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TECHNICAL BRIEFING NOTE
Cable Management for Underpasses & Tunnels

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1 BACKGROUND

The purpose of this memorandum is to provide additional advice/guidance to designers on the options for cable management in tunnels and underpasses and to encourage designers to consider alternative solutions which may present a better long term maintenance and service solution for cabling in these safety critical locations and structures.

The subject of cable management and design for cable management in tunnels has been raised by a number of designers. Due to the design constraints around tunnel dimensions and the nature of the limits of work areas for delivery of tunnels (inclusive of both bore and cut and cover tunnels) there have been a number of designs submitted to date where the cable management design for tunnels needs attention to meet maintenance and long term serviceability requirements.

To maintain ongoing tunnel safety operational requirements (and service levels), the requirement to rapidly and easily reach core communications network cabling (and power) for maintenance reasons in tunnels is a priority. Ease of access for services being progressively implemented for tunnels placed into early operations prior to full completion is another compelling reason for the use of cable trays and cable management systems as opposed to the use of shallow cut embedded or wall attached & exposed UPVC ducts in tunnels.

This early opening scenario has arisen following the decisions around construction parameters being made for Tunnels which have preceded design activities for cable management. In some cases, (more specifically underpasses and shorter tunnel sections), recent requirements for flood monitoring equipment and SCADA systems have resulted in designers specifying post construction cable management using generic UPVC conduit.

UPVC when correctly specified is only suitable for straight cable runs external to tunnels and is adequate for rapid deployments in short well ventilated underpasses, however its use in longer tunnels is not acceptable for both fire safety reasons and because it imposes bend radius limitations, creates mounting issues and removes immediate access to critical cables.

UPVC whilst fire resistant (unlikely to combust) has a relatively low melting point which renders it largely ineffective as an additional fire protection layer for the cables located in it. Further to this, UPVC when exposed to heat like all PVC products releases chlorine gas which is highly toxic and when mixed with water from sprinkler systems or moisture forms hydrochloric acid.

All such cables should have a specified level of fire resistance in any case and be Low Smoke Zero Halogen, (LS0H). In addition, where communications involving any form of copper cable are involved power and communications cables must be kept separate.

From an aesthetics perspective any conduit /cable trays/ cladding use depends entirely on subjective taste.

Cladding as an example presents a noise/fluid dynamics/ utilities/ maintenance and fire protection solution for tunnels. Cladding has a high level of potential aesthetic possibility and therefore in the case of cladding we see that aesthetics should be considered as a relevant architectural design element. This document however focuses on more pragmatic issues around cabling solutions in tunnels

For the purposes of this document unless explicitly stated otherwise (in ground installations) it is assumed that all cable management solutions are mounted at suitable heights above the ground and are not exposed to immersion risk during flooding conditions.

There are five identified possibilities where designers can consider simplifying and improving maintenance access for cables and communications in Tunnels:

Type A) Use suspended cable trays for cable management, either suspended off the ceiling or the walls of the tunnel. Such arrangements assume the use of fire resistant/ retardant Low Smoke Zero Halogen, (LS0H) protected cables. The trays should be galvanised or stainless steel and have removable lids which allow for ease of maintenance and also provide a degree of elemental protection, (fire, water, particulates, dust etc.). Cables must be clearly labelled. Power and communications cables should be separated. Cantilever mounting approaches are preferable for maintenance access and cable routing ease.

Type B) Specify or use Tunnel cladding systems to conceal and manage the presence of cables and cable trays and or to provide easy access capabilities to communications. Again the use of LSOH cables is expected. The use of cladding needs to be by design as cladding effectively reduces the available area inside the tunnel. Cables must be clearly labelled. Power and communications cables should be separated.

Type C) Specify or use a combination of both A) and B) above to best effect. Cables must be clearly labelled. Power and communications cables should be separated.

Type D) Where LS0H conduit has been specified, consider the placement of these conduits into a managed tray type structure rather than direct attachment or embedding into the tunnel walls. All such cables used in conduits must also be certified LS0H and have a fire resistance of at least 15 minutes. Cables must be clearly labelled. Power and communications cables should be separated.

Type E) Where cables are installed in manholes and cable ducts beneath the walkways, cable trays are not required however there should be some degree of cable management in place and clear labelling used. Power and communications cables should be separated. (In every case where there is any copper based communications cable involved, this should apply, suitable separation distances between cables depend on voltage in power cables and on shielding on copper communications cables).

The embedding of LS0H conduit in concrete walls is only effective against fires when the conduits are embedded at a significant depth. The optimal depth to embed conduits/cables and services in a tunnel wall to avoid destruction in megawatt fires is in excess of 60mm embedded. Even at this depth, cable runs and junction boxes which connect to outside services will need to use LS0H cable to do so, which will not survive if in the vicinity of the fire.

The running of cables into emergency walkways is another feasible option however this presents a risk to evacuation in the event a fire traverses into the cables in the walkways. In this case should there be no other option but to do this type of installation then the cables must be LS0H, extraction ventilation must be present in the emergency escape route and the cables must be run in a sealed, lidded galvanised or stainless steel tray as a minimum.

2 FIRE RESISTANCE

For life safety systems in Tunnels, fire resistant and Low Smoke Zero Halogen (LS0H) producing cables, conduit and cladding shall always be used. This requirement is mandatory and should always be followed irrespective of conduit, cladding or tray selection.

LS0H materials are composed of thermoplastic or thermoset compounds that release very limited smoke and no halogen when exposed to sources of heat/flame. Halogen-free materials do not produce a dangerous gas/acid combination (cyanide/acid) or toxic smoke when exposed to flame.

LS0H is required for protection of people and equipment from toxic and corrosive gases and in any area which could be subject to a fire in a relatively confined space such as a tunnel.

Fire resistance in cables is defined as the ability of a cable to maintain functionality during a fire and the duration of its survival whilst still operating in working condition. The resistance-to-fire performance of cables is typically indicated in terms of survival time: the times typically used by manufacturers in line with European Standards are 15, 30, 60, 90 and 120 minutes of operation in a standardized fire condition at European Level (CENELEC) and equivalent international (IEC) level of fire intensity.

Also worth review by designers is NFPA 502 & NFPA 70 both of which address fire life safety issues in Tunnels and electrical systems. Please note in a major fire every fire retardant/resistant cable has a flash point, (where it catches fire), which will be reached depending on the combustion state, duration, spread and severity of the fire.

3 CRITERIA FOR USE OF CABLE TRAYS, LADDERS AND CLADDING IN TUNNELS

The following criteria need to be met with respect to the use of cable trays in Tunnels for works underway and planned in the State of Qatar:

1) UPVC duct should not be used for any reason to carry or convey cables to ITS equipment located in tunnels. Where UPVC duct has been used or located in a Tunnel for any application, the UPVC used must be removed and replaced with a LS0H rated conduit meeting the following minimum standards:

- EN1452-2
- ISO 4422-2
- DIN 8062 / ISO 161
- BS 3505
- DIN 4925-II & III

Please note PVC is less likely to actively burn due to the presence of high levels of chlorides in the plastic however this does not prevent the material from melting at relatively low temperatures in tunnel fires and releasing clouds of toxic chlorine gas in the process.

For this reason, the use of double dipped galvanised or stainless steel ducts/cable trays and related corrosion resistant mounting hardware is recommended. The use of materials proven to be suitable for harsh tunnel operating environments is therefore a pre-requisite. Designers and contractors must take all due care to avoid mixing of tray types of differing metals and connectors or mixing mounting hardware of differing metals in tunnels to prevent galvanic reaction and accelerated corrosion.

2) Where feasible, vertical risers to suspended cable trays either suspended from the ceilings or attached to tunnel walls shall be able to be used. Vertical risers are expected to be constructed of steel and to be galvanised and painted to assure corrosion resistance. In the case of new tunnels, such risers may be facilitated by the use of chases/channelling in the walls, incorporating cable management and covered with galvanised steel plates or cladding.

3) Suspended cable trays located over any road surface are not to compromise minimum height clearances in tunnels – where cable trays are affixed to walls without cladding these should be installed between 5-6m above shoulders or access ways in tunnels. Lateral clearances for tray widths should also be taken into consideration to assure that they do not compromise space requirements or other systems from correct operations.

4) In the case of new tunnels the use of chases/ channelling in the walls, where cable tray or trunking could be recessed and could be covered with suitable high grade stainless steel covers or cladding should be considered.

5) Suspended cable ladders are also often used in tunnels to run heavy cables with relatively large cross -sectional areas, (Armoured Power Cables) and flexible galvanised steel conduits. These should not be confused with suspended cable trays which are often run across such ladders. In the case of the use of these devices the same care needs to be taken in relation to relative heights in the tunnel and the proximity of other devices such as jet fans etc.

4 TUNNEL CLADDING

Cladding is regularly used in Europe and around the world to simplify tunnel cleaning, manage noise, improve ventilation and air flow and conceal or contain cabling and services as opposed to using trenches or ducts to run cables. It is important to note that cladding may not be appropriate or desirable in a number of cases where it is deemed that its presence adds no value, or the tunnel environment does not call for its use.

The use of tunnel cladding is an effective mechanism to conceal and control management of cables in tunnels, cladding also presents an opportunity for designers to add aesthetic value to tunnels with minimal additional effort. The expectation in this case is that the cladding would either incorporate a cable management system or conceal cable trays.

Tunnel cladding should be considered or dismissed at design stage to prevent on tunnel gauges and walkways. Where tunnel cladding is to be retrofitted to existing tunnels, partial cladding or graded thicknesses of cladding, may be more appropriate to mitigate impacts on walkways and tunnel widths.

All materials supplied as part of tunnel cladding from vendors are expected by default to survive 15, 30, 60, 90 and 120 minutes in a standardized fire condition at European Level (CENELEC) and equivalent international (IEC) level of fire intensity and not contain materials which under combustion create toxic gasses etc.

Designers should also be mindful of the following, when use of cladding in tunnels is considered:

1) Use of cladding should extend to coverage of all utilities not just ITS, cable management in this case could incorporate lighting elements, power, communications and ITS equipment connections.

2) Cladding should allow for the fitment of CCTV and other tunnel equipment as part of the overall Tunnel management infrastructure without prejudice to the operation of the equipment.

3) In the case of retrofitting cladding incorporating cable management systems to existing Tunnels, then consideration should be given to retaining existing LS0H conduit and or other LS0H ducting as well as removing or replacing it. Retrofitting of cladding to tunnels ideally should not result in any impact on any of the existing systems in use in the tunnel or its vicinity.

4) Any cladding used in a tunnel whether decorative or functional should be checked to assure that under combustion it does not produce toxic gasses.

5 SUMMATION

Critical points for designers & contractors to note:

- All cables used in tunnels are to be LS0H
- Any cable trays are to be either double dipped galvanised or stainless steel with similar mountings
- Dissimilar metals are not to be combined (in contact) in installations
- The use of covered chases / channelling in walls to support conduit/cable management/trays is acceptable as are vertical risers
- Cladding should be considered at design stage
- Cladding should be fire resistant and also LS0H
- All cladding and or cable management devices/systems must not intrude into the tunnel or compromise height restrictions in the tunnel – this extends to lateral intrusions as well.
- The use of vertical risers in tunnels is acceptable these should be either galvanised double dipped steel or stainless steel and mounted in such a way as to be flush with the walls (channels) and capped with either cladding or suitable lid.

6 FURTHER REFERENCES:

- Tunnels Manual World Road Association Website:

http://tunnelsmanual.piarc.org/en/operational-safety-requirements-tunnel-response-fire/reaction-materials-fire

- Extract from UK's Highways Agency BD78/99 Road Design Manual:

Cabling

8.59 Low smoke zero halogen (LSOH) insulation and sheathing materials shall be used for all cables inside a tunnel in order to minimise the hazards of smoke and toxic fumes arising from burning cable insulation. Normal cable compounds such as PVC give off fumes and halogen gases which, when combined with moisture, form toxic and corrosive acids. Where very short lengths (less than one metre) of low voltage communication cables are required, engineering judgement shall be used to assess whether the potential risks are low enough for the LSOH requirements to be relaxed.

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8.60 All cables shall be enclosed in cable ducts. The walkway or verge ducts shall be designed to be two hour fire resistant against a 250$_0$C temperature, with the covers in place. Smoke/fire barriers shall be installed at intervals of approximately 50m within each duct and at junctions to prevent the unrestricted spread of fire or combustion products.