

# ASHGHAL

## Interim Advice Note No. 020

### Road Tunnel Fire and Life Safety Systems

#### Revision No. A2

EXW-GENL-0000-PE-KBR-IP-00020

#### Summary

This Interim Advice Note (IAN) provides information and guidance on the minimum design requirements for Road Tunnel Fire & Life Safety Systems for use on Public Works Authority (Ashghal) projects and any road tunnels to be operated and maintained by Ashghal. This IAN recognises that the current Qatar Highway Design Manual (QHDM) does not currently include design requirements for Road Tunnels. Specifically, this IAN:

- Provides the definition of a Road Tunnel and related Fire & Life Safety Systems on Ashghal projects.
- Defines the minimum requirements regarding the design and implementation of Road Tunnel Fire and Life Safety Systems. The minimum requirements shall vary based on the Road Tunnel length, traffic and other risk factors associated with the particular Road Tunnel as described in this Interim Advice Note.

This document supersedes IAN 020 Rev 1 dated September 2013. Third parties not working on Ashghal projects make use of this document at their own risk. Paper copies of this document are uncontrolled. Refer to Ashghal's website for the most recent version.



| Rev | Date      | Reason For Issue                                | Auth | Chk | App |
|-----|-----------|-------------------------------------------------|------|-----|-----|
| A2  | Jul 2016  | Adapted to New NFPA 502 2014 Edition            | AR   | SA  | AA  |
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| 1   | Oct 2012  | For issue to EXW Consultants & Contractors      | SS   | EB  | AA  |
| 0   | Jul 2012  | For discussion with Civil Defence               | SS   | EB  | MG  |

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## 1. Foreword

- 1.1 Interim Advice Notes (IAN) may be issued by Ashghal from time to time. They define specific requirements for works on Public Works Authority (Ashghal) projects and any other road tunnels to be operated and maintained by Ashghal, subject to any specific implementation instructions contained within each IAN.
- 1.1 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.
- 1.2 Ashghal directs which IANs shall be applied to its projects on a case by case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay), a departure from standard shall be applied for by the relevant Consultant / Contractor.
- 1.3 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.
- 1.4 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.
- 1.5 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Roads Design Department, Infrastructure Affairs.

Signed on behalf of Design Department:

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**Abdulla Ahin A A Mohd**

**Roads Design Department Manager**

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## 2. Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

| Please complete all fields necessary to identify the relevant item |  |                  |  |
|--------------------------------------------------------------------|--|------------------|--|
| IAN title:                                                         |  |                  |  |
| IAN number:                                                        |  | Appendix letter: |  |
| Page number:                                                       |  | Table number:    |  |
| Paragraph number:                                                  |  | Figure number:   |  |
| Description comment:                                               |  |                  |  |
|                                                                    |  |                  |  |
|                                                                    |  |                  |  |
| Please continue on a separate sheet if required:                   |  |                  |  |
| Your name and contact details (optional):                          |  |                  |  |
| Name:                                                              |  | Telephone:       |  |
| Organisation:                                                      |  | Email:           |  |
| Position:                                                          |  | Address:         |  |

Please email the completed form to:

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We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

### **3. Introduction**

- 3.1 This Interim Advice Note takes immediate effect and should be read in conjunction with the Qatar Highway Design Manual (QHDM), Qatar Construction Specifications (QCS) and other Ashghal Interim Advice Notes (IANs).
- 3.2 For the avoidance of doubt, a Road Tunnel shall be an enclosed roadway of any length designated for motor vehicle traffic with access that is limited to portals, including all underpasses.

### **4. Withdrawn / Amended Standard**

- 4.1 Road Tunnel Fire and Life Safety Systems on Ashghal Projects shall be designed in accordance with “NFPA 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways, 2014 Edition” as modified by Appendix A of this Interim Advice Note.
- 4.2 In all cases, the design of Road Tunnels shall include an Engineering Analysis including the development of a Risk Assessment to assess the applicability and requirement for Fire and Life Safety Systems in each of the Road Tunnels within the specific Project. The Risk Assessment shall be undertaken in accordance with the requirements described in Appendix B.
- 4.3 This Interim Advice Note does not cover facilities covered in NFPA 502 other than Road Tunnels. This includes Bridges, Limited Access Highways and Air-Right Structures.

### **5. Implementation**

- 5.1 This IAN is to be used with immediate effect on all road tunnels to be operated and maintained by Ashghal and also on projects as follows:
  - All Ashghal projects in Design Stage
  - All Ashghal projects in Tender Stage
- 5.2 Ashghal projects in Construction Stage shall be reviewed by the Project Consultant / Contractor and the implications of adoption of this Interim Advice Note discussed with the respective Ashghal Project Manager. In this case the Consultant shall undertake a risk assessment on the current design in accordance with this Interim Advice Note to review the implications of any deficiencies within the current design when compared with the Interim Advice Note and the practicalities of modifying the design and construction to meet this Interim Advice Note.
- 5.3 The only exceptions are:-
  - Projects already in Construction, where a significant portion of construction and procurement has already occurred and design modification would not be practicable.
- 5.4 If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager or designated Programme Management Consultant (PMC) on a scheme specific basis.

## **Appendix A – Modifications to NFPA 502 (2014 Edition)**

For the purposes of this Interim Advice Note, the following modifications shall be made to NFPA 502 2014 Edition.

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*Revise Section 4.3.1 to read as follows:*

**4.3.1** Regardless of length of the facility, as a minimum, the Consultant shall undertake an engineering analysis including a detailed Risk Assessment of the Road Tunnel in accordance with Appendix B of this Interim Advice Note.

\*\*\*

*Revise Section 7.2 to read as follows:*

## **7.2 Application.**

**7.2.1** For the purpose of this standard, factors described in 4.3.1 shall dictate fire protection and fire life safety requirements. The minimum fire protection and fire life safety requirements are based on tunnel length and traffic type and count as categorized below. These minimum requirements, which are more fully described within this Standard, are summarized in Table A.7.2.

- Category X\* — Where tunnel length is less than 90 m
- Category A — Where tunnel length is 90 m or greater
- Category B — Where tunnel length equals or exceeds 240 m
- Category C — Where the tunnel length equals or exceeds 300 m
- Category D — Where the tunnel length equals or exceeds 1000 m

\* - Where a tunnel is less than 90m long but includes a long length of ramp into or out of the tunnel then consideration shall be given to categorising the tunnel as A based on the outcomes of the Risk Assessment.

\*\*\*

*Add a new 7.2.2 as follows:*

**7.2.2** Table A.7.2 identifies certain systems as “Conditional Mandatory Requirement” for some tunnel categories. The determination (condition) of whether these systems are necessary or not shall be based upon an approved engineering analysis addressing the factors outlined in 4.3.1.

\*\*\*

Revise Table 7.2 as follows:

**Table A.7.2 Minimum Road Tunnel Fire Protection Reference**

| Fire Protection Systems                                      | NFPA 502 Sections | Tunnel Categories  |                    |                    |                    |                    |
|--------------------------------------------------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                                                              |                   | X<br>[See 7.2.(1)] | A<br>[See 7.2.(2)] | B<br>[See 7.2.(3)] | C<br>[See 7.2.(4)] | D<br>[See 7.2.(5)] |
| <b>Engineering Analysis</b>                                  | 4.3.1             | MR                 | MR                 | MR                 | MR                 | MR                 |
| <b>Fire Protection of Structural Elements<sup>a</sup></b>    | 7.3               | CMR                | MR                 | MR                 | MR                 | MR                 |
| <b>Fire Detection</b>                                        |                   |                    |                    |                    |                    |                    |
| Detection, identification, and location of fire in tunnel    | 7.4               | -                  | -                  | MR                 | MR                 | MR                 |
| Manual fire alarm boxes                                      | 7.4.6             | -                  | -                  | MR                 | MR                 | MR                 |
| CCTV systems <sup>b</sup>                                    | 7.4.3             | -                  | CMR                | CMR                | CMR                | CMR                |
| Automatic fire detection systems <sup>b</sup>                | 7.4.7             | -                  | -                  | CMR                | CMR                | CMR                |
| Fire alarm control panel                                     | 7.4.8             | -                  | -                  | MR                 | MR                 | MR                 |
| <b>Emergency Communications Systems<sup>c</sup></b>          | 4.5/7.5           | CMR                | CMR                | CMR                | CMR                | CMR                |
| <b>Traffic Control</b>                                       |                   |                    |                    |                    |                    |                    |
| Stop traffic approaching tunnel portal                       | 7.6.1             | MR                 | MR                 | MR                 | MR                 | MR                 |
| Stop traffic from entering tunnel's direct approaches        | 7.6.2             | -                  | -                  | MR                 | MR                 | MR                 |
| <b>Fire Protection</b>                                       |                   |                    |                    |                    |                    |                    |
| Fire apparatus <sup>d</sup>                                  | 7.7               | -                  | -                  | -                  | -                  | -                  |
| Fire standpipe                                               | 7.8/10.1          | -                  | MR                 | MR                 | MR                 | MR                 |
| Water supply                                                 | 7.8/10.2          | -                  | MR                 | MR                 | MR                 | MR                 |
| Fire department connections                                  | 10.3              | -                  | MR                 | MR                 | MR                 | MR                 |
| Hose connection                                              | 10.4              | -                  | MR                 | MR                 | MR                 | MR                 |
| Fire pumps <sup>e</sup>                                      | 10.5              | -                  | CMR                | CMR                | CMR                | CMR                |
| Portable fire extinguishers                                  | 7.9               | -                  | CMR                | MR                 | MR                 | MR                 |
| Fixed water-based fire-fighting system <sup>f</sup>          | 7.10/9.0          | -                  | -                  | -                  | CMR                | CMR                |
| Emergency ventilation system <sup>g</sup>                    | 7.11/11.0         | -                  | -                  | CMR                | CMR                | MR                 |
| Tunnel drainage system <sup>h</sup>                          | 7.12              | CMR                | MR                 | MR                 | MR                 | MR                 |
| Hydrocarbon detection <sup>h</sup>                           | 7.12.7            | -                  | CMR                | MR                 | MR                 | MR                 |
| Flammable and combustible environmental hazards <sup>i</sup> | 7.15              | -                  | -                  | CMR                | CMR                | CMR                |
| <b>Means of Egress</b>                                       |                   |                    |                    |                    |                    |                    |
| Emergency egress                                             | 7.16.1.1          | -                  | -                  | MR                 | MR                 | MR                 |
| Exit identification                                          | 7.16.1.2          | -                  | -                  | MR                 | MR                 | MR                 |
| Tenable environment                                          | 7.16.2            | -                  | -                  | MR                 | MR                 | MR                 |
| Walking surface                                              | 7.16.4            | -                  | -                  | MR                 | MR                 | MR                 |
| Emergency exit doors                                         | 7.16.5            | -                  | -                  | MR <sup>e</sup>    | MR                 | MR                 |
| Emergency exits (includes cross-passageways) <sup>j</sup>    | 7.16.6            | -                  | -                  | MR                 | MR                 | MR                 |
| Dividing walls                                               |                   | CMR                | CMR                | MR                 | MR                 | MR                 |
| <b>Electrical Systems<sup>k</sup></b>                        |                   |                    |                    |                    |                    |                    |
| General                                                      | 12.1              | -                  | CMR                | MR                 | MR                 | MR                 |
| Emergency power                                              | 12.4              | -                  | CMR                | MR                 | MR                 | MR                 |
| Emergency lighting                                           | 12.6              | -                  | CMR                | MR                 | MR                 | MR                 |
| Exit signs                                                   | 12.6.8            | -                  | CMR                | MR                 | MR                 | MR                 |
| Security plan                                                | 12.7              | -                  | CMR                | MR                 | MR                 | MR                 |
| <b>Emergency Response Plan</b>                               |                   |                    |                    |                    |                    |                    |
| Emergency response plan                                      | 13.3              | MR                 | MR                 | MR                 | MR                 | MR                 |

MR: Mandatory requirement (3.3.37). CMR: Conditionally mandatory requirement.(3.3.37.1)

Note: The purpose of Table A.7.2 is to provide guidance in locating minimum road tunnel fire protection requirements contained within this standard. If there is any conflict between the requirements defined in the standard text and this table, the standard text must always govern.

<sup>a</sup> Determination of requirements in accordance with Section 7.3 of NFPA 502, 2014 Edition.

<sup>b</sup> Determination of requirements in accordance with Section 7.4 of NFPA 502, 2014 Edition.

<sup>a</sup> Determination of requirements in accordance with Sections 4.5 and 7.5 of NFPA 502, 2014 Edition.

<sup>d</sup> Not mandatory to be at tunnel; however, they must be near to minimize response time.

<sup>e</sup> If required, must follow Section 10.5 of NFPA 502, 2014 Edition.

<sup>f</sup> If installed, must follow Section 7.10 and Chapter 9 of NFPA 502, 2014 Edition.

<sup>g</sup> Section 11.1 of NFPA 502, 2014 Edition allows engineering analysis to determine requirements.

<sup>h</sup> If required, must follow Section 7.12 of NFPA 502, 2014 Edition.

<sup>i</sup> Determination of requirements I accordance with 7.16.2 of NFPA 502, 2014 Edition.

<sup>j</sup> Emergency exit spacing must be supported by an egress analysis in accordance with 7.16.6 of NFPA 502, 2014 Edition.

<sup>k</sup> If required, must follow Chapter 12 of NFPA 502, 2014 Edition.

\*\*\*

*Revise the first sentence in 7.3.1 to read as follows:*

**7.3.1** Where required by Table A.7.2 or 7.3, acceptable means shall be included within the design of the tunnel to protect all primary structural concrete and steel elements in accordance with this standard in order to:

\*\*\*

*Revise 7.3.3 to read as follows:*

**7.3.3** All exposed structural concrete elements above roadway level shall include either a structural fire protection material or a minimum 1kg of Class 1a, straight, mono-filament polypropylene fibres per 1m<sup>3</sup> of concrete in accordance with BS EN 14889 Part 2. The final design shall be suitable such that during a 120-minute period of fire exposure, the following failure criteria shall be satisfied:

- (1) Explosive spalling shall be prevented for all structural concrete elements.
- (2) Steel or cast iron tunnel linings shall be protected such that the lining temperature shall not exceed 300°C (572°F).

\*\*\*

*Add new Section 7.3.5 as follows:*

**7.3.5** Where polypropylene fibres are proposed a structural analysis shall be undertaken to determine the impacts of strength degradation of both the concrete and reinforcement on the structural capacity of the tunnel under a 120-minute fire as described in Section 7.3.2. The structural analysis shall be undertaken in accordance with BS EN 1991-1-2:2004.

\*\*\*

*Add new Section 7.3.6 as follows:*

**7.3.6** Where polypropylene fibres are proposed workability tests of all proposed concrete mix designs shall be undertaken prior to construction to confirm the suitability of the concrete mix for the intended works.

\*\*\*

*Add new Section 7.3.7 as follows:*

**7.3.7** Siliceous aggregates shall not be used for all exposed structural concrete elements above roadway level.

\*\*\*

*Revise 7.4.1 to read as follows:*

**7.4.1** Where required by Table A.7.2, Road Tunnels shall include Manual Fire Alarm Boxes in accordance with 7.4.6 for detecting, identifying and locating a fire. In addition, Road Tunnels with 24-hour supervision shall adopt CCTV in accordance with 7.4.3 for identifying and locating a fire. Road Tunnels without 24-hour supervision shall have an automatic fire detection system in accordance with 7.4.7.

\*\*\*

*Revise 7.4.5 to read as follows:*

**7.4.5** All ancillary spaces within tunnels (such as pump stations, utility rooms, cross passages, egress stairs and passages, etc.) shall be supervised by automatic fire alarm systems in accordance with 7.4.7..

\*\*\*

*Revise 7.4.6.1 to read as follows:*

**7.4.1.6.1** Where required by Table A.7.2, manual fire alarm boxes mounted in NEMA Enclosure Type 4 (IP 65) or equivalent boxes shall be installed at intervals of not more than 90 m (300 ft) and at all cross-passages and means of egress from the tunnel.

\*\*\*

*Revise 7.4.7.6 to read as follows:*

**7.4.7.6** Automatic fire detection systems within a tunnel shall be zoned to correspond with the tunnel ventilation zones where tunnel ventilation is proposed and water based fixed fire-fighting system zones where water based fixed fire-fighting systems are proposed. In tunnels with fixed fire-fighting systems and tunnel ventilation, the automatic fire detection system shall be zoned to the fixed firefighting system.

\*\*\*

*Revise 7.4.8 to read as follows:*

**7.4.8** Fire Alarm Control Panel. Where required by Table A.7.2, an approved fire alarm control panel (FACP) shall be installed, inspected, and maintained in accordance with NFPA 72.

\*\*\*

*Revise 7.5.1 to read as follows:*

**7.5.1** Where required by Table A.7.2, a separate radio network capable of two-way radio communication for fire department personnel to the fire department communication centre shall be provided.

\*\*\*

*Revise 7.9.1 to read as follows:*

**7.9.1** Where required by Table A.7.2, portable fire extinguishers, with a rating of 2-A:20-B:C, shall be located along the roadway in approved wall cabinets at intervals of not more than 90 m (300 ft).

\*\*\*

*Revise 7.12.1 to read as follows:*

**7.12.1** A drainage system shall be provided in tunnels and any approaching ramps where the collected drainage will lead to the tunnel, to collect, store, or discharge effluent from the tunnel, or to perform a combination of these functions.

\*\*\*

Revise 7.16.1.2 to read as follows:

**7.16.1.2** Illuminated directional signs indicating the distance to the two nearest emergency exits shall be provided on the side walls at distances of no more than 25 m (82 ft).

\*\*\*

Revise 7.16.6.2 to read as follows:

**7.16.6.2** Where required by Table A.7.2, the spacing between exits for protection of tunnel occupants shall not exceed 300 m.

\*\*\*

Add 7.16.6.8 to read as follows:

**7.16.6.8** Cross-passageways shall not be farther than 120m apart.

\*\*\*

Add new Section 7.17 as follows:

**7.17 Dividing Walls.** Where required by Table A.7.2, a 2-hour fire-rated wall shall be used to separate tunnel carriageways. The dividing wall shall comply with the requirements of Section 7.3.

\*\*\*

Add new Section 7.18 as follows:

**7.18 Breaks in Barriers.** Where F-type road side barriers are required to be broken to enable access to emergency exits the downstream section of the barrier shall be stepped back a minimum 350mm and flared at an angle of no greater than 1:15 to prevent a sharp obstruction to errant vehicles. The break in the barrier shall be 1.0m long.

\*\*\*

Add new Section 7.19 as follows:

**7.19 Fire rating of fixings.** Support devices for equipment fixed to the ceiling and walls must be capable of maintaining support under an air temperature of 450 °C for two hours.

\*\*\*

Add new Section 7.20 as follows:

## **7.20 Ventilation for Control of Pollutants**

7.20.1 All tunnels longer than 90 metres shall be assessed to see whether mechanical ventilation for pollution is required. As a minimum, the assessment shall take account of the length, gradients, frequency of congestion, vehicle emissions in congestion and at speed, number of lanes, bidirectional/ unidirectional traffic, proximity of adjacent tunnels and the frequencies and directions of external winds. The assessment shall be undertaken in accordance with the current version of the PIARC "Road Tunnels Manual".

7.20.2 Pollution monitors shall be installed in all tunnels in which mechanical ventilation is required for control of pollutants. As a minimum, monitors shall be installed to measure nitrogen oxides (NO<sub>x</sub>) and visibility. The number and location of monitors shall be as follows:

- (1) Duty and standby monitors for each pollutant shall be installed approximately 50 metres inside the tunnel from each exit portal where only one direction traffic is proposed.
- (2) In all tunnels where the traffic direction could be reversed, duty and standby monitors shall be installed approximately 50 metres inside the tunnel from each entry and exit portal.
- (3) In all tunnels greater than 500m long additional duty and standby monitors shall be installed at approximately the tunnel mid-point.

\*\*\*

Revise 10.1.1 to read as follows:

**10.1.1** Where required by Table A.7.2, standpipe systems shall be designed and installed as Class I systems in accordance with NFPA 14, except as modified by this standard.

\*\*\*

Revise 10.3.1 to read as follows:

**10.3.1** Fire department connections shall be as required by Qatar Civil Defence.

\*\*\*

Revise 10.4.4 to read as follows:

**10.4.4** Hose connections shall be as required by Qatar Civil Defence.

\*\*\*

Revise 11.1.1 to read as follows:

**11.1.1** Emergency ventilation shall not be required in tunnels greater than 300m but less than 500m in length, where it can be shown by an engineering analysis, using the design parameters for a particular tunnel (length, cross-section, grade, prevailing wind, traffic direction, types of cargoes, design fire size, etc.), that the level of safety provided by a mechanical ventilation system can be equalled or exceeded by enhancing the means of egress, the use of natural ventilation, or the use of smoke storage.

\*\*\*

Revise 11.4.1 to read as follows:

**11.4.1** The design fire size [heat-release rate produced by a vehicle(s)] shall be 50MW with a fast growth rate as defined by NFPA 72 Table B.2.3.2.3.6.

\*\*\*

Delete Section 11.4.2.

\*\*\*

Revise 12.4 to read as follows:

**12.4 Emergency Power.** Where required by Table A.7.2, road tunnels shall be provided with emergency power in accordance with Article 700 of NFPA 70. For emergency and standby power systems, other than separate service, see NFPA 110.

Add new Section 12.4.2 as follows:

**12.4.2** Extra fuel tanks for standby generators to supply tunnel systems with emergency power shall not be required, where the specified generator's fuel tank capacity will ensure at least 8 Hours of continuous operation on full load and means of remotely monitoring the level of fuel in the generator fuel tank are provided.

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## **Appendix B – Requirements for Road Tunnel risk Assessments**

## **Appendix B**

### **Requirements for Road Tunnel Risk Assessments**

Regardless of length of the Road Tunnel, as a minimum, the Consultant shall undertake an engineering analysis including a detailed Risk Assessment of the Road Tunnel to identify the specific hazards and risks associated with the proposed Road Tunnel to determine if the proposed Mandatory Requirements as listed in Table A.7.2 of NFPA 502 and as modified by this Interim Advice Note are suitable to control the risks to a suitable level. Where the risks are determined to still be too high after the implementation of the Mandatory Requirements additional Conditional Mandatory Requirements shall be added to the design such that the risks are now controlled to a suitable level.

The engineering analysis together with the risk assessment shall consider the following factors as a minimum.

- B1. The road geometry including road widths, shoulder widths, horizontal and vertical geometry (e.g. tight radii) and stopping distances.
- B2. The specific users of the facility including potential distribution of heavy and light vehicles, the anticipated cargo / property being transported by heavy vehicles as well as whether Dangerous Goods vehicles will potentially use the Road Tunnel.
- B3. The type and range of fire and other emergencies that may occur within or in close proximity to the Road Tunnel.
- B4. The potential for more than one fire or other emergency to occur within or in close proximity to the Road Tunnel at the same time.
- B5. The location of the Road Tunnel with respect to distance from emergency response facilities and the emergency response time.
- B6. The expected traffic conditions including potential for traffic congestion within and downstream of the Road Tunnel.
- B7. The time for emergency response vehicles / personnel to reach the location of the fire or other emergency should the Road Tunnel and vicinity have heavy traffic congestion.
- B8. The ability for emergency response vehicles / personnel to easily access, rescue and remove injured persons from the Road Tunnel.
- B9. Lighting conditions including potential impacts from sun glare when entering/exiting the Road Tunnel, in particular in morning and evening periods.
- B10. Impacts to existing buildings and structures in close proximity to the Road Tunnel should structural integrity of the Road Tunnel be lost during a fire or other emergency.
- B11. The ability to close roadways above and in vicinity to the tunnels during a fire or other emergency event within the Road Tunnel.
- B12. The impact to the surrounding road network should the Road Tunnel be closed for an extended period of time.
- B13. The impacts of exposing the emergency systems within the Road Tunnel to elevated temperatures.
- B14. The impact of natural factors such as prevailing wind on the behaviour of smoke during a fire and the potential impact on any ventilation system design.
- B15. The length of any depressed roadways that lead into and out of a tunnel that further limits access.
- B16. The restricted vehicles access and egress
- B17. Traffic operating mode (unidirectional, bidirectional, switchable, reversible).