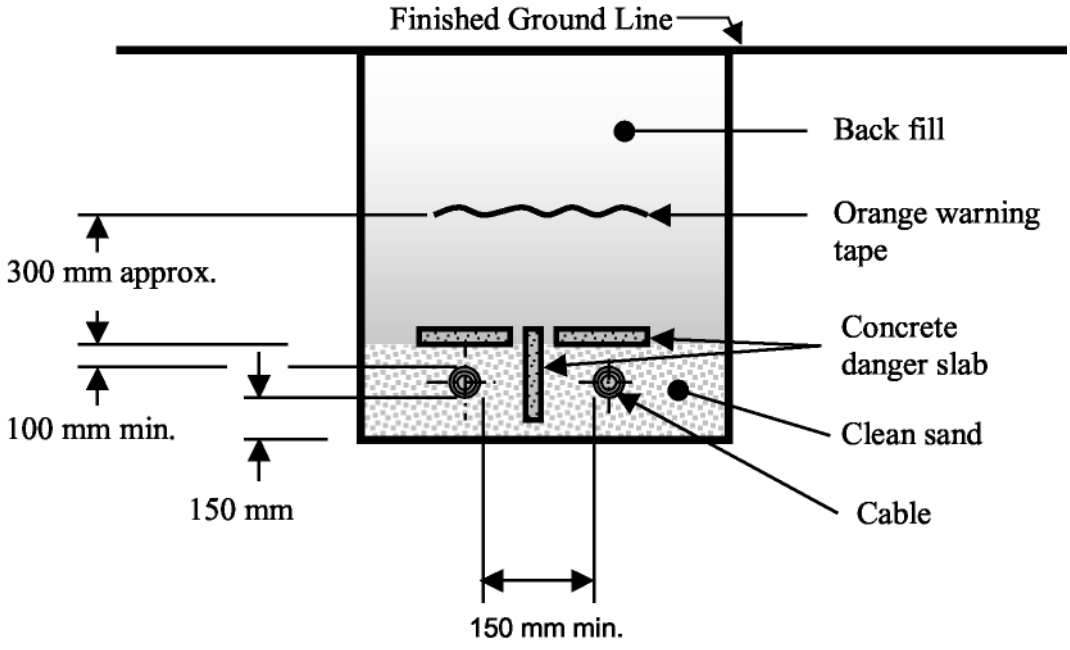


Figure 5 - Separation between high voltage cables

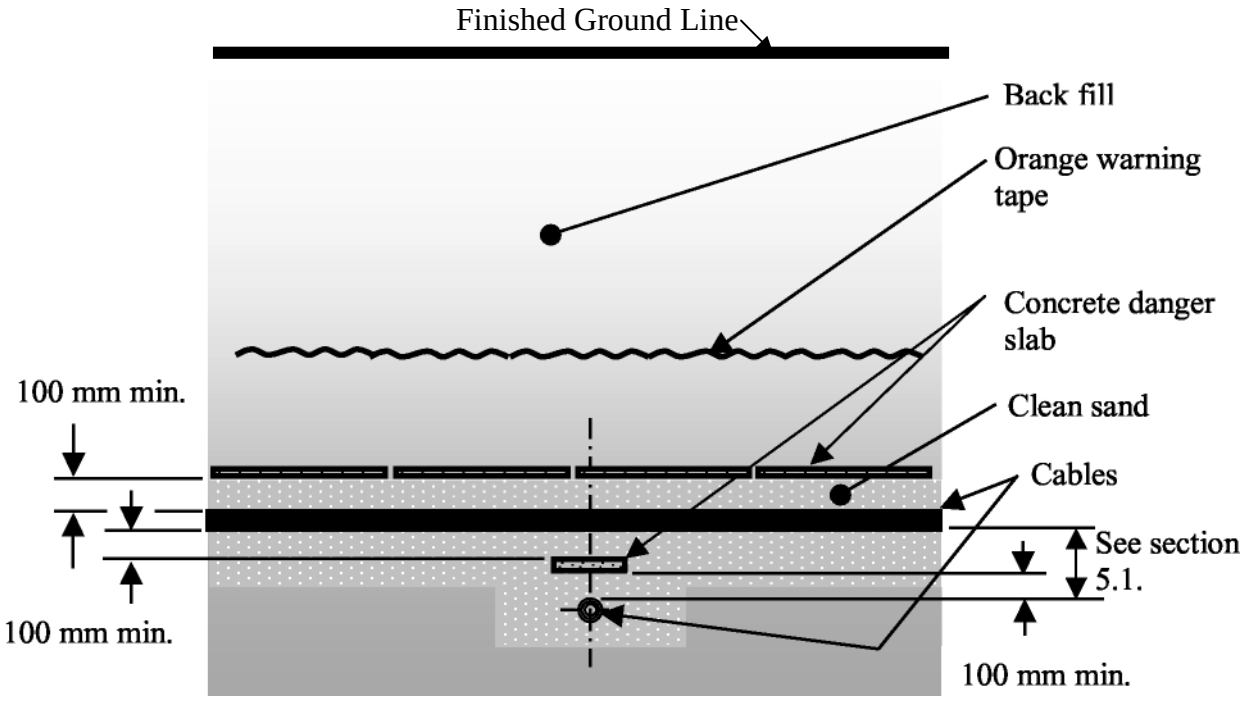


Figure 6 - Separation between cables laid mutually at right angles

5.2 Separation of high voltage cables from other services

Shared trench arrangements with services other than high voltage cables may be entered into and such arrangements may require additional conditions to those specified in this document.

Communications cables installed near high voltage cables shall comply with the requirements of SAA HB 29 - 2000 – Communications cabling handbook, Section 2.3.4. Segregation - General.

6 Cable route markers

Markers shall be provided at the location of all underground cables. A typical cable route marker, mounting post and installation requirements are shown in drawing No. A2/89781.

NOTE

Old cable route markers may display SRA or RAC as the asset owner. These assets are now owned by ARTC.

6.1 Location of markers

On the rail corridor markers shall be located above the buried cable at:

- points of entering and leaving the rail corridor.
- each point where the route changes direction except for very minor deviations.
- at not greater than 50 m intervals along the route such that at least two markers shall be visible at any point along the route.
- Markers shall not obstruct vehicle access along the side of the track or infringe structure gauge. In yard areas they shall not obstruct footpaths, walkways or vehicle access ways.

6.2 Marker requirements

Markers shall comply with the following requirements:

- comply with AS 1319 except the word “CAUTION” shall replace the word “WARNING”.
- be mounted on a post as shown in drawing No. A2/89781.
- markers shall be made from yellow colour class 1, retroreflective material to AS 1906, part 1. (3M type 3871 series or equivalent).

6.3 Wording on markers

Wording on markers shall include the following and comply with the requirements of AS 1744:

- the name of the owner.
- description of the service.
- warning not to excavate prior to obtaining authority.
- telephone number to be used in the case of emergencies.
- course of action in the event of emergency.

6.4 Orientation of markers

Cable route markers are to be orientated to face the railway tracks.